Combining agroecological knowledge and empirical knowing to build pastoral management guidelines within multipurpose land use.

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Building Bridges : Grasslands to Rangelands

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Given the uniqueness of this joint International Grassland and Rangeland Congress it is fitting that the Chairs of these two organizations give their opening address jointly . It is also appropriate that the events and actions that have lead to this joint event are recorded .

From the earliest of beginnings , our global grazing lands have been essential to human survival . Our relationship with grazing lands has been increasingly exploitive , but there is now a slow reawakening of our interdependence with the many services provided by grazing lands . Sustaining the natural capital of our grazing lands is crucial , as these areas represent a very large part of our global terrestrial ecosystems . This challenge is grounded in the socio-economic expectations of land users and nations .

Over time , research and development in our global grazing lands has evolved into highly specialized areas . A reductionist emphasis has lead to the understanding of underlying functions and mechanics of grazing lands . This has underpinned increased productivity and product quality in pasture and harvested forages . In contrast , work in rangeland ecosystems has been more oriented towards integrative ecology and sociology . This difference in emphasis lead to the separation of the International Grassland Congress (IGC) and the International Rangeland Congress (IRC) in the 1970s .

Ironically , since then many common areas of interest have emerged in environmental and social concerns , ecology and multifunctional uses of our grazing lands . Increasingly , new bridges are needed to provide interaction and synergy between those people working in rangelands and grasslands .

By the 1990s a groundswell of interest in closer coordination between ICG and IRC was surfacing . Delegates at the XVIII IGC in Canada in 1997 , instructed the Continuing Committee to approach the Continuing Committee of the IRC about the possibility of a joint meeting of the two Congresses , and on possible eventual amalgamation of the two Congresses . In 1997 , Bob Clements (Chair , Continuing Committee , IGC) and Margaret Friedel (Chair , Continuing Committee , IRC) met and set out arguments for and against a shared Congress with a view to ongoing closer coordination of the Congresses . They suggested that such a shared congress might take place by 2003 .

In July 1999 , the IRC met in Townsville , Queensland , Australia . Three motions were put to the delegates as follows : 1) to promote a more efficient and effective interchange of information on all aspects of range and grassland science , and to meet common goals and objectives , the IRC endorses the concept of closer cooperation with the IGC , 2) the chair of the IRC Continuing Committee should explore mechanisms for meeting common goals and objectives with the chair of the IGC Continuing Committee , 3) the IRC endorses the concept of a shared conference with the IGC by the year 2007 and requests the Continuing Committee of the IRC to develop in collaboration with the Continuing Committee of the IGC the framework for a shared Conference program and procedures for selection of a host country . Motions 1 and 2 were passed but motion 3 failed to pass .

Two years later in 2001 at the XIX IGC congress in São Paulo , Brazil , three resolutions were presented to the delegates at the final business meeting , with the first two being the same as the first two at Townsville . The third was : the members of the XIX IGC request that the chair of the IGC Continuing Committee meets with the chair of the IRC Continuing Committee within the next 12 months to jointly identify and promote shared activities for meeting common goals and objectives . All three resolutions were passed unanimously .

Meanwhile , China had submitted an unsuccessful bid for the IGC venue at both the 1997 and the 2001 IGC congresses . Interest was high , however , in developing a bid that would be submitted in Ireland in 2005 for the 2009 IGC venue . To this end , Vivien Allen , IGC Chair , Gavin Sheath (Region 5) , Masakazu Goto (Region 6) and Geza Nagy (Region 10) traveled to China in July 2001 to discuss the potential of China being a venue . It was agreed that the Continuing Committee would work with the Chinese organizers in developing the bid for XXI IGC . Discussions progressed between the IGC Continuing Committee and the organizers in China over the next several months .

In December , 2001 Vivien Allen (chair , IGC) and Jim O'Rourke (member of IRC Continuing Committee) attended a meeting in Washington , D .C . It was revealed that the IRC Continuing Committee was anticipating a bid from China for their 2007 venue while the bid under discussion between the IGC and China was for the 2009 IGC venue . Neither congress had been in China previously . Thus , both were interested in this location but there were obvious concerns about holding two major international congresses on grazing lands just 2 years apart . A possible solution was to combine these meetings , but Motion 3 from Townsville clearly stood in the way . Much discussion followed with the organizers in China and between the leadership of the two congresses .

Thus , in June , 2002 , Vivien Allen (IGC chair) and Maureen Wolfson (IRC president) met in Chicago , Illinois to discuss the possibility of a joint venue in China for the two congresses . It was agreed that : 1) China would be encouraged to submit a bid to both congresses for a shared meeting in 2008 (one year out of the rotation for each congress) ; 2) the IRC would pursue other bids as well ; 3) the IGC would continue to work toward a China venue . In lieu of the failed Motion 3 from Townsville , it was agreed that at the VII IRC in Durban , South Africa in 2003 , the concept and opportunities of a joint meeting would be presented to the Delegates . It would be emphasized that this was not a suggestion of permanent merging of these congresses , but was a unique opportunity of this particular venue . The vote in Townsville would have to be reversed before the Continuing Committee could vote on the bid from China . Thus , the delegates would be voting on the concept of a shared venue , not on the acceptance of the bid .

At the 2003 IRC held in Durban , South Africa , there was interest from the Chinese in a joint congress to be held in 2008 with IGC in Hohhot , Inner Mongolia , People's Republic of China . Following the vote against such an event at the 1999 IRC in Townsville , considerable lobbying occurred during the Durban congress to convince the membership of the advantages of doing so . The China bid was unanimously accepted . Following the IRC's acceptance of the bid by China for a joint IGC/IRC congress , the IGC Continuing Committee received a parallel bid from China at the Dublin IGC in 2005 . The bid was accepted unanimously . Thus , 8 years after discussions officially began in Canada expressing support for the concept of holding a joint IGC/IRC congress , the bids were accepted and the venue was set for Hohhot in June of 2008 .

Since late 2005 , Gavin Sheath (IGC chair) , Jim O'Rourke (IRC chair) and Gordon King (IRC secretariat) have worked with the China Organizing Committee . The fruits of this joint work are evident in the sponsorship gained and the program developed . Global sponsorship has exceeded US $ 500 ,000 and is derived from a wide range of sources . The lesson-a joint Congress ensured two similar organizations were not competing for increasingly scarce funding support . The program is a well balanced mix of production , sustainability and people themes-the essence of multifunctional grasslands and rangelands . The lesson-we will make best progress in sustaining the world's grazing lands and communities when we draw on the best brains and experience .

This IGC-IRC 2008 congress provides an opportunity to build bridges between researchers working in different science disciplines and people who are working to develop sustainable systems and communities in different regions of the world . While work involving singular disciplines of study has provided knowledge of greater depth , we also need a better understanding of the interactions and emergent properties of our grazed ecosystems . The long-standing principles of ecology , armed with the analytical power of simulation modeling , has a major role to play in understanding and designing sustainable systems of the future .

People must be an integral part of any future system design . They are not observers and their expectations will shape the way grazed ecosystems will be managed . While some people seek high quality food and a pristine environment , we must recognize that many other communities simply seek a little more food and economic wealth to survive . Good science must not take a political position with regards to resolving tensions and managing our grazed lands in a better way . Rather , it must inform the various communities of interests . In the end , wise solutions will be a balance of tradeoffs that are based on informed decisions and actions .

It will be interesting if the desired changes we seek in people will occur voluntarily , or will require incentives and regulations . Like most things in life , a mix will probably be required to ensure the necessary knowledge and motivation is in place .

As we address the urgencies of global warming , a growing global population that demands higher living standards and a better diet , social stability , alternative energy sources , and protection of our environment and natural resources , we increasingly turn to our global grazing lands resources to find solutions . New bridges have brought together the IGC and the IRC for the first time in history in Hohhot , Inner Mongolia in the Peoples Republic of China . Perhaps history will look upon this as the stimulus for new collaborations that will lead ultimately to solving these grand challenges .

Overview of grassland and its development in China

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Key points :
1 . About 400 million hectares of grasslands occur in China , which accounts for 41 .7% of the country s total land area . Various types of grassland/rangeland are represented in China with abundant forage plant resources , but productivity varies significantly among different types of grassland .
2 . Since the 30 years of reform and opening up , material progress has been seen in protecting the grassland in China . The grassland law and regulations have been accomplished , the grassland management official teams have been enlarged , large projects implementation in grasslands have benefited the area significantly , the grassland economy has been growing fast , and the ability in science and technology has been increased .
3 . Several challenges of grassland development need attention for the development of a grassland industry , including the severe situation of grassland ecology , the marked contradiction between grassland protection and utilization , over population and shortage of grassland resources , the unreasonable exploitation of grassland , the underdeveloped mode of production in stockbreeding system , and the natural calamities in grassland area , etc .
4 . China has drafted the developmental strategy of grasslands to define the objectives and steps needed in the future in order to protect and utilize grassland resources in a reasonable way .

Key words : grassland , protection , development , science and technology , development , strategy

Resource of grassland in China

1 . Area and distribution

China is a country with a large area of grassland . There are about 400 million hectares of grassland , which account for 41 .7% of the country's total land area , 2 .5 and 3 .3 times that of forest and arable land , respectively .

If we draw a line in the map of China from the Great Xingan Mountain areas to the east side of Tibet-Qinghai Plateau , we can see two parts of China , the northwest part and the southeast part . The grassland is mainly located in the northwest area , which mainly contains mountains and plateaus in the arid and semi-arid pastoral areas . The 320 million hectare of grassland in this region accounts for 80% of the country's total grassland area . The southeast part , however , is mainly hilly grassland covering 80 million hectare , accounting for 20% of the country's total grassland . About 75% of the grassland is distributed in the arid and semi-arid pastoral areas , including Tibet , Inner Mongolia , Xinjiang , Qinghai , Sichuan and Gansu , of which Tibet has the largest grassland area with about 82 .05 million hectare , then Inner Mongolia with 78 .80 million hectare , Xinjiang with 57 .26 million hectare , Qinghai with 36 .3697 million hectare and Gansu with 17 .9042 million hectare (Figure 1) . The south part of China is mainly the agriculture area with few grasslands .

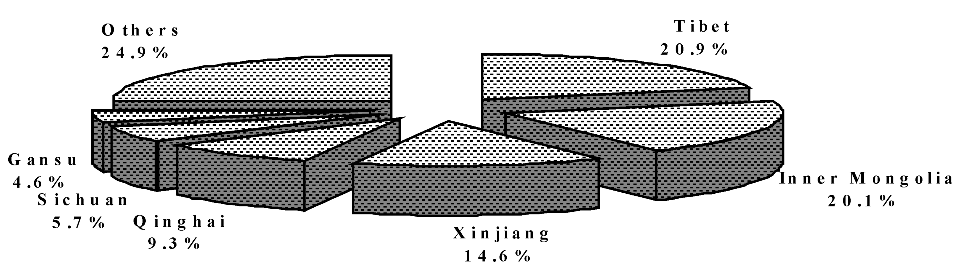

Figure 1 *Area proportion of China main grassland region .*

2 . Grassland types and resources

China , with a vast territory , encompasses the tropical , subtropical , warm-temperate , mid-temperate and cold-temperate types from south to north . The annual precipitation decreases from 2000 mm in southeastern coast to below 50 mm in the west , while the altitude increases from 100 m below sea level to more than 8000 m above . These complex and diverse natural conditions form a rich variety of grassland .

According to the standards for Chinese grassland classification , it can be divided into 18 categories , namely temperate meadow , temperate steppe , temperate desert grassland , temperate grassland-like desert , temperate desert , alpine meadow , alpine grassland , alpine meadow-like grassland , alpine desert grassland , alpine desert , warm tussock , warm shrubby tussock , tropical tussock , tropical shrubby tussock , drought hot tree-less grassland , lowland meadow , maintain meadow and marshes . The area of alpine meadow is largest with 63 .72 million hectares ,accounting for 16 .2% of the country's total grassland , following the temperate desert , alpine grassland , temperate steppe , lowland meadow , temperate desert grassland and others with 45 .06 , 41 .62 , 41 .09 , 25 .22 , 18 .92 million hectares ,accounting for 11 .5% , 10 .6% , 10 .6% , 6 .4% , 4 .8% of the country's total grassland , respectively . The remaining 12 types of grassland are 40% .

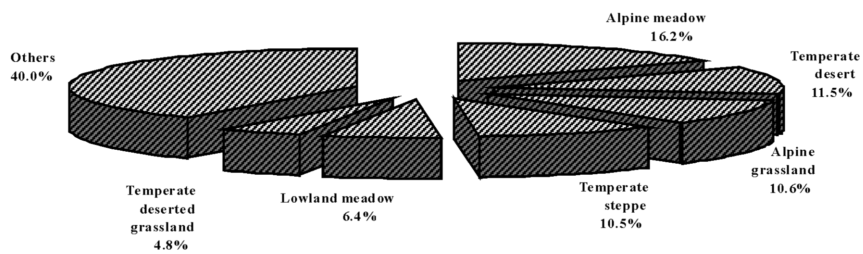

Figure 2 *Ratio of Chinese grassland types .*

3 . Forage plant resource of grassland

There are 6704 forage species belonging to 1545 genera and 246 families . According to the statistics on forage families in China , there are 100+ species in Legume , Grass , Composite , Sedge , Rose , Goosefoot , Lily and Knotweed families , whilst 1238 and 1148 species belong to the Legume and Grass families , respectively .

Table 1 *Forage resources in Chinese grassland .*

family	species	Proportion%
Legume	1238	18 .47
grass	1148	17 .13
Composite	538	8 .03
Sedge	358	5 .34
Rose	230	3 .43
Goosefoot	198	2 .95
Lily	195	2 .31
Knotweed	143	2 .13
Others	2578	40 .34
Total	6704	100

4 . Grassland productivity

According to the statistics of Ministry of Agriculture , the average annual hay production of China in 2007 was about 760 kg/ha , and the livestock carrying capacity was 0 .59 sheep unit/ha . The Strategies for utilization and protection of the grassland separates grassland in China into four parts which are semiarid and arid region in the north , the semi-humid and humid region in the northeast , the Tibetan Plateau high-cold region , and the meadow and steppe in the south . The arid and semiarid region is located in northwest China ,northern area of north China , and westen area of northeast China with the annual precipitation below 400 mm . Precipitation also following an east-west-trend , which is the same trend of productivity . The types of grassland are mainly temperate steppe , temperate desert grassland , temperate desert . The annual hay productivity is 200-1000 kg/ha with a livestock carrying capacity of 0. 2-0. 5 sheep unit/ha . The semi-humid and humid region in the northeast has favorable water/thermal elements with annual precipitation above 400 mm and also has high vegetation cover , good grass quality and high productivity . The grassland type is mainly temperate meadow , warm tussock and warm shrubby tussock . The annual hay productivity is 1000-1800 kg/ha with a livestock carrying capacity of 1 .0-1 .6 sheep unit/ha . The Tibetan Plateau high-cold region located in the Tibetan Plateau with the altitude above 3000 m , has low productivity due to the elevation , short frost free periods and cold temperatures . The grassland type is mainly alpine meadow , alpine grassland and alpine desert . The annual hay productivity is 100-300 kg/ha with a livestock carrying capacity of 0 .1-0 .3 sheep unit/ha . The meadow and steppe in the south China has a relatively warm climate and rich water resources with annual precipitation above 1000 mm . The growing season is long and the productivity is high . The grassland type is mainly tropical tussock and tropical shrubby tussock . The annual hay productivity is 2000-3000 kg/ha with a livestock carrying capacity of 2 .0-2 .5 sheep unit/ha .

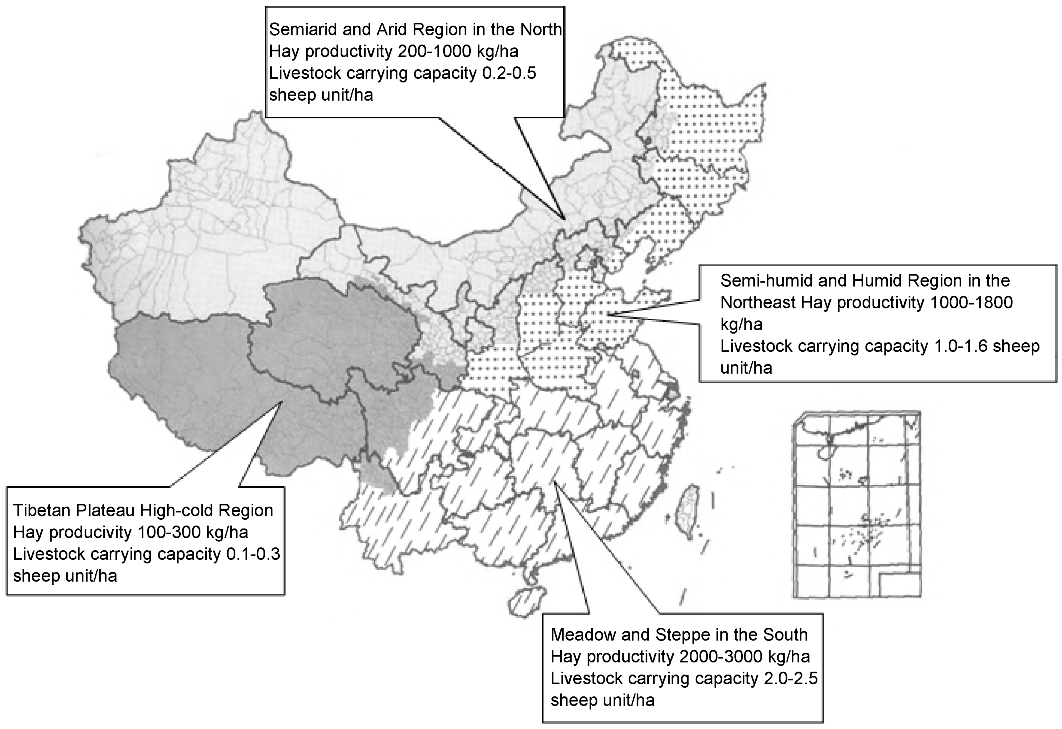

Figure 3 *Carrying capacity pattern chart of different grassland classes* .

Grassland conservation and development

In order to protect the grassland and to improve the grassland environment , the national government has been paying more attention to grassland conservation and development . Since the reform and opening up , especially the entry of the new century , there are marked progresses in grassland conservation and development .

1 . Grassland law and regulation development

Since the building of the legal system in China , the first Grassland Law" was promulgated in 1985 , and amended in December 2002 . The Ministry of Agriculture introduced the the management of grass and livestock" and practices of grass seed management" , the management of levy review and approval of grassland requisition" , the management of collecting licorice Ephedra grass" and some relatively supporting laws and regulations . Inner Mongolia , Heilongjiang , Sichuan , Ningxia , Gansu , Qinghai , Tibet , and other provinces introduced regulations on the grassland area . At present , the improved grassland law and regulation have been developed , providing legal basis for the grassland management and protection .

In addition , a series of laws concerning the grassland resources and ecosystem protection have been unveiled in China during this period , including environmental protection law" , law of preventing and controlling sand" , agricultural law" , pastoral law" , law of rural land contract" and wildlife protection law" . These laws provide specific stipulations for the grassland protection and management in various areas .

2 . Grassland organization policies

Since the 1980s , the national government has implemented the household contract system in grassland as a basic policy . It gives the farmers and herders the right to operate their grasslands independently . Farmers and herders have the initiative of protecting as well as reasonably utilizing the grassland , which shows their main role in grassland protection and development . At present , 70% of the whole available grassland area is in the household contract system .

The policy for grassland protection , forage and animal balance and banning grazing has been implemented by the national government in order to perfect the management policies . Some concrete measures of improving grassland productivity have also been put forward . At the same time , mechanisms for ecological compensation and resources utilization have been sent forward .

3 . Management team development

The governments at all levels are responsible for the management of grassland in China . Since 2003 , grassland monitoring and management has been gradually established and improved from banner (County) to provincial and Central governments in the management system. At present, more than 794 grassland monitoring institutions are located in the country, including national level 1, provincial level 24, prefectures-level 116, county level 653, and almost 10,000 grassland Supervisors. Most of these institutions were established after the Grassland Law" was amended and passed in 2003. Grassland management agencies at all levels combat all kinds of illegal destruction to grasslands making them an important force in protecting grasslands. According to statistics from 2003 to 2007, nearly 50,000 cases of illegal activities occurred, the rising trend of such cases was curtailed effectively. At the same time, a support team for the development of a grass system has also been initiated. The nationwide number of above county level grassland technology promotional agencies is over 900, and the technical promotion staff is over 10,000. The three agencies, namely the grassland management agency, the law enforcement monitoring agency and the techniques extension agency, perform their duties and cooperate with each other to promote the development of Chinese grassland management.

4. Project development on grassland

Since entering the new century, the national government has been adhering to the scientific development concept and increasingly investing in the grassland protection. Since 2000, the central government has invested more than 10 billion RMB to grassland vegetation recovery including grass seed bases establishment, grassland fencing, grazing ban on heavy degraded areas, and sandstorm control around Beijing and Tianjin. The project of vegetation recovery was initiated in Inner Mongolia, Sichuan, Yunnan, Gansu, Qinghai, Ningxia, Xinjiang, Tibet, Guizhou, Xinjiang, and 8.5 billion RMB was invested from 2003 to 2007. Prior to 2007, the paddock area was 38 million ha, sown pastureland was 10.86 million ha and over 16 million ha were occupied by improved grassland. Several major developmental projects have achieved positive ecological, economic and social benefits and have promoted the transition of production methods. With the implementation of the project, the grassland and livestock grazing balancing system, the improvement of livestock breeds and upgrading of management level have been implemented at the same time. At present, the country has 20% of the grasslands under a grazing banning system and the vegetation recovery has been remarkable.

5. Grassland industry development

The grassland industry includes grassland animal husbandry, grass seed industry, grass production and processing industry and turf industry. Of all the herbivorous livestock products of China, beef production reached 7.5 million ton, which accounted for 11.7% of the world's beef output in 2006; lamb production reached 4.7 million ton, which accounted for 34.6% of the world's lamb output; the production of beef and lamb has increased by 40.8% and 71.4% since 2000. Milk output including dairy cow, goat and buffalo is 33.03 million ton, accounting for 5.1% of world's output. Milk production of dairy cow is 31.94 million ton, the number of cows is 13.63 million, respectively 3.86 and 2.79 times as many as there were in 2000. In recent years, the country has built a number of grass seed farms which meet the requirements for the development of grasslands. At present, there are more than 190 grass production and processing enterprises in China with annual production capacity of more than 4.6 million ton. Exports of grass products have also increased annually, becoming the new highlights in export trade. The turf industry, emerging as a newly developing industry in the past 20 years, enjoys a rapid growth. The number of enterprises in turf industry has exceeded 5000. The grassland industry development also benefits many other relevant industries such as food, textile, leather making, pharmaceutical, chemical, papermaking, energy, pesticide and machinery. This plays an important role in increasing labor employment and peasants' income.

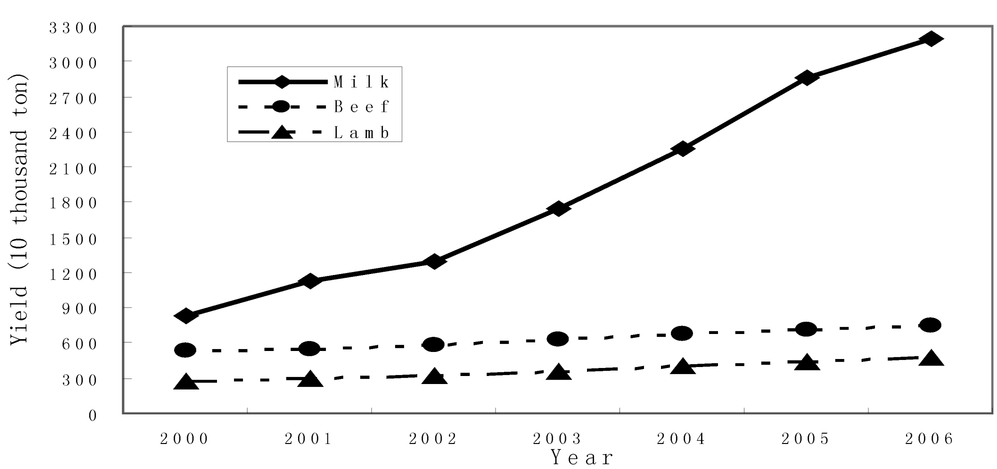

Figure 5 *China Beef and Lamb production and Milk yield from 2000 to 2006.*

Grassland science and technology research

1 . Science and education system

After 50 years , China's grassland education courses have changed gradually from a single to a comprehensive system with teaching specialist , undergraduate , master's and Ph .D . levels . At present , there are more than 40 institutions with a grassland major with more than 1 ,500 teachers . The number of students in this major is more than 13 ,000 , of which more than 1 ,900 are post-graduate students with more than 440 doctoral candidates . While training and educating professionals about grasslands , these universities take advantage of their situation and make great achievements in scientific research . At the same time , professional scientific research institutions are also enjoying advancing development . In the late 1950s , the Chinese Academy of Agricultural Science and the National Institute of Animal Husbandry in provinces and autonomous regions have established forage research centers . In 1964 , the Chinese Academy of Agricultural Science organized China's first national grassland professional research institution-Institute of Grassland Research in Hohhot , Inner Mongolia . At present , the country has established a National Grassland Research Institute , five provincial-level Institutes of Grassland , 4 provincial and ministerial key laboratories , 20 Grassland Research Centers , 2 National Field Stations . The grasslands scientific research institutions have also played an important role in educating master and Ph .D students . Professional colleges and scientific research institutions work together to form the China grassland science , technology and educational system . In addition , the technology promotion departments at all levels and enterprises are playing an increasingly significant role in transforming the scientific research into practice . They actively participate in the relevant scientific research and worker training which has become an important component in China's grassland science , technology and education area .

2 . Innovation capacity

As for the grasslands scientific theory innovation , the China grassland science education fellows have developed a set of grassland scientific theories , such as grassland ecology , pasture taxonomy , grassland taxonomy , forage breeding , the cultivation of pasture , grassland management , forage seed science , grass production and processing of products , turf-school science , benefiting from the essence of the grasslands scientific theory in the world . Modern biotechnology , information technology and other advanced applications of science and technology have been applied to continuously improve China's grassland science and technology innovation capabilities . For example , biotechnology has been fully used in forage breeding research , molecular biology technology in pasture genetic resources research , remote sensing , geographic information systems and global positioning system (3S technology) , as well as computer technology in grassland resources monitoring and disaster warning study .

As for the operating mechanisms in grassland science research , technology transfer and educations , there are more and more communication and contact in grassland professional colleges and universities , scientific research institutions , technology promotion body , administrative departments , law enforcement agencies , as well as grass industry enterprises , working with each other in personnel training , science and technology research , technology promotion , technical service , the integration of resources to gradually establish and promote the formation of a common development in grassland science and technology , education and health .

3 . Achievement in science research

After the unremitting efforts of generations of grassland science education fellows , we have achieved fruitful grassland research results . In the area of forage germplasm resources and new breeding research , we have collected more than 10 ,000 forage germplasm resources , and cultivated and audited nearly 400 new species of forage . In efficient utilization of technology in the grassland in South , we have worked out a comprehensive way of managing the improved natural grassland , sown pasture and livestock grazing . In the area of forage seed production and the industrialization of technological research , we have develop methods for cultivation of alfalfa and other forages and the harvesting and packaging technology and related machinery . In the development of information technology research , the successful application of 3S technology has been used in grassland areas for monitoring dynamic disasters and early warning , monitoring major projects in grassland development , remote sensing and quick search of grassland resources , and monitoring livestock balance . In forage biotechnology research , we have worked with the technology of tissue culture , transgenic breeding , marker-assisted breeding and other technical problems , and modern molecular biological techniques to evaluate forage germplasm resources . In turfgrass research , we have implemented research in establishment and management of golf courses and football pitches , meanwhile positive progress has also been seen in breeding anti-adversity species . In grazing management research , we have analysed the mechanism of grassland degradation and the impact of grazing on the vegetation , and tried to optimize the reasonable use of grassland resources . In pest control research , we have successfully developed a combination method of biological control , chemical control and physical combat techniques . These achievements not only further enrich the theoretical foundation of China's grasslands science , but also play an important role in grassland management practices .

Current challenges in China

Although some significant advances have been made in protecting grassland in China and in the education and research areas , considering the whole picture , the Grassland Industry in China is still at a primary stage and many challenges await us in the future and these are summarized below .

1 . Severe situation of ecology

Influenced by the natural effects of the global warming and arid climate and some artificial factors , 90% of the grasslands in China show degeneration in various degrees . The sandstorm , desertification and soil and water loss are making the situation severe . Although there has been some recovery of grassland condition in the major development projects , the deteriorating trend of grassland condition is not under control .

2 . The protection cannot meet the development and utilization of grassland

In China , the grassland environment is becoming worse , and needs to be protected immediately . However , the pressure of population is still high with increasing livestock numbers and unreasonable use . Consequently , while part of the grassland has been protected , the entire area is suffering degeneration . The sustainable development can hardly be realized if the situation isn't changed by means of protecting the ecological environment and allowing the vegetation to recover on grassland as soon as possible . In addition , the economy in the grassland area lags far behind the others which indicate we must accelerate the development so as to fulfill the goal of becoming a well-off society in this area . Grassland is the main area supporting a large amount of poverty in our country , where there is 70% of the poor and 70% of the rural towns as reported by the National Strategy of Poverty Reduction . We all know that the grassland industry is the traditional superior industry in this area , and it is also irreplaceable . Developing the grassland industry , however , would make it more difficult to protect the local environment . Hence , only when we manage the protection and the utilization properly , may we implement the development of ecology and economy at the same time .

3 . Population of people and livestock increase with shortages of grassland resources

For one thing , the proportion of the grassland is shrinking . Since the last century , grassland in northern China has moved back almost 200 km to north and 100 km to west . In recent years , the decrease rate of grassland in China has been 1 .5 million hectares per year and the situation worsens . For another thing , the number of people and livestock on grasslands is increasing every year . In 2006 , the number of cattle and sheep on China's grassland was 2 .7 times and 3 .5 times , respectively , of that in 1978 . Thirty four percent of China's grassland are overgrazed , 17% higher than in the 1980s . During the recent 50 years , the population in pasturing areas has grown several fold . Presently , the population in Inner Mongolia , Xinjiang , Qinghai and Gansu is 4 .24 times , 4 .03 times , 3 .66 times and 2 .72 times of that in the 1950s , respectively , even in Tibet the population is more than 2 times of that in 1951 . The grassland provides the basic subsistence for the peasants to produce and survive . However , due to the increasing number of people and livestock and the shrinking area of grassland , there must be growing pressure and impact on the existing grassland .

4 . Unreasonable utilization of grassland resources

Due to the economic interests , non-agriculture uses such as coal mining , collecting grassland wild plants , and illegally utilizing grassland have not been fully stopped . Since the 1950s , areas of non-agriculture uses have totaled about 20 million hectare . As a result of little precipitation and the arid climate , nearly 50% of these disturbed grasslands have become bare or sandy land . Some wild plants such as glycyrrhiza , Chinese ephedra and caterpillar fungus are removed from the grassland , which substantially reduces the wild plant resources and seriously damages the grassland ecological environment . Still , there is unreasonable exploitation of water in some area , causing the downstream lakes to dry up and the disappearance of oasis and external vegetation .

5 . The lagging production mode of animal husbandry

The grassland animal husbandry was under extensive management with undeveloped management and low interests . For a long time , the animal husbandry mainly relied on natural grassland grazing . Further more , the infrastructure on the grassland area is so undeveloped that the situation of agricultural production relying on nature is unchanged . Scientific utilization of grassland has not been effectively implemented in the majority of areas . Sown pastures only occupy less than 3% of the total grassland area . The degradation of livestock breeds and decline in production are obvious . Nevertheless , the economic increase of traditional grassland animal husbandry depends on the increase in number of livestock which not only damages the grassland resources but also produces low income .

6 . Frequent occurrence of natural disasters

Severe disasters happen in China every year , for instance , grassland fires , pest outbreaks , snowstorms . Over the last decade , on the average annual grassland fires occurred hundreds of times , and there were 30 severe fires . Some areas suffer from rodents and pest , about 40 million hectares and 20 million hectares , respectively . Over the past 50 years , there were over 60 snowstorms and 26 droughts in Inner Mongolia , Xinjiang , Tibet , Qinghai , Sichuan and Gansu . Frequent occurrence of natural disasters causes huge economic losses each year , and the direct economic loss resulting from livestock deaths is several billion RMB .

Grassland development strategy

For reasonable protection of the grassland resources , and the promotion of the ecological , economic and social sustainable development , China's Ministry of Agriculture has prepared a strategy for the future sustainable development of grasslands , and proposed the strategic thinking, strategic objectives and strategic measures to protect the building of China's grasslands for the future.

Strategic thinking

Grassland protection should convert from the dominance of economic benefits to the balance of economic, social, ecological benefits, as well as ecological priorities. Measures should also be taken to promote the conversion of the prairie grassland's economic growth mode, animal husbandry production and the lifestyle of farmers and herdsmen, to speed up the implementation of key projects of grassland protection and development, to promote scientific and technological progress and industrial development, to establish a complete security system to support and enhance grassland sustainable development capacity, and to promote the development of production, affluent life and good ecology for the grasslands.

Strategic objectives

1. Overall objective

Through utilization of fences, grassland improvement, sown pasture establishment, scientific farming, as well as improved livestock grazing, resting and rotational grazing and a series of comprehensive measures, we can stop the degradation of the grassland gradually, we can help the grassland ecological environment continue to improve, make further improvement of grassland agricultural and pastoral industry and economic structure, effectively enhance the ability of grassland sustainable development, complete the support system for grassland protection, and preliminarily establish healthy ecosystems in which humans live harmoniously with the natural resources and environment, and finally achieve the goal of green prairie grassland animal husbandry-up, and the farmers and herdsmen become rich".

2. Specific tasks

By 2010, the total area of fenced grassland should reach 100 million hectares, the area of improved grassland 40 million hectares, and the area of sown pasture 20 million hectares. Grazing prohibition, resting, and rotational grazing should be used in 40 percent of the country's available grassland. The area of natural grassland overstocked with livestock should decrease from the current 34 percent to below 25 percent. A total area of more than 110 million degraded, desertified, and salinized grassland should be treated.

By 2020, the total area of fenced grassland should be 150 million hectares, 60 million hectares grassland should be improved, and sown pastures should be 30 million hectares. Accumulated improvement from reducing degradation, desertification, salinization should be more than 165 million hactares. Grazing prohibition, resting, and rotational grazing should be utilized in 60 percent of the country's usable grassland. Natural grassland and livestock become balanced, grassland vegetation recovers, and grassland productivity increases significantly.

Strategic measures

1. Enhance the government's emphasis, and increase investment in the development of the protection of grassland

The development of grassland protection should be taken into the consideration and be given active support, when governments at all levels formulate the economic development planning and industrial development policies. The mechanism in which government investment acts as the mainstay for investing in the grassland ecological development should be developed. Special funds should be established to ensure steady growth of the developmental input for the protection of grasslands. At the same time, we should actively encourage domestic and foreign enterprises, social organizations, and the farmers and herdsmen to personally invest in pasture protection development.

2. Complete the system of laws and regulations, increase the intensity of the implementation of laws and regulations

According to the Grassland Law", supporting laws and regulations should be formulated and completed for grassland protection, grassland surveys, grassland statistics, grass seed management, and management of grassland occupation and levy. We should speed up revision and perfection of local grassland regulations, improve operability and effectiveness of the law, strengthen grassland law education, constantly enhance the legal quality of the farmers and herdsmen, and enhance social awareness of the law to protect grasslands. We should increase the intensity of the implementation of laws and regulations in grassland protection, be strict in grasslands law enforcement monitoring, and control the illegal destruction of the grasslands in accordance with the law.

3. Promote sound grassland household contract system and expedite the implementation of various systems for the grassland protection

We should further improve the implementation of the household contract system in grasslands, give the peasants and herders the long-term utilization rights, and fully mobilize their enthusiasm and creativity to protect grasslands. As for the grasslands under the contract, we will strengthen the management and standardize the transfer of management rights; as for the grassland yet on the contract, we will accelerate the implementation. While continuously improving the household contract system, we are fulfilling the basic grassland protection, grazing balance system, and the reasonable use of grassland resources.

4 . Plan the protection and major development project

According to the national grassland protection and building planning" , we will speed up nine projects , namely the implementation of grazing ban , managing the sources of sandstorms in grasslands , vegetation recovery in desertified areas , grass seed industry , disaster prevention and reduction , development and utilization of grassland , Grassland Nature Reserve building , and nomadic settlement . Strengthening the management of the developmental projects , improving project quality and efficiency , and promoting the grassland ecological restoration and enhancing grassland production capacity , and improving conditions in pastoral areas of infrastructure allow us to be able to achieve comprehensive economic development in pastoral areas .

5 . Strengthen monitoring and management team and raise the level of management in accordance with the law

We will establish and improve the monitoring and management of grassland institutions to further perfect the national , provincial , prefecture , and county grassland monitoring and management system . We will also improve grassland management authority infrastructure and grasslands law enforcement . We would strengthen the grassland professional and technical training for monitoring and management to enhance operational capacity of grassland Supervisors .

6 . Establishing the grassland eco-compensation mechanism and the paid system in using grassland resources

On the grassland ecological protection areas , it is the Government who will provide certain economic compensation to the farmers and herdsmen to ensure not to reduce their income , and thereby mobilize their enthusiasm in protecting grassland . At the same time , also in accordance with the users pay" principle , we will charge the users of grassland resources .

7 . Develop sown pasture and upgrade the animal husbandry production level

In rural areas , we have actively promoted the use of food crops and pasture rotation . A ternary" planting structure has been established and the area of high-quality forage planting has been expanded . In the agro-pastoral and semi-pastoral areas , we will transform farming land which is not suitable for cultivation to grassland to ease the pressure of grazing on the natural grassland . At the same time , we will make full use of free land , sloping land , saline land , and low-yielding farmland , coastal beach , and other lands which are not suitable for grain production to develop the grassland agriculture .

8 . Accelerate scientific and technological progress and innovation

Fully concerning the critical technical issues of grassland protection , such as grassland degradation and rat pest control , adapted species in forage breeding , sown pasture development , and ley farming technology , we will strengthen research and strive to make breakthroughs . Accelerating the promotion of research achievements , and establishing a system with enterprises as the main body , market-oriented , and the combination of production and technological innovation , we can promote the transformation of scientific and technological achievements and constantly improve the technological content of pasture protection . We also attach great importance to enhancing the education level of peasants and herdsmen and giving full attention to the peasants and herdsmen in pasture protection .

9 . Increase scientific and technological exchanges and cooperation and promote rural development of all countries

We will continuously expand new areas cooperatively through introducing technology , exchange of delegations and scholars to give lectures , organizing symposiums , exchanging genetic resources and information in a variety of ways . We will organize international cooperative work to make breakthroughs in bottleneck" problems . We should help each other , in accordance with the principle of mutual benefit , to strengthen and expand regional cooperation and to achieve the common development of all nations

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Sustainability and optimization of rangeland uses : issues of perspective and scale

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Key points : Numerous environmental factors that influence sustainable provision of rangeland commodities and ecosystem services are undergoing rapid , unprecedented change . Stakeholders making claims on rangeland products are increasingly diverse and contribute to policy decisions that shift management priorities . Many of the environmental processes and stakeholder demands transcend traditional rangeland delineation . Challenges to sustainability and optimization of rangeland uses emerge as temporal and spatial scales of management expand . Scientific insight regarding these emergent issues is a limiting factor to adaptive management attempts to reconcile social , economic , and ecological considerations in ways that are compatible with sustainability goals . Broadening the scope of scientific inquiry to more effectively integrate issues of perspective and scale can enhance the effectiveness of adaptive rangeland management .

Key words : sustainability , optimization , ecology , management , policy

Introduction

Rangelands—broadly defined as all uncultivated land with the potential to support grazing by domestic animals—cover about 70% of the world's land area (Holechek et al . 2004) . It is well recognized that the vast rangeland cover type provides multiple products and services to society (e .g . , livestock , wildlife , water , recreation , minerals , forage and other plant products , aesthetics/existence value) .

The magnitude of the challenges facing rangeland managers of today is unprecedented in the history of civilization . Many factors influencing rangelands are undergoing a pattern of rapid change , as depicted by the function illustrated in Figure 1 .

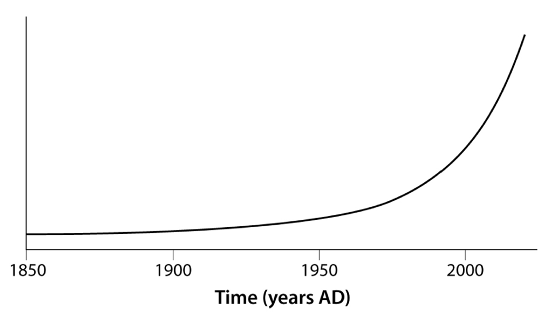

Figure 1 *Exponential function reflecting the rapidly changing environmental variables that influence rangelands .*

The y-axis on the figure is intentionally not labeled . Please pause and think for a moment about what different types of environmental variables could be plotted on the y-axis to match the function plotted on the graph .

Examples of environmental changes following the pattern of rapid increase illustrated in Figure 1 include :

- Global human population (US-CB 2004) . Throughout much of the world the primary factor propelling intensified use of natural resources is the increasing consumptive demand associated with the increase in the number of people . Some of the most rapid population growth rates in the world are in the African countries , where semi-arid rangelands dominate .
- Global food production (Goklany 1999) . Increasing global food production has allowed human populations to continue to rise . Most gains in food production are related to expanding the area used for irrigated agriculture , often on what had originally been rangelands .
- Water consumption (UN-FAO 2000) . Increasing irrigated agriculture is the primary element driving the increases in global water consumption and the corresponding reduction in base flow that historically maintained riparian habitats and dry-season pasture , often the most critical component influencing the overall production potential and patterns of use of rangeland landscapes .
- Soil degradation (Pimentel et al . 2004) . Increasing cultivation of lands is strongly tied to increases in global soil erosion , waterlogging , and salinization rates .
- Extinction rates (Pimm et al . 1995) . Increasing land conversion to agriculture and use of water for irrigation are the greatest sources of habitat loss which , in turn , reduces biodiversity and increases the risk of extinction .
- Atmospheric carbon dioxide (Keeling et al . 2005) . The dynamics of global climate change are complex , but there is growing consensus that rangeland-dominated high elevation and arctic biomes and water-limited grasslands and savannas

biomes are likely to experience the greatest changes to the structure and function of associated ecosystems (Walker et al. 1999).

- Combustion of fossil fuels (US-DOE 2007). Fossil fuel use has many impacts in addition to the increase in atmospheric carbon dioxide. The mines and drilling operations located on rangelands are a significant source of fossil fuel production. The scale of disturbance at these sites often poses great challenges to maintaining the integrity of the existing plant and animal communities. Reclamation is often a great challenge on rangelands which, due to climatic constraints, are often slow to recover. This is especially true when invasive species have colonized the disturbed areas and/or there has been substantial disruption of water and nutrient cycles.

Numerous other environmental factors are increasing at an exponential rate; for the sake of this discussion, the key point is that these trends illustrate that many of the challenges faced by rangeland managers today are increasingly driven by dynamics that transcend the temporal and spatial scales that are the current focus of most rangeland management decisions and most rangeland research efforts. This mismatch between the scale of relevant processes and the management objectives of local and regional interests is a growing challenge to rangeland stewardship. These challenges are further complicated by the fact that the intensity of rangeland use is increasing. Furthermore, the priorities for the products provided by rangeland to society are increasingly determined by distant stakeholders who do not make their living directly from traditional husbandry of livestock.

Philosophical foundations of rangeland management

The philosophical underpinnings of the rangeland management profession involve the simultaneous pursuit of two goals: 1) to strive for sustainable conservation and development of the rangeland resource and 2) to optimize the production of goods and services in combinations sought by society. To implement actions to achieve goals, the goals themselves must be clearly understood. Both of the goals of rangeland management are complex and value-laden. The concept of sustainability requires meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987). Stated another way, sustainability means preserving the principal and learning to live off of the interest. This definition implies a moral obligation to current and future generations for wise resource stewardship, thereby reflecting a strong element of ethics. The concept of optimization embodies the belief that it is desirable and possible for humans to shape their environment to serve their objectives. Optimization also assumes that the mix of goods and services sought by society may change over time as conditions change. Such changes in preferences are likely to be driven by the host of environmental factors that could be plotted on the y-axis of Figure 1.

Getting ahead of the curve" is a common phrase signifying the need for proactive leadership. It will be very difficult to cope with the implications of the various environmental issues represented by the exponential curve depicted in Figure 1. Even though crafting strategic research decisions and management configurations to be responsive to the needs of evolving rangeland uses and policies will no doubt be immensely challenging, it is our duty to try. When facing the great issues of his time, Abraham Lincoln said, You cannot escape the responsibility of tomorrow by avoiding it today." These words are appropriate for characterizing the substantial, unprecedented challenges faced by the rangeland management profession today.

Challenges to making the philosophical foundation operational

Is the character of the rangeland profession up to tackling what is ahead? Stressful situations do not build character as much as they provide a chance to let shine the character that is already ingrained. The role of values, and the responsibility of scientists, managers, and policy makers to making those values operative, raises many thorny issues that are highly relevant to professionals working with rangeland resources. Too often sustainability and optimization are used as rhetorical buzzwords, assumed to embody generally accepted standards of correctness (Callicott et al. 1999). In reality, individual values and experience influence perception, so there is a wide range of viewpoints about how the ecological, economic, and social components of the human environment should be melded to achieve sustainability and optimization.

Just as each of the legs on a three-legged stool must be present and be in balance with the others, so is there a need for ecological, economic, and social components to be truly integrated. Each component has something vital to offer to managers and policy makers. Ecology probes the structure and function of biophysical processes upon which all life depends. Economics addresses the costs and benefits of consumption, conservation, and development. Sociology considers community and cultural values and the social conventions and institutions used to influence behavior. Put another way, ecological and economic disciplines tend to focus on identifying options and tradeoffs. This information is processed through a social filter to develop the policy framework within which management must function (Goodland 1995).

A commonly stated objective of rangeland scientific inquiry is to provide information that will improve management and policy. There are many practical obstacles to achieving this objective. Most scientists are trained in highly specific disciplines. Most research is strongly influenced by short-term (2 to 5 year) planning and budget cycles. Most scientific journal review processes focus on precision. These factors combine to encourage scientists to conduct efficient experiments that study one or two variables while all others are held constant. To do this, small-plot field designs are usually used to enable replication and to control variability and cost. Given these issues, it is not surprising that integrated ecological, economic, and social research is rarely undertaken at the temporal and spatial scales at which management happens. Consequently, managers and policy makers are often exasperated because most scientific research is not conducted or presented in ways which are relevant to their needs, and yet, scientists feel they have special insight that entitles them to express their criticism of managerial or policy actions (Baskerville 1997). Furthermore, since scientists, managers, and policy makers are usually the products of highly discipline-specific graduate programs within universities, it is not surprising that rangeland development projects are often compartmentalized to focus on a particular sector and a single discipline. This is often done to foster the short-term efficiency of crafting a team who can work together without encountering the sometimes uncomfortable and always time consuming transaction costs associated with melding cross-disciplinary perspectives.

Failure to reconcile emergent issues at the interface between the ecological, economic, and social considerations has repeatedly resulted in management and policy actions that do not achieve the objectives of optimizing yield of rangeland products in a sustainable manner. The magnitude of this problem is further complicated by temporal or spatial scale mismatches between biophysical processes and socio-economic expectations (Lee 1993). When perception is not able to encompass the full range of process, there is a danger that expectation will be incorrect, thus the resource will be degraded. Expectation is an exceedingly difficult variable for management to deal with because various forms of the term are synonymous with anticipation (e.g., expected forage production on a site based on past experience), hope (e.g., hopeful inaction waiting for cattle prices to rise or a drought to end regardless of whether there is any information available to support or contradict the hoped for condition), and demand (e.g., expectation that historical livestock grazing use patterns should be maintained regardless of other societal changes that may alter prioritization of products within the context of multiple use policy). When many variables affecting rangelands have the functional relationship depicted in Figure 1, it is unclear how expectations regarding biophysical and socio-economic factors are likely to interact. The result is uncertain, difficult to predict, hard to change and likely to generate conflict.

To have any realistic prospect of meeting the challenges posed by the rapidly changing future, it is vital that research, management, and policy formulation be coordinated in temporal and spatial scales which make sense. In space and time, different issues emerge as scale changes. These emergent properties are endlessly difficult to study and manage. Rangeland scientific inquiry can make progress toward its joint objectives of sustainability and optimization by paying keen attention to issues of scale, as detailed below.

Temporal scale issues

Perception of normal

Management and policy expectation tends to be heavily influenced by experience in the recent past. This puts the resource in danger of being subject to a managerial and political ratchet effect. This phenomenon is initiated when a period of favorable resource conditions is accompanied by a gradual shift in expectation and an increase in capital investment designed to optimize management of the current level of resource production. When conditions return to a long-term normal or below normal, there is often intense pressure for the government to protect the people (and their investments) who have become dependent on the favorable conditions being maintained. The term ratchet effect was first coined to express difficulties in managing irregular fluctuations in marine fisheries (Caddy and Gulland 1983), but is also applicable to managing irregular fluctuations of rangeland products such as forage and water.

The ratchet effect characterizes irrigated agriculture and municipal developments built during a period of several wet decades in the western U.S. There is intense political pressure to ensure that the expectation of water supply developed during recent wet decades continues to be met when the water yield returns to the longer-term normal or dry decades, as represented by data spanning two or more centuries. The politically expedient solution has been a pattern of transferring more water from wildland ecosystems to agriculture and municipal interests during normal or dry years. This decision is reinforced by the huge economic disparities that currently exist between different water uses. Water flowing in wildland systems is considered a free good, with reliable legal protection of base flow only in cases where endangered species rely on maintenance of aquatic habitat. In contrast, for example, 1.2 million liters of water (1 acre-foot) is currently valued for household use at US＄1,311 in San Diego, California, USA, but is valued at US＄17 when applied to irrigated croplands adjacent to that city. This pattern of water diversion has had a significant negative impact on maintenance of in-stream flow in many ecosystems of the world (Rijsberman 2006), particularly in regions dominated by arid and semi-arid rangelands. Consequently, the sustainability of wildlife, fisheries, and wetlands in rangeland ecosystems has reached a critical point in many regions of the world (Lemly et al. 2000). In-stream flow depletion is neither intended nor desired. Nonetheless, it is noteworthy that in-stream flow has continued to worsen over the last several decades despite widespread public and scientific awareness of growing negative impacts on rangeland ecosystems.

Perception of change

Many ecological processes occur at a slow, gradual rate that is difficult to perceive within a generational time-step. For example, interrill erosion on shallow sites may slowly reduce water-holding capacity. In such an instance, perplexed land users may experience an increasing frequency and severity of drought stress (perceived in the context of plant and livestock performance) compared with what previous generations experienced, even though the meteorological record indicates that there is no change in the timing or amount of annual precipitation. Encroachment of unpalatable shrubs may also occur over generations at a rate that is difficult to perceive. Loss of soil or encroachment of shrubs may result in lower forage production, necessitating the reduction of stocking rate across decades even though the year-to-year management seemed prudent (Thurow and Taylor 1999). Obviously, the long-term management was not appropriate for sustainable livestock grazing if unpalatable shrubs were encroaching and soil was being lost; management failed because the temporal scale of observation used by management was not sensitive enough to detect biophysical changes that manifest their impacts gradually over the course of generations.

Similarly, many socio-economic processes occur at a slow, gradual rate (e.g., the value of harvested commodities not keeping pace with the rate of inflation or life-style expectation, resulting in a reduced viability of enterprises that historically dominated the region). A gradual change in condition may also set the stage for rapid socio-economic change. For example, a struggling enterprise may rapidly collapse in the face of what otherwise would have been taken in stride as a short-term stress, such as a drought. Or gradual change in public sentiment may build until a political environment is created which suddenly gives way to rapid change in policy. For example, the gradual increase in public concern for the environment evolved in the U.S. over several decades before the political climate was ripe for enacting over several years a set of new laws [e.g., National Environment Policy Act (1969), Endangered Species Act (1973), National Forest Management Act (1976)] that radically altered management of U.S. rangelands.

Perception of risk

Risk tolerance of degradation of biophysical processes differs radically if the management planning horizon is years, decades, or centuries. For example, friction between ranchers and government officials is often driven by differences in risk tolerance. A rancher must balance short-term pragmatic financial obligations with long-term sustainability goals. Therefore, in the early stages of a drought, the rancher may be willing to accept more short-term risk of soil erosion or degradation of plant community than a government official charged with sustaining long-term biological production potential. The cumulative effects of ranchers accepting multiple short-term risks over the course of several generations, and sometimes guessing wrong, can lead to degradation that, at some point, may result in a self-perpetuating change and a transition to an alternative ecological state that is less useful from a human perspective.

Perception of monetary value

Monetary value is obviously highly subjective and is often influenced by a temporal context. For example, the time value of money (discount rate) is influenced by perceived risk, inflation, and benefits from alternative investment opportunities. Economic theory asserts that conservation will occur when the discount rate indicates that the future potential for benefits is deemed more valuable than the current demands. However, this is complicated by the fact that human behavior will likely be determined on an individual basis, reflecting a unique mix of risk tolerance and the perception of quantitative and qualitative benefits and costs. In extreme situations, the discount rate may be so high that anything other than meeting immediate needs is unacceptable. Thus, a starving pastoralist will rationally focus on doing whatever it takes to enable immediate survival for him and his family; future productivity considerations are of zero value if current needs are not met. In a less dire situation, the same choices can be made, such as the need to make the loan payments to avoid bankruptcy—future productivity of the ranch may seem of little consequence if there is imminent danger of losing ownership via foreclosure.

Partly because of the values implicit in the discounting detailed above, many economists remain skeptical of whether a focus on sustainability is a useful guide for policy (Nelson 1995). Just as some economists argue that running a deficit is a valid way to manage a country's operating budget, it follows that they reject sustainability due to the relatively small discount rate it implies. Furthermore, some economic analysis focuses on assessing the value of what is produced, rather than emphasizing the underlying conditions that make production possible. Ecosystem services are assessed in terms of what is produced for sale. Accordingly, the price of rangeland has been historically set by the value of livestock that could be produced, or, in more recent times in affluent countries, by the aesthetic value of the panoramic landscapes used as home sites. The rationale of valuing only what can be sold does not consider the very important non-marketed services these landscapes provide to society. The importance of non-marketed service considerations were effectively highlighted by the Chipko forest preservation movement of India whose slogan was What do forests bare? Soil, water, and clean air." Ecological economics is a growing field that attempts to factor in the ecosystem service values in a cost-benefit analysis conducted at a societal scale, including future valuation as well as today's market valuations. Ecological and conventional economists clash due to a mismatch in both temporal and spatial scales of their analysis.

Spatial scale issues

Overlap of management units with conflicting objectives

Many wild herbivore communities migrate, as do traditional pastoralists guiding their livestock. Such a strategy is adaptive for maintaining the flexibility necessary to cope with wide variability in forage production associated with the irregular spatial distribution of rainfall characteristic of many rangelands. Traditional political boundaries were established to secure resource access rights necessary to cope with the spatial variability of forage production and water distribution. As central government structures were created, other political considerations emerged such as regulation of security and commerce, or provision of health, education, and religion. These new political considerations imposed management units that had little or nothing to do with natural resource management, thereby undermining the traditional flexible movement patterns and associated management units that were developed with long-term ecosystem function at their core.

Artificial separation of dependent management units

Failure to recognize inherent biophysical connections within a landscape can trigger one-way chain reactions that create negative impacts in other portions of the landscape. For example, this commonly occurs when there is a disparity of management objectives between upland and lowland systems, such as heavy grazing and timber harvest in uplands increasing downstream susceptibility to flooding or siltation. In such a situation, the greatest benefits of conservation or reclamation of upland resources may be to the downstream interests. It is very difficult to fully assess the serial costs of upstream degradation to downstream interests or the serial benefits of upstream conservation or reclamation to the downstream interests (Thurow et al. 2000). Therefore, if the project area is delineated as an upland site, the off-site benefits are often not considered in a cost/benefit appraisal of the project. Consequently, the economic viability of a project may vary greatly depending on how the project area is defined. Assessing rangeland investments only in the context of rangeland products (a common practice) often does not consider, or grossly underestimates, the value of the project to off-site interests. It is often desirable to change the scope of analysis to include off-site interests in rangeland management investment decisions, in order to increase the potential for obtaining funds from off-site stakeholders. A reason for resistance to this practice from ranchers and pastoralists is that the priorities for rangeland management specified by people living away from the rangelands are often quite different from the priorities of people making their living from the rangelands.

Dependent planning units also operate disjointedly when natural resource management units are separated by cultural or political issues thereby limiting coordination. For example, a road that would aid livestock marketing and herd management in an area populated by clashing ethnic groups may be opposed by one or both groups because the road could also be perceived to be a security liability. Water development placement to optimize resource productivity may be opposed due to a variety of socio-political considerations, since removing this previously limiting factor may cause strife in areas that were once not considered worth contesting. Installation of communication infrastructure may be opposed by established marketing interests who would stand to lose profit if there were greater access by pastoralists to timely information (e.g., cellular phone systems are helping previously disenfranchised ethnic groups to access information by skipping over the step that once required politicians from different ethnic groups to license land-line installation).

Demand overwhelming production capacity of a management unit

The increase in the pastoral population, and the concomitant increase in livestock necessary to support these additional people, has undercut traditional management of communal lands (Brown 1971). This is done by individuals seeking to provide for their personal needs through private livestock ownership, while passing on the costs of their livestock grazing pressure to the communal unit (Hardin 1968). These demographic pressures, in tandem with the scale issues associated with political boundaries discussed above, have prompted attempts to reconfigure land use patterns toward systems based on privatization/sedentarization. Systems such as group ranches, grazing associations, or adjudication of previously communal land into privately owned parcels have generally not been of sufficient size to provide flexibility of movement necessary to cope with the irregular spatial distribution of rainfall and forage production, creating conditions that lead to long-term degradation (Ellis and Swift 1988).

A mismatch between production needs and plot size is not only limited to poor countries. In affluent countries, a disconnect between recreation demand, the quality of the recreation resource (biophysical limitation), and the quality of recreation experience (social considerations) is increasingly causing rangeland recreation amenities to deteriorate. Another trend in affluent countries is subdivision of ranches into private lots for housing. Many of these new home sites disrupt the ecology of the area in that they tend to be located on critical winter range or dry season pasture, thereby disrupting wildlife access to critical resources within the landscape which had been compatible with traditional livestock production. The homeowners also tend to be accompanied by pets (dogs and cats) creating subsidized predator densities far in excess of what could normally be supported. Confining pet herbivores such as horses or llamas to small pastures degrades the cover, creating runoff and water quality problems and promoting establishment of noxious weeds that provide seed sources to invade native rangelands .

Experience issues

Different experiences may cause people diverge in their interpretation of the same set of facts . For example , a waving field of yellow flowers under an open understory of shrubs was viewed as a desirable management goal when a picture of such a landscape was viewed by urban citizens , but was viewed with horror by ranchers who recognized the yellow flowers as belonging to a poisonous forb (*Hymenoxys odorata* DC) and who realized that the open understory of shrubs was created by extremely heavy browse pressure (S . Whisenant , personal communication) . Perception and interpretation differences based on lack of knowledge can often be overcome with education .

Many terms used by managers and policy makers (e .g . , drought , health , restoration) are , by their nature , ambiguous . In such cases the differences in emphasis and expectation embedded in the definition of the terms may be quite different for different stakeholders , fostering confusion and lagged responses as a result of muddled views . For example , expectation of inherently variable parameters such as precipitation are influenced by risk tolerance and by the length of time considered in the calculation of what is normal . Emphasis within the definition of drought is influenced by what is most important to the stakeholder . Therefore an agriculturalist may define drought in terms of when forage or grain production is less than expected , a hydrologist may define drought in terms of when water level in a reservoir is less than expected , a meteorologist may define drought in terms of amount of precipitation expected within a period of time , an economist may define drought in terms of when production declines begin to influence jobs or commerce . Given such diverse perspectives of emphasis , a short-duration intense storm may have enough precipitation to end a meteorological drought and may produce runoff to end a hydrologic drought , but may not help forage or grain production (agriculture drought) . Conversely , a small amount of precipitation each day for a month may enable a large amount of forage or grain production , ending an agriculture drought but may do nothing to end a hydrological drought reflected by tracking water level in a reservoir . Confusion associated with the use of this term fosters inaction and leads to many policy makers portraying drought as temporary climatic aberration , when in reality it is a normal , albeit unpredictable , climatic phenomenon . This can enable drought being a scapegoat for faulty policies instead of being viewed as something that is a managerial responsibility . It also fosters moral hazard behavior in that lack of response to the risks of drought is routinely bailed out by emergency aid predicated on the assertion that a drought is unique and beyond the scope of proactive policy (Thurow and Taylor 1999) .

Adaptive management of unintended consequences

Most managers and policy makers perceive that resource problems are not really environmental problems ; they are human problems that we have created at many times and in many places , under a variety of political , social , and economic systems" (Ludwig et al . 1993) . It is germane to emphasize that the political , social , and economic systems are not purposefully pursuing resource degradation . Rather , these consequences are unintended . Rangeland managers can learn from classical economic studies of human decision-making in markets to appreciate the pitfalls and possibilities of integrating optimization and sustainability goals of resource management . A central tenet of the Adam Smith's (preeminent economist of the 18^{th} century) interpretation of human behavior was that an individual makes decisions intended to promote personal gain , but that in so doing also promotes unintended consequences . These unintended consequences may be manifest in various ways , either facilitating the social good of commerce or setting in motion self-sustaining biophysical feedback loops leading to desertification . However , human behavior is not solely driven by an attempt to achieve maximum personal gain in every transaction ; there are also ethical preferences that modulate the rationale of individual choice (Harsanyi 1955) . Rather than pure pursuit of self-interest (a rational fool) , behavior is regularly altered by the commitment of individuals to non-monetary values . Exploration of this duality : the pursuit of immediate self interest and the commitment to broader ethical values , and how it alters behavior , was the contribution which won Amartya Sen a Nobel Prize in Economics . Smith's and Sen's perspectives offer hopeful insights to discussions of whether sustainability and optimization are useful concepts for rangeland management and policy formulation .

Tactical methods for dealing with the tension between optimizing self-interest and honoring the ethical values of sustainability goals in rangeland stewardship and policy often focus on adaptive approaches . Adaptive management is based on the notion that we often have insufficient information to anticipate ecosystem responses to human use , as well as inadequate information to understand how people make choices relative to their interactions with the ecosystem . Therefore , policy formulation and implementation is viewed as a process of learning to reconcile seemingly divergent views , with data from scientific experiments being pivotal . Scientists continually modify and augment today's research agenda according to what has been learned through past trials . This includes shifts in the scale and scope of scientific analysis . Policy formulation is viewed as a series of experiments from which lessons can be learned about how to ensure that human activity is compatible with the maintenance of the ecosystems services upon which humans ultimately depend . The ultimate role of science in this process is to provide information on what is biophysically possible and the environmental tradeoffs associated with balancing provision of multiple rangeland products .

Adaptive management has proven to be very difficult to achieve because the various temporal , spatial , and experience-based perspectives associated with framing a problem, such as those discussed in the previous sections of this paper, may work at cross-purposes and may mean different things to different stakeholders. It is therefore not surprising that it is extremely difficult to engage stakeholders with opposing priorities into an integrated decision making process. This is further complicated by many ingrained barriers in government institutions that are not amenable to providing the flexibility necessary for adaptive management to succeed (Johnson 1999). These common barriers to adaptive management illustrate that the limiting factor to resource management is not so much the need to assemble a mountainous accumulation of scientific facts, but rather is the difficulty of fostering insight into and reconciliation of social, economic, and ecological processes for the greater good (Lee 1999). These issues must be reconciled at the outset when attempting to form a collaborative structure for management and policy to build upon. This is easier said then done. Often the stakeholders attempting to implement an adaptive management process are doing well to coexist but cannot achieve true conflict resolution.

Where adaptive management cannot overcome vested interests working at cross-purposes against the ethical considerations associated with sustainability, there may be a temptation for scientists to become engaged in political discourse intended to help form policy that will compel intransigent self-interests to conform to behavior that will be compatible with the greater good. Scientists have understandably been reluctant to engage in overtly supporting political agendas because of the fear of losing a claim to objectivity, thereby encouraging opposing groups to question their credibility and disregard the scientific information they generate (Rykiel 1997). However, as scientists document the variety of environmental variables that are represented by the function shown in Figure 1, and as the implications of these trends are analyzed, there is a growing urgency among scientists who believe that the lag in responsiveness by governments is unacceptably slow or narrow. This is leading many scientists to realize that they need to become more effective at providing policy-oriented information to a broader audience. Some scientists are choosing to give up their cloak of scientific neutrality and assume an advocacy role to promote the enactment of better environmental policy.

Conclusions

The underlying philosophical goals of the rangeland management profession are sound, but the implementation of the joint goals of sustainability and optimization is becoming much more complex. The stakeholders making claims on rangeland products and shaping management priorities are increasingly diverse. The policy-relevant temporal and spatial scales are rapidly shifting and are highly context-specific. There is compelling evidence (Figure 1) that we are well underway to an unprecedented intensification of pressure on rangeland ecosystems. This pressure may threaten the sustainable provision of many rangeland products and services, an unintended consequence of current political, social, and economic systems. There is strong reason to believe that these human-derived systems influencing resource use patterns can be responsive to scientific input, but this is likely to occur only if the products rangeland scientists produce get much better at melding the ecological, economic, and social issues in ways that are directly responsive to addressing the barriers to integrated decision making. The motivation for challenging ourselves to improve at this task is the realization that our role as scientists will ultimately be determined by the new visions scientific insight can inspire among stakeholders and policymakers seeking to achieve sustainable management of rangeland resources.

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Livestock production and poverty alleviation—challenges and opportunities in arid and semi-arid tropical rangeland based systems

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Key points :

Rangelands are the largest land use system on Earth . They predominate in arid and semi-arid areas of the World . Large numbers of poor and vulnerable people live in them . Arid and semi-arid rangeland systems are constrained by low primary productivity , low population densities , lack of market access and infrastructure and high transaction costs .

Population density and climate change are creating important changes in land use , access to resources and livelihood strategies of pastoralists in these areas . Arid and semi-arid rangeland systems are no longer seen as livestock enterprises but as multiple use systems with important consequences for the global environment and for more diversified livelihood strategies . They are crucial for the protection of ecosystems goods and services , for tourism and for mitigating climate change . Research agendas need to take into account the trade-offs and synergies arising from these multiple uses so that the poor are able to reap the multiple benefits provided by these ecosystems .

Introduction

Rangelands are the largest land use system on Earth . They constitute some 35 million km^2 of the earth's surface , with the majority in developing countries and some 65% (almost 22 million km^2) of this in tropical Africa . Over 180 million people in the developing world depend for their livelihoods on these systems , with just over half of them living on less than $2 per day and a quarter on less than $1 per day (Thornton et al ., 2002) . Rangelands predominate in dryland areas where they may be defined as regions where there are less than 20 persons/km^2 and where the length of the growing period (LGP) is less than 60 days/annum and does not permit significant crop growth . Figure 1 shows the location of the arid and semi-arid rangeland systems in tropical and subtropical regions of the World .

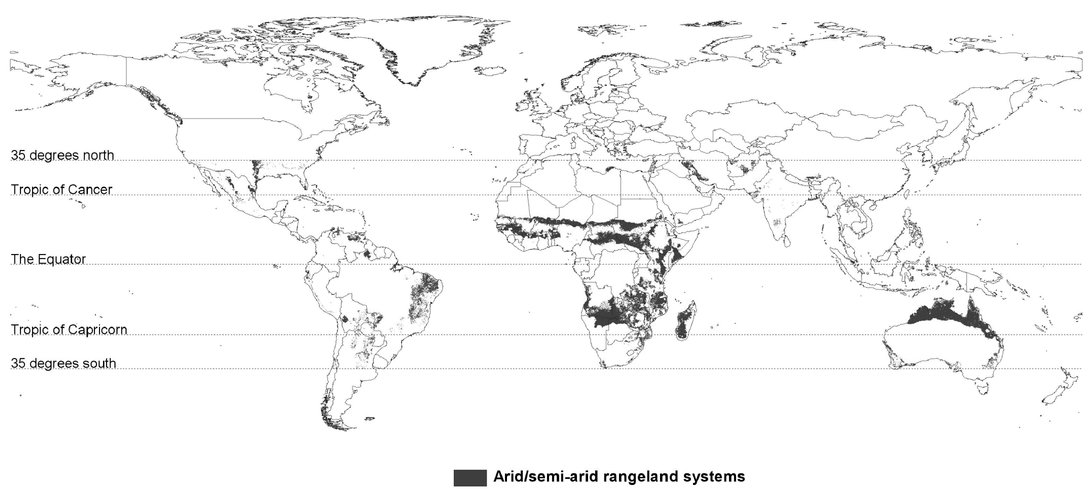

Figure 1 *Distribution of tropical and subtropical arid and semi-arid rangeland systems (ILRI Targeting and Innovation databases 2008) .*

These pastoral systems are heterogeneous , as there are marked differences between pastoral groups , between communities , and access to livelihood assets . There are those in which people depend entirely on livestock for their livelihoods , to mixed agro-pastoral systems where there is close integration of pastoral resources with cropping (FAO , 2001) . In some cases , the role of diverse sources of off-farm income also plays a significant role in the subsistence of pastoral households . For example in parts of Maasailand (Kenya) , income diversification and remittances can account for more than 50% of the family's income (Kristjanson et al ., 2002 ; Nkedianye et al ., 2008) .

These systems make use of natural vegetation and other natural resources and play a key role in the protection and maintenance of ecosystems goods and services . However , they have a limited primary biomass production with considerable , and increasingly unpredictable , temporal and spatial variation . In this respect , a key feature of these systems is the movement of animals to take advantage of spatial and temporal variation in feed and water resource availability (often linked to weather patterns). Whilst pastoral movement is traditionally considered in relation to these two key elements, there are other reasons too, some of which become increasingly prevalent in today's changing world—such as access to markets, or social issues like conflicts, provision of services like schooling, health services and others.

Worldwide pastoral and agro-pastoral systems are undergoing unprecedented changes, and combined with the uniqueness of such systems, these present some particular development challenges which in turn imply research cannot be conducted as business as usual, but must be tailored so as to ensure the changing multiple service roles of these ecosystems are taken into consideration in order to have positive impacts on livelihoods and the environment. Increasingly, livestock are being recognised as part of integrated solutions for sustainable natural resource management in the broader development context (World Bank 2007).

This paper focuses on dryland pastoral and agro-pastoral systems in the tropics and sub-tropics. It describes the major drivers and trends changing these ecosystems at global, regional and local levels and the challenges these present for development. It also presents elements of a new research agenda that will be required to deal with the increasingly varied uses of these ecosystems. This is, at a fundamental level, related to choices that can help to alleviate poverty and vulnerability of pastoral communities living in these ecosystems, while ensuring that the poor living in these regions are able to take advantage of new opportunities provided by a rapidly changing world.

Drivers of change in pastoral regions

Human population density: Table 1 presents the human and livestock populations of arid and semi-arid regions in different parts of the World. On a global scale, the increase in human population density is a major driver of change for a wide range of livestock production systems, including pastoral and agro-pastoral systems. Increases in population density have serious consequences on different dimensions of pastoral regions. First, land use changes can be significant as there is increased competition between rangelands and marginal cropping in these areas. At the same time, increases in cropping and sedentarisation have led to land fragmentation, which in turn decrease the grazing ranges and mobility of pastoralists and reduce the buffer dry season grazing reserves. This has led to a reduction in livestock numbers and increased vulnerability in these areas (Reid et al., 2004). For example, in Maasai regions the numbers of animals (tropical livestock units) per capita have decreased from 15-20 to 3 animals per person in a span of 50 years (Herrero et al., 2003). In some areas, notably in parts of Africa, this has also led to increased conflicts in pastoral regions.

Overall, livestock numbers in these regions are slowly increasing, partly due to the increases in demand for livestock products caused by the increases in human population densities and economic growth (Delgado et al. 1999). For example, Herrero et al (2008) estimated rates of increase below 1%/year to 2030 for the livestock populations of diverse rangeland ecosystems in Africa. Since this rate of growth is lower than the human population growth rate, animal numbers per capita are generally decreasing in these regions. This increases the vulnerability of pastoralists in general and creates a need for finding more diversified livelihood strategies to survive.

Climate change is also a driver, though its effects will be most severely felt in the coming decades—its key effects will be increased dryness and higher temperatures, reductions in primary productivity, land use changes, animal disease distributions, land degradation in some cases, changes in species composition (and thereby animal diets and feeding strategies), livestock productivity, incomes and food security. Climate change impacts that lead to some regions becoming drier may also mean that areas previously suited for crop production become too risky for such enterprises, and that pastoral systems become the only way of managing such environments well. Climate change is also a key driver that will determine a new research agenda for the rangelands of the world. Since this is the largest ecosystem on earth, there is an increased need to understand the role that rangelands might have in determining global climatic patters and how their management might affect climate change.

A number of local and global trends are placing increased pressure on productivity and livestock production of the rangelands in pastoral and agro-pastoral areas. Some of the key consequences, are described below.

Table 1 *Area, human population and ruminant livestock numbers in tropical and subtropical rangeland systems of the World (ILRI Targeting and Innovation 2008).*

Region	Area (Km^2)	Tot. people (yr 2000)	Cattle TLU total	Sheep TLU total	Goat TLU total	Buffalo TLU total
East Asia	39,286	517,388	142,511	136,593	78,475	9,161
North Africa	51,364	1,931,660	137,064	218,806	92,353	0
South Asia	44,078	5,821,210	642,833	187,932	150,070	283,456

(continue)

Region	Area (Km^2)	Tot. people (yr 2000)	Cattle TLU total	Sheep TLU total	Goat TLU total	Buffalo TLU total
Lac	1,006,230	8,886,420	9,796,930	447,039	413,432	0
Se Asia	38,750	386,390	221,684	729	4,768	138,949
West Africa	841,451	15,579,500	4,309,350	1,077,310	1,283,290	0
Central Africa	572,019	3,228,620	1,636,200	123,222	284,505	0
East Africa	1,535,010	14,826,800	12,858,600	2,111,240	2,123,430	0
Southern Africa	2,051,810	12,739,900	5,735,070	280,616	488,221	0
Australia/Oceania	1,672,811	311,839	7,054,910	2,252,895	5,529	0
Total	**6,179,998**	**63,917,888**	**35,480,242**	**4,583,487**	**4,918,544**	**431,566**

Consequences of the drivers of change

(1) *Land use changes*. Land use change has increased pressure on pastoral communities because it affects their access to natural resources and hence their ability to respond to new shocks. For example, the fraction of rangelands in agro-pastoral territories in South-western Niger declined from 78% in 1950 to 13% in 1996 whereas the fraction of land cultivated increased from 10% in 1950 to 55% in 1996 (Turner et al., 2005). In addition, the marginal lands that were previously used by pastoralists for their livestock are increasingly coming into focus as protected areas for biodiversity conservation and tourism (FAO, 2001). There is increasing pressure on governments to declare large regions as protected areas, in response to the conservation lobby and the potential income from tourism, for example in East Africa where large mammals are still abundant and the tourist industry is highly developed (Reid et al., 2007). The key is to find mechanisms to ensure that pastoralist communities share the benefits from these alternative sources of income.

(2) *Transformation of land ownership from common to private property in some pastoral areas*. Privatization of former grazing lands is ongoing in Africa, Central Asia and China. It is often the more productive areas that are the first to pass into private hands for agricultural use. This again impacts on resource access and thereby reduces resilience of pastoralists since these key resource" areas used to act as grazing refuges during times of drought (Reid et al., 2007).

(3) *Sedentarization policies*. The Tragedy of the Commons hypothesis (Hardin, 1968) has been influential among policy makers and has led to resettlement and sedentarization policies in various parts of the world (FAO, 2001). In many cases these policies have led to further degradation of the pastures they were designed to preserve (e.g. Wu and Richard, 1999). As well as centrally influenced sedentarisation, mobile pastoralists increasingly choose to reduce their mobility as they develop closer linkages with markets and social services and as they purchase land (Fratkin and Roth, 2005). This reduction in mobility can lead to concentration of grazing pressure on particular areas and reduces the resilience of grazing lands previously subject to rotational grazing as a result of mobility.

(4) *Market development and evolution*. Changes in market access resulting from increased population, urbanisation and the demand for livestock products are also an important consequence for the development of rangeland systems. Market access provides new income opportunities both from direct provision of livestock as well as service functions associated with such improved markets and associated infrastructure. Market development demands new and improved communication of information to pastoral communities and new social organisation mechanisms. These also provide improved opportunities for input and service provisioning.

In some cases policy and institutional responses have supported pastoral development. These include advances in service delivery and access to technologies, as well as increases in prevalence and function of pastoral self-help organizations.

Development challenges

The trends observed in pastoral systems and their consequences have resulted in a number of development challenges. For pastoral and agro pastoral systems, the overarching development challenge is to reduce poverty and vulnerability in these regions and also to provide livelihood strategies that provide sustainable pathways out of poverty. Because of the particular circumstances and both macro and local drivers and trends, these systems present some distinct challenges. In this section we will consider these challenges and future research needs.

(1) *Low population density and low carrying capacity of the ecosystem*. The key constraint of dryland pastoral regions is their low biomass productivity and consequent low human population density. Low biomass productivity and high climatic

variability make these regions to be inhabited by households inherently food insecure and following semi-subsistence livelihood strategies . In general terms , these marginal areas with low population densities have high percentages of poor people and a high depth of poverty (Kelley and Byerlee 2007) . Unfortunately data on the distribution of poverty in pastoral and agropastoral areas are scarce . However , estimates by Thornton et al (2002) show that pastoral and agropastoral systems account for 24% of poor people in South Asia , 34% in Sub-Saharan Africa and 32% in WANA . Recurrent droughts exacerbate the vulnerability and poverty of these pastoral societies mainly due to loss of their livestock assets (Little et al ., 2007) . These levels of poverty combined with low education levels and lack of development of these regions present a formidable challenge for the promotion of new alternatives beyond very modest levels of livestock production .

(2) *How to link poor pastoralists to the national economies ?* The lack of investment and infrastructure in dryland pastoral regions makes them intrinsically areas with poor market access . This in turn makes it increasingly difficult to integrate these regions with the rest of the national economy due to very high transaction costs . Traditionally , pastoralists sell only a limited number of livestock products , and only sell live animals in period of emergency (mainly droughts) . The marketing of livestock as the primary household livelihood strategy (rather than keeping animals and selling their products) is a fairly recent phenomenon in Africa and Asia (Reid et al ., 2007) . Hence , pastoral livestock markets are not well developed and are not fully integrated into the national economy . There is a general isolation of pastoralists from the economic development process in many countries in sub-Saharan countries , for example , the Fulani pastoralists in West Africa and the Borana pastoralists in southern Ethiopia (Desta and Coppock , 2003) . Mobility presents challenges for transfer of quality information on market prices , However with recent advances in communications technologies (i .e . mobile phones) this constraint is rapidly disappearing . Besides , the lack of infrastructural development makes it difficult for pastoralists to meet the hygiene and food safety demands required to have access to regional and global livestock markets . Projected increases in global demand for livestock products (Delgado et al ., 1999) do , however , present opportunities for increased marketing of livestock by pastoralists .

(3) *Systems of low priority for public investment* . Marginal arid and semi-arid areas are of low priority for national governments and the private sector . This has led to pastoralists having a weak voice in national politics (Chang and Koster , 1994) . Many factors combine to weaken the influence of pastoral people in national fora . For example , policy makers tend to view pastoralists as a minority vote and view their way of life and farming system as backward and inefficient , especially when only considering the animal productivity of these regions . The general weak representation of pastoral organisations in many regions has not helped advocacy of the pastoral cause before the national governments . Pastoralists are not often keen to develop social institutions to defend their interests as a group , in part because their mobility and flexibility make it hard for such institutions to function over long periods . Beside the weak pastoral organisations , pastoralists generally have an inbred distrust of national government . The marginalization of pastoralists is however beginning to change with increasing interest in the pastoral sector by international organizations .

(4) *Natural resource degradation* . Global rangeland resources are widely perceived to have become heavily degraded in recent decades (e .g . Pittroff et al . 2002 , Steinfeld et al ., 2006) although objective measurement of vegetation degradation is relatively rare and the overstocking paradigm is controversial (Mace , 1991) . Some degradation has undoubtedly occurred , and a variety of factors has contributed to the process of degradation of pastoral lands . Pastoralists have often been accused of overgrazing and desertification because livestock is the major user of primary production in the semi-arid and arid regions . Results from ILCA's long-term monitoring studies in East and West Africa (Ellis , 1992 ; Hiernaux , 1993) have challenged the assumption that livestock are responsible for rangeland degradation and have provided evidence that climate , and not livestock , is the main determinant of changes in the arid/semiarid environments and that the rangelands are resilient and capable of recovery . ILCA studies concluded that the strong seasonality of rangeland production in the Sahel limits the risk of overgrazing damaging the environment to short periods and consequently to confined areas ."

(5) *Conflict in managing common resources* . The use of common property resources by pastoralists inevitably leads to two types of conflict . On one hand , there are substantial conflicts related to access rights and the management of common grazing lands . The poorer sectors of society are largely excluded from the benefits of these common lands . Secondly , conflicts also arise with other forms of land use such as agriculture , forestry and wildlife . Development activities within particular sectors can be politically sensitive and there are multiple examples of development initiatives that have failed because of lack of awareness of the natural resource implications of particular interventions for other sectors . Conflicts over natural resources have occurred for millennia but rising population pressure , demarcation of national boundaries , increased incidence of drought and increasing urbanisation have all increased the potential for conflict in recent decades (Fratkin and Roth , 2005) . These conflicts have changed in nature , as more sophisticated weapons are now used by rival fractions .

Consequences and opportunities for research

Due to the heterogeneity of pastoral systems , clearly there is no one-size-fits-all solution , but a complex of inter connected dimensions that need to be taken into account . Overall , the issue is supporting the inevitable transitions in livelihoods that are going to take place in coming decades and this relates overall to two aspects—the mitigation of risk and the potential to implement new livelihood strategies that include new market opportunities and engaging in other sectors of the economy. There are several potential transition routes for pastoralists: 1) continuing as usual 2) continuing as pastoralists but implementing new management strategies for their animals and for the environment (to address markets for livestock or ecosystem services) 3) settling and combining livestock raising with new diversified livelihood options 4) exiting pastoralism.

Results from several pastoral livestock projects suggests that technical intervention will have only a very limited impact on overall development of pastoral and agro-pastoral areas (FAO, 2001). A major lesson from the failures of production-oriented technical interventions in different countries is that an increase in livestock production and productivity is not tantamount to the social development of pastoralists and agro-pastoralists (FAO, 2001). In other words, pastoral development is more than livestock productivity. Some of the issues to address in development initiatives for pastoral and agro-pastoral areas include the following:

- Increasing need to provide more people with food.
- Livestock mobility to access key resources, pasture and water, especially in period of droughts.
- Improving access to inputs and services for livestock production systems that are already intensifying.
- Improving the resilience of pastoral and agro-pastoral systems in response to climate change and variability.
- Promoting a more efficient use of existing natural resources.
- Livestock asset security and diversification to mitigate risks. Diversification options need to include non-livestock based livelihoods.
- Building marketing infrastructure to link pastoralists and agro-pastoralists to regional and global livestock markets.
- Co-generation and co-sharing of knowledge and information. Sharing of information has changed substantially in parts of Africa. A range of innovative approaches has been tested in the developing world, based primarily around ICT. Access to mobile phones has changed significantly the way pastoralists trade their livestock products. By having access to information about prices, they are able to make better informed decisions on buying and selling animals (KACE, 2005).
- Building local capacity and institutions, and facilitating community-based initiatives, especially indigenous management of natural resources. For community initiatives to succeed under conditions of poverty and marginalization, enabling policy and legislation are vital. Providing a platform for pastoral communities to advocate their own concerns should be an integral part of any development initiative. Building local capacity and institutions is more than creating organizational structures but also entails the institutional support to organisations in terms of funding, mandate, responsibilities, and technical knowledge and skills available.
- Strengthening pastoral safety nets as these are the primary means of dealing with drought in sub-Saharan Africa. For example, Maasai pastoralists in East Africa maintain kin-based networks for mutual assistance to ensure survival of households during crisis, which includes access to pasture and water (Reid et al., 2007).
- Promotion of alternative sources of employment without losing cultural identities. Rural/urban migration to seek alternative sources of income by some members of the pastoral household has had a profound effect on the cash economy of pastoral societies (Nkedianye et al 2008). Remittances from members of the family from within or outside the region (rural/urban migrations) have significantly reduced vulnerability of pastoral families.

The prioritisation of development issues raised above will depend on policy environment, natural resource base, land use patterns, property rights, credit facilities, market potential and capacity of pastoral organisations. It should be emphasised that many of these development issues cannot be implemented in isolation at local community level but will require the active involvement of regional and national governments.

Perry et al. (2002) identified three pathways out of poverty through livestock: 1) increasing animal productivity 2) protecting and securing livestock assets 3) increased market integration. It is under this framework that we examine the potential for research in pastoral and agropastoral systems. Table 2 presents some of the research needs for pastoral systems.

Table 2 *Some researchable areas in arid and semi-arid pastoral and agro-pastoral systems.*

Research area	Opportunities for research
Spatial analysis, impact assessment	• Spatial analysis: Where are the most vulnerable groups of pastoralists now and in the future • Household level analysis: What determines the vulnerability of pastoralists • Trade-off analysis of multiple uses of rangeland ecosystems • Impact assessment and priority setting of integrated rangeland ecosystem uses
Adaptation options to climate variability and change	Management practices • Rangeland management for multiple uses (animal production, payments of ecosystems goods and services) • Rangeland management to mitigate climate change effects • Strategies for selling and buying animals • Health management practices • Water harvesting techniques • Insurance-based schemes to reduce vulnerability • Early warning systems

(continue)

Research area	Opportunities for research
Diversification of income sources	• Development of practical approaches to quantify delivery of environmental services by pastoralists and markets for such services • Exploitation of niche markets for livestock products with certain characteristics • Development of biofuel crops for ASALS • Mechanisms for promoting increased revenues for communities from wildlife conservation and tourism • Off farm income , remittances and/or exiting from pastoralism
Increased market access	• Collective action mechanisms for selling animal and other products • Novel methods of networking and sharing benefits of ecosystems • Increased information and communication on marketing options • Identification of new market options (specialization and diversification)

Research outputs need to lead to development outcomes at local and regional levels . Targeting and spatial analysis can help to identify where these different aspects should be the focus for research and development initiatives . For example , studies by Thornton et al (2006) have combined climate change predictions and proxy indicators of vulnerability to assess the areas most vulnerable to climate change in Africa . Given the heterogeneity of systems on the ground , such broad brush approaches also need to be scaled down to local and regional levels . Risk mitigation at local level needs to take account of poverty , availability of food , safety nets and insurance . ILRI has conducted research to help target appropriate risk response aspects , focusing on livestock interventions . In a study on livestock , livelihoods and vulnerability in Lesotho , Malawi and Zambia commissioned by the Food and Agriculture and Organization of the United Nations (FAO) , economic shocks , drought , livestock losses due to animal diseases and declining efficacy of delivering livestock services to poor people are identified as major sources of vulnerability (Freeman et al . , 2007) . The study reported that households use a wide range of informal and formal strategies to manage and cope with risks . The study also reported marked differences in ownership of productive assets , livelihood strategies and vulnerability between men and women , and showed that women and female-headed households were more likely to be more vulnerable than the general population (Freeman et al . , 2007) . A major lesson from this study for pastoral and agro-pastoral systems is that vulnerability is an issue that must be addressed in any pastoral development initiatives . It should take into account of the increasing emigration of young men from pastoral areas to urban centres and the associated increase in number of households headed by females .

One of the keys to responsiveness to change , be it market or climate variations , is enhancing the capacity of local institutions and communities . This has been addressed in an ILRI project in East Africa on better policy and management options for pastoral lands called Reto-o-Reto" (in Maa language , Reto-o-Reto" means I help you , you help me") . This project was designed to create the knowledge and relationships to enable poor agro-pastoral communities to influence district and national land use policies affecting their livelihoods and the sustainability of biodiversity in the areas where they live (ILRI , 2005) . To facilitate communication with and active participation of the communities in the project , community facilitators were engaged who served as representatives of their communities . Besides , the facilitators worked with the researchers and represented the communities interests' to the policy makers . Under the project , the community facilitators were trained in GIS mapping and they in turn trained members of their communities to map their land areas . Information products including radio programs and posters in local vernacular languages were disseminated providing information on various practices for effective resource management .

A critical pathway out of poverty is the promotion of new and growing markets . Studies in West Africa (Okike et al . , 2004 ; Williams and Okike , 2007) have shown that in many instances , livestock traders dictate prices because of lack of information by the producers—often the pastoralists , meaning there is little incentive for increased production , whilst in reality there are opportunities for a wide range of cross-regional linkages to increase market opportunities Such research has identified key entry points for improving the income and opportunities for pastoral livestock producers especially in relation to growing regional livestock markets . These include opportunities for credit arrangements to allow value added processing , lowering transportation and handling costs , development of livestock market information systems and harmonising regional policies on livestock trade . New opportunities arise from the increased demands of livestock products by affluent sectors of society domestically and internationally . For example , niche markets for animals with certain characteristics or certain breeds are starting to be exploited as added value alternatives in pastoral regions (i .e . Sudan desert sheep exported to the Middle East , El Chaco beef and others) .

An increasingly important opportunity for pastoral livelihoods relates to the role in managing them for protecting or increasing environmental services . Opportunities will arise for receiving payments for the provision of these services once adequate mechanisms are put in place by the global environmental community . This presents an opportunity of global and local significance . As said before , rangelands are the largest ecosystem of the world and have significant potential to reduce greenhouse gas emissions through management of the carbon cycle. They have the potential to mitigate carbon dioxide emissions by protecting existing carbon resources (conversion of grazing land to cropland leads to huge carbon losses), by sequestering carbon (e.g. through grasses replacing cropland, reducing grazing intensity and erosion and improving species mixes (e.g. more browse means more carbon sequestered) (Reid et al., 2004). At the same time rangelands provide other services such a protection of ground and surface water sources in most basins in Africa (Peden et al., 2007). Traditionally, they have been managed from an animal productivity perspective but these new global and regional roles of rangelands will need increased understanding of their multiple values and the trade-offs arising from them. New quantitative and qualitative data will be essential to establish under which circumstances and management practices these multiple uses can satisfy several simultaneous functions. This opportunity will also require new research on the local and global institutional arrangements needed for different sectors to benefit from these multiple uses of the rangelands.

Conclusions

The perceptions about arid and semi-arid pastoral regions are rapidly changing. It is increasingly recognised that these are ecosystems with many functions and some alternative development options. Some of these options, while important for households and communities are also of global and regional interest and might turn into economically viable livelihood strategies if the right systems of incentives and policies are put in place. For poor household this will mean alternatives beyond traditional livestock production such as the payments for ecosystems good and services like water, carbon sequestration and others, tourism, biofuel production and the development of niche markets. An increased number of options might make these regions more attractive for public and private investment. This could in turn lead to better services and infrastructure in these regions.

Traditional research paradigms for the rangelands have been largely about increasing the primary productivity of the land via management approaches and introducing new forage species and drought management interventions. The new role this ecosystem can play requires a different more holistic research paradigm. This new research agenda will have to focus on assessing the synergies and trade-offs, from different perspectives (economic, social, ecological) of the diverse set of options for different members of society. It should seek to find what may work where and also how can the poor benefit from these increased livelihood alternatives. While well engrained in pastoral societies, some of these alternatives will require new collective action mechanisms in order to promote the adequate benefit sharing and proper management of the natural resources.

Rangeland systems will diversify but will also require a degree of specialisation of their livestock systems. This specialisation will be driven by increased integration of the pastoral economy with other regions. Diversification will also lead to more inclusion of different segments of society into the economy and less competition between households, as the potential for different combinations of livelihood strategies expands.

Pastoralism is no longer seen as a tragedy for common grazing areas but rather as having the potential as a viable part of complex livelihood strategies. Redressing the balance of productivity, environment and livelihoods in such fragile regions raises the potential of addressing the needs of the vulnerable. It is a complex and challenging assignment, but increasingly urgent.

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Public demands on intensive grassland systems and agri-environmental policies of OECD members

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Introduction

Public demands are expressed by several actors of the society . The role of lobbies is undoubtedly important in the media and has a direct influence on decision makers . Their common influence is the result of diverse interests that are often partly or totally contradictory like those of agro-industries , farmers , scientists , environmentalists and consumers . The resulting perception of the problems and challenges by politicians is finally reflected in public policies . With regard to agriculture and environment problems , these policies changed rapidly in many OECD countries in the last decades .

Public demand related with agriculture is associated mainly with food security , food safety , soil protection , water quality and availability , climate change , animal welfare , biodiversity conservation , landscape quality and recreation opportunities . The sensitivity of the public varies although widely in space , between continents , between countries of the same continent , between social groups within a country . It varies also with time ; food safety , environmental problems and animal welfare for instance are increasingly important in the public mind and in policies of many countries . In the last decades , there has been an obvious evolution of public demands on intensive grasslands .

Intensive farming is not easy to define ! It can be related to the use of land , labour or capital . It is usually presented as a type of agriculture that uses high quantity of inputs per surface unit (land) , like fertilizers , feeds , seeds , pesticides , irrigation water and energy . Most of these inputs are non-renewable energy dependent . It is frequently associated with high investments (capital) in machinery and/or buildings and sometimes with high land prices . It can also be characterized by labour-intensive systems . In grassland , intensive systems are using high amounts of fertilizers , especially nitrogen , associated with high stocking rates and animal performances per ha . Although these systems are able to respond to an increasing World food market at relatively low prices and provide relatively high income to farmers , they present several environmental shortcomings that are more and more badly perceived by the public .

This paper presents and analyses case studies in OECD countries or State Federation that are all concerned by intensive farming : the European Union (EU) , the United States of America (USA) , Canada , New Zealand (NZ) and Australia . All parts of their territory are not concerned by intensive systems , but they have all developed public policies about grasslands as a result of public demand . More emphasis is given to the case of the EU that includes very intensive grassland systems and has developed a complex legislation about environmental problems in agriculture . For each case study , the importance and the evolution trends of grassland areas are described , the main environmental challenges in agriculture and grassland are identified and the policy responses are discussed .

Grassland functions and values

Public demands on grasslands are related with their multiple functions and values . These functions and values are defined by USDA (2004) as follows .
Grazers : provision of forage for grazing and browsing animals , both domestic and wild .
Water : enhancement of recharge of groundwater areas , water quality and provision of a clean water source for communities .
Atmosphere : ability to sequester carbon and enhancement of clean air .
Soil : protection of the soil from wind and water erosion and build-up of organic matter in soils .
Biodiversity : support of the biodiversity of wildlife and provision of habitats .
Rural economies : support of rural communities , their infrastructure and tax incomes .
Quality of life : support of landscapes that are aesthetically pleasing , provision of recreational opportunities and open space , and improvement of the quality of life .

European union policy

In 2005 (EU27) , grasslands and rangelands covered 56 million ha (33% of the Agricultural Area (AA)) including about 17 .5 million ha of rangelands (10% AA) in mountain areas notably (Eurostat , 2008) . There are big differences between Member States . In West Europe , the proportion of grasslands in the AA is usually higher , like in UK (62%) and Ireland (73%) , while in East Europe the proportion is usually lower like in Poland (21%) and Rumania (33%). That reflects the differences of ecological conditions and also of meet consumption between the richest countries of the North West and the poorest countries of the East. The situation could change and grassland area could increase with the economic development and the improvement of living standards in the East. Between 1975 and 1990 (EU15), the grassland area was significantly reduced in favour to the production of fodder maize and cash crops. After 1989, many agricultural areas and especially grassland areas were abandoned in countries in transition. Even in the EU15 countries, marginal grasslands tended to be abandoned, especially in mountain areas.

Two major trends characterized grassland management since 1960: intensification or abandonment. In the lowlands, nitrogen fertilization in grassland became used at a large extent since the 1960s. Stocking rate, frequency of cutting for conservation, fertilizer use, drainage, irrigation, re-sowing and over-sowing, weed control with herbicides became increasingly important. The number of plant species and especially dicots felt dramatically in grassland swards while forage yields increased and feeding quality improved. Insect and bird populations followed the same trend than plants. Ground waters were polluted by increasing concentrations of nitrate, notably in arable land areas but also in grassland areas especially in intensive dairy systems and when pig and/or poultry slurry was applied on grassland. The monitoring networks implemented recently by the European Commission and the Member States indicate that over 20% of ground waters and 30-40% of lakes and rivers are showing excessive nitrate concentrations. Nitrogen from agricultural sources accounts for 50-80% of the nitrates entering Europe's water (Europa, 2007). Surface waters are polluted by the discharge of groundwater tables, by the run-off of phosphate and nitrate and by the access of cattle to rivers. At the same time, the traditional landscape was modified by the enlargement of plot size that followed the fast reduction of farm numbers and increase of farm size. In bocage regions, most hedges and traditional orchards disappeared in grasslands in the last 50 years which badly affected landscape. That had a huge negative impact on wildlife too. The specialisation of productions resulted in the progressive disappearance of mixed farming. Some regions specialised in arable crops while other regions specialised in animal husbandry. The importance of temporary grasslands and especially lucerne declined. The use and the proportion of legume species in swards were also reduced by a widespread and almost general use of nitrogen fertilizers. These two last trends, specialisation of production and reduction of forage legume species, had a very negative impacts on farmland bird populations (PECBMS, 2007) that often need both grassland and crop for their feeding and nesting requirements (Robinson *et al*., 2001; Robinson *et al*., 2002; Benton *et al*., 2003). These birds are finding much more food in legume-based swards than in pure grass swards or in crops. On the other hand, many marginal grasslands were abandoned, especially in mountain areas. These plots were invaded by shrubs and trees according to a natural succession process or planted by trees and this resulted in a marked reduction of patrimonial species linked with grassland and extensive animal husbandry. Additionally, in these areas, grassland management often changed: species-rich cutting meadows at high altitude, remote or located on slopes, tended to be uniquely grazed which also reduced plant diversity.

Two main policy programmes are addressing environmental problems in agriculture: the agri-environmental scheme (regulations 2078/92 and CEE 1257/99) and the Nitrate Directive (Directive 91/676/CEE). They are both dating back to the early 1990s. Some Member States tested Agri-Environment Measures (AEM) as early as in the 1980s. The idea was adopted by the EU in 1985 in Article 19 of the Agricultural Structures Regulation, but remained first optional for Member States. In 1992, it was introduced for all Member States as an accompanying measure to the Common Agricultural Policy (CAP) reform. AEM are designed to encourage farmers to protect and enhance the environment on their farm. Farmers receive a payment in return for a service. Their commitment of improving the environment is only rewarded if it goes beyond the application of usual Good Farming Practices (GFP). These GFP are defined in a code formalised in national legislations. At the EU level, the maintenance of the present grassland area is included in these GFP. It is a recognition of the positive impact of grasslands compared to crops for biodiversity, landscape, carbon storage in soil organic matter (SOM), soil fertility, protection of water quality and replenishment of ground water reserves. Farmers sign a contract with their local administration and are paid for the additional cost of implementing the measures and for any losses of income notably due to reduced production. Agri-environmental payments are co-financed by the EU and the Member States. The contribution from the Community budget varies from 60 to 85%. AEM are adapted to local farming systems, ecological conditions and environmental issues that vary greatly throughout the EU; they are designed at national, regional or local level. This makes agri-environment a flexible tool. AEM have two main objectives: reducing environmental risks associated with modern farming on the one hand, and preserving biodiversity and cultivated landscapes on the other hand. They are based on the following principles: they are optional for farmers; they are site-specific, they can be adapted to different agronomic and environmental circumstances; they have a minimum duration of 5 years since environmental issues require a structured and long-term approach; MAE contracts must compete with the most profitable land use, so payment levels have to be sufficiently high to attract farmers; agri-environment payments may only be made for actions above the reference level of mandatory requirements defined by codes of GFP (this is an application to agriculture of the Polluter Pays Principle); Member States have a wide degree of discretion in how to design and implement AEM. The agri-environmental policy is notified to the World Trade Organisation. Since agri-environmental payments are limited to the extra costs or loss of income involved, they are classified in the Green Box which implies that agri-environment payments are not considered to be trade-distorting (Anon., 2005b). AEM include the support of the conversion to Organic Farming (OF) and in some Member States to the maintenance of OF. This type of farming has developed rapidly since the implementation of the AEM, with more than 5.8 million ha, 3.4% of the AA and almost 140,000 organic farms in 2004 (EEA, 2007b). Some examples of AEM related with grasslands are given in Table 1.

Table 1 *AEM types and environment parameters where positive effects are expected (Anon., 2005b).*

Measure types	Soil quality	Water quality	Water quantity	Agricultural biodiversity	Wild biodiversity	Landscape
Input (fertilizer, pesticide) reduction	x	x			x	
Organic farming	x	x		x	x	x
Extensification of livestock	x	x		(x)	x	x
Conversion of arable land to grassland and rotation measures	x	x	x		x	x
Actions in areas of special biodiversity interest		(x)	(x)		x	x
Genetic diversity				x		(x)
Maintenance of existing extensive systems	(x)	(x)			x	x
Farmed landscape					x	x
Water use reduction		x	x			

Legend: x = primary effect; (x) = secondary effect.

In 2002, the EU15 spent 2 billion euros for AEM implementation *i.e.* about 4.6% of the total amount of CAP funds. About 85% is still devoted to the first pillar of the CAP: the support to production through surface subsidies. In 2000-2003, 16.3 euros were spent in average per ha AA of the EU for AEM. It reached 89 euros per ha AA in Austria. An average of 89 euros were received by EU farmers per ha under AEM contract. In 2002, the share of agricultural land enrolled in AEM in the EU15 reached about 25% AA but it varies from less than 5% in the Netherlands and Greece to more than 80% in Austria, Sweden, Finland and Luxemburg (EEA, 2006).

In contrast to AEM, the Nitrate Directive is mandatory for farmers. Under this Directive, Member States must identify on their territory surface and ground waters affected or which could be affected by pollution, as well as vulnerable zones which contribute to pollution. They must define a code of GFP to be implemented by farmers. They must design and implement action programs in respect of each vulnerable zone. These action programs must include the measures prescribed in the codes of GFP. They must also include measures to limit the spreading on arable and grasslands of any fertilizer containing nitrogen and they have to set limits for the spreading of livestock effluents. These limits imply a control of stocking rate on the farm area. Farmers are also required to have the storage capacity for their manure in order to be able to spread them in optimal conditions. For slurry storage, this capacity reaches about 6 months in many regions. That represents a significant financial investment. Member States must monitor water quality, applying standardized reference methods to measure the nitrogen compound content. This Directive is at an advanced stage of implementation by Member States and it has a significant influence on farm structures and practices.

Two other directives have an impact on the agricultural area even if their application concern the whole area of the EU, including outside the AA, like woodlands, wetlands, coastal and marine areas for instance. It is the Bird (79/409/EEC) (1979) and Habitat (92/43/EEC) (1992) Directives. They are focusing on biodiversity conservation. These directives are the legal basis for the NATURA 2000 network that is now covering almost 20% of the EU land mass. Socio-economic activities are maintained in this network when applicable, farming can thus be concerned. It is estimated that approximately 16% of the habitats in NATURA 2000 areas depend on a continuation of extensive farming practices especially the continuation of an extensive grassland management (EEA, 2007a). Measures must be taken for maintaining or restoring, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest. Financing of the network management is coordinated with existing financial instruments. Farming inside NATURA 2000 sites is thus part of the CAP financial support and, structural interventions, being part of rural and regional development policies. That induces a strong relation between AEM and NATURA 2000 implementation on agricultural land. The network area is almost complete but management agreements with landowners and managers are still under intense, and sometimes difficult, discussions. The identification and conservation of High Nature Value (HNV) farmland was given high priority in the Kiev Resolution on Biodiversity (2003). It was agreed to identify all HNV areas by 2006 and that a significant proportion of these areas would be under biodiversity sensitive management by 2008. A map of HNV farmland prepared for the European Environment Agency is currently being updated, but a limited proportion of HNV farmland is designated as protected sites. Management of these areas has still to be implemented (EEA, 2007b).

Other citizen expectations are covered by the EU product quality policy (European Commission, 2007). It is dealing with the protection and the promotion of products of local origin introduced in 1992 (PDO-Protected Designation of Origin, PGI-Protected Geographical Indication and TSG-Traditional Speciality Guaranteed) (EC No 1898/2006) and OF. Healthy food, superior taste and positive effects on the environment are the main expectations of the consumers related to these aspects.

Organic farming legislation started in the EU in 1991 (regulation CEE 2092/91 completed and revised several times since then), it is supported by legislation and direct payments (EEA, 2007b).

In the 2004-2006 period, total support to producers felt to 34% Producer Support Estimate (PSE), still above the OECD average (29%) (OECD, 2007). Many efforts have been made recently to simplify the CAP and the procedures.

United States policy

Historically, grasslands and shrub lands occupied about one half of the territory of the 48 contiguous United States (US); about 50% of these lands have been converted to cropland, urban areas and other land uses. In 2002, grassland pasture and range land covered 238 million ha (25.9% of the US land area and 57% AA) (Lubowski, 2002). Their surface increased by almost 2.8 million ha (±1%) from 1997 to 2002. Total grazing land area (grassland pasture and rangeland, cropland pasture and grazed forests) accounted for 317 million ha in 2002, which is about 35% of US land area. In contrast with the surface of grassland pasture and range land only, it decreased from 1997 to 2002, continuing a decline since the 1940s. Pasture and range surface are converted to arable land when demand for crop products is high. However, grazing lands have been more often shifted to recreational, wildlife and environmental uses. Under favourable growing conditions, particularly in the East, pasture land may revert to forest. Many rangelands are subject to brush invasion if fire is excluded and some of these brush species are fire tolerant and very difficult to control. A significant and rapidly expanding land area is being converted to urban expansion and use. These forces explain the long-term net decline in pasture and range.

The main environmental problems associated with intensive grassland systems are soil erosion, air and water pollution, wetland and other wildlife habitat conservation. Soil erosion is particularly important in mountain areas and in the Prairie ecosystem where soils are particularly sensitive to all forms of erosion including that provoked by wind. The problem is however more acute in arable land than in grassland. As in the EU, major pollutants associated with animal production are nutrients (nitrogen and phosphorus), ammonia, methane, odorous gases, pathogens and dust. Animal husbandry is a significant contributor to water pollution in several regions. For instance, in the Mississippi basin, it is considered that animal manure contributes to 15% of the nitrogen load entering the Gulf of Mexico. Animal manure has been estimated to contribute to 50% of all anthropogenic ammonia emissions, 25% of nitrous oxide emissions and 18% of methane emissions (USDA, 2007a). About one half of the total manure amount is generated in pasture-based systems, the other half by confined animals. In certain conditions, livestock grazing is also considered a factor in the decline of threatened and endangered species (USDA, 2007b). The main causes of grassland and rangeland habitat degradations are overgrazing, fire suppression and invasive species.

The US policy for protecting the environment in agriculture includes education, organic and other eco-label certification, financial incentives, taxation, compliance mechanisms and regulatory requirements (USDA, 2007c and 2007d). The Farm Security and Rural Investment Act of 2002 (2002 Farm Bill) is the basis of policies that provide monetary supports to farmers who develop environmentally beneficial activities. It authorized the implementation of the Environmental Quality Incentives Program (EQIP) (1996) that provides technical and financial assistance for managing natural resources in farms and ranches. Payments are made under 5-to 10-year contracts for eligible practices defined at farm level in an approved conservation plan. Livestock production attracts 60% of the funds. In 2004, more than $95 million was devoted to unconfined livestock but most of this amount is targeted to usual grazing operations and not to environmental problems. The 2002 Farm Bill includes several other programs. The Grassland Reserve Program (GRP) (2002) is a voluntary program offering landowners the opportunity to protect, restore, and enhance grasslands on their property (USDA, 2004). The program aims to conserving vulnerable grasslands from conversion to cropland or other uses and to conserving valuable grasslands by helping maintain viable ranching operations. The easements and rental agreements must permit common grazing practices, mowing and harvesting with restriction during the nesting season of some bird species, fire rehabilitation, construction of fire breaks and fences. The conservation practices are generally designed to provide feed and water for livestock production; enhance wildlife diversity and habitat; protect air, soil and water resources; and provide a basis for diversifying farm income. Practices involve prescribed grazing (manipulation of stocking rate, duration and distribution of grazing), prescribed burning, establishment of native or introduced forage species, planting of shrubs and trees, brush management, fencing, nutrient management for optimizing yields while minimizing the risk of water pollution, pest management, watering facility development, upland wildlife habitat management. Several enrolment options are possible for periods from 10, 15, 30 years and even permanent easement. Between 2002 and 2007, 809,000 ha had to be restored or improved for up to $254 million. Other USDA voluntary programs for landowners and managers in grassland include the Conservation Reserve Program (CRP) (1985), the Conservation Security Program (CSP) (2002) and the Farm and Ranch Lands Protection Program (FRPP) (1996). The CRP supports the removal of environmentally sensitive lands (especially marginal croplands) and the establishment of long-term covers including native grass covers. Haying and grazing are not allowed on these areas but in time of critical need such as extreme drought. In this condition, permission to graze or hay can be requested and permitted in some restrictive conditions as part of an approved conservation plan but not during the bird nesting period (15 May to 1st August). The CSP provides technical and financial assistance to exemplary land managers. The FRPP aims at maintaining management to several types of official organisations and NGOs for conservation purposes. Two other programs can be adopted by farmers in grassland areas although not directly targeting grasslands: the Wetlands Reserve program (WRP) (1985) ($2.125 billion between 2007-2017) and the Wildlife

Habitat Incentive Program (WHIP) (1998). They are offering financial incentives for enhancing wetlands on marginal agricultural land retired from production for the control of the water cycle and biodiversity conservation (WRP) and for establishing and improving wildlife habitats (WHIP). In the 2007 Farm Bill, several programs have been reorganised or merged with others for avoiding redundancy and overlapping; the GRP for instance has been reorganised with other programs into a new Private Lands Protection Program but all these programs were consolidated. Five billion dollars a year will be spent for improved soil, water and wildlife resources on 2.1 million farms. More than 16.19 million ha of important habitat for prairie birds and waterfowl will be conserved (NWF, 2007).

The main regulatory requirements for grassland farmers are defined in the Clean Water Act (CWA) (1972) and the Endangered Species Act (ESA) (1973) (USDA, 2007d). The Nonpoint Source Program of the CWA requires States to develop management programs in agriculture. They are usually based on voluntary actions and funded ($200 million in 2005) for the adoption of best management practices for animal manure and land manager education programs. Confined animal feeding operations (feed lots) that are considered as point source of pollution under the CWA, must obtain permits for the production area (animal housing and manure storage) and for the land area where the manure is spread. This regulation may impose significant costs for manure management. Under the ESA, private landowners cannot develop activities in grasslands that can harm endangered species unless they obtain a permit from the US administration. ESA may also concern the irrigation of intensive grasslands because water pumping must not threaten the flow of rivers supporting endangered species like salmon.

In 2006, total support to producers felt to 11% PSE, less than the half of the OECD average (OECD, 2007), and 11% was devoted to conservation and forestry on agricultural land (USDA, 2007e). Although the GRP is a relatively new program, several other programs were initiated at the end of the eighties or in the beginning of the nineties of the 20th century. The conservation policy in agriculture as a whole clearly tackles all environmental aspects, with a relatively strong emphasis on wildlife and habitat conservation and restoration. In the last Farm Bill, there is a trend of a better horizontal integration of environmental problems in the legislation. An improvement in analytical methods for the evaluation of agri-environmental policies is desirable for a better targeting of fields and farmers to be supported in order to achieve better environmental results (OECD, 2007).

Canada policy

Agricultural land in Canada occupies 68 million ha which corresponds to only 7.3% of total country land mass. That reflects the huge importance of the taïga and the tundra in this immense country. Grazing land (30% AA and about 20 million ha) and forage crops (11% AA and about 7 million ha), including lucerne (7% AA), cover 41% of the AA. About 80% (23 million ha) of native rangeland and seeded forages are located in the Prairie Provinces. Crop land and set-aside were reduced in favour to cultivated and sown grazing land due to the decrease of agricultural income, low prices and natural disasters. For instance, the area of crop land was reduced by 1.3% between 2001 and 2006 and, more importantly, the surface of sown grazing land has increased by 18.5% between 1956 et 2006, because crop land and set-asides have been sown with forage plants for grazing in order to cover the feeding needs of cattle that were not slaughtered because of the crisis of Bovine Spongiform Encephalopathy (BSE). The surface of other agricultural lands that include woodlands and wetlands (9% AA), has increased by 12.9% between 2001 and 2006 as a result of governmental policies that pay farmers for the management of the environment or by the fact that some farmers can find other incomes sources by producing wood instead of food. During the same 5-year period, low crop prices and high input prices have lead farmers in many provinces to abandon annual crops for perennial forage plants like lucerne, cropped hay and sown grazing land (Statistics Canada, 2008).

Prairie soils are sensitive to wind, water and tillage erosion. Some of them are affected by salinity (about 1.4 million ha are moderately to severely affected). They lost 14-40% of their organic matter originally present before cultivation began. Water quality can be a problem for the same reasons than in the EU. Although grasslands and rangelands offer a protection for these sensitive Prairie soils, notably against soil erosion, a survey has shown that more than half of Prairie rangelands is in less than good condition. Their condition could be improved through the implementation of planned grazing systems combined with some range management techniques. That could increase production, reduce soil erosion, create wildlife habitats and increase SOM contents. The group of farms that is the most specialised in grassland use (more than 70% of their land used for grazing and forage) is located in the drier areas and along the geographical limits of agriculture. These farms are very important areas of biodiversity. In 1996, 71% of their farmland was in native vegetation (Smith & Hoppe, 2000). The main factor responsible of degradations of the grassland area has been an intensification of agriculture across much of the country (McRae & Smith, 2000).

Agricultural policy is defined in a Policy Framework (AFP) (AAFC, 2008). It is revised every 5 years (2003-2008) and includes an environmental pillar. This program aims to enhance soil, water, air and biodiversity. Among the goals being considered for environment are the implementation of conditions that ensure compatibility between biodiversity and agriculture as well as the reduction of (i) water contamination from nutrients, pathogens and pesticides, (ii) agricultural risks to soil health and soil erosion, (iii) particulate emissions, odours and greenhouse gases. The environmental pillar of the AFP include several programs, some of them are related directly with grasslands: Environmental Farm Planning (EFP), Greencover

Canada, National Agri-Environmental Standards Initiative (NAESI), National Agri-Environmental Analysis and Reporting Program (NAHARP), National Farm Stewardship Program (NFSP), National Water Supply Expansion Program (NWSEP), Shelterbelt Enhancement Program (AAFC, 2008). It is not possible to describe them all in this paper. The Greencover Canada program ($110 million in 5 years) aims at improving grassland-management practices, protect water quality, reduce greenhouse-gas emissions, and enhance biodiversity and wildlife habitat by converting environmentally sensitive land to perennial cover, including on agricultural land near water, and by planting trees on agricultural land. The Shelterbelt Enhancement Program offers an increased access to trees, weed-controlling materials and specialized mulch application equipment for the planting of hedges.

The Community Pasture Program is managed by the Prairie Farm Rehabilitation Administration. It is not an AFP program. It is the largest and longest-running contribution to soil conservation. Created in the 1930s to reclaim badly eroded areas on the Prairies, the program has returned more than 145,000 hectares of poor-quality cultivated lands to grass cover. It currently encompasses in excess of 900,000 hectares of productive rangeland. The program uses cattle grazing as a tool for maintaining a diverse landscape, representative of the natural Prairie ecosystems. It aims at combining an environmentally responsible management of bio-diverse rangelands with the utilization of the resource to complement livestock production. The program involves each year about 3,000 producers, 220,000 head of livestock and over 3,000 bulls. The Prairie Shelterbelt Program is another non-AFP environment program: it offers the opportunity to producers in the Prairie to get tree and shrub seedlings for the cost of shipping and handling.

In particular, biodiversity conservation goals in grassland are achieved mainly through the following programs: EFP, NFSP, Prairie Shelterbelt Program and Shelterbelt Enhancement Program. Experiences of invasive species control in grassland have been conducted by agreements between the Prairie Farm Rehabilitation Administration and the Canadian Wildlife Service. Cattle are used on site at risk for the implementation of good grazing practices that increase the number of different plant species on rangeland and create patchy habitats which enhance biodiversity.

In the 2004-2006 period, total support to producers felt to 22% PSE, below the OECD average (OECD, 2007). In the past, agricultural policy has focussed mainly or exclusively on economic and production objectives. Recent policy reforms have been guided by environmental considerations, along with more traditional social and economic criteria (MacGregor & McRae, 2000). Although, agriculture has made since then considerable progress in conserving the natural resource, some soils remain at risk of severe degradation and agriculture's compatibility with natural systems is still in balance. Conversion of arable land into permanent grassland cover offers a good opportunity to mitigate greenhouse gas effects by increasing SOM contents, especially in the Prairie soils that were originally rich in carbon and that can fix a lot of this element.

New Zealand policy

About 45% of the NZ territory is used for agriculture (all types of woodland and shrubland excluded). Grasslands and other grazing areas occupy the main part of the AA (11.5 million ha). In 2002, grassland represented 68% (8.2 million ha), tussock and *Danthonia* used for grazing 27.5% (3.3 million ha), arable land including fodder crops 3.5% and horticulture 1%. Between 1994 and 2002, the importance of grazing and arable lands has decreased by 12%, while horticultural land use and wine grapes have increased. The area planted in production forest has increased by more than a quarter since 1994 as marginal farming land is converted. The intensity of grassland use has increased as sheep numbers continue to decrease and dairy cattle numbers increase (Statistics New Zealand, 2007). Deer numbers have now approached those of cattle.

NZ lost much of its original biodiversity and habitats since colonization by man: 90% of wetlands, 85% of lowland forest areas and 90% of tall tussock grasslands were destroyed, 50% of endemic bird species are extinct. Most grassland swards are dominated by exotic species, including European forage grasses and legumes. The biological context of the country ecosystems is thus particularly artificial but agriculture kept for long a green and clean image because the farming economy was dominated by extensive sheep and beef systems using low levels of inputs. Grassland production was traditionally based on grass-clover mixtures and the use of synthesis nitrogen fertilizers was much lower than in many European countries yet attained similar levels of animal production. In recent years, the fast intensification of NZ grassland systems exerted an increasing pressure on the environment and biodiversity. Intensification occurred from increasing dairy cow numbers through conversions from sheep and beef farming and intensification of dairy systems themselves (up to 3.0-3.5 cows/ha now). That lead to significant increases in inputs, both nitrogen and concentrated feed, and hence losses of nutrients. Surface and ground water quality is threatened by the increase in the use of synthetic fertilizers, especially nitrogen and phosphorus. A growing use of irrigation water depleted water reserves and increased nitrate leaching. Higher stocking rates induced microbial pollution in surface water. Increasing numbers of animals, especially dairy cows, lead to high emissions of methane and ammonia into the atmosphere. Intensification of grassland management is threatening local biodiversity. The quality of the environment degraded thus rapidly because of these changing farming structures and practices (PCE, 2005).

NZ is now at a turning point for improving environmental impacts of its agriculture. The Polluter Pays principle has never been applied in the past and very few specialised programs helped or constrained farmers to take actions (Salmon, 2007). Some regulations are dealing with animal welfare, use of chemical pesticides and veterinary drugs, natural resource and conservation but the most significant legislation about the impact of farming on the environment is the Resource Management Act 1991 (RMA). The objective of this Act is to promote the sustainable management of natural and physical resources including soil, water, air, biodiversity and the coastal environment. It should be implemented through national policy statements and till now only one has been released, on air quality, in 2004. Most responsibilities under the RMA are assigned to regional and district councils. Regional councils develop their own plans on air, water and soil, and provide frameworks for district plans on land use, landscape and biodiversity (PCE, 2005; Anon., 2005; OECD, 2007). The Sustainable Farming Fund (SFF) (2000) is another policy program that aims at improving the productive and environmental performances. It is based on community-driven projects. Many projects funded under SFF focus on efficient water use. In recent years, a project has been developed around Lake Taupo, which is under severe threat of eutrophication, for the control of water quality and nitrogen release by farming activities. The discussions with relevant partners are still under progress. The expectation is that nitrogen use on intensive pastures will decline and NZ will aim to return to the high quality grass, clover pastures that sustained dairy farming for much of the past century. That will though probably require a reduction in stocking rates. The Pastoral Greenhouse Gas Research Consortium (PGGRC) was established in 2002 and combines the industry and the government. It aims at discovering innovative ways to reduce CH_4 and N_2O emissions.

Two recent programs (2003) are focusing on water quality: the Sustainable Water Program of Action and the Dairying and Clean Streams Accord. The objective of the first one is maintaining water quality and ensuring water availability including for irrigation. The Program of Action, co-led by the Ministry of Agriculture and Forestry and the Ministry of Environment, aims *inter alia* at raising public awareness on water management issues and to disseminate good practices for riparian management and fertilizer and pesticide uses. The second program, grouping the dairy cooperative Fonterra, the ministries and regional councils, has developed targets for achieving clean water in dairying areas including stock exclusion and regulating stream crossings.

The expectation of New Zealanders for a quality environment is obvious and that is the reason why a report, Growing for Good, has been coordinated by the Parliamentary Commissioner for the Environment for analysing the situation and exploring tracks of solutions (PCE, 2005). The Government decision on climate change in 2007 could be a first step in a change of attitude of public authorities towards the responsibility of the farming sector for its impact on the environment. It expresses a willingness to put a price on agriculture's greenhouse gas emission. However, farmers will be exempted of payment until 2013 and will not pay the full cost of their emissions before 2025 (Anon., 2007). This legislation could lead to other regulations on the protection of water and soil resources in agriculture (Salmon, 2007). There is thus an urgent need for an organisation that could: stimulate a constructive dialogue around the farming sector, create a vision for NZ farming that should be more sustainable, facilitate research to support dialogue and promote technical solutions (PCE, 2005). At this stage, working groups, research and innovation, technology transfer including in pilot projects, communication and engagement seem to play a crucial role for moving forward. In the dairy sector, the main priorities are the control of nitrate and phosphate losses to water, of microbial contamination of surface water, of water availability and of greenhouse gas emissions (Anon., 2006).

Total support to producers was 1% PSE in 2004-2006. It is the lowest of the OECD. The 2007 OECD report concludes that efforts for environmentally sustainable development should continue. The new environmental policy for agriculture in NZ could guarantee the access of farming products to overseas markets where good environmental practices could be required for the access to the market.

Australia policy

About 59 to 67% (according to the way of calculation) of Australia land's area is used for agriculture in the World's driest inhabited continent. The vast majority of this farmland (408 million ha and 90% AA) is rangeland and is used extensively with sheep and beef cattle though native kangaroos still contribute significantly to grazing pressures, particularly since more watering points were developed. A particular feature of the continent is the high rainfall variability which makes optimising pasture management, stocking rates and avoiding over-grazing very difficult. Sown pastures and grasses occupy 5% (24 million ha) and crops 5% (Australian Bureau of Statistics, 2007). Intensive pasture-based dairy production has been located along coastal fringes especially in the South-East where soils and rainfall are the more favourable and also in inland irrigation districts, particularly along the increasingly stressed Murray and other rivers. The trend has been for dairy farms to move inland, in part because of high land values on the coast, and also to be closer to where cereals are grown to reduce feed costs, to access irrigation and to access more land. On intensive farms, the typical forages vary from temperate perennial grasses and legumes, to tropical perennial grasses and to annual forage crops. No native species are used, they are more relevant in medium to low rainfall areas and for sheep and beef cattle. The availability of quality land is though a constraint, which leads to pressures to intensify production and attendant environmental issues. Land prices are though less than in New Zealand which has resulted in New Zealand farmers crossing the Tasman Sea to expand dairy farming.

In recent years, all livestock type numbers increased except sheep. Total cattle numbers are now twice that of sheep, on an animal unit basis. The number of dairy cows increased from 1.65 million in 1989/1990 to 2.37 million in 2001/2002. Intensive production systems are thus increasing in importance . In 1999-2000 for instance , the crop area increased by 2% and the area devoted to sown pastures and grasses by 6% . Irrigation is crucial ; the irrigated area is only about 5% but it produces about 25% of the gross agricultural production value . Irrigation of pastures is though increasingly considered an important cause of salinisation and waste of water , though many dairy farms depend upon it . Soil degradation caused by farming activities is a major problem . It includes soil salinity in irrigated and non-irrigated lands , soil sodicity and soil acidity . Soil sodicity together with overgrazing induce soil erosion which contributes to a large sediment loading of rivers . Water quality is severely threatened by farming activities also because of increasing sodium , nutrient and pesticide concentrations in rivers . In part , this reflects the low flow rates in rivers , which increases concentrations . Soil acidity is increased through pasture improvement and nitrogen fertilisation (PCE , 2005) , mainly on the less productive land ; lime applications are more profitable on more profitable land .

Since 2001 , the country has faced an extensive and devastating drought that has focussed the attention on water utilisation and quality . The areas irrigated declined dramatically and the cost of purchased fodder escalated .

The Natural Heritage Trust (NHT) has been created in 1997 by Environment Australia and the Ministry of Agriculture , Forestry and Fisheries for restoring and conserving the environment and natural resources . It builds on earlier programs originally developed in partnership with farmer organisations and relies heavily on community volunteers . It has three objectives : biodiversity conservation , sustainable use of natural resources , community capacity building and institutional change . The Trust provides funds for environmental activities at three levels : national investment delivered in accordance with the National Strategic Plan , regional investment delivered in conjunction with the NAP (see below) and local action delivered through the Australian Government Envirofund . The Government committed $1.975 billion for 5 years from 2008-2009 to 2012-2013 . The following 10 areas of activity define the scope of the NHT :

- protecting and restoring the habitat of threatened species , threatened ecological communities and migratory birds ;
- reversing the long-term decline in the extent and quality of native vegetation ;
- protecting and restoring significant freshwater , marine and estuarine ecosystems ;
- preventing or controlling the introduction and spread of feral animals , aquatic pests , weeds and other biological threats to biodiversity ;
- establishing and effectively managing a comprehensive , adequate and representative system of protected areas ;
- improving the condition of natural resources that underpin the sustainability and productivity of resource-based industries ;
- securing access to natural resources for sustainable productive use ;
- encouraging the development of sustainable and profitable management systems for application by land-holders and other natural resource managers and users ;
- providing land-holders , community groups and other natural resource managers with the understanding and skills necessary to contribute to biodiversity conservation and sustainable natural resource management ;
- establishing institutional and organisational frameworks that promote conservation and the ecologically sustainable use and management of natural resources .

While these programs are not directly aimed at agriculture , they have influenced the ways farmers manage their land .

The National Land and Water Resources Audit was organised by the NHT for assessing the status of natural resources notably on soil , water , vegetation cover and rangeland monitoring .

The Australian State and territory governments adopted the National Action Plan for Salinity and Water Quality (NAP) in 2000 . In conjunction with the NHT , it forms the basis for the delivery of Australia's integrated regional natural resource management initiatives . NAP funding reaches $1.4 billion over seven years (2001-2008) . The NAP is jointly delivered at a regional level with the NHT . Under this program , government , community groups , individual land managers and local businesses work together to reduce salinity problems and improve water quality at regional level . It supports practical remedies such as the protection and rehabilitation of waterways , improvements of native vegetation , engineering works , and land and water use changes (Australian Government , 2008) . The National Landcare Program (NLP) funding is delivered under the Natural Resources Management Act 1992 . It is a longstanding program within the Department of Agriculture , Fisheries and Forestry . It is an additional and complementary program to the NHT . It is financially supported by the Government ($151 million over 4 years from 2008-2009 to 2011-2012) and provides funding to encourage action that will result in enhanced sustainable natural resource management (land , water and biodiversity) at the farm , catchments and regional level . It stimulates landholders by supporting collective action by communities . The NLP has been highly effective in encouraging farmers to adopt sustainable management practices and improve their productivity , profitability and the condition of natural resources , both on and off farms . Around 75% of primary producers are involved in Landcare type activities or benefit from the shared knowledge gained from these activities (Landcare Australia , 2008) . The main concerns have been that many activities have focused on hot-spots in the landscape , limited work has been done at *e.g.* farm scale and most land managers have only adopted part of better environmental management practices on their own properties . Ways of demonstrating the production benefits from improved environmental practices are seen as a needed area of research to continue to improve on-farm practices . The Program is though judged a great success at reversing many problems and at improving land management generally .

In 2006, the National Agriculture and Climate Change Action Plan 2006-2009 was released. It identifies four key areas to manage climate change risks: adaptation of agricultural systems, mitigation to reduce emissions from agriculture, research and development investment, awareness and communication to improve the understanding of the problem by rural communities. Several audits have been carried out for agricultural sectors and regions. They have identified problem areas. That was the basis for actions implemented in collaborations between local governments, industries and other organisations. They have defined codes of good practices. The good management practice schemes are considered to be successful because they are industry led, implemented on a voluntary basis and strongly supported by external organisations. They are flexible and simple to use, they have clear and achievable objectives and focus on practical issues.

Achieving results for the environment in agriculture in Australia was delayed for long by conservative, market-oriented federal policies. Until recently in Queensland and earlier in other States, to retain their rights over leased land, farmers were required to clear the land irrespective of the merits of doing so! However, Australian citizen's attitudes are changing; farming is no more a question to conquer the land but to adapt the systems to the natural limits. Experience has been that most farmers would now retain or restore 10% or so of their farms in a natural state, but going beyond this limit requires Government support. Biodiversity conservation on farms has seen some experimental approaches. In the State of Victoria, farmers were invited to tender for the cost of restoring or maintaining special areas on their farms. This has proved popular and more cost-effective than setting payments by Government. Dairy farms are conscious of limiting any nutrient losses into waterways and more riparian zones are fenced to exclude livestock. Models to help farmers better manage nutrients are available, backed by research which showed that the economic levels of fertiliser were often significantly lower than what farmers were applying.

Recent years have highlighted the need to better manage water in the landscape. Better pasture management will result in more water being captured and used on farms. Water ways are likely to be constructed on farms as a chain of ponds, which improve the available water for pastures in lower parts of the landscape. The net effect could be less water in rivers and for irrigation in below average rainfall years, but limited change in above average years. How intensive livestock industries adapt to this will take time to resolve.

Total support to producers was 5% PSE in 2004-2006. It is the second lowest of the OECD after NZ. The agri-environmental policy aims have been to encourage self-regulation by industries and to find market-based solutions wherever possible to provide in-built incentives for change. The 2007 OECD report concludes that although natural resource policies have been expanded and strengthened, concerns remain for soil quality, pressure from sheep and cattle grazing on sensitive habitats, state and fragmentation of habitats in some areas. As for NZ, future exports of agricultural products should be ensured by a reinforcement of agri-environmental policies.

Discussion

Intensive grassland systems have succeeded in increasing yields and quality of forages. That ensured a fast increase of the total production of milk, meat and fibres and these productions per ha. This process was accompanied by many other fundamental changes that can be called the silent revolution of traditional farming systems. These changes included a huge decrease of farmer's population, an increase of farm size, a general modernisation of agriculture that used much more inputs than in the past like nitrogen and other fertilizers, soil amendments, herbicides, irrigation, concentrate feed, fodder crops including maize. Many investments were made in buildings and machinery. Specialisation in animal husbandry systems lead to important differences in grassland management. All these changes induced enormous productivity gains whose benefits were largely transferred to the rest of the society. The farming sector provided also the manpower that was necessary in other sectors of the economy. These systems provided safe food at a relatively low price and in a regular manner (food security) for the consumers. The success of intensive grassland systems in reaching its goals is thus unquestionable.

However, several unforeseen effects of these systems progressively appeared: landscape changes, biodiversity reduction, pollution, misuses of natural resources and degradation in product taste. In some areas, irrigated forage production started to compete with industry and urban areas for water use. The geographical concentration of the systems induced abandonment of marginal areas and a reduction of landscape diversity in intensive regions. Many changes had a negative impact on the attractiveness of tourist regions and on recreation possibilities in general. All these consequences of intensification changed the vision of citizens on agriculture that was no longer considered as a clean activity, close to nature, but as an industry like another. Grasslands are however considered as less detrimental than crops. At the same time, grassland farming is keeping a particular responsibility in the society because it is managing important surfaces (especially in the EU, USA, Australia and NZ). In the future, although modern grassland systems must be market-oriented, they must also be environment-friendly and multifunctional for responding to all demands of the society. For instance, in some regions tourism now generates more income than livestock *e.g.* semi-arid Australia, Pantanal in Brazil, Portugal and Spain which means that farmers seek to keep their grasslands in an attractive state but that is a trend for extensive grassland systems rather than for intensive ones.

Policy responses to these problems were very diverse across the continents. All agri-environmental policies are focusing mainly on reduction of nitrate and phosphate pollutions, biodiversity conservation or restoration, landscape protection including aspects of the natural and the cultural heritages, better use of soil and water resources. More recently, policies were developed on climate change mitigation. In Europe, policies on local origin products, OF and the promotion of tasty products are particularly important. Many questions can be raised about the efficiency of these policies. Are the funds sufficient compared with the challenges and other agricultural policies? Are the programs efficient for improving the environment and restoring biodiversity? Are the methods of the programs adequate? It appears that the budget associated with environmental policies remains rather modest. Support to farmer's income should be more envisaged as a reward for their positive contribution to land and natural resource management as well as to biodiversity restoration instead as a financial help for supporting them to compete with other producers on the World market. Environmental payments need to be a separate income stream that should be divorced from any considerations of production, so that they do not distort markets for agricultural products. The transition between this new agricultural policy and the old ones based on price or production support is not yet totally achieved, especially in the EU, USA and Canada. In Australia and NZ, the situation is almost the reverse with regard to the World market, but the proportion of the budget devoted to agri-environmental policies is still too small, much smaller than in the other OECD countries. Studies on the efficiency of AEM in the EU have shown hat they were relatively unable to restore biodiversity and even to slow down its decline (Kleijn, *et al*., 2001; Kleijn *et al*., 2004; Feehan *et al*., 2005; Aviron *et al*., 2007; Wilson *et al*., 2007). They should be better targeted, farmers should receive more advice from experts and AEM contracts should last longer for producing results. Although more expensive to control, performance-based measures are probably more effective than measures based on mean obligations. For instance, a minimum plant species density in a meadow could be a better target of an AEM compared with the date of a late cut. A revolution has still to be done in farmer's mind to transform them in biodiversity and landscape producers in addition to their role of food, fuel and fibre producers. In most cases AEM were also unable to recreate an ecological network because they are applied at a farm and not at a landscape level. Community projects should thus be encouraged like it is in Australia for instance. These projects, associating several farmers working in the same area, could take different forms that should be experimented and progressively formalised. The identification of HNV farmlands in Europe is an excellent initiative but specific funds should be associated to the implementation of managements adapted to these areas. The same is true for the management of NATURA 2000 areas. With regard to natural resources and pollution, better results are expected compared with biodiversity. Long-term programs are although also necessary.

Considerable efforts have been devoted to the development of agri-environmental indicators but data are still dramatically lacking on species-rich grasslands and on plant and insect diversity in grasslands. Almost no data are available on soil life that is though extremely important for the ecosystem. More data are available on birds and chemical components of the grassland habitat. Environmental agencies should devote more efforts to collect data on the field and by remote sensing techniques. It is difficult to design and to evaluate policies without this crucial information. Applied research, policy evaluation and continuous adaptations of these policies are necessary to achieve tangible results in the improvement of the environment. Although socio-economic and ecological conditions are very different from one continent to another, lessons from failures and successes of agri-environmental programs should be more exchanged between OECD members.

Results achieved by agri-environmental policies are now facing a new threat, the development of agro-fuels. Agro-fuels from the first generation could induce a reduction of grassland surface and a further intensification of grasslands. That would provoke new environment degradations. Second generation agro-fuels could be an opportunity if perennial forage plants could be used for the purpose of energy production. Much attention should be paid to this new challenge of the World agriculture.

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Grasslands/Rangelands Resources and Ecology

—Ecology of Grasslands/ Rangelands

Rangeland ecology and management in a changing world

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Key points: Rangeland ecological science and management over the past century has emphasized external human actions to supplement and direct natural ecological processes in the hope of achieving sustained production. The focus has usually been on an improved efficiency of production, generally achieved by adding fossil fuel based inputs, to increase consistency of harvest. The results have been relatively benign in the more mesic and fertile rangelands and unsuccessful to disastrous in the more arid and infertile areas. We suggest a broader view of the interactions of humans and rangelands, one that includes people as a vital component within the system, might be a more realistic approach to achieving economic, ecological and social sustainability. An increased emphasis is necessary to develop new tools for capturing, organizing and communicating information and to provide testable hypotheses that can advance rangeland ecological science and management.

Key words: ecological site descriptions, state and transition models, multiscale management, ecological disturbance

The ecology of rangelands: people are really important Rangelands are often defined as any lands that are not considered arable or forest, and capable of providing support for human well-being from the native or naturalized vegetation (SRM 1989). Estimates of the global extent of rangelands generally range from 60%~75% of total land area, with occurrence on every continent other than Antarctica. Although definitions and inventory procedures vary somewhat, several aspects of the ecology of rangelands emerge.

All rangelands, both by their nature and our definition, are managed. Regardless of the broader context of social and economic system within which they exist, there are no rangelands beyond influence by human decisions. Even in seemingly remote areas where it may be difficult to detect direct human influence, the historical impact, as well as the current influence on the global climate and atmospheric chemistry, link people and rangelands inextricably. Thus, the concept of pristine' may be academically interesting, but is of little use to people in inventorying, planning and assessing rangelands.

Rangelands, in addition to the managerial definition, are also defined functionally by their limitations, generally low and/or erratic rainfall, infertile or rocky soils, difficult topography or inaccessibility. These limitations are important because they define what we can expect from rangelands. Too often, these limitations are ignored and humans suffer because of it. From a management perspective, the greater and more varied the limitations, the more unlikely rangelands are to respond to inputs, especially those based on increasingly expensive fossil fuels. The history of rangeland science and management is littered with schemes predicated on the erroneous belief that these limitations could be overcome with enough inputs, either management or fossil-fuel based.

Three related themes emerge as the critical elements in the ecology of extant rangelands and, it should follow, in the conduct of research and management. First is the realization, acknowledgement, acceptance and integration into research, development and management of the idea that human actions, regardless of their motivations, result in the disturbance of rangelands (Archer and Stokes 2000). These new disturbance regimes are not recreations of natural' disturbance regimes, but are wholly human in their origin and effects. Regardless of how closely anthropogenic disturbance regimes try to mimic our perceptions of nature, they are limited both by our ability to interpret nature and by our ability to recreate what we have interpreted. Regardless of intention, these new disturbance regimes do have a similar effect as natural regimes in that they govern the rate and magnitude of ecological processes that drive ecosystem behavior and determine the array of goods and services that can be extracted.

Second, rangeland management is a multiscale endeavor, and understanding and management at the landscape and regional scales are just as important as what occurs at the community scale (Pringle and Tinley 2003). Multi scale complexity, a product of the interactions of geology, climate, past and present vegetation, as well as current and historic management also contribute to the unique ecology of rangelands. Although this complexity could logically be included among the many limitations of rangelands, it is also very much a defining factor in developing strategies for extracting rangeland ecosystem services. Croplands and forests are largely homogenized at mesoscales (ha to km^2) by human inputs. At the more mesic and fertile end of the scale, potential returns warrant investments to enhance the mesoscale homogeneity of rangeland plant communities, but often at the expense of ecological functions at more extensive scales. For the arid and semi arid rangelands that are most common around the world an emphasis on homogeneity becomes not only counterproductive, but wholly unrealistic. Because of the wider range of interests that have emerged in rangeland goods and services and new tools that are available for study, our understanding of cross-scale ecological processes has taken on greater importance (Havstad et al 2007).

Finally, it is clear that while ecology may be at the core, rangeland science encompasses many disciplines, among them agronomy, geology, animal science, soil science, economics, wildlife science, rural and urban sociology, anthropology and forestry . Emerging fields are those that consider society's involvement in the management of rangelands , from both a policy and a human dimension standpoint . Among the most important of these may be geography , both cultural and physical . Clearly , how scientists provide information to assist in decision making and how managers use that information in the future will be determined how well our profession can integrate and apply varied physical , social and economic aspects of the ecology of rangelands . In the end , without application we are left without relevance (Reynolds et al . ,2003) .

The ecological basis for rangeland R & D : the world is our plot Given the extensive human use and reliance on rangelands globally , it would be illogical to view rangelands as anything other than human manipulated systems . However , it would also be mistaken to assume that rangelands can be intensively managed like croplands and forestlands . For better or worse , the condition of rangelands will be determined by how well humans indirectly manage and/or impact ecological processes . Thus , research and development to benefit rangelands must be focused on the interactions of humans and rangeland ecological processes . From a research and development perspective , the impact of humans on rangelands is best viewed in a framework of ecological disturbance . For the first century of rangeland research , scientists focused their attention on the orderly progression of plant communities through time from post disturbance simplicity to the increasing complexity associated with lack of disturbance . Disturbance (fire , overgrazing , frequent or severe drought) may have caused dramatic alterations but the change was reversible once the disturbance was removed . Disturbances were viewed as degrading to ecosystem processes and protection from disturbance allowed processes to return to a normal , stable range . In essence , anthropogenic disturbance was viewed as external to rangeland ecosystems and human decision making was relegated to the narrow framework of how to best simulate nature . Through a combination of observation and experimentation , ecosystem processes have been shown to exhibit much more complexity than simple linear succession (Vavra and Brown 2006) .

Just as important as the human imposition of new and novel disturbances is the human influence on existing disturbance regimes . For decades , rangeland research pursued the elusive goal of stabilizing productivity through the application of a combination of fossil-fuel based (fertilizer , herbicide , reseeding , fencing , water developments , supplements) and management (rotational grazing , herding , distribution) . These novel , anthropogenic disturbance regimes were intended to enhance efficiencies by stabilizing species composition to favor forage species , enhancing forage production and to improve harvest . In the more mesic , fertile rangelands , these technologies were relatively successful . But in the more arid and infertile ecosystems , which encompasses the bulk of the world's rangelands , the attempts to stabilize production of livestock products generally resulted in degradation , loss of stability and ultimately , reconfiguration of ecosystems in less desirable states (Brown and Ash 1996) .

Understanding how disturbances change landscapes , either in a positive , stabilizing or negative direction is the challenge for scientists studying rangeland ecology . During the last 20 years , the development of non-equilibrium theory that defines plant succession over time as a series of multiple states that change (transition) in response to disturbance and may cross a threshold that represents irreversible change from a human timescale , has provided insight into the drivers , patterns , extent and limits of change observed over the past 50 to 100 years . While there are always exciting new techniques and methodologies for investigating the effects of disturbances on ecological processes , it is the context and interpretation of existing information and emerging tools for the use of that information that will determine our success in managing rangelands for human well-being .

The ecological basis for rangeland management : tools to organize knowledge While scientists would like to believe that their current experiments will dramatically alter the management of rangelands , the reality is that rangeland management for the next twenty years will most likely be a reflection of what is in the existing literature today . There are numerous examples throughout the history of ecology and rangeland science that support this assertion , and there is little evidence that any emerging idea or technology is going to dramatically shorten that time lag . So , our greatest challenge is how do we take what we already (think we) know and organize disparate , and sometimes conflicting , sources of information into a transparent , credible and flexible decision making framework .

Ecological Site Descriptions (ESDs) and their key component , State and Transition Models (STMs) are a relatively new technology for land management decision making (USDA NRCS 2003) . ESDs are composed of four main parts :

- Physical setting-the soils , landscapes and climatic conditions for each ESD . This section tells the user how to determine which ecological site they are on .
- State and Transition Model for soil and vegetation dynamics .
- Interpretations for specific land uses-this section describes the values associated with each state .
- Supporting information-contacts , literature , anecdotal observations , historical records , comment opportunity for on-line applications .

ESDs are based on soils , not on existing vegetation , and reflect the strengths and weaknesses of any given soil mapping protocol . Because any particular soil (however narrowly defined) includes an assumed distribution of properties that have important effects on vegetation behavior , a soil may be associated with a similar range of vegetation attributes . We know that the climatic , soil , vegetation and animal components of sites vary widely in their properties across their range of occurrence as individual attributes and have significant and complex interactions . These properties and interactions should be viewed as a distribution function rather than as an average . Regardless of the scale of mapping , soil map units are generally associations of distinct soils . Typically several soil mapping units are combined into a site assuming the climatic and soil properties and the vegetation behavior and animal impacts are similar . Vegetation assemblages on any particular soil also reflect disturbance and short term climatic fluctuations . Thus , however it is defined , a rangeland soil may be occupied by a relatively wide variety of vegetation communities and present managers a confusing array of choices . ESDs can be used to display and explain those dynamics within the context of management decisions . ESDs , due to the nature of rangeland ecosystems , must include a relatively wide range of variability in any given soil or vegetation property . While they lack the illusion of precision of narrowly defined mathematical models , they have the flexibility necessary to accommodate uncertainty associated with complex ecosystems and multiple land management objectives .

While ESDs have tremendous potential as a land management decision making tool , they are only as good as the information contained in them . The core component of an ESD is a State and Transition Model (STM) that describes soil/vegetation dynamics in response to climate and management (Figure 1) . States are relatively broad groupings of plant communities possessing similar ecological function and structure . Transitions are the trajectories between states that contain a threshold . Generally , moving between states , whether by design or unintended consequence , requires a substantial event (drought , fire) that alters ecological processes and cannot be reversed by managerial responses once it is breached . Plant communities and pathways occur within any individual state and are generally regarded as being amenable to relatively common management actions or climatic fluctuations .

While they can accommodate information derived from virtually any theoretical or empirical interpretation of community scale change in rangeland ecosystems , they are most identified as a way to capture dynamics associated with rangelands not at equilibrium . As a nonequilibrium approach to vegetation dynamics supplanted the climax approach in the late 1980s , a new conceptual model for rangeland management applications was required (Westoby et al . , 1989) . STMs were first proposed in the late 1980s and have been extensively applied to rangeland situations throughout the world . In many ecosystems , vegetation dynamics do not follow a linear path following disturbance . This so-called classical succession model (e .g . disturbance>forbs >annual grasses>perennial grasses>shrubs>trees) may be partially adequate for some systems , but in many cases the varying nature of disturbance and recovery processes result in multiple stable states . In these systems , a transition between states is not an autogenic (self contained) process , but one which requires active management , such as mechanical or chemical inputs . Key elements in this approach are the concepts of resistance and resilience . In many arid land systems , STMs have been expanded to include soil/plant interactions that are central to the resistance and resilience characteristics of any ecological site .

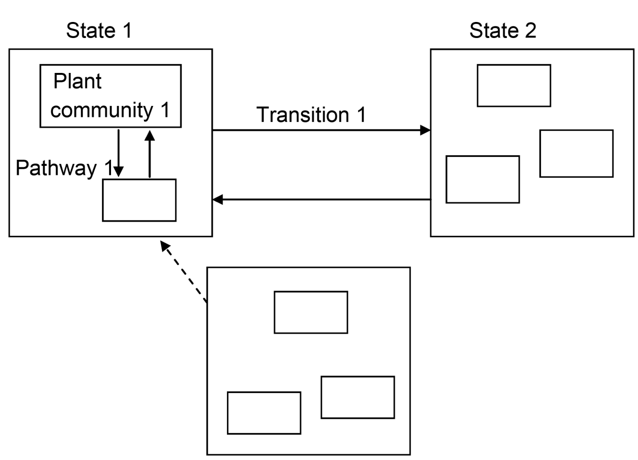

Figure 1 *A generic state and transition model for a rangeland plant community showing the relationship among states , transitions , communities and pathways . Plant Communities and Pathways occur with States . States contain thresholds that are generally regarded as irreversible by standard management actions . Dotted line transitions have not been demonstrated to exist .*

Essentially , STMs regard anthropogenic disturbance and management responses as part of the system rather than as external to the system . States are used to describe the general configurations that a particular plant community may assume (i .e . short grass vs shrub-dominated) and the associated soil and vegetation attributes . Transitions describe the trajectories of change between states . These descriptions include climatic , natural disturbances and management associated with the change and the probabilities that each of these combinations may occur . Particularly useful is the identification of climatic events that may facilitate the successful application of a management response . Land management using STMs is a fairly logical process of inventory (what is the current state ?) , planning (what is the desired state ?) , implementation (applying management under appropriate circumstances) to achieve (or avoid) the change and monitoring (are the actions having the desired consequence ?) .

In early applications , STMs have greatly improved communications among land managers , scientists and the interested public . Scientists have used STMs to illustrate to land managers where research fits in the context of land management and the importance of understanding ecological processes . Land managers have used STMs to frame their problems for scientists and to better explain decisions to the interested public and funding bodies . Constructing STMs is an iterative process . By far the most important input is expertise , whether it is experimental or management based . Many ecosystems have been the subject of extensive and exhaustive investigation , but on-the-ground experience is critical for interpreting the information in management terms . There is no single mathematical model underlying STMs , but many STMs have been constructed based on model outputs , experimental results and observations . The definition of the poorly known is as important as the elucidation of the well-known (Bestelmeyer et al ., 2004) .

A challenge in developing , implementing and testing STMs is the availability of information . For the most part , rangeland ecosystems are well researched from a production standpoint , but poorly understood from an ecological dynamics perspective . Of even greater concern is the behavior of ecological systems in the face of novel climates , species introductions and uses . Obviously , it is impossible to have statistically valid experiments to support every state , transitions and pathway for every ESD that can predict outcomes of as yet unknown disturbance regimes . Thus , interactions and communications among researchers and users are critical in identifying key questions and conditions upon which to build a system of STMs and ESDs . Much effort has been expended , with much more likely to come in the definition of thresholds , a key point in the transition from one state to another (Briske et al 2005) . The tendency toward reductionism among scientists can be very misleading and counterproductive in this instance . A general description of an important threshold is completely adequate to provide managers with the information necessary to make critical decisions . The pursuit of precision in defining a threshold for a very narrow site and vegetation combination can waste limited time and resources and create a false sense of security among managers . The more the illusion of precision in the definition of a threshold , the more likely managers are to push the limits of resilience in rangeland ecosystems in the name of enhancing production efficiency .

Conclusions Ecology as a science is relevant to rangeland management only as it can be applied to the improvement of decision making and implementation . Resource professionals and the organizations they work for possess two kinds of information critical for making good resource management decisions : data and knowledge . Our challenge in the coming decade is to organize these sources of information and put them into a format that is accessible and interactive so that they can be used most effectively . We use knowledge to make decisions , including the design of experiments to generate new data . The difficulty comes when we attempt to use knowledge to fill in missing data without the benefit of scientific experiments and fail to identify it as such . We also have to seriously consider how we package" the knowledge . We often make assumptions , often without good understanding of the end user , who must also perform their own synthesis .

Another element in successful information management is making the information available to users . We have a variety of users ranging from people trying to make decisions about managing a particular piece of land to public interest groups trying to make inferences about the state of the land in general to scientists trying to determine what we know and how to generate new information to expand that understanding . While our information has always been available to anyone interested in it , the internet has dramatically changed accessibility . Before , people had to know enough to ask for a particular piece of information , now they need only know a few keywords to run a search engine and have the fortitude to find the relevant data within the often lengthy results of that search . It is not unusual for people to find information and not know how to use it (data without knowledge) . It is also common for people to find opinion (disguised as knowledge) and have no idea of the validity of the data that supports it .

ESD information can be very complex and , in many cases , difficult to understand . We cannot change that by dumbing it down . However , using a structured context for accessing that information and clearly defining what the information means and where it came from can increase its utility at all levels . In the end , ESDs have the potential to capture information applicable to all 3 of the critical themes of rangeland ecology . These descriptions reflect our understanding of the impacts of disturbances , they provide a basis for scaling our actions from a thorough understanding of a central scale , and they provide a framework for housing information that then can be accessed for a multitude of applications . In this fashion , we have a means where we can meld ecology and management , and actually practice resource conservation .

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Isotopes as natural recorders of grassland ecosystem functioning and change

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Key points: The use of stable isotope analysis in grassland science has increased enormously in the last two decades. It is providing insight into the functioning of grassland systems, including aspects such as the biogeochemical cycles of carbon, nitrogen and water, C_3:C_4 vegetation dynamics, the nutritional ecology of grassland fauna, and the (agro) ecology of cattle production systems. This paper deals with the natural stable isotope compositions of three major bioelements (carbon, nitrogen and oxygen) and how they behave in organisms and ecosystems, and it describes examples of recent research progress in the ecology of grassland systems, which were made with the help of stable isotope analysis.

Key words: stable isotopes (^{13}C, ^{15}N, ^{18}O), biogeochemical cycles, C_3:C_4, grazer ecology

Introduction Until 1990 stable isotope analysis was used only sporadically in grassland research. Today, more than 6% of all grassland publications appearing in the ISI Web of Science data base employ stable isotope analysis. Several reviews and books have been published in the last years, which covered various aspects of the application of natural stable isotope analysis in ecology and in the study of stable isotope behaviour in the environment and in organisms (e.g. Dawson & Siegwolf, 2007; West et al., 2006; Flanagan et al., 2005; Hobbie & Werner, 2004; Schmidt, 2003; Werner and Schmidt 2002; Dawson et al., 2002; Robinson et al., 2001; Evans, 2001; Handley et al. 1999; Ehleringer et al., 1997), and some of these have also dealt with grassland flora, fauna and ecosystems. The interest in stable isotope analysis in ecology of grassland (and of other biomes) stems from the fact that the natural stable isotope composition of organisms and ecosystems hold many clues about their functioning and physical environment, including the relative availability of resources (or resource limitations).

The major elements of the biosphere (including carbon, oxygen and nitrogen) occur in the form of two or more stable isotopes (carbon: ^{12}C, ^{13}C; oxygen: ^{16}O, ^{17}O, ^{18}O; nitrogen ^{14}N, ^{15}N). The isotopic composition of an element in a sample is conventionally expressed as a δ-value, which is defined as the deviation of the isotope ratio (R) of the sample relative to that of the international standard. Thus, for carbon, $\delta^{13}C = (R_{sample} - R_{standard}) / R_{standard}$, with R the molar abundance ratio, $^{13}C/^{12}C$. In an analogous way the isotope composition of nitrogen is given as $\delta^{15}N$, and that of oxygen as $\delta^{18}O$. The standard is PeeDee Belemnite (PDB) for ^{13}C, air for ^{15}N, and standard mean ocean water (SMOW), or PDB for ^{18}O.

The distribution of the isotopes is not homogeneous in the biosphere; but follows characteristic spatial and temporal patterns. These patterns originate from the different behaviour of isotopes in physical and chemical processes, and are controlled by environmental conditions (including anthropogenic factors) and biological properties of organisms and ecosystems. As a rule, the lighter isotope is transferred (e.g. diffuses) faster and is preferred in (bio) chemical reactions, so that the light isotope tends to accumulates in the product (or sink), whereas the heavy isotope tends to stay in the substrate (or source). For example, photosynthetic CO_2 fixation prefers ^{12}C over ^{13}C (^{13}C discrimination), so that plants are relatively ^{13}C-depleted, whereas atmospheric CO_2 becomes ^{13}C-enriched. As another example, isotopically light water evaporates more readily, than heavy water, causing ^{18}O-enrichment of leaf water during transpiration.

In general, the isotopic composition of an element in a given ecosystem, organism or compound is determined by the isotopic composition of its source and isotope effects in transfer or transformation processes. But, isotope effects are fully expressed only if the substrate is infinite (or: only a small fraction is consumed in the reaction). If all substrate is consumed, then the (accumulated) product has the same isotopic composition as the substrate, even if the reaction has a strong intrinsic isotope effect (Robinson, 2001). Isotope effects can be expressed completely in fully open systems, whereas closed systems tend to suppress the expression of isotope effects. One example for the latter is the isotope effect of Rubisco on $^{13}CO_2$ (relative to $^{12}CO_2$), which is almost completely suppressed in C_4 plants, because of the localization of Rubisco in the CO_2-tight bundle sheath cells. Furthermore, a consideration of possible closed-system phenomena is also important for understanding the nitrogen isotope composition of ecosystems. A particular opportunity for the expression of isotope effects is offered at branch points of pathways.

Carbon isotope analysis for studies of C_3:C_4 vegetation dynamics, and drought effects on C_3 grassland The carbon isotope composition of all plants ($\delta^{13}C_P$) is determined by the $\delta^{13}C$ of atmospheric CO_2 ($\delta^{13}C_{CO_2}$) and carbon isotope discrimination during photosynthesis ($^{13}\Delta$), so that $\delta^{13}C_P = (\delta^{13}C_{CO_2} - {}^{13}\Delta) / (1 + {}^{13}\Delta)$ (Farquhar et al., 1989). $^{13}\Delta$ is variable and, in particular, it differs strongly between C_3 and C_4 plants, allowing a distinction of the photosynthetic types on the basis of their $^{13}\Delta$ (e.g. Smith & Epstein 1971, and Figure 1).

C_3 and C_4 plants coexist in many grasslands in the tropics, subtropics and warm temperate regions. Variation of C_3:C_4 abundance has wide biogeochemical and land use implications: it affects the efficiency with which vegetation uses radiation, water und nutrients, and it may affect soil carbon storage, water use and nutrient cycling (Connin et al., 1997; Tieszen et al., 1997; Bird and Pousai, 1997; Epstein et al., 1998; Sage and Kubien, 2003; Semmartin et al., 2004). There is abundant evidence that the current distribution of C_4 plants is primarily controlled by growing season temperature, and that this is related to the higher effective quantum yield of CO_2 fixation and higher maximum photosynthetic rate of C_4 plants at high temperature (Ehleringer et al., 1997). But the seasonal distribution of precipitation, aridity, soil fertility, and disturbance (for instance by overgrazing) may exert secondary, modifying effects. Predominance of summer rainfalls benefits the C_4 more than the C_3, whereas predominance of precipitation in the cool season benefits C_3 growth (Murphy et al., 2007). C_4 dicots predominate in hot arid, saline or highly disturbed habitats (Ehleringer et al., 1997). Nitrogen loading can cause a replacement of C_4 grasses by C_3 grasses (Wedin & Tilman, 1996). It may be expected that such secondary controls could have a strong effect on C_3 :C_4 abundance in those regions which have a growing season mean temperature that is near the C_3 :C_4 transition-temperature. This is true for a large proportion of the worlds' grasslands (Collatz et al., 1998). For instance, a large part of the steppe of Inner and Outer Mongolia exhibits such a climate, with average temperature near the C_3 :C_4 transition-temperature during the summer months when most of the annual precipitation falls. In many regions of the world grassland utilization is heavy, with overgrazing leading to degradation and erosion and declines in the carrying capacity of the grassland. Such conditions could promote the spread of ruderal species, including annual C_4 grasses and C_4 dicots (Ehleringer et al., 1997; Wang, 2002), and this could be further promoted by climate warming. However, the effect of warming is offset by the increasing atmospheric CO_2 concentration, which increases the quantum yield in C_3 plants, thus promoting their spread. Collatz et al. (1998) have predicted a general increase in the relative abundance of C_3 plants in mixed C_3 :C_4 grasslands in the last century.

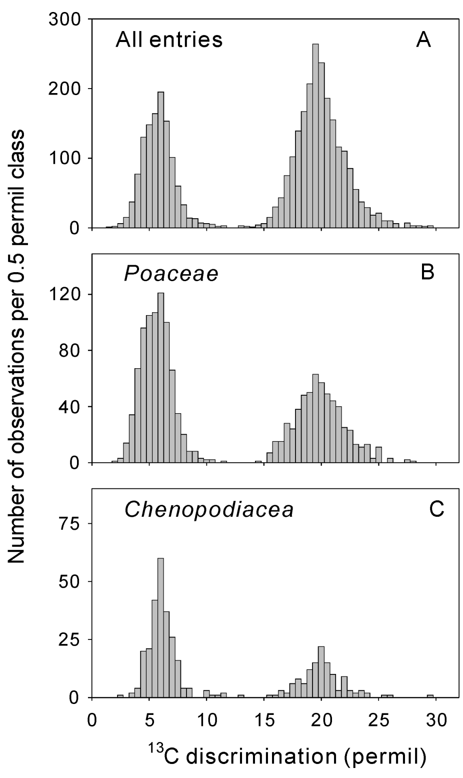

Figure 1 *Frequency distribution of ^{13}C discrimination, $^{13}\Delta$, of grassland plants (A).*
The bimodal distribution of $^{13}\Delta$ is due to the presence of two photosynthetic types with different carbon isotope discrimination: C_4 plants (left hump) and C_3 plants (right hump). Both photosynthetic types occur in the grasses (B), chenopods (C), and other plant families (not shown).
The data were compiled from > 40 references with a total of > 3000 entries.

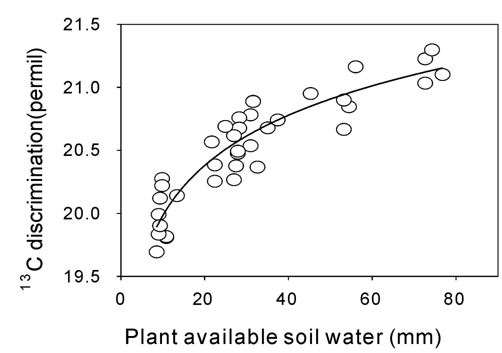

Figure 2 *Influence of soil water availability on ^{13}C discrimination of C_3 grassland (from Schnyder et al., 2006).*

Whether or not these changes have actually occurred has not been studied in any detail. Answering this question by empirical studies is important from practical and scientific biogeochemical, ecological and economic perspectives. For instance, changes in the C_3 :C_4 abundance could hold important consequences for the nutritional quality of the herbage, and for the seasonal pattern and abundance of grassland production. A verification of the predictions of Collatz et al. (1998) would enhance our understanding of the interplay of factors controlling C_3 :C_4 abundance in grassland. Because of the difference in $^{13}\Delta$, the analyses of the $\delta^{13}C$ of grassland and of its changes over time is one promising means by which the relative abundance of C_3 and C_4 plants in grassland can be assessed.

One of the challenges in using ^{13}C for studies of C_3 : C_4 vegetation dynamics lies in the variability of $^{13}\Delta$ within the photosynthetic types (Figure 1). This variability is not fully understood, and causes uncertainty in the choice of the $^{13}\Delta$ of the C_3 and C_4 end-members in the mixing model used to estimate the relative abundances of C_3 and C_4 plants in grassland communities.

Potential variation of $^{13}\Delta$ is particularly large in C_3 plants (Figure 1), and much of this may be related to effects of drought (Figure 2). $^{13}\Delta$ in C_3 plants is linearly related to the ratio of leaf intercellular to ambient CO_2 partial pressure (p_i/p_a) according to: $^{13}\Delta = a + (b - a)\ p_i/p_a$, with a the ^{13}C fractionation during diffusion of CO_2 in air (4.4‰), and b the net fractionation caused by carboxylation reactions (mainly Rubisco, approx. 27‰) (Farquhar et al., 1989). This means that $^{13}\Delta$ of C_3 plants is mainly controlled by the (stomatal) conductance and photosynthetic activity of leaves. Because of this $^{13}\Delta$ is also a quantitative indicator of physiological water use efficiency (Farquhar & Richards, 1984), and a measure of the leaf-level coupling of the hydrological and carbon cycles. Drought/aridity often leads to a reduction of stomatal conductance, decreasing p_i/p_a, and $^{13}\Delta$ (e.g. Farquhar & Richards, 1984; Schnyder et al., 2006; Wittmer et al., 2008).

Another challenge for studies exploring long-term C_3:C_4 vegetation dynamics is presented by the fact that the life span of shoot biomass is very short in grassland (weeks to <1 year) and vegetation composition may change strongly during the season. As did others, Witt et al. (1998) used the wool of sheep and Schnyder et al. (2006) the tail switch hair of cattle to monitor the ^{13}C composition of grassland vegetation. This method takes advantage of the sampling' activity of grazing animals. The wool from a yearly shearing reflects the $\delta^{13}C$ of all feed ingested by the flock during the year. Provided that the sheep graze only grassland, and grazing is non-biased with respect to the isotopic composition of sward components (e.g. sheep do not prefer one photosynthetic type over the other), this method also reflects the $\delta^{13}C$ of herbage on the entire grazing ground of the herd. Other animal tissues such as bones or teeth have also been used. Enamel of teeth is a particularly durable recorder of the isotopic composition of the diet of animals, and has provided evidence for the expansion of C_4 grasslands 6-10 Mio years ago (Morgan et al., 1994; Cerling et al., 1997).

$\delta^{15}N$ in the nitrogen cycle As is the case for carbon, the $\delta^{15}N$ of a plant is dependent on the $\delta^{15}N$ of the external nitrogen sources and isotope fractionation associated with uptake and transformations (Evans, 2001; Robinson, 2001; Werner and Schmidt, 2002). But, identification of the source(s) and estimation (or measurement) of its isotope signature(s) is more difficult for nitrogen than for carbon (which is normally atmospheric CO_2 with a known $\delta^{13}C$): plants can uptake nitrogen from the soil solution or from the air, and uptake can occur in several chemical forms (ammonia, nitrate, amino acids) or by atmospheric nitrogen fixation. The different putative sources of nitrogen in the soil can have widely differing $\delta^{15}N$ (e.g. Dijkstra et al., 2006), opening up opportunities for the assessment of nitrogen partitioning between plants in a community.

Variation of $\delta^{15}N$ among soil nitrogen pools is strongly affected through isotope fractionation in soil nitrogen transformations by soil (micro) organisms. In particular, NH_3 volatilization, and N_2O and NO production during NH_4^+ oxidation have strong isotope effects, which can lead to massive ^{15}N-depletion (up to ~ 60‰) in the respective gasses, if the conversion is incomplete. Such processes lead to ^{15}N-enrichment of soil nitrogen: elevated soil $\delta^{15}N$ is often found in spots of nitrogen accumulation and mineralization such as in wet depressions in landscapes (e.g. Handley et al., 1999) or at urine-or dung-affected microsites in grazed grasslands (e.g. Dijkstra et al., 2006). On the other hand, volatilized (^{15}N-depleted) NH_3 may be absorbed by nitrogen-limited vegetation located downwind of the volatilization source, lowering the $\delta^{15}N$ of these plants (Erskine et al., 1998).

Variation in the $\delta^{15}N$ of plant nitrogen exists at many scales, from the molecule (e.g. amino acids) to the globe (e.g. Werner and Schmidt, 2002; and Figure 3). At the regional or global scale there is a negative relationship between plant or soil $\delta^{15}N$ and rainfall (e.g. Handley et al., 1999; Amundson et al., 2003; see Figure 3). In line with the mechanisms discussed above, the elevated ^{15}N of plants and soils in dry regions has been interpreted in terms of an open nutrient cycle (Swap et al., 2003, Aranibar et al., 2004).

Handley et al. (1999) and others have pointed out that the negative correlation between water availability and soil or plant $\delta^{15}N$ (evident at the regional or global scale) often fails at the landscape scale, where wet spots can be ^{15}N-enriched relative to their drier surroundings. Schwertl et al. (2005) analyzed hair of cattle from farms representing the whole spectrum of cattle production systems in South Bavaria, Germany. There was large variability in $\delta^{15}N$ between farms, and this was unrelated to rainfall. Of all studied parameters, the nitrogen balance surplus of the farms exhibited the strongest relationship with $\delta^{15}N$ of cattle hair. $\delta^{15}N$ increased with nitrogen surplus ($r^2 = 0.78$), again indicating increasing volatile losses of nitrogen with nitrogen balance surplus. The same study also yielded evidence for substantial plot-scale variation of $\delta^{15}N$ in some of the farms. Plot-scale variation of $\delta^{15}N$ in plants and soils was analyzed by Watzka et al. (2006) in long-term experiments on montane grassland. They observed an increase of $\delta^{15}N$ of top soil and plants with increasing amounts of applied fertilizer and nitrogen balance surplus. Again, this result was interpreted in terms of a stimulation of soil processes, which discriminate against ^{15}N and enhance the loss of ^{15}N-depleted compounds from the system. In the same experiment soil $\delta^{15}N$ depended also on the type of fertilizer, with organic fertilizers causing a stronger ^{15}N-enrichment of soils and vegetation than synthetic fertilizers. This was related to the different $\delta^{15}N$ of these fertilizers. Synthetic fertilizers (and biologically fixed atmospheric nitrogen) have a $\delta^{15}N$ which is close to that of nitrogen in air ($\delta^{15}N$ 0‰), whereas organic fertilizers are generally (but very variably) enriched in ^{15}N (Bateman et al., 2007).

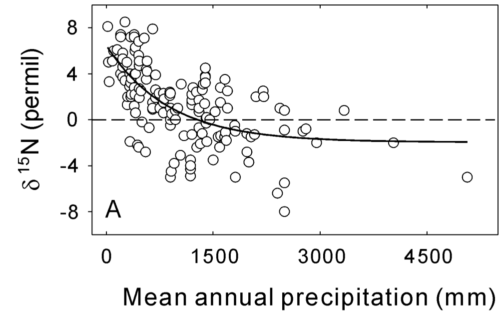

Figure 3 *$\delta^{15}N$ of plants as related to mean annual precipitation. Data compiled from Handley et al. (1999), Jacot et al. (2000), Amundson et al. (2003), and Swap et al. (2004).*

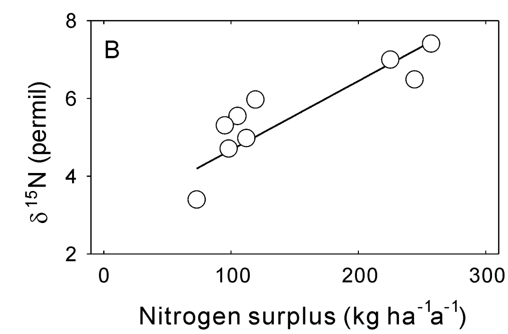

Figure 4 *$\delta^{15}N$ of cattle hair versus nitrogen balance surplus of cattle farms in South Bavaria, Germany (Schwertl et al. 2005).*

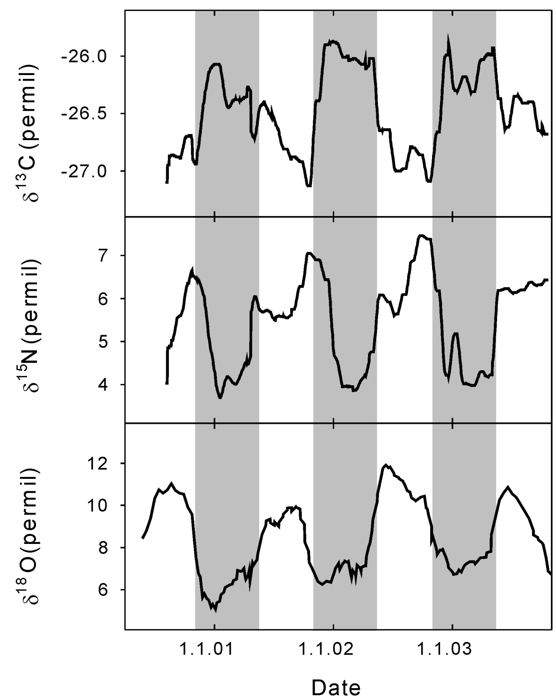

Figure 5 *Inter-annual and seasonal variation of carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and oxygen isotope composition ($\delta^{18}O$) in new hair growth of cattle at Grünschwaige Grassland Research Station, Germany.*

Animals grazed grassland with high soil water capacity in summer. During winter (shaded period) animals were held in confinement and were fed with hay and silage harvested from (sown) grassland with low soil water capacity (see Schnyder et al. 2006). The time course was retrieved by segmental analysis of cattle tail switch hair sampled at different times. Time-assignment of the segmental data was performed as described by Schwertl et al. (2003).

Isotopes in the ecology of animals and production systems The isotopic composition of animals reflects that of their diet (DeNiro and Epstein, 1978, 1981; Kohn et al., 1996), so that (single-or multi-element) isotope analysis of animal bodies, tissues or products can be used to study the production ecology of cattle farming systems (Schwertl et al. 2003), the contribution of different diet sources (Phillips et al., 2005) or the behavioural ecology of animals, including migration patterns and dietary preferences (Cerling and Harris, 1999; Cerling et al., 2006; West et al., 2006). Different types of animal tissues have been used for such analysis, including bones (apatite or collagen), teeth and hair. Animal products have been studied with the aim of characterizing/authenticating production systems and to trace their origin (e.g. Rossmann et al., 2000). Hair is a particularly interesting object for studies of animal ecology, because it allows reconstruction of the dietary history with high temporal resolution (Schwertl et al., 2003; Ayliffe et al., 2004; and Figure 5).

The $\delta^{13}C$ of animal tissues or products gives an estimate of the proportion of C_3 and C_4 plants in the diet, allowing distinction of grazers, browsers and mixed feeders in savanna systems (Cerling and Harris, 1999), or the proportion of maize in the rations of dairy and beef cattle (Schwertl et al., 2005). The use of ^{15}N in studies of food webs/trophic networks is probably one of the most popular examples of the use of stable isotopes in ecology (e.g. Post 2002). It takes advantage of the fact that the ^{15}N of consumers is generally enriched by about 3‰ relative to their diet, allowing estimation of the trophic position of organism in food chains, based on the $\delta^{15}N$ of food chain components (Diet and hair also exhibit a systematic isotopic shift for ^{13}C (e.g. Männel et al., 2007)). Cattle also track environmental effects on the isotopic composition of plants/feed, such as the effect of altitude on the $\delta^{13}C$ and $\delta^{15}N$ of grassland vegetation in the European Alps (Männel et al., 2007).

The oxygen isotope composition of animals is greatly influenced by that of drinking water and free water in food (Kohn et al., 1996). In cattle grazing fresh pasture a large proportion of the ingested water is in the form of leaf water. Leaf water is enriched in ^{18}O due to fractionation during transpiration (Flanagan et al., 1991), distinguishing it from drinking (well) water which has a $\delta^{18}O$ close to that of meteoric water. Accordingly, rations with different proportions of fresh herbage should produce different ^{18}O signals in animal bodies and products, such as meat and milk. However, the ^{18}O of water also exhibits strong geographic variation, which is related to effects of altitude, latitude, distance from the coast, amount of precipitation, and season on the ^{18}O of meteoric water (e.g. Bowen and Wilkinson, 2002). Thus, drinking water contains geographic information, which is imprinted in animal tissues and products.

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Small-scale species richness and its spatial variation in an alpine meadow on the Qinghai-Tibet Plateau

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Key words: grazing, high species richness, *Kobresia* meadow, Qinghai alpine meadow, winter grazing

Introduction We investigated how the high small-scale species richness of an alpine meadow on the Qinghai-Tibet Plateau, China, is maintained. This area is characterized by strong wind and severe cold during long winters. In winter, most livestock is grazed on dead leaves in small pastures near farmers' residences, whereas in the short summer, livestock is grazed in mountainous areas far from farmers' residences.

Study area and methods The number of plant species and the aboveground biomass were surveyed for three adjacent pastures differing in grazing management: a late-winter-grazing pasture grazed moderately from 1 February to 30 April (LWG), an early-winter-grazing pasture grazed lightly from 20 September to late October (EWG), and a whole-year-grazing pasture grazed intensively throughout the entire year (WYG). In each pasture, we harvested the aboveground biomass from 80 or 100 quadrats of 0.01 m^2 along a transect and classified the contents by species.

Results and discussion We observed 16-20 species per 0.01 m^2, which is high richness per 0.01 m^2 worldwide (Table 1). The species richness in the two winter-grazing pastures was higher than that in the whole-year-grazing pasture. The spatial variation in species richness and species composition in the two winter-grazing pastures in which species richness was high was greater than that in the whole-year-grazing pasture in which species richness was lower. Most of the leaves that are preserved on the winter-grazing pastures during summer are blown away by strong wind during winter, and the remaining leaves are completely exhausted in winter by livestock grazing. A pasture with a high richess is accompanied with a high spatial variation in species richness and species composition. There is a high possibility that the characteristics of spatial variation is also caused by the traditional grazing practice in this area.

Table 1 *Mean species richness observed in 80 0.01-cm^2 in 2002 and 100 0.01-cm^2 in 2003, variance in richness among quadrats, coefficient of variation (CV) of richness, and the total aboveground richness biomass per 0.01-m^2 quadrat.*

Item	EWG	LWG		WYG	
	2002	2002	2003	2002	2003
Mean species richness (0.01-m^{-2}) ±se	19.36±0.30	19.09±0.33	19.69±0.38	16.11±0.24	15.51±0.30
Evenness for species biomass*	0.770	0.688	0.775	0.727	0.780
Variance for richness (0.01-m^{-2})	7.22	8.79	14.64	4.51	9.08
Observed CV of richness	0.139	0.155	0.194	0.132	0.194
Theoretical CV of richness**	0.137	0.144	0.146	0.145	0.156
Observed CV/Theoretical CV	1.01	1.08	1.33	0.91	1.24
Biomass (g/0.01m^2)±se	3.32±0.115	3.10±0.097	3.02±0.081	3.26±0.109	3.14±0.099

Calculated by the formula of $\{\Sigma p_i(1-p_i)/(\Sigma p_i)^2\}^{1/2}$, where p_i denotes the occurrence rate per quadrat for species i, and Σ means sum for all species appeared. The theoretical CV-value was calculated under an assumption that each species distribute at random quadrat.

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Spatial heterogeneity of soil fertility, plant biomass, and productivity in grasslands

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Key words: Mitscherlich's growth equation, plant biomass, plant production, soil fertility, spatial heterogeneity

Introduction Grassland vegetation under livestock grazing is spatially heterogeneous, because animal grazing and excretion disturb the vegetation. We clarified the relationship between spatial heterogeneity and plant production. The following assumption is plausible: plant biomass y at a site with soil fertility x varies according to Mitscherlich's (1930) growth equation among plots. That is, if soil fertility is low, then there will be little biomass, and biomass will increase with an increase in fertility; however, if soil fertility is high, then the increase in biomass with increases in fertility is low (Figure 1). Mitscherlich's equation is expressed as: $y_1 = K\{1\text{-}\exp(-ax)\}$, where a is the increasing coefficient, and K is the maximum limit of biomass as $x \to \infty$.

Biomass If fertility is evenly distributed and $x = \mu$, then the relationship between x and y is expressed as $y = K[1 - \exp(-a\mu)]$, which indicates that fertility is the same throughout the grassland. In a grassland where fertility is not even, as is generally the case, x follows the gamma distribution $f(x)$ with a mean of μ and shape parameter p:

$$f(x) = \frac{x^{p-1} p^p}{\Gamma(p)\mu^p} \exp\left(-\frac{p}{\mu} x\right).$$

Total biomass in the grassland is then expressed as

$$y_2 = \int_0^\infty K\{1 - \exp(-ax)\} \times \frac{x^{p-1} p^p}{\Gamma(p)\mu^p} \exp\left(-\frac{p}{\mu} x\right) dx = k\left\{1 - \left(\frac{p}{a\mu + p}\right)^p\right\}.$$

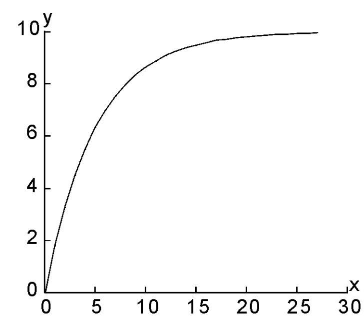

Figure 1 *An example of Mitschelrich's growth equation for fertility x, where a = 0.2 and K = 10.*

The difference between y_1 and y_2, Δy, for any μ is as follows:

$$\Delta y = K\{1 - \exp(-a\mu)\} - K\left\{1 - \left(\frac{p}{a\mu + p}\right)^p\right\}.$$

Δy is 0 for $p \to \infty$, otherwise $\Delta y > 0$. This equation indicates that biomass is lower when fertility is spatially heterogeneous than when it is evenly distributed.

Plant productivity When fertility is evenly distributed throughout the grassland, if fertility is improved by δ throughout the grassland, then biomass is expressed as $y = K[1 - \exp\{a(\mu + \delta)\}]$. Then the increase of biomass, Δy_1, is $K\exp(-a\mu) - K\exp\{-a(\mu + \delta)\}$ for any μ. Now assume that fertility is spatially heterogeneous. Here we use the gamma distribution to express fertility heterogeneity. The increase in biomass, Δy_2, based on a fertility increase is expressed as:

$$\Delta y_2 = \int_0^\infty K[\exp(-ax)\} - \exp\{-a(x + \delta)\}] \times \frac{x^{p-1} p^p}{\Gamma(p)\mu^p} \exp\left(-\frac{p}{\mu} x\right) dx = K\left\{\frac{p}{a\mu + p}\right\}^p \{1 - \exp(-a\delta)\}.$$

When we compare Δy_2 to Δy_1, $\Delta y_2 - \Delta y_1 = K\left[\left\{\frac{p}{a\mu + p}\right\}^p - \exp(-a\mu)\right][\{1 - \exp(-a\delta)\}] > 0$.

This result indicates that the increase in biomass with improved fertility is larger in a heterogeneous fertility environment than in an even environment, excluding the case of $p \to \infty$.

Reference

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Dynamic study on inter-species competition in mix-sowing community of white clover and bermudagrass

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Key words : mix-sowing community ,inter-species competition ,biomass ; white clover ,bermudagrass

Introduction The dynamic relationship of the two species , white clover and bermudagrass , contest in mix-sowing sward was studied within three years . The purposes were to test if the two species can grow together harmoniously , and find theoretical basis for constructing mix-sowing sward with good properties (yield , quality and longevity) .

Materials and methods White clover , *Trifolium repens* L .cv . Emu No .1 and SS_{21} , a cultivar of bermudagrass were selected as materials .Experimental treatments were : A (White clover , 100%) , B (White clover , 75% ; Bermudagrass , 25%) , C (White clover , 50% ; Bermudagrass , 50%) , D (White clover , 25% ; Bermudagrass , 75%) , E (Bermudagrass , 100%) . The inter-species competition ability of the two species was calculated by the relative yield total (*RYT*) and competition ratio (*CR*) (Jonathan ,1982 ;Masresha , 2003) .

Results Three-year results showed the herbage mass in mix-sowing sward was higher than monoculture with white clover and bermudagrass , except for treatment B and D with lower herbage mass in mix-sowing sward (3872 g/m^2 and 3482 g/m^2) than mono-sowing bermudagrass in the first year . The whole herbage mass in the three years was highest in treatment C (18158 g/m^2) (Figure 1) .The value of RYT of treatment B , C and D was larger than 1in March and April every year (Table 1) , which indicated that white clover and bermudagrass had different ecological niche and used different resources . However , as the experiment progressed , the ecological niche of white clover and bermudagrass overlapped and a resistance relationship appeared . The appearance of resistance was earlier in treatment D than B and C . Because of the strong stoloniform stems of white clover , it outcompeted bermudagrass at the beginning of experiment every year , but as temperature started to increase , white clover stopped growing and bermudagrass was not affected . For that reason , bermudagrass had the stronger competing ability in the last growing period . The competing relationship became more significant as the experiment progressed .

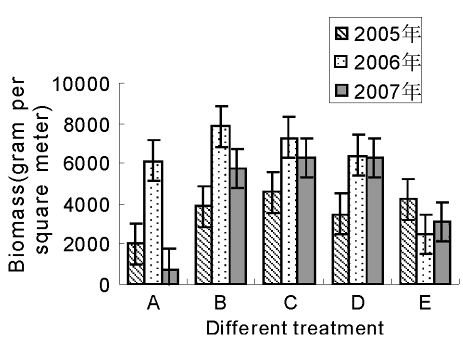

Figure 1 *Biomass dynamic in 3 years .*

Table 1 *Relative yield total and competitive ratio of mixed community (2006) .*

Treatment		3—27	4—19	5—17	7—24	9—6
	RYT	1 .17	1 .08	1 .01	0 .87	0 .88
B	CR_W	11 .0	9 .80	8 .56	0 .23	0 .00
	CR_B	0 .12	0 .16	0 .32	4 .50	23 .0
	RYT	1 .25	1 .05	1 .03	0 .95	0 .89
C	CR_W	4 .65	2 .23	2 .40	0 .16	0 .00
	CR_B	0 .87	0 .45	0 .42	6 .31	infinity
	RYT	1 .06	1 .03	0 .98	0 .84	0 .81
D	CR_W	0 .48	0 .46	0 .23	0 .16	0 .00
	CR_B	2 .05	2 .13	6 .85	12 .5	infinity

Conclusions If only herbage mass was considered , treatment C (White clover 50% +Bermudagrass 50%) is the best in the mix-sowing pasture . If the stability of community is considered , under high cutting frequency , the combination of white clover and bermudagrass for mix-sowing was not recommended .

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Effects of lucerne plants on germination of lucerne

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Key words : Loess Plateau ,allelopathy

Introduction Auto-toxicity , an intraspecific form of allelopathy , occurs when chemical substances from plant material inhibits or delays germination and growth of the same species . Lucerne (*medicago sativa*) , a perennial legume , contains water—soluble substances that are toxic(Chung and Miller , 1995) . Given the likelihood of allelopathy effects when interplanting , double cropping , no-till planting and nonrotational cropping , we looked for evidence of allelopathy in lucerne as may be important when reestablishing lucerne in a former lucerne field .

Materials and methods 1- , 4- , 6- and 10-year lucerne plants grown at Qingyang experimental station Lanzhou University , were harvested at full bloom stage in June 2006 . Leaves , stems , roots and flowers were separated and soaked in distilled water for 24 h at 24℃ (2g of tissue per 100ml of water) . In addition , a whole-plant extract was made by mixing 10ml aliquots from each plant part extracts . The plant extracts were added to 50 lucerne seeds that were surface-sterilized with 1% NaClO solution and evenly placed on filter paper in sterilized 9-petri dishes Total of 50 alfalfa seeds were surface-sterilized with 1% NaClO solution and evenly placed on filter paper in sterilized 9-petri dishes . Germination was determined by counting at 24h intervals ,the number of germinated seeds over 6-days and expressed as total percent germinated . Radicle and hypocotyl lengths were determined by measuring 10 representative seedlings on Day 7 .

Results and discussion Extracts from lucerne plant parts inhibited germination but not always . Flowers were the most toxic . Stems released no toxins . Leaves and roots released toxins also but the inhibition varied with stand age ; lucerne from 6-year stands had the most inhibitory effect (Table 1) . The effects on seed hypocotyl and radical lengths were more pronounced and general than for seed germination . Radicle length was more affected by the extracts than was hypocotyl length . The greater effect of the toxins on extension (both of the hypocotyl and the radical) than on germination indicates the possibility for poor establishment of lucerne seedlings in lucerne fields . Auto-toxicity , if it is confirmed in the field , may require a rethink of timing of cutting . Lucerne mown before flowering hastens plant death but this may be justified in a rotation .

Table 1

Extractant	Relative germination					hypocotyl length					Radical length				
	Lucerne age				LSD (0 .05)	Lucerne age				LSD (0 .05)	Lucerne age				LSD (0 .05)
	1-	4-	6-	10-		1-	4-	6-	10-		1-	4-	6-	10-	
Ck	100	100	100	100		1	1	1	1		1	1	1	1	
Flower	6 .08	7 .43	6 .76	8 .11	8 .37	NA	NA	NA	NA		NA	NA	NA	NA	NA
Leaf	77 .7	89 .53	35 .81	89 .53	15 .34	0 .82	0 .77	0 .14	0 .47	0 .63	0 .40	0 .36	0 .04	0 .13	0 .26
Stem	89 .19	86 .49	85 .81	81 .08	13 .77	0 .87	0 .75	0 .84	0 .75	0 .59	0 .45	0 .15	0 .40	0 .35	0 .20
Root	65 .54	87 .5	51 .05	90 .2	11 .23	0 .21	0 .33	0 .77	0 .53	0 .63	0 .08	0 .12	0 .16	0 .13	0 .30
Mixture	75 .68	69 .93	68 .92	74 .32	31	0 .87	0 .58	0 .50	0 .86	0 .29	0 .46	0 .09	0 .18	0 .30	0 .25
Control=74%						Control=3 .75cm					Control=5 .54cm				
LSD(0 .05)	14 .88	19 .67	15 .36	19 .16		0 .33	0 .52	0 .46	0 .59		0 .17	0 .26	0 .19	0 .26	

NA : no applicable

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Kura clover (*Trifolium ambiguum*) in pastures for western Canada

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Key words: clover, binary-mixtures, establishment, species composition

Introduction Kura clover (*Trifolium ambiguum*) is a rhizomatous perennial clover native to the Caucasian region of Russia. Kura shows a greater range of tolerance to drought, soil type, pH, elevation and grazing intensity than other legumes commonly used in North America (Taylor and Smith, 1998). Western Canada currently lacks a persistent pasture legume species.

Materials and methods Tests occurred in Edmonton, Alberta, Canada from 1999 to 2005. Our objectives were to test (a) yield and quality of kura clover monocultures when harvested one-five times per growing season, (b) the productivity and persistence of kura when grown in binary mixtures with either meadow bromegrass (*Bromus biebersteinii*) K-MB; orchard grass (*Dactylis glomerata*) K-OG; timothy (*Phleum pratense*) K-T; or Kentucky bluegrass (*Poa pratensis*) K-KBG and (b) to examine the effects on species composition and forage yield of seeding meadow bromegrass into an establishing kura stand. Data were analysed using the general linear model procedure of SAS (2003) $p < 0.05$.

Results and discussion Kura monocultures yielded from 4,300 kg/ha dry matter to 13,000 kg/ha dry matter in the first production year. Yield did not significantly differ whether harvests occurred two, three, four or five times per season (Table 1). K-MB mixtures produced the greatest biomass, however, both meadow bromegrass and orchard grass severely out-competed the kura clover (Table 2). The highest percentage of kura clover (45%) occurred in the K-KBG mixtures (Table 2). Meadow bromegrass, seeded into establishing kura clover prior to the clover reaching the 1st and 3rd true leaf stage, achieved a good species balance in the second and third production years.

Table 1 *Total annual yield and quality of kura clover at five harvest frequencies in the first and second production year for plots established in 1999 or 2000.*

	Total annual production (kg/ha)			Forage Quality			
	First Production year (estab 1999)	First production year (estab 2000)	Second Production year		Average Percentage (first production year, estab. 1999)		
Harvest Frequency				Harvest Frequency	Crude Protein	NDF	ADF
1	4344.14 b	4344.13 c	3728.85 b	1			
2	10324.08 a	5941.35 b	7631.18 a	2	17.58 c	41.53 b	34.80 b
3	11288.57 a	7157.96 a	7129.62 a	3	19.52 b	33.97 ab	25.67 a
4	13093.56 a	8811.73 a	9830.24 a	4	22.36 a	33.01 a	24.33 a
5	10493.97 a	8384.27 a	8053.69 a	5	23.49 a	31.40 a	24.40 a

Table 2 *Total annual dry matter yield (kg/ha) and species composition of mixtures of kura clover with Kentucky bluegrass (K-KBG), meadow bromegrass (K-MB), orchard grass (K-OG), or timothy (K-T) or kura in monoculture (K) in the first (2000) and second production years (2001).*

Mixture	First production year				Second production year			
	Total annual yield (kg/ha)		Percentage clover		Total annual yield (kg/ha)		Percentage clover	
Kura	12,600	bc			6,940	b		
K—KBG	12,908	bc	45.0	a	6,828	b	47.0	a
K—MB	14,429	ab	7.0	cd	10,174	a	14.0	b
K—OG	12,901	bc	5.2	cd	5,760	c	24.1	a
K—T	11,427	cd	12.2	c	4,290	d	33.0	a

Conclusion Kura clover has considerable potential as a new pasture legume for western Canada.

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Breeding apomictic bahiagrass (*paspalum notatum* flügge) in southeastern USA

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Key words: apomixis, bahiagrass, tetraploids

Introduction Livestock production systems in the southern Coastal Plain of the USA are mainly based on warm-season grasses. Bahiagrass, *Paspalum notatum* Flügge, is one of the most important species in the region. The tetraploid ecotypes reproduce by apomixis which has restricted breeding efforts to ecotype selection. The production cycle of currently available ecotypes is restricted to the warmer part of the year. The general objective of our breeding program is to generate apomictic hybrids with an extended growing season and improved nutrient uptake.

Materials and methods Approached crosses were made between induced sexual and apomictic bahiagrass tetraploids during summer 2004. Two clones of each progeny were transplanted into the field located in Gainesville, Florida in May 2005, and evaluated for growth habit, cool-season regrowth and cold tolerance. Progeny were classified as sexual or apomictic based on embryo sac observations. Ten superior apomictic progeny and the cultivar Argentine were planted in small plots in May 2006. These plots were harvested once on October 2006, and eight times at 4-wk intervals during 2007 starting in May. The N and P concentrations of the harvested material were determined by a modified Kjeldahl procedure described by Hambleton (1977).

Results and discussion Six hundred hybrids were generated by crossing 13 different combinations of sexual and apomictic bahiagrass tetraploids. A ratio of 2.6 sexual to 1 apomictic (facultative and obligate) progeny and a ratio of 1 obligate apomictic (potential new cultivar) progeny to 8 others (facultative and sexual) were observed. As expected, the obligate apomictic progeny set similar amounts of seed when self-or cross-pollinated. In contrast to previous reports for other apomictic grasses (Noirot, 1997), the bahiagrass sexual hybrids were more self-fertile than the sexual parents. The non transmission or non expression of the self-incompatibility genes present in the autotetraploid parents (Acuna et al., 2007) should be further investigated.

The heterozygous condition of the apomictic parents was reflected by the marked variability observed among the progeny. The growth habit of the progeny varied notably from being mainly upright for some hybrids to markedly prostrate for others. Genetic variation for cool-season growth and cold tolerance was also observed.

Most of the 10 apomictic clones grown in plots outperformed the cultivar Argentine for forage production during the fall of the first growing season and during the spring of the second season. They also showed higher ability for N and P extraction during most of the evaluated period compared to Argentine. Further studies analyzing the responses of these clones to grazing pressure are needed.

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A survey about understorey covering in areas (lands) under the cultivation of *Haloxylon* in Ardestan area

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Key words : *Haloxylon* , understorey covering ,desert , Ardestan

Introduction From 1985 in Iran *Haloxylon* plantation was used in order to wind erosion control and sand dune fixation . At first the seed of this plant was imported from USSR . The impacts of *Haloxylon* plantation were protection of roads , farms , waterways and quadrates from sand dunes coverage and wind erosion control . The total area of sand dune fixation methods such as seedling , forestation and mulch application for plantation increased from 100 hectares in1985 to 6200000 hectares in 1997 (Bakhshi , 2005) .

Materials and method For researching in to the effect of *Haloxylon* plantation on plant cover of this region , at first we determined its geomorphology maps , for this reason we collected statistical data about climate , soil , plant cover , geology , geomorphology and prepared topography plan at the scale of 1/50000 and also a plan on gradient , direction and height . Then by going over , *Haloxylon* region from 10-15 and 20-25 years of age and also over the ages of 26 were determined in a geomorphologic maps . At lost area that its maps is like to *Haloxylon* area and without any plant was determined as reference area . These areas have been similarity climatology . By going over , a field observation was selected in each of the area . Via statistical Methodology , the number of plates calculated in each pile (Mesdaghi 2004) .

Results According to received results from variance analysis , the significant difference between the percent of crown and density of the whole species under and between the *Haloxylon* trees in *Haloxylon* area and reference areas is about 1 percent level . On the basis of accomplished compression , the overage data of the percent of compression crown of the whole species between treatments , there is significant variance between 3 category , group A (between the trees over the age of 26 years) , group B (the treatment under the trees over the age of 26 years , between the trees from 20-25 years of age) and group C , reference area (under trees from 10-15 years of age) and also there is no significant difference between the treatments among trees from 10-15 years of age and under the trees from 20-25 years of age .

According to accomplished compression between the coverage data of compression of the whole species among the treatments , there is no significant difference between the treatments from 20-25 years of age under and between the *Haloxylon* trees in *Haloxylon* plantation over the age 26 years with reference area , and also there is significant variance between the treatments over the age of 26 years (group A) and the treatment between the trees from 10-15 years of age (group C) with other treatments (group B) .

Conclusions On the basis of shown result in this text , we can say the cultivating of the *Haloxylon* change the accumulation and the percent of crown and density on species understories between the *Haloxylon* trees .

In the area over the age 26 years , there are the most percent of the crown and density species compression . The most important reasons consist of the decrease in the intensity of wind and also Evapotransporation , the distance of special microclimate and agreeable species to *Haloxylon* in this area . On the basis of Saeid Afkham Shoara (1996) research at the south of Khorasan province , *Haloxylon* plantation is more compressed than distances which are without any *Haloxylon* .

According to received results , the most percent of crown and density of the whole species is between the trees over the age of 26 years , and the least percent is on the *Haloxylon* area from 10-15 years of age . The principle reason of the drop in the percent of crown and density of the whole species is destruction factors , in the other land , with the passing time and overcoming of annual species the percent of the crown and density of the whole species in understories of the *Haloxylon* plantation increase .

And also the percent of crown and density of the whole species between the *Haloxylon* trees that its principle reason is the effect of upper level on understories cover .

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An investigation on total nonstructural carbohydrate trends in three *Agropyron* grasses of Golestan National Park in northern Iran

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Key words: *Agropyron* spp., total nonstructural carbohydrate, phenological stages

Introduction We examine total nonstructural carbohydrate (TNC) concentrations in three grasses within the genus *Agropyron*: of *Agropyron cristatum* (L.) Gaertner, *Agropyron trichophorum* (Link) Richt., *Agropyron intermedium* (Host) Barkw. and D.R. Dewey, within Golestan National Park in northern Iran. Our objectives were to (1) compare TNC reserves among root, crown, and rhizoms and (2) compare TNC concentrations during phenological development.

Material and methods Plant materials root, crown, and rhizome were collected throughout growth of three grasses and were dried at 70℃ for 48 hours then ground to pass a 35-mesh screen. The TNC concentrations were determined colorimetrically. Data of TNC concentrations in the root, crown, and rhizome in different stages were analyzed using ANOVA and completely random design.

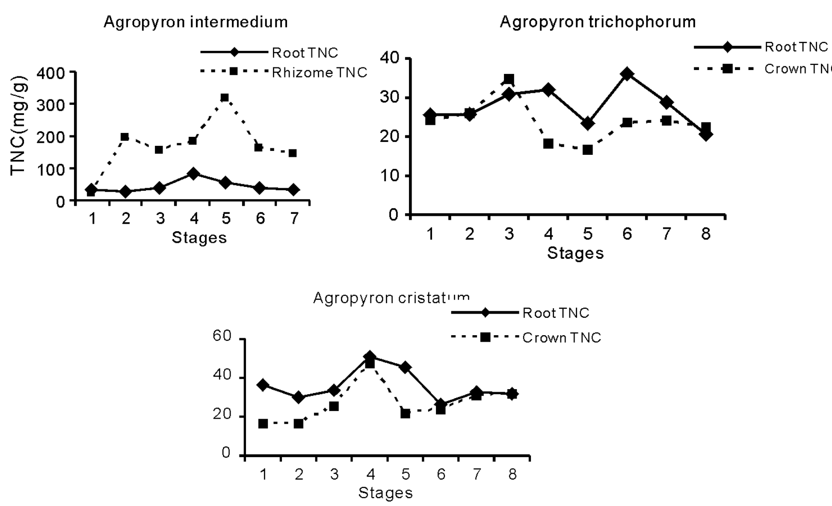

Figure 1 *Total nonstructural carbohydrate concentrations at 8 growth stages. Stages 1, 2, and 3 in (a) and (b), 1 and 2 in (c) are vegetative growth. 4 in (a) and (b), and 3 in (c) are heads in boot. 5 in (b), and 4 and 5 in (c) are heads out. 5 in (a), and 6 in (b), and (c) are full flowering. 6 in (a), and 7 in (b), and (c) are seed ripening. 7 in (a) and 8 in (b), and (c) are seed dissemination.*

Results As it is shown in Figure 1. the concentration of TNC are different ($p<0.05$) in root and rhizome for *Agropyron intermedium*. These concentrations are similar for *Agropyron cristatum*, but are still significant ($p<0.05$). The concentration of TNC are even more similar for *Agropyron trichophorum*, but are not significant ($p>0.05$).

Conclusions In general, seasonal variation of TNC concentrations in storage organs varying among these closely related grasses with time. Further research will help elucidate grazing intensity and timing that promotes the vigor of these species.

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Leaf morphogenesis as a basis for developing defoliation management strategies in multispecies plant communities of the Flooding Pampa (Argentina)

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Key words: Flooding Pampa, leaf morphogenesis, proper defoliation regime, temperate natural grasslands

Introduction The time of full expansion of the maximum number of leaves per tiller is considered an indicator of the optimal time between successive defoliations in terms of DM production, physiological status and efficiency of herbage utilisation (Lemaire and Agnusdei, 2000). The leaf morphogenesis of three temperate grasses, two native perennials [*Hordeum stenostachys* (Hs), *Stipa neesiana* (Sn)] and one naturalised annual [*Lolium multiflorum* (Lm)] under natural field conditions was studied. The information was used to simulate the accumulated net leaf length per tiller (ANLL) under different defoliation regimes after complete defoliations.

Materials and methods The study was conducted in a natural grassland (37°45′ S lat. and 58°18′ W long.) temporarily excluded from cattle. Leaf number, turnover and elongation were measured in marked tillers during 2 years in five periods that covered a wide range of mean air temperatures. Leaf appearance and leaf elongation rates were related with mean air temperature (LER-temp).

Results and discussion Estimated phyllochrones were 196±12, 147±9 y 345±41℃.day for Hs, Lm and Sn, respectively. Lineal functions were fitted for LER-temp, Lm having the highest slope as compared to Hs and Sn. The functions were supported by closed to 1 observed/estimated final leaf length ratios (according to Lemaire and Chapman, 1996). The simulations of ANLL were performed at the own leaf life span of the species and at *S. neesiana* rhythm (slowest leaf turnover). They indicate that extending the defoliation interval in order to match Sn leaf turnover would considerably reduce the potential harvestable forage of Hs and Lm (around 0.40 in blade length). Results encompass important implications for the grazing management of multispecies vegetation, emphasizing the relevance of the morphogenetical heterogeneity of coexisting species as a key and unavoidable factor to handle when an acceptable compromise between herbage utilisation efficiency and sustainability of plant communities is desired.

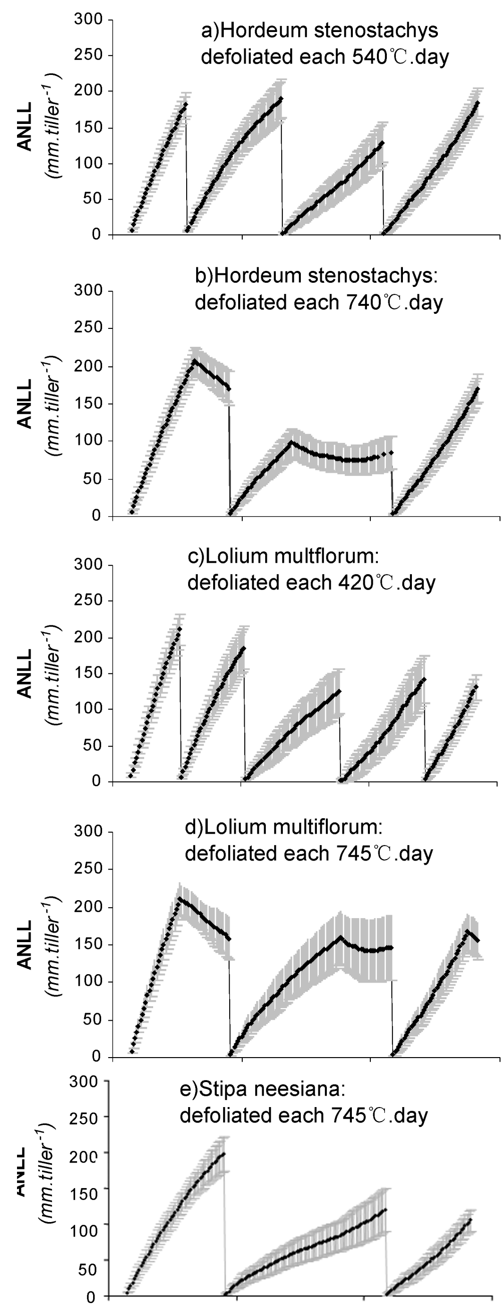

Figure 1 *Simulated net leaf length per tiller (mm, ANLL).*

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Re-generation ecology of *Cymbopogon jwarancusa* and *Chrysopogon aucheri* grassland in Highland Balochistan , Pakistan

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Key words : Seed Dispersal ,Soil Seed Bank ,Microhabitats

Introduction *Chrysopogon aucheri* and *Cymbopogon jwarancusa* are the dominant bunchgrasses in grassland ecosystems of highland Balochistan . These grasses are found on a wide variety of soils over a wide range of elevations and play an important role in ecosystem level processes (Carney , 1989) . Both species provide the major source of forage for small ruminants . Overgrazing , coupled with human disturbances has degraded most of these grasslands . Management strategies aimed at reversing the degradation of *Cymbopogon-Chrysopogon* grasslands require an understanding of many aspects of plant ecology and recruitment (Schoot , 1995) .

Material and methods Highland Balochistan has a continental arid to semi-arid climate which is Mediterranean in character , with annual rainfall varying from 150 to 350 mm . Most of the rainfall occurs in the winter months . Temperatures vary with elevation ranging from 40 °C in summer to -10℃ in the winters . Soils are mostly skeletal and are derived from sandstone , limestone and shale . Field experiments were conducted to investigate the seed attributes , movements and fates of dispersal units , soil seed bank and seedling establishment of *Chrysopogon aucheri* and *Cymbopogon jwarancusa* in a representative grassland ecosystem in highland Balochistan . All the experiments were conducted on the natural stands of grassland . Three parallel transect were established for monitoring the seed dispersal (phase I & phase II) and soil seed bank . Seven major microhabitats (*Cymbopogon jwarancusa* plants , *Chrysopogon aucheri* plants , dead centers of *Cymbopogon jwarancusa* plants , dead centers of *Chrysopogon aucheri* plants , *Artemisia maritime* plants , gravel interspaces between plants , and soil interspaces between plants) were also evaluated to seedling recruitment and seedling establishment .

Results *Cymbopogon jwarancusa* had more filled and viable caryopses than *Chrysopogon aucheri* . *Chrysopogon aucheri* caryopses had greater mass (1 .2 ± 0 .1 mg) than *Cymbopogon jwarancusa* caryopses (0 .6 ± 0 .1 mg) . Seed viability of *Cymbopogon jwarancusa* was better (63%) than *Chrysopogon aucheri* (50%) . Seeds (spikelets) of both species have similar morphological features . Spikelet dispersal occurs primarily by wind over a 2 to 3 week period in late June or early July . *Chrysopogon aucheri* has one dispersal unit , a triplet spikelet . *Cymbopogon jwarancusa* has four different dispersal units : a paired spikelet , a partial raceme , an entire raceme , and a partial inflorescence (two racemes) . Mean phase-1 dispersal distances of spikelets from the edges of the basal crown of *Cymbopogon jwarancusa* and *Chrysopogon aucheri* were recorded 94 and 79 cm , respectively . Spikelets of *Cymbopogon jwarancusa* and *Chrysopogon aucheri* moved mean distances of 26 and 32 cm , respectively on the ground surface before becoming trapped in a microhabitat . Gravel interspaces and plants canopies occupied higher proportional area and captured relatively a higher proportion of spikelets of both species . Both species had a weakly persistent soil seed bank with higher amounts of seeds found under plant canopies compared to open interspaces . More spikelets were found in the upper (0-2 .5 cm) soil depth than the lower (2 .5-5 .0 cm) soil depth in different microhabitats . Ants (*Tica Verona*) were the main spikelet predator for *Chrysopogon aucheri* . *Cymbopogon jwarancusa* had higher seedling densities and more tillering capacity than *Chrysopogon aucheri* .

Conclusions Gravel microhabitats had the highest proportional seedling survival for both species . Gravel interspaces were suitable microhabitats for seedling development , possibly due to the vertical entrapment of dispersal units and reduced competition from more distant established plants . *Cymbopogon jwarancusa* has a greater regeneration potential than *Chrysopogon aucheri* in this grassland ecosystem in highland Balochistan . It may be difficult to increase the composition of *Chrysopogon aucheri* , the more desirable species in these grasslands , when using management techniques that rely on natural regeneration .

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Trajectories of ecological change at a patch scale in a semi-arid woodland

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Key words : semiarid ,landscape function ,patches ,interpatches , heterogeneity

Introduction This study is exploring the complex biogeochemical processes which drive ecosystem function in a patchily vegetated woodland . It quantified the differences in functionality which occur at a patch scale and draws management implications .

Materials and methods The sampling was conducted in semiarid red sandplains supporting acacia (mulga) shrublands with perennial grasses in Western Australia (28°40′S , 116°30′E) . A total of 11 different condition subclasses of patches and interpatches were originally identified based on biophysical features . Six parameters were measured (see Figure 1) on representative individual patches and interpatches from each subclass . Data was analysed using a Principal Component Analysis . Transect data was used to calculate the relative proportions of the patch and interpatch subclasses on a paddock scale .

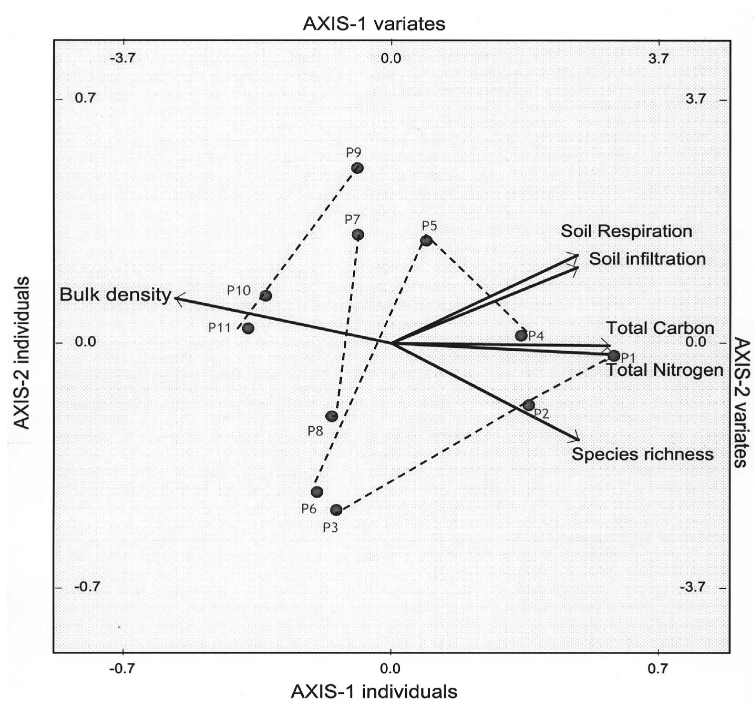

Figure 1 *Differences in patch and interpatch subclasses based on key biophysical parameters (dotted lines highlight the observed gradients between condition subclasses within the same class (i .e . trees and shrubs > 3 m-P1 , P2 and P3 ; trees and shrubs < 3 m-P4 , P5 and P6 ; perennial grasses-P7 and P8 ; interpatch zones-P9 , P10 and P11) .*

Results The results clearly support the hypothesis that different patch and interpatch condition subclasses could be uniquely categorised based on biophysical and chemical properties . High-order patches (e .g . P1 , P4 , Figure 1) were more biologically active , had more than twice the number of perennial species , had 50% higher infiltration rates , and had up to five times higher nutrient content than low-order (P10 , P11) interpatches ($P<0.05$) . Clear condition gradients were established between the different condition subclasses (Figure 1) . Transect results suggest that the proportion of these subclasses in a landscape can be altered by management .

Conclusions Managers should adopt practices which maximises perennial ground cover and biodiversity in mulga woodland by protecting existing high-order patches and promoting the ecological succession of low-order patches and interpatches .

Effects of traditional range enclosures and seasonality on herbaceous plants biodiversity in southern Ethiopia

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Key words: range enclosures, seasonal grazing, species richness

Introduction Traditional range enclosures have played important roles in the restoration of herbaceous plant biodiversity in degraded rangelands. In southern Ethiopia, the use of range enclosures has been ongoing for the last three decades due to changes in land use from nomadic to sedentary grazing (Angassa, 2007). We sampled six enclosures varied in age from 12-14 years, 17-24 years and 26-30 years old representing younger, medium and older age categories, respectively. The adjacent rangelands were continuously grazed.

Materials and methods Herbaceous vegetation was sampled by randomly locating 10 1×1 m^2 plots in the individual enclosures and the same numbers in adjacent grazed rangelands during two wet seasons (November 2003 and May 2004) and one dry season (February 2004) ($n=120$ plots). The proportion of grass basal cover (%) was estimated visually based on the area covered by grass base compared to bare ground. Herbaceous species richness was determined as numbers of species per unit area. Herbaceous biomass was hand harvested and reported as dry-weight (gm m^{-2}). Abundance was direct counts. Diversity was assessed using the Shannon index.

Results The effect of management was significant for herbaceous biomass, grass basal cover, herbaceous species richness and diversity, but not for species abundance (Table 1). There was a strong seasonal variation by all variables (Table 1). The enclosure management had more herbaceous species richness (26 species) than the grazed rangelands (24 species). There was no clear evidence that the response of herbaceous variables to management changed with age of enclosures. Indeed, the effect of age was significant only for grass basal cover and herbaceous species richness (Table 1). Herbaceous species richness decreased with increasing age of enclosure (Estimate±SE-0.029±0.011). Herbaceous species richness was greater in the medium age (4.9±0.01 species m^{-2}), than younger (4.8±0.1 species m^{-2}) and older (4.6±0.1 species m^{-2}) enclosures.

Table 1 *Analysis of variance for the effects of management, age and seasonality on herbaceous vegetation variables.*

Response variable	Source	df	*F*	*P*
Biomass	Management	1	145.06	***
	Age	1	0.20	NS
	Season	2	114.31	***
	Management * season	2	23.80	***
Grass basal cover	Management	1	139.75	***
	Age	1	13.66	**
	Season	2	11.80	***
	Management * season	2	5.32	**
Abundance	Management	1	0.00	NS
	Age	1	3.43	NS
	Season	2	50.48	***
	Management * season	2	1.23	NS
Richness	Management	1	17.61	***
	Age	1	6.30	*
	Season	2	3.32	*
	Management * season	2	0.40	NS
Diversity	Management	1	13.18	***
	Age	1	9.11	NS
	Season	2	14.39	***
	Management * season	2	3.35	*

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, NS $P > 0.05$

Conclusions We found significantly greater herbaceous biomass and grass basal cover in the enclosures than in the grazed sites. The enclosures had more herbaceous species richness than the grazed rangelands. However, the older enclosures had no superior benefits over the younger in terms of herbaceous production, herbaceous species richness and diversity. From the current finding, it can be concluded that management and seasonality were more influential in driving the productivity and diversity of herbaceous plants in the rangelands of southern Ethiopia than age alone.

Oat and wheat added to annual ryegrass pasture to improve the seasonal forage offer

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Key words: mixtures, annual ryegrass, oat, wheat, seasonal yield

Introduction Grazing of annual ryegrass (Lolium multiflorum L) pasture is extensively used on livestock farms of Argentina (Jacobo et al, 2000) providing high quality forage during winter and early spring. Nevertheless, in the subhumid region of the country, forage shortage begins during fall and early winter annual crops such as oat can be more adequate (Brizuela et al, 2001). Complementary use of winter annual crops with different seasonality is proposed in mixtures to elongate the grazing period during the cold season (Juskiw et al, 2000).

Materials and methods During 2004 and 2005 an experiment was conducted in the south of Buenos Aires Province (sub-humid area) to evaluate the mixture of annual ryegrass (cv. Magnum) with oat (cv. Boyera), and wheat (cv. Estrella). Treatments (9) were ryegrass (600 live seeds m^{-2}) and the addition of each cereal to ryegrass at seeding rates of 29, 117, 206 and 290 live seeds m^{-2}. These treatments were seeded in March on a Hapludol soil of moderate fertility on 5 complete randomized blocks and fertilized with 120 Kg/ha of urea in April. Forage yield was evaluated by cutting the central 5 m^2 area of each plot in June (fall yield), September (winter) and November (spring). Effects of year, treatment and period were analised by ANOVA and orthogonal contrasts were used to evaluate the effect of both cereal additions, when significant F-test was reported for treatments.

Results The annual forage yield was not different between years and effects of treatment. However, period and their interactions were significant ($P \leqslant 0.01$) and consequently results of each period are presented (Table 1). Both cereals added to ryegrass increased the fall yield and the effect of oat was higher than that of wheat. An inverse effect and trend along seeding rates occurs in spring and in winter by adding oat. The total yield was increased when both cereals were added.

Table 1 *Forage yield of annual ryegrass and its mixtures with oat and wheat at different seeding rates.*

		Fall	Winter	Spring	Total
		DM Kg ha^{-1}			
Pure ryegrass		1045	1984	1910	4939
Oat added	Seeds m^{-2}				
	29	1598	1659	1728	4986
	117	2231	1313	1500	5044
	206	2894	1198	1378	5470
	290	3213	1342	1333	5888
Wheat added	Seeds m^{-2}				
	29	1181	1973	2168	5323
	117	1348	1888	1873	5108
	206	1640	1880	1865	5384
	290	1873	1821	1608	5301
Effects					
	Oat addition	**, L^{**}	**, L^{*}, Q^{*}	*, L^{**}	*, L^{**}
	Wheat addition	**, L^{**}, Q^{*}	NS	*, L^{**}	*
	Oat vs wheat	**	**	**	NS

**: $P < 0.01$; *: $P < 0.10$; NS: $P > 0.10$; L and Q: linear and quadratic effects of seeding rate, respectively.

Conclusions Addition of cereals of early fall growth to annual ryegrass pasture can improve seasonal distribution of forage yield and it could be a profitable practice if adequate species and varieties are used.

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Large-scale changes in ratio of C_3 and C_4 plants in central Asian grassland during the last century as recovered from wool archives

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Key words: Carbon Isotope Discrimination, C_3 plants, C_4 plants, Central Asian Grassland

Introduction The Central Asian grassland is one of the largest biomes on earth with significant influence on global biogeochemical cycles. It is characterized by the co-existence of plant species with either C_4 or C_3 photosynthetic pathways, which differ in carbon isotope composition. The C_3/C_4 ratio is controlled by climate and land use which have changed during the past century (global warming and atmospheric CO_2 increase; increased stocking rates). However, it is unknown if these changes have actually elicited changes in the C_3/C_4 ratio. We used old and modern woollen materials and carbon isotope analysis to reconstruct vegetation changes, which are recorded in the hair of the grazing animals.

Material and methods 414 wool samples from 99 sites in Inner Mongolia (Figure 1) dating form 1928 to 2005 were collected and analyzed for carbon isotope composition. The C_3/C_4 ratio was then computed from the carbon isotope composition by taking into account the change in the carbon isotope composition of atmospheric CO_2 and the influence of aridity on the carbon isotope composition of the C_3 component.

Results Average C_4 abundance in Inner Mongolia increased in two steps from 1% (1928—1962) to 9% (1963—1998) and 25% (1999—2005) with simultaneously increasing scatter due to the evolution of a spatial pattern. No significant trends in C_4 abundance and scatter occurred within any period. These findings contradict predicted decreases in C_4 abundance due to rising CO_2 concentrations. The increase in C_4 abundance seems to be caused by a combination of rising regional temperature, increased human impact (increased stocking rate and decreased herd mobility) and short-term weather events, all favouring the spread of C_4 plants. The C_4 abundance especially increased around large towns in the desert steppe.

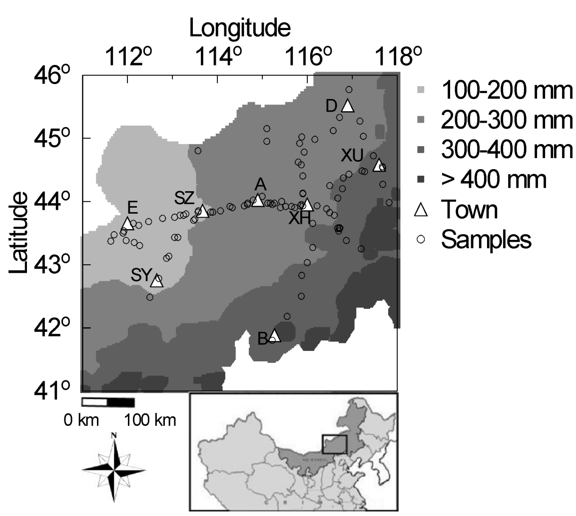

Figure 1 *Location of the sampling sites in Inner Mongolia. The shades of grey display the mean annual precipitation of the last normal period.*

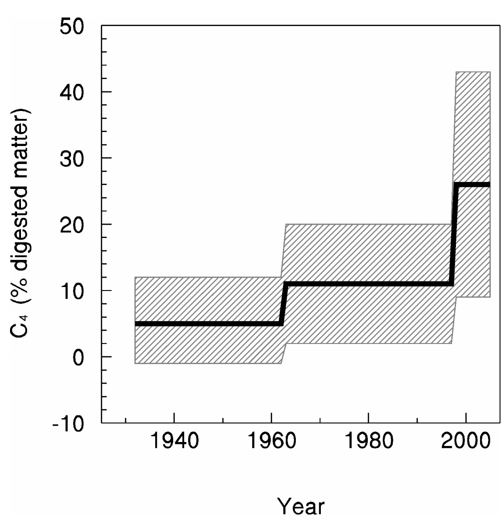

Figure 2 *Proportion of C_4 plants in feed of small grazers (mean ± standard deviation).*

Conclusions The C_4 abundance in the Inner Mongolian steppe increased probably due to overgrazing and regional warming. These factors were strong enough to override the effect of the rising atmospheric CO_2, which should have favour C_3 expansion.

Growth parameters of forages in a cool semi-arid climate

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Key words: grazing, harvest, bromegrass, wheatgrass, wildrye, alfalfa, fall rye, maximum growth rate

Introduction Comparative studies have been conducted on yield performance of forages adapted to the Parkland region of the Northern Great Plains. However, these studies have failed to provide generalized descriptions of the seasonal growth patterns of these species. The objective of this study was to examine and compare the seasonal growth patterns of forage species in a cool, semi-arid environment.

Materials and methods The field study was conducted in northeast SK, Canada, with mean annual temperature of 1℃, total precipitation of 413 mm and approximately 105 frost free days. Forages (listed in Table 1) were planted in the year prior to the commencement of sampling, arranged in a randomized complete block design (4 blocks), and fertilized with 100 kg N ha^{-1} (except for alfalfa). The forages were sampled regularly from early May to August for 5 years; new plot areas were sampled each time and year to avoid effect of previous sampling. Analysis of variance was done with species as main plot and sampling date as subplot. Also, growth data was fitted to a non-linear Gompertz equation in order to characterize and calculate growth parameters for these species (DAFS is day after first sampling):

$$\text{Yield} = ae^{be^{(-k \times DAFS)}}$$

Results Analysis of variance showed significant species x sampling date interactions. Results from fitted Gompertz equations for each species are presented in Table 1. Maximum growth rate occurred earliest (May 9) and was greatest (indicated by coefficient b) for CWG. Due to rapid early growth, CWG would be available for grazing (based on 1500 kg ha^{-1} standing biomass) about a week earlier than the other species. Growth rate of other perennial species peaked about a week later than CWG (May 16-21) whereas fall rye peaked May 26. Maximum growth rates (MGR) for all perennial species occurred at < 12℃ mean daily temperatures, which is lower than optimum for cool season grasses (15-25℃) (Nelson 1996). MGR occurs during the phenologically-determined stem elongation phase when there is a strong a sink for carbohydrates from the crowns and leaves. Maximum growth rate was lower for MB than CWG possibly due to a weaker sink associate with lower proportion of seed-forming reproductive tillers. The dominant cultivated grass in the region, SB, had an intermediate maximum growth rate. With their more rapid growth and discrete asymptotes (coefficient k), CWG and ALF reached 90% of maximum yield over three weeks before the other grasses, and both species had the lowest ADF and NDF at this milestone (not shown). These crops can be harvested earlier, whereas the optimum date of cutting is less distinct for SB, MB, IWG and AWR. Despite relatively large differences in b and k coefficients, the a (maximum yield) coefficients were similar for all grasses. Paradoxically ALF had the greatest growth rate and the lowest maximum yield, but ALF also has the greatest potential for regrowth after harvest. In this water limited region, early growth (CWG) benefits from lower vapour pressure deficits whereas later growth (IWG and MB) benefits from more abundant precipitation in late-June to early July.

Table 1 *Gompertz coefficients (SE) for fertilized grasses and alfalfa for a 5-yr period in Melfort SK. (a indicates asymptote, b indicates steepness of rapid growth and k reflects flatness of asymptote)*

		a	b	k
Crested wheatgrass (CWG)	*Agropyron cristatum* L. Gaertn.	3.6 (0.1)	6.9 (1.0)	2.7 (0.4)
Altai wildrye (AWR)	*Leymus angustus* Trin. Pilger	3.3 (0.2)	4.6 (0.9)	1.7 (0.3)
Smooth bromegrass (SB)	*Bromus inermis* Leyss.	4.4 (0.2)	5.4 (0.7)	1.9 (0.3)
Meadow bromegrass (MB)	*Bromus biebersteinii* Roem & Schult.	3.8 (0.4)	3.4 (0.7)	1.2 (0.3)
Inter. Wheatgrass (IWG)	*Elytrigia internedia* (Host) Nevski	4.0 (0.2)	4.5 (0.7)	1.6 (0.3)
Alfalfa (ALF)	*Medicago sativa* L.	2.4 (0.1)	9.4 (2.2)	3.4 (0.8)
Fall rye (FR)	*Secale cereale* L.	3.5 (0.2)	7.6 (1.2)	2.6 (0.4)

Conclusions The Gompertz coefficients were effective for describing average growth patterns over 5 years, and the equations were useful for calculating parameters such as dates of critical herbage biomass for grazing or harvesting. The shape of the growth curves reflected attributes of the species such as flowering synchrony and reproductive tendency.

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Classification of rangeland vegetation and modelling of vegetation patterns at the Jabal al Akhdar mountain, northern Oman

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Key words: Hajar mountains, rangeland vegetation, species indicator analysis, two way cluster analysis, discriminant analysis

Introduction The species diversity and the levels of endemism within the northern mountains of Oman are particularly high. Despite some earlier work, data are lacking about the distribution and ecology of different plant species, and also the vegetation response to environmental conditions and land use, particularly grazing. The aim of this study therefore was to describe the species composition, floristic diversity and vegetation patterns of open woodlands at Al Jabal al Akhdar along an altitudinal and a grazing gradient.

Materials and methods The species composition and several environmental variables such as browsing/grazing intensity, sward structure and distance to the settlement were investigated for 62 samples (20×30 m) using a nested plot design. Classification analysis (two-way cluster analysis and indicator species analysis) and ordination methods (DCA) was used to define vegetation types and to identify underlying environmental gradients. The species diversity and the functional diversity were calculated to show the effects of grazing intensity and altitude on biodiversity. A modelling approach based on discriminant analysis and the GIS were used to model the distribution of vegetation types within the study area.

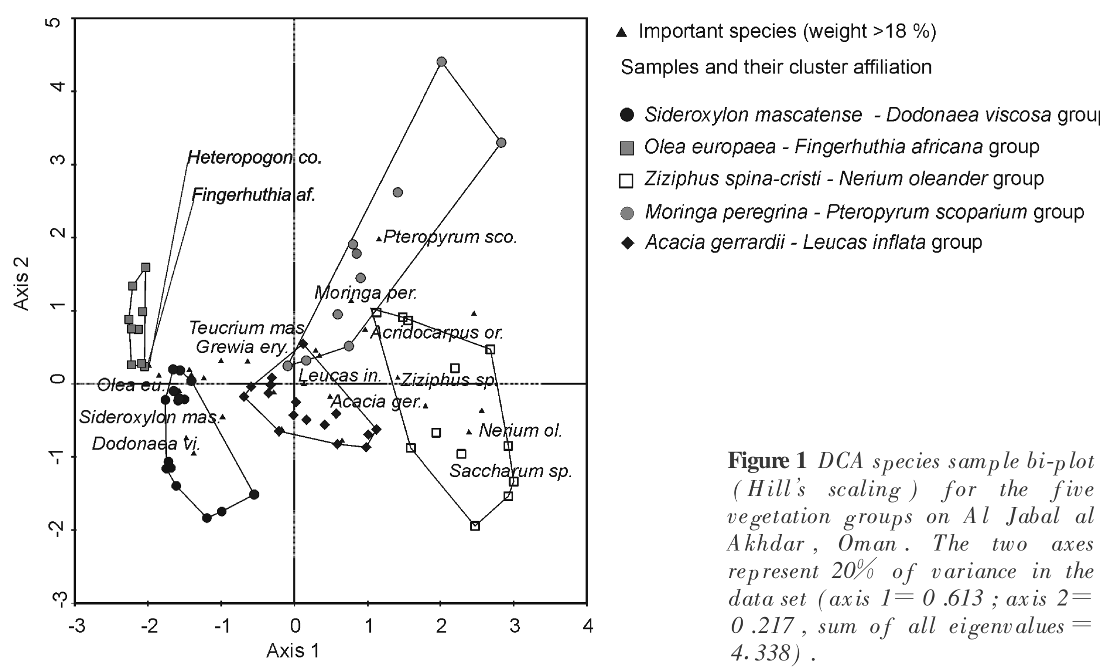

Figure 1 *DCA species sample bi-plot (Hill's scaling) for the five vegetation groups on Al Jabal al Akhdar, Oman. The two axes represent 20% of variance in the data set (axis 1 = 0.613; axis 2 = 0.217, sum of all eigenvalues = 4.338).*

Results The five group stage of the cluster analysis was the most informative, with the maximum number of significant indicators (67). Floristic and structural differences between groups were mainly due to altitude, followed by topographic location and grazing intensity. Groups were defined on the basis of the dominant species: the *Sideroxylon mascatense-Dodonaea viscosa* group on grazed and the *Olea europaea-Fingerhuthia africana* group on ungrazed plateau sites at 2 000 m a.s.l., the *Ziziphus spina-cristi-Nerium oleander* group on wadi sites, and the *Moringa peregrina-Pteropyrum scoparium* group at 1200, and the *Acacia gerrardii-Leucas inflata* group at 1700 m. The plant species richness followed a unimodal distribution along the altitudinal gradient with the highest number of species in the intermediate altitudinal belt. Altogether, 27% of the species showed a high degree of grazing damage.

Conclusions The main environmental factors, altitude and topographic location, surmounted the grazing effects on plant species richness in the present investigation. Future work should attempt to quantify more clearly the grazing effects with the successional shift in species composition and the regeneration ability.

Dynamics of 4-species plant systems over three years at 19 sites across Europe

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Key words: species dynamics, multi-site, climatic gradient, grass, legume

Introduction The ability of a community mixed plant species to remain stable over time may depend on a number of factors including the species present, the initial evenness and the climatic conditions. Previous work on grassland mixtures shows that diversity benefits in respect of yield and unsown species are higher when the proportions of four species are relatively evenly distributed (Kirwan *et al.*, 2007). In this paper we examine results from a multi-site agrodiversity grassland experiment carried out under the auspices of COST852 and assess the development of the dynamics of the experimental 4-species communities over three harvest years. Mixtures that remain somewhat evenly distributed over time may be superior at delivering important ecosystem functions.

Materials and methods A common experiment was carried out over a wide climatic gradient at 19 sites across Europe using four species (two grasses and two legumes) and is described in full in Kirwan *et al.* (2007). At each site, fifteen experimental communities were established at each of two sowing densities (low being 60% of high). There were four monoculture communities (one for each species) and 11 four-species communities where the initial proportions of each species was varied; of these 11, there were four communities with one dominant species (70%, 10%, 10%, 10%), six communities with two species dominant (40%, 40%, 10%, 10%) and a centroid with each species equally present (25%, 25%, 25%, 25%). One of two species-groups was used at each site; the Mid-European group (ME) with species *Lolium perenne* (G_1), *Dactylis glomerata* (G_2), *Trifolium pratense* (L_1) and *Trifolium repens* (L_2) was sown at 14 sites and the Northern-European group (NE) with species *Phleum pratense* (G_1), *Poa pratensis* (G_2), *Trifolium pratense* (L_1) and *Trifolium repens* (L_2) was sown at the remaining five sites. A number of harvests was taken at each site over a period of three years and the annual total yield of each of the sown species and of unsown species was recorded.

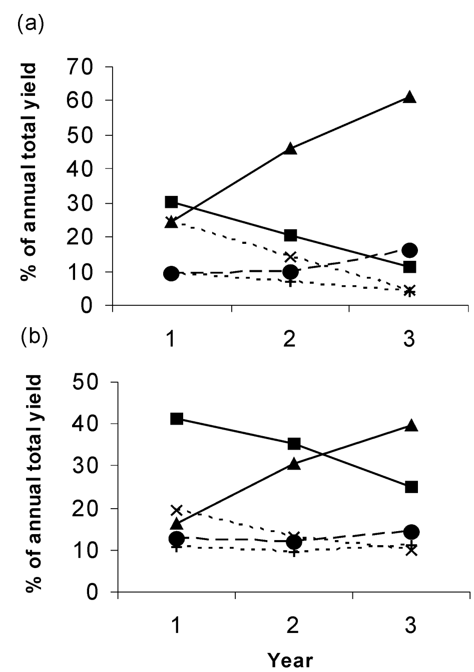

Figure 1 *Annual average percentage of total yield for each of the fours species (G1 ■; G2 ▲ L_1 ×; L_2 +) and for unsown species (●) for (a) the ME group and (b) the NE group.*

Results and discussion For the ME group, *Dactylis glomerata* (G_2) became increasingly dominant over the three years and in year 3 it dominated on average 61% of annual harvest [Figure 1(a)]. For the NE group the grasses *Phleum pratense* (G_1) and *Poa pratensis* (G_2) became dominant, and in year 2 and 3 together accounted for more than 60% of annual harvest while the legumes in this group decreased slightly over the three years [Figure 1(b)]. Unsown species increased in the third year in the ME group but remained stable over the 3 years in the NE group.

Conclusions In both groups grasses became dominant over legumes over the three year period, however the relative importance of the two grass species changed over time. In the ME group both grasses were strong in year 1 but G_2 dominated in year 2 and 3. In the NE group G_1 dominated in year 1 but both G_1 and G_2 were dominant over legumes in year 2 and 3.

Reference

Kirwan, L., *et al.*, (2007). Evenness drives consistent diversity effects in an intensive grassland system across 28 European sites. *Journal of Ecology* 95, 530-539.

Grassland diversity enhances productivity at low and high levels of nitrogen addition

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Key words: Biodiversity, Grassland productivity, Nitrogen fertilisation

Introduction A central theory of ecology postulates that ecosystem processes in more diverse ecosystems are more stable than in less diverse ones, especially when environmental changes occur. Thus, diversity can provide insurance for some ecosystem function responses, such as biomass production (Yachi & Loreau, 1999). This study quantifies the contribution of species identity and evenness to biomass production in mixed grassland systems under different N addition regimes.

Material and methods A split-plot field experiment was established in autumn 2006. The main plot treatment varied plant diversity and the split-plot treatment varied nitrogen (N) application (+ 155 kgN/ha/yr). All plots received a total of 45 kg/ha/yr N in two applications and were harvested 3 times in 2007. Plant community composition consisted of two grasses (G1: *Lolium perenne* and G2: *Phleum pratense*) and two legumes (L1: *Trifolium pratense* and L2: *Trifolium repens*) sown at proportions defined within a simplex design. Thus, evenness (E), a measure of the distribution of the relative abundance of species in a community, was varied (Kirwan *et al*., 2007). The basic design consisted of 4 monocultures (E=0), 6 two sp.-mixtures (E=0.67) and 18 four sp.-mixtures dominated in turn by each species (88:4:4:4, E=0.29 and 70:10:10:10, E=0.64), by pairs of species (40:40:10:10, E=0.88) and equally represented at the centroid (25:25:25:25, E=1). The design was repeated at two levels of overall initial abundance (low being 60% of high). Total yield was analysed as a function of species identity and evenness (Kirwan *et al*. 2007) using linear mixed models to account for the split plot random effects. Likelihood Ratio Tests (LRT) were used to identify significant terms in the model. Analyses were performed in R (version 6.0).

Results and discussion Both evenness (LRT $\chi^2_1 = 7.81$; $P = 0.005$) and N addition (LRT $\chi^2_1 = 47.68$; $P < 0.001$) had significant and positive effects on total yield (Figures 1 and 2). There was a linear relationship between yield and evenness, which was maximum at the centroid where estimated yield was 1.63 t/ha more than expected from monoculture yields. The interaction between N treatment and evenness ($N^* E$) was not significant (LRT $\chi^2_1 = 0.91$; $P = 0.341$). The positive overall effect of N addition depended on the increase in yield of the two grass species (average increase of 1.14 ± 0.14 t/ha in monocultures at high N level; Figure 2).

Unlike other similar studies (Kirwan *et al*., 2007) transgressive overyielding did not occur; mixtures ($E > 0$) did not consistently yield higher biomass than the best-performing monoculture (Figures 1 and 2). The centroid yield at the low level of N addition was comparable to the yield of the best-performing monoculture at the high N level.

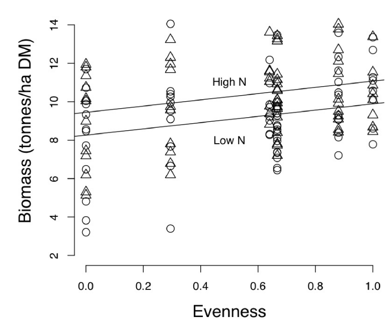

Figure 1 *Total yield at different levels of sown evenness. Lines represent high (triangles) and low (circles) levels of N addition.*

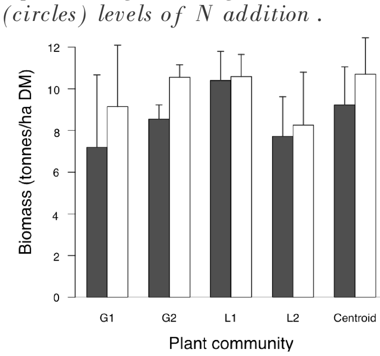

Figure 2 *Mean (+ sed) yield of species in monoculture and at the centroid (dark grey: low N; light grey: high N).*

Conclusions These results indicate benefits of using agronomic mixtures in managed grasslands under high and low levels of N addition. The positive effect of evenness at both high and low levels suggests that the diversity effect was not solely due to symbiotic N fixation. Other benefits of grassland mixtures will be investigated, and include stability of yield over time and resistance to weed invasion.

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Controls of seedling recruitment of annual species in temperate perennial pastures

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Key words: emergence, dormancy, bromegrass, red clover, production stability

Introduction Temperate pastures are characterized by low growth rates during the winter. The incorporation of annual species in the mixture gives the opportunity to balance the distribution of the forage allowance through the year. However, successfully seedling recruitment every year depends upon the environmental conditions which: (1) allows the reproduction of the mother plant at the end of the growing season (Forcella, 2000) and (2) breaks the dormancy of the seeds (Benech et al., 2000). The objective of this work was to evaluate the patterns of seedling recruitment of two annual species, brome grass (*Bromus catharticus*) and red clover (*Trifolium pratense*), under different environmental conditions.

Materials and methods We registered the emergence of brome grass and red clover seedlings in two temperate pastures during 2005-2006 in a dairy farm located at General Las Heras, Buenos Aires province, Argentina (34°59′S; 58°50′W). The grazing regime was low intensity and high frequency. Density of emerged seedlings of the two species (seedlings/m^2) was estimated by the frequency grid method from Vogel and Masters (2001). We also registered the distribution of rainfall and the air temperatures during the period of evaluation. We analyzed the results through the repeated measures method (Manova).

Results and discussion Seedling recruitment of brome grass occurred since April to June in both years (80%-90%) [Figure 1 (a)]. However, the total density of seedlings recruited differed between years: it was significantly higher in 2005 compared with 2006 ($p < 0.001$). We propose two possible explanations: the first is associated with moisture requirements of posmaturity in brome grass. Whereas seeds postmatured under drought conditions, can emerge under a dense canopy, seeds posmatured under high moisture conditions need lighted gaps for successful emergence (Mollard et al., 2007). Differences between rainfall in summer 2005 (regular) and summer 2006 (+50%) could make the differencs about this subject. The second is associated with rainfall during the fall, necessary for emergence after the dormancy break. Again, both years differ by 50% in fall rainfall. Seedling recruitment of red clover was less than that of brome grass but it occurred along the whole year, and it was less significant in 2006 than in 2005 ($p<0.001$) [Figure 1(b)]. Legumes produce hard seeds and the hardness loss is regulated by temperature whereas the survival of the seedlings is influenced by moisture conditions (Frame et al., 1998).

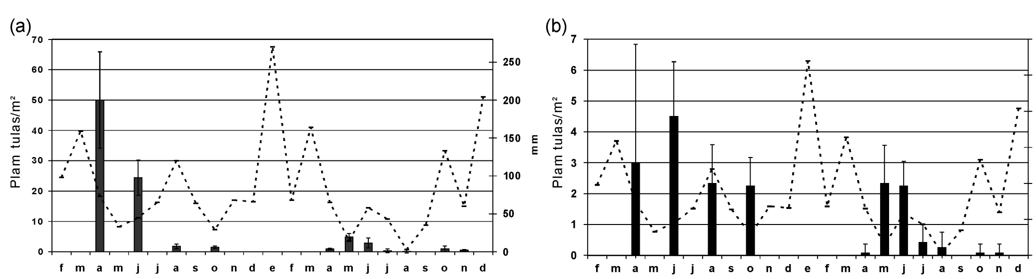

Figure 1 *Seedling density of (a) brome grass and (b) red clover (seedling/m^2). Vertical lines show standard deviation. Dotted lines show monthly rainfall.*

Conclusion Brome grass and red clover showed different patterns of seedling recruitment. The main factor that explained the trend of seedling recruitment observed in brome grass was the occurrence of rainfall previous and during the period of emergence. Red clover didn't show a specific pattern. Knowledge of these factors is required for defining strategies that guarantee the stability of forage production during the useful life of the pasture.

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Central Afghanistan rangelands

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Key words: Afghanistan, Hindu Kush, vegetation, soils, rangelands

Introduction Afghanistan, encompassing 63 million hectares, is a little larger than the states of Arizona and New Mexico combined and has a long history of human occupation. It is a culturally diverse country peopled by tribes of Turkish, Persian and Mongolian descent. The northern foothills of the Hindu Kush, the major mountain range of Afghanistan, are within the historic range of the domestication of wheat and barley and sheep and goats some 10 to 11,000 years ago. The grazing of small flocks of closely herded sheep and goats over the last 4-5000 years has been an important factor in shaping the development of Afghan plant communities. Today rangelands comprise between 60 to 75% of the land area depending on the source of the information. These rangelands are critical for supplying Afghanistan with livestock products, fuels for heating and cooking, building materials, medicinal plants and habitat for wildlife. Rangeland watersheds feed the springs, streams and rivers; the lifeblood of the country that nourishes nearly 4 million hectares of irrigated lands.

Methods The author spent four months in central Afghanistan in 2006 on a USAID funded project to train Afghan Ministry of Agriculture employees in rangeland management. This project and subsequent study yield an introduction into the character of the rangelands of Central Afghanistan.

Results The climate of central Afghanistan is continental with cold winters and hot, dry summers. Moisture comes as snow in the winter and rain in the spring. Kabul, at 1800 meters elevation, 34 degrees north latitude and with 270 mm of annual precipitation has vegetation that looks remarkably similar to that of the hills around Reno, Nevada. Rangelands in the central region occur across the Hindu Kush at elevations from 1000 to 4000 meters and with mean annual precipitation ranging from 150 to 500 mm. The natural vegetation across most of this region is sagebrush steppe with large areas capable of supporting open woodlands of juniper or pistachio. The soils are nearly all calcareous; primarily as a result of secondary enrichment by carbonates from wind-blown dust. The soil moisture regime is xeric and temperature regimes range from thermic to frigid (at the higher elevations). Shallow to moderately deep (25 to 60 cm) coarse textured soils occur on hill-slopes. They are classed as haplocambids or haplocalcids. Deep soils occur in valleys and appear to be mixtures of loess and gravely stream alluvium. Textures are silty; gravel content is variable. They are calcareous, yellow in color and classified as haplocambids. Plant communities across the region appear simplified in areas close to cities and villages. Intense human use of these lands during the last 23 years of war, drought, lawlessness and population increase has resulted in the loss of shrub and tree cover and in plant communities dominated by annual grasses and forbs. But, upon closer inspection, many are surprisingly diverse, especially the plant communities of rocky hill sites. Existing plant communities are well adapted to heavy utilization as livestock grazing has occurred for 4-5000 years. Perennial grass and grass-like species and herbs exhibit many adaptations to close grazing. Bulbs, rhizomes, rootstocks, dormant seed, awns and barbs are common. Hundreds of herbaceous annual species occur in these plant communities. Shrubs tend to be well armed with thorns or spines or have high levels of toxic substances or essential oils like alkaloids and terpenes. Several species of juniper and two species of pistachio occur in this region. These low trees presently exist in isolated areas but formerly had much more extensive ranges. Sagebrush or *Artemisia* species fill a dominant niche in these xeric and grazing intense environments. The essential oils in sagebrush (terpenes) inhibit rumen microflora and greatly reduce the digestion of cellulose. Many species are not grazed at all during the growing season. Shrub cover is extremely important to provide soil protection, trap snow on the land, shade the soil surface, as wildlife habitat, to develop rooting structure and break up soil compaction. The present day utilization of sagebrush for fuel is not sustainable and is one of the most pressing problems in rangeland management in Afghanistan.

Conclusions Rangelands in central Afghanistan are very similar to the sagebrush and juniper rangelands of the Great Basin of the western United States. Overgrazing and overharvest of shrubs for fuel threaten these ranges.

Modeling the growth of alfalfa (*Medicago sativa*) in the Pampas region

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Key words: lucerne, primary productivity, incident radiation, actual evapotranspiration

Introduction Carrying capacity of grazing systems on the Pampas (Argentina) and its secondary production depend on the aboveground net primary productivity (ANPP) of their forage resources. While there is descriptive information about the seasonal variability in the productivity of grown perennial forage species, there is less information about the environmental controls of this variability from a long time series and spatially well distributed in the region. Among the cultivated species, the alfalfa (*Medicago sativa*) is the most important forage legume because the large sown area and the wide environmental gradient it occupies. Simulation models that allow estimating crop growth have been developed for various parts of the world (McCown et al., 1996). The objective of this study was to construct a model to estimate the PPNA for this species, from local soil and climate data.

Materials and methods We used data from biomass harvests from a three-year crop network test (Chamber of Seed Traders-CSBC), located at different sites in the Argentine Pampa and for 7 years (1996—2003). We averaged for each month the daily PPNA, calculated from the aboveground biomass accumulated between successive cuts. We worked with the information of four experimental sites located between 31° and 37° south latitude and 59° and 63° west longitude and covering an mean annual temperature ranges from 13.6℃ to 18.4℃ and annual precipitation from 840 mm to 1123 mm. Out of a total of 316 cuts, cuts for the establishment phase and those periods of low growth rates were eliminated. The monthly ANPP were correlated, through multiple regressions, with the average monthly temperature, precipitation, incident radiation (Rad) and actual evapotranspiration (ETr). The latter was estimated from the above variables and data such as soil field capacity and wilting point. We evaluated the best model developed with information from the northern location, using the data from that location is not taken into account for the construction of the model and those for the other three seats, for its validation.

Results and discussion The model that best explained the PPNA includes Rad and ETr [mean monthly daily ANPP (kg DM / ha.day) = 4.24 * Rad + 4.71 * ETr − 8.93]. The application of this model for the whole dataset showed a good agreement against the measured ANPP (Figure 1). Overall, the model presented a satisfactory adjustment for all the analyzed locations (Figure 2). The slope of the relationship between estimated and measured by cuts was not significant different to the line 1:1 ($p = 0.92$). This model does not include ANPP monthly values that exceed 70 Kg DM/ha.day, believing that these values would be explained by factors not taken into account in the design of the model, such as soil fertility or structural variables of cultivation.

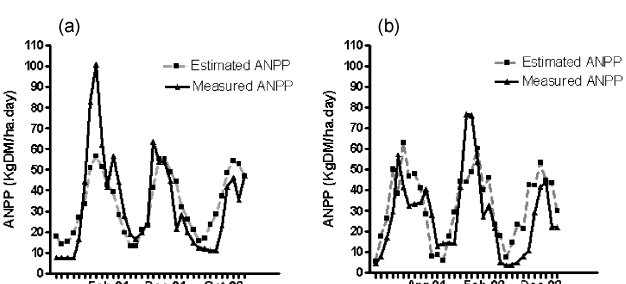

Figure 1 *Seasonal dynamics of the ANPP (2000/2003), for two contrasting sites: (a) Rafaela and (b) Cnel. Suárez.*

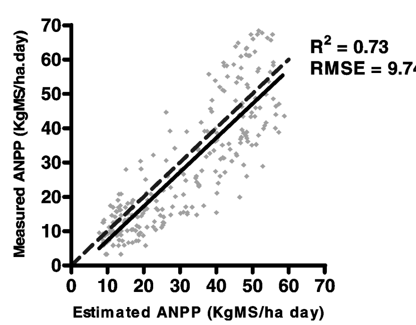

Figure 2 *Relationship between the measured and the estimated by the model ANPP for the four sites. Full line is the regression line and the dashed line is the 1:1 relationship.*

Conclusions Our results suggest that it is possible to estimate the ANPP from climatic data for a wide range of conditions in the Argentinean Pampas. The model could help to better understand the controls of ANPP and to make a more accurate planification of stocking rate in grazing systems. Moreover, it could help to estimate the effects of climate changes on the ANPP of alfalfa.

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Botanical composition of a phalaris-dominant pasture 5 years after the introduction of intensive rotational grazing

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Key words: phalaris, botanical composition, grazing management

Introduction Phalaris (*Phalaris aquatica*) is a significant grass component of many sown permanent pastures in the high rainfall zone of southern Australia (>600mm annual average rainfall), including the lower south east of South Australia. Its ability to persist through the summer-dry, its high growth rate and the observation that it grows well on the shallow, heavy clay/loam soils of high pH (8.0-8.5) that appear to be less well suited to most other perennial grass species often promoted for the region, all help explain its widespread use in the area. Although it has been widely adopted, there has been relatively little work undertaken on the effects of rotational grazing on this species. Virgona *et al*. (2000) is the most recent example that studied the effects of differeing grazing management, concluding that rotational grazing can be used to increase or maintain phalaris in summer-dry environments. This paper reports a 5 year study of the effects on botanical composition of changing the grazing management of a phalaris-dominant pasture from many years of set stocking with sheep and cattle to intensive rotational grazing predominantly with cattle.

Materials and methods In 2002 Struan Research Centre converted 190ha of phalaris-dominant pasture, divided into 10 paddocks, into an intensive rotational grazing set up using TechnoGrazing™ principals and fencing hardware. This resulted in 48 paddocks of 4 ha each that can be further subdivided into 60 individual cells of 0.67ha each using temporary electric fencing. The area that was converted had been sown to phalaris, strawberry clover (*Trifolium fragiferum*) and annual ryegrass (*Lolium rigidum*) between 1969 and 1984. The botanical composition in six of the new paddocks was estimated at least seasonally by a single observer using the BOTANAL technique (Tothill *et al*., 1992). Plant species were assessed as phalaris, clover, weeds or other grasses. Composition was generally not assessed in the summer-dry period due to the lack of dry matter at that time of year. Data are presented as averages of the six paddocks and have been analysed using a general linear model in SAS v9.1.3 (SAS Institute Inc, Cary, NC, USA).

Results and discussion The percentage (dry matter basis) of phalaris and weeds in the sward has not altered in the 5 years since the grazing management of the paddocks was changed in 2002 from set stocking to intense rotational grazing, indicating the stability of the phalaris component of the sward (Table 1). In contrast, the clover component of the sward was significantly greater in autumn 2002 (P=0.004) and 2006 (P=0.001) than in autumn 2007 while the other grasses component was significantly greater in autumn 2007 than in autumn 2002 (P=0.006) and 2006 (P=0.001).

Table 1 *Botanical composition (% of dry matter) in paddocks soon after being re-fenced into a TechnoGrazing™ configuration in 2002 and in the corresponding seasons in 2006 and 2007.*

	Phalaris			Clover			Weeds			Other grasses		
	2002	2006	2007	2002	2006	2007	2002	2006	2007	2002	2006	2007
Autumn	40	47	37.6	22.7	21.1	4.6	10.4	3.2	4.6	26.9	28.7	53.2
Winter	39.9	39.6	35.5	14.4	8.7	3.6	6.5	7.2	9.1	40.2	44.5	51.7
Spring	37.8	34.6	35.1	10.3	7.7	4.9	1.8	5.4	9.6	50.2	52.3	50.3

Conclusions These findings support those of Virgona *et al*. (2000) that rotational grazing maintains the phalaris component of a pasture but provides no support to the proposal that intensive rotational grazing results in phalaris dominating the sward. The implication of this finding is that the work reported here involved a high intensity rotational grazing system, with defoliation in spring as often as every 25-30 days. Given that spring is when reproductive development occurs, it is significant that there has been no effect on the density of the phalaris component of the sward over the 5 years of study. In contrast, it appears that the significant effects on the clover and other grasses components may be more influenced by seasonal conditions than grazing, since 2006 was the driest year on record for the Struan Research Centre region, which is likely to have resulted in the impact on clover regeneration noticed in 2007.

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Unravelling the mechanisms behind the invasion of an introduced and now undesirable grass species

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Key words: disturbance, competition, species richness, nutrients, grazing

Introduction The introduction of *Eragrostis curvula* (African Lovegrass, hereafter Lovegrass) for pasture improvement across Australia has not been successful. Instead Lovegrass, a C_4 perennial grass originating from Southern African, has proven unpalatable to stock and to have low nutritional value if stocks do eat it. It has spread prolifically along roadsides, stream banks, conservation areas and pastures. Because control efforts have not been effective, our aim was to determine the putative mechanisms responsible for the dominance of Lovegrass, specifically disturbance (selective grazing) and competition.

Methods To achieve this aim, we established a factorial field trial with a split-plot design in a secondary pasture grazed by cattle and dominated by Lovegrass. The pasture is located in the Millmerran region, Queensland, Australia. The average rainfall of this area is 600 mm/year in summer (October to April) and the soil is classified as yellow sodosols. Four large blocks (50m by 50m) were established, with two fenced and two unfenced to create grazing/no grazing treatments. In each of these blocks, 48 smaller plots (5m by 5m) were established. The following treatments in all combinations (four replicates per block) were applied: (1) fertilizer (N-P-K), (2) herbicide and slashing and (3) seed addition (two native species *Bothriochloa decipiens* (Pitted bluegrass) and *Themeda australis* (Kangaroo grass)). From October 2006 to April 2008, we are monitoring changes in plant community composition and abundance (point intercept method) in response to these treatments.

Results Results from the first year of measurements (October 2006 to April 2007) have shown that simply preventing grazing does not encourage the re-establishment of native species [Figure 1(b)], but instead increases Lovegrass abundance particularly when fertiliser is applied [Figure 1(a)]. The herbicide treatment was the most effective at reducing the abundance of Lovegrass [Figure 1(a)] and when grazing was prevented was also the most effective treatment at encouraging native species to re-establish [Figure 1(b)]. The slashing treatment was also effective at reducing Lovegrass abundance, but did not encourage native species establishment. The seed addition treatment was not successful so the established native species emerged from the seed bank or dispersed into the plots naturally.

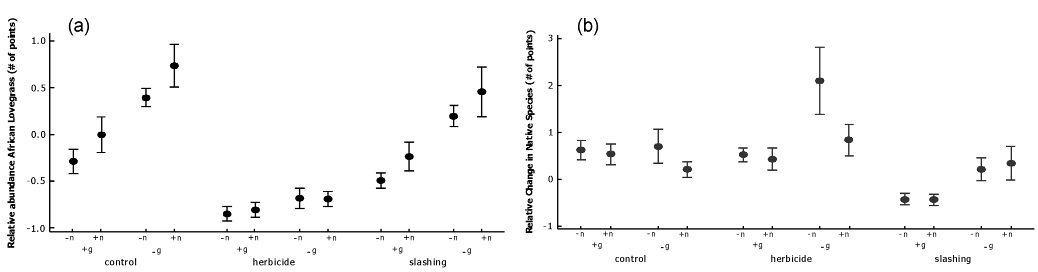

Figure 1 *(a) and (b): the relative change in abundance (a) Lovegrass and (b) native species one growing season after the grazing, nutrients, herbicide and slashing treatments were established. + n = fertiliser, − n = no fertiliser, + g = grazing permitted, − g = grazing not permitted, control = no treatment and bars indicate one standard error.*

Discussion Several recent studies have proposed that invasion is facilitated by either disturbance or competition (MacDougall and Turkington, 2005, Seabloom et al., 2003). Our preliminary results (although this may change after second year measurements) suggest that the invasion of Lovegrass may be explained by both disturbance and competition. We found that only when the pressures of selective grazing were removed (disturbance) and Lovegrass killed (competition removed), did native plants re-establish. The addition of nutrients to the soil did not favour native species, but instead favoured Lovegrass establishment.

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Effects of 10 years of fire and climate variability on perennial grass cover in shortgrass steppe

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Key words: fire, drought, shortgrass steppe, *Buchloë dactyloides*, *Bouteloua gracilis*

Introduction The objective of this study is to examine the effects of 10 years of fire and climate variability on perennial grass cover in shortgrass steppe. The research is part of a long-term, 18-year study examining effects of fire in the growing *vs*. dormant season at return intervals of 3, 6 and 9 years. In general, the response of grasslands to fire seems to depend primarily on pre-and post-fire levels of precipitation (Ford, 1999). The southwestern United States has experienced drought 9 of the past 10 years, with an extreme drought occurring in 2002.

Materials and methods The study site was located in semi-arid shortgrass steppe in the southern Great Plains of northeastern New Mexico, USA (36°31′20″ N, 103°3′30″ W). The site has mostly native vegetation with *Buchloë dactyloides* and *Bouteloua gracilis* being the dominant plant cover. The majority of precipitation occurs from May through September, with peak rainfall in July. Thirty-year mean annual precipitation (MAP) for the site was 356 mm. Total precipitation was slightly below average in 1996, the year prior to fire treatments, as well as for 1997, the first year fire was applied. Total precipitation in 1998 was 50 percent below MAP and drought conditions also existed in 2003, and was again below average in 2006 (Figure 1). The experimental design was completely randomized, with 7 treatments replicated 5 times on 2-ha plots/treatment. The treatments discussed here are (1) **D**, dormant-season fire applied April 1997 and (2) **U**, unburned. Live perennial grass cover was measured annually from 1996-2006.

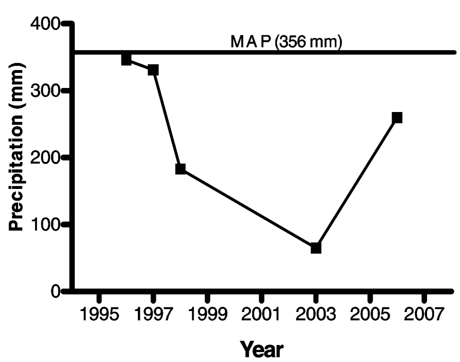

Figure 1 *Total annual precipitation.*

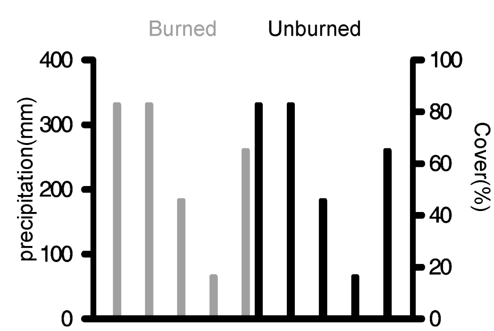

Figure 2 *Perennial grass cover.*

Results D and U perennial grass cover (percent) and total annual precipitation (mm) were plotted over 5 sample periods (pre-treatment 1997, and post-treatment 1997, 1998, 2003, 2006). There appeared to be a direct positive relationship between perennial grass cover and precipitation, and precipitation appeared to override fire effects (Figure 2).

Conclusions Though the MAP for the site was 356 mm, most actual total annual precipitation for the site over the 10-year period was generally lower than MAP, and in some cases as much as 50 percent lower. For management purposes, the frequency and severity of drought are more important than long-term average climate conditions. Too often, land managers plan for average climate conditions, rather than the climatic extremes that can be expected (Potter and Ford, 2004). Since this and other studies have indicated weather patterns can supersede fire effects in shortgrass steppe (Ford and Johnson, 2006), the use of fire as a management tool in a drought year should be carefully considered and aligned with management goals (Ford *et al*., 2004).

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When an introduced pasture grass becomes a conservation threat : managing buffel grass in the rangelands of Australia

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Key words : *Cenchrus ciliaris*, production, biodiversity, hybridisation

Introduction Buffel grass (*Cenchrus ciliaris* L.) is native to Africa, the Middle East through to India, and Indonesia. It has been imported into other continents to improve production on grazing lands, and has established readily in many arid and semi-arid environments. In some regions, extensive areas have been cleared of native woody vegetation to enhance its establishment and productivity. Buffel grass was introduced accidentally to Australia in the 1870s in the pack saddles of camels, and remained a very minor component of rangeland vegetation for many decades. Once its grazing value was recognised ranchers encouraged its spread and, from the 1950s, numerous varieties were imported and tested successfully. Productivity was such that ranchers and rural communities derived great financial benefit from it, particularly in semi-arid Queensland where tree clearing and sowing buffel grass were economically viable. Buffel grass has also played an important role in rehabilitation of degraded grazing lands (Payne *et al*., 2004).

Problem definition Tolerance of buffel grass for drought, fire and heavy-grazing are major assets for the grazing industry but these same attributes have had serious consequences for the biodiversity of Australia's rangelands. For example, buffel grass invasion enhances fire (Butler and Fairfax, 2003) and it has a negative impact on a diversity of taxa, not just those susceptible to fire (e.g. Franks, 2002; Friedel *et al*., 2006). It has the potential to invade over 60% of mainland Australia (Lawson *et al*., 2004). Clearing to sow buffel grass has reduced the area of native vegetation in one bioregion of Queensland to only 12.7% and remaining fragments are subject to invasion (Butler and Fairfax, 2003).

New cultivars continue to be developed which may be better adapted to clay soils or frost (Hacker and Waite, 2001; Ben Wilder, pers. comm. 2007) and there is evidence of hybridisation in arid central Australia (Friedel *et al*., 2006). Consequently the potential for colonising new areas is increasing.

Management options On grazing lands, monospecific buffel grass pastures can be undesirable when quality declines during periods of low rainfall. Some ranchers achieve a proportion in the order of 30% buffel grass and the remainder native forage species with carefully timed grazing. There are few prospects other than grazing for broad scale control of buffel grass in areas where it is not wanted. Burning is not an option because it thrives on fire. Biocontrol is indiscriminate, costly to develop and there is no guarantee of success. Strategic grazing of invaded conservation parks is unlikely to succeed because ranchers will want their livestock to be grazing their own buffel grass at a time when it will need grazing in conservation parks. Alternatively parks will need to retain their own herds, which is unlikely to be socially or economically feasible. Combinations of herbicides, fire, slash and hand removal are only practical in high-value conservation areas, due to cost.

Seeking solutions There is little chance of an imminent solution for this contentious issue. It may be possible to reduce spread by controlling vectors and creating buffer zones but there is no guarantee these will work (Rieks van Klinken, pers. comm. 2007). Limiting introduction of new cultivars is another option, although it cannot resolve the existing conservation dilemma. More biophysical research may identify further management options, but they all need to be examined carefully for their social and economic acceptability, since these are the real drivers of management choice.

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Is there a link between anthropogenic disturbance and the diversity and abundance of rodent flea communities ?

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Key words : Flea assemblages , rodents , vector-borne disease , anthropogenic disturbance

Introduction Fleas are among the most common arthropod vectors of many of rodent borne diseases like plague (*Yersina pestis*) . Human outbreaks of plague are commonly associated with the presence of peridomestic rodent species (Perry and Featherston , 1997) . Anthropogenic disturbance with respect to both habitat use and climate change can affect disease emergence and prevalence through its impact on hosts and host-parasite (vector) ecology (Daszak et al ., 2001) . Vector-borne disease transmission is often related to species diversity (Keesing et al ., 2006) . In addition , flea abundance and host spectrum (number of hosts infested) relate to the likelihood of flea-mediated disease transmission , particularly with respect to plague (Krasnov et al ., 2006) . Anthropogenic disturbance can influence rodent community diversity (Tikhonova et al ., 2006) , which in turn can affect flea diversity (Krasnov et al ., 2004) , and may lead to decreased host specificity among flea parasites (Gettinger and Ernest , 1995) . The goal of this paper is to examine the influence of anthropogenic disturbance on flea communities from a variety of habitats across the world . In particular , this analysis focuses on the effect of disturbance on flea diversity and flea species abundance and specificity behaviors .

Methods Literature was compiled on studies conducted across the world that reported the entire flea assemblage from comprehensive rodent community surveys (Friggens , 2008 for comprehensive list) . Basic criteria for inclusion in this analysis were studies that demonstrated live capture trapping and active flea collection and provided habitat characterization and detailed data for flea and rodent species . Studies sites were categorized according to three impact levels : (1) High impact such as urban or densely populated areas ; (2) Intermediate , which included rural villages , and crop and rangelands ; and , (3) Low impact sites characterized as remote or wild habitat . For each study/habitat type , rodent and flea diversity (Shannon's H) and abundance (when available) , number of infested hosts and average flea burden per host species were calculated . Data was analyzed using t-tests or linear regression in SigmaPlot 9 .0 .

Results Thirty seven studies were included in this analyses . These comprised 11 high impact , 16 intermediate , and 10 low impact sites . Desert , Grassland and Deciduous forest type habitats were represented in each impact category . Overall , rodent and flea diversity was lowest at high impact sites (Figure 1) . As rodent diversity increases , the average number of fleas/host decreased . Flea diversity and number of host species infested was highest in habitats which experienced intermediate levels of habitat disturbance (Figure 2) .

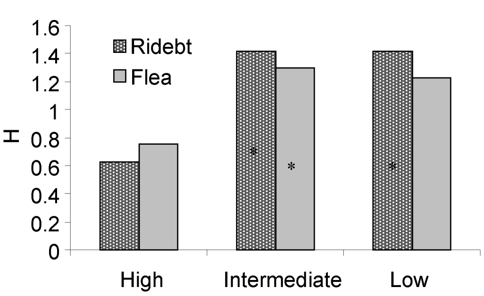

Figure 1 *Rodent vs . Flea diversity (Shannon's H) for habitats divided according to 1 of 3 disturbance levels ; * P< 0 .05 when compared to high impact sites .*

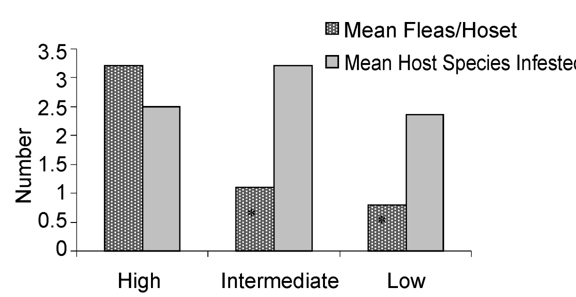

Figure 2 *Flea infestation parameters for rodents collected at 3 habitat types categorized according to disturbance level ; * P< 0 .05 when compared to high impact sites .*

Conclusions Transmission of zoonotic disease from wild reservoirs to humans most commonly occurs in rural environments . These sites provide the peridomestic rodent species essential to carrying disease from the wild reservoir hosts to commensal rodent living in proximity to humans . In addition , the results of this analysis suggest that the characteristics of flea assemblages within these communities appear to be conducive to plague transmission . Namely , flea diversity and host spectrum is greatest in areas that experience moderate amounts of disturbance .

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Morphological changes associated with forage quality in temperate pastures fertilized with nitrogen in autumn

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Key words: orchardgrass, bromegrass, lamina mass, lamina/sheath ratio

Introduction In the humid temperate region of South America, low temperatures of autumn and winter limits grasses growth (Gastal et al., 1992) and the rate of soil organic nitrogen mineralization. In consequence, strategic nitrogen application at this time is an effective tool to reduce the seasonal forage deficit. Growth, morphology, anatomy and nutrient content are related in forage plants (Lin et al., 2001). Nitrogen effects on growth dynamics and its short-term impact on the sward structure and forage digestibility, change in agreement to species composition, evaluation dates (Duru and Ducrocq, 2002) and rest defoliation periods considered. The aim of this study was to examine the modifications of some fractions of the herbage mass related to forage quality of annual and perennial grasses, occurring in the short term as a consequence of 50 kgN/ha applied in autumn.

Materials and methods The experiment was carried out in Gral. Las Heras, Buenos Aires province of Argentina (34°59′S and 58°50′W) in a 2-year-old pasture composed by Dactylis glomerata (orchadgrass-OR-) and Bromus catharticus (brome grass-BG-). The treatments were two, N0: 0 kg N/ha and N1: 50 kg N/ha applied in autumn, arranged in a complete random design with 3 replicates; the experimental units were paddocks of 40 m×220 m which randomly received the treatments. Data were compared by a T test ($p < 0.05$). The evaluation period took place between fertilization date, May 11 and the first grazing event, June 1, 20 days from fertilization date. Ten subsamples of the herbage mass were cut in each experimental unit; the harvested material was separated into died and alive, the latter in lamina and sheaths and oven dried. The determination of acid fiber detergent (AFD) was an indicator of forage digestibility.

Results and discussion Despite it was predicted a higher response of the annual grass, the short rest period from fertilization until defoliation probably would not allow the expected response [Figure 1 (a) and (b)]. The perennial grass didn't show a significant response either.

Figure 1 *(a) Lamina mass (g/m^2) and (b) Lamina/sheath (g/g). Minuscule different letters indicate significant differences ($p < 0.05$) between treatments. Capital different letters indicate significant differences ($p < 0.05$) between grasses.*

The perennial OR showed a decreasing trend in lamina/sheath ratios when it was fertilized (N0: 3.12 g/g 0.45 vs. N1: 2.06 g/g 0.22, p=0.1069) and a trend towards major AFD values compared with the annual BG when it was fertilized (BG: 20.57 ±0.54 vs. OG: 22.55±0.62, p=0.07). This would indicate that during the evaluation period, when successive leaves appeared, they were longer and contained more structural material, especially in case of nitrogen fertilization; also, AFD increments may be associated with the presence of longest sheaths which elongation occurred rapidly (Duru and Ducrocq, 2002). OR reduction in the proportion of lamina (p=0.012) took place with aging when it is frequently observed a concomitant nutritional value reduction (Lloveras and Churches, 2001).

Conclusions Attention must be paid about nitrogen fertilization decisions because of the occurrence of modifications such as lamina/sheath ratios in the perennial grass, issue potentially associated with forage digestibility decrease and its quality. Besides, a trade off seems to exist between the duration of the rest period required to generate significant increases in herbage mass, specially of the annual grass.

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Botanical composition :a tool to evaluate rangeland condition trends under different management conditions

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Key word : Botanical composition , rangeland management , dry matter production

Introduction Subtropical humid rangelands in Argentina are composed mainly of tropical species . Botanical composition is varied ; but C_4 grasses are predominat and produce most of the dry matter . Other botanical families are important depending of the soil type and management applied . Uncontrolled fire and overstocking affect the rangeland condition . There is some information related to changes in botanical composition . The objective of the research was to evaluate changes in the botanical composition of the rangeland under different burning frequencies and stoking rate .

Materials and methods The treatments applied were T0 : burning every 3 years no grazing ; T1 : burning every 2 years no grazing ; T2 : burning every 1 year no grazing and T3 : burning every 1 year and grazing of a stocking rate of 3 animals/ha . The botanical composition was evaluated on transects , 100 meters long , 5 transects in each treatment . Registers of range were made on areas 50×50 cm=0 .25 m^2 and every 10 meters . Botanical Composition was evaluated with Dry Weight Rank Methods (DWRM) (Mannetje & Haydock ; 1963) and analysed using software developed by INTA Corrientes Experimental Station . The botanical composition was analysed by ANOVA . The statistical design was completed at random design with five replications (transects) and the test of Duncan (α=0. 05) was applied . The changes , in botanical composition , produced by the treatments were described by cluster analysis .

Results The trial was conducted from September/1997 to March/2006 , Figure 1 shows the similarity between the treatments and Table 1 the contribution of each family group .

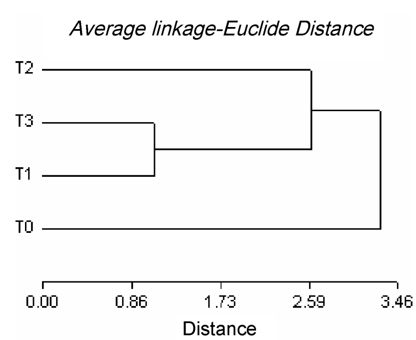

Figure 1 *Relation between treatments of botanical families .*

Cluster analysis was used as a tool , which proved to be useful , to describe changes produced in botanical composition by the treatments . T1 and T3 are closer and there is some difference between them and T2 . But they are quite different to T0 . The changes in botanical composition are similar under burning every 2 years no grazing and burning every 1 year plus grazing . The greater frequency of burning produced more changes than the changes produced by adding grazing .

Table 1 *Contribution (%) of each family group .*

Treatments	Grass	Legumes	Grass like plants	Other families
T0	68 .4a	3 .9ab	3 .9a	26 .9b
T1	72 .0a	3 .7ab	6 .2bc	21 .6a
T2	73 .3a	4 .9b	4 .5ab	21 .8a
T3	72 .5a	3 .3a	7 .5c	20 .6a

Conclusions Rangeland botanical composition was affected by treatments applied . T2 promoted the contribution of grass and legumes . T3 and T0 promoted the contribution of grass-like-plants and other families . Means with the same letter are not significantly different (α=0 .05) .

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The effect of aspect on persistence of several perennial grass species

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Key words : aspect , *Dactylis* , *Phalaris* , *Festuca* , *Lolium* , microclimate

Introduction Areas of the high rainfall zone ($>$600mm , average annual rainfall zone , AAR) of southern Australia have landscapes with variable topography . *Dactylis glomerata* , *Phalaris aquatica* , *Lolium perenne* and *Festuca arundinacea* are the main perennial grass species used in pasture of this region . Pasture establishment costs have been estimated at ＄230/ha with a minimum of 12 years required to recoup costs (Scott and Keys , 2007) . Therefore it is important that pastures species chosen for use are persistent . Varieties of *D . glomerata* , *P . aquatica* and *F . arundinacea* differ in their level of summer dormancy and this has been shown to affect persistence (Hackney *et al .*, 2006) . While New Zealand research (Radcliffe , 1982) has shown significant differences in pasture production , and microclimate due to variation in topography , this area of research has been overlooked in Australia . The aim of this study was to assess the persistence of *D .glomerata* , *P .aquatica* , *F .arundinacea* and *L .perenne* cultivars on two aspects of a hill paddock .

Materials and methods The experimental site was located at Burraga (149° 34′S , 34°51′E) . On 30th May 2005 *D . glomerata* (cvv . Kasbah , Uplands , Currie and Porto) , *P . aquatica* (cvv . Atlas PG and Holdfast) , *F . arundinacea* (cvv . AU Triumph , Quantum MaxP , Resolute Max P and Fraydo) and *L . perenne* (cvv . Victorian and Camel) were sown into a prepared seed bed , plots 2m×4m replicated three times on an east and west-facing aspect . Chemically the soils were identical on both aspects : pH_{CaCl_2} (0-10cm) of 5 .3 and at 10-20cm pH was 4 .2 with 25% exchangeable aluminium . Soil temperature at 10cm and soil moisture (10cm and 30cm) were measured on each aspect . Long-term AAR of the site was 750mm . Persistence was measured on 27th November 2007 by counting plant bases present in a 1m×1m quadrat .

Results Soil temperature was higher (Figure 1) and soil moisture consistently lower (not shown) on the west compared to the east aspect . There were significant cultivar by aspect effects (p=0 .009) on persistence of perennial grasses (Figure 2) . Persistence of all species (except *D . glomerata* cvv . Kasbah and Uplands) was significantly higher on the east compared to the west aspect . The summer dormant (SD) *D . glomerata* cultivars Kasbah and Uplands were the most persistent on the west aspect , with Uplands and the summer active (SA) cultivar Porto , the most persistent on the eastern aspect . Holdfast , a moderately SA *P . aquatica* cultivar persisted at higher densities than Atlas PG a SD cultivar , on both aspects but its persistence was inferior to the most persistent *D . glomerata* cultivars . All *F . arundinacea* cultivars except Fraydo were as persistent as the best *D . glomerata* cultivars on the eastern aspect , but were inferior on the western aspect . The SA cultivar AU Triumph was more persistent than the SD cultivars Resolute Max P and Fraydo on the *western aspect . Persistence of L . perenne* cultivars was lower on the east and west aspect compared to the most persistent *D . glomerata* cultivars .

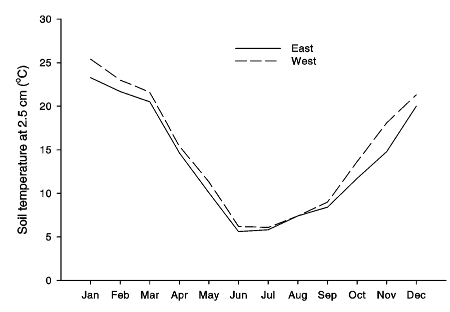

Figure 1 *Average monthly soil temperature on east and west aspects .*

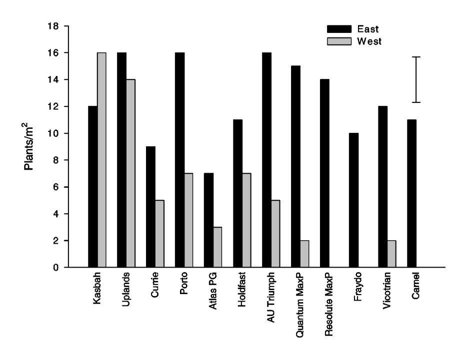

Figure 2 *Density of* D . glomerata , P . aquatica , F .arundinacea *and* L . perenne 2 .5 *on an east and west aspect .*

Conclusions Aspect and microclimate conditions had a significant impact on persistence of perennial grass species sown . Therefore farmers must consider these factors along with soil conditions in choosing the most appropriate species to grow in these landscapes . In some instances it may be possible to target SD varieties to areas of the landscape with harsher microclimates to improve persistence .

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Influence of growing season rainfall amount and clipping intensity on aboveground net primary productivity in *leymus chinensis* steppe

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Key words : rainfall variability , clipping times , transparent rainfall manipulation shelters , soil moisture , biomass

Introduction Aboveground net primary productivity (ANPP) is the foundation to assess structure and function of grassland ecosystem . The amount of rainfall is dominant climatic driver and clipping times (or grazing intensity) is important external perturbation to the variability of ANPP in the *leymus chinensis* steppe of China , However there're many different opinions on the relationship (Cai et al ., 2005 ; Bai et al ., 2004) . The objective of this study was to evaluate the adaptable clipping intensity under potential changes in rainfall .

Materials and methods This study was conducted in the Ba Shang steppe of Hebei , China (41°45′N , 115°39′E) . The main vegetation of productive , perennial rhizomes grass *L .chinensis* , perennial C_4 grass *Cleistogenes squarrosa* and *Artemisia eriopoda* . Mean growing season(may through September) rainfall totals 275 mm , annual mean temperature is 1 .4℃ . The experiment was implemented in 2005 , there is 6 combined-treatments including 3 rainfall gradient * 2 clipping intensity , each with three replicates . Rainfall gradient including R_1-using the Transparent Rainfall Manipulation Shelter (Figure 1) decreased 50% rainfall , R_2-ambient , R_3-increased 50% rainfall each time rainfall event occurred , extra 50% percent water was applied immediately . Clipping gradient including C_1-clipping during 20-25 august each year , C_2-clipping at the each beginning of growing month (Jun . to Sep .) each year . ANPP was estimated annually by accumulate each clipping aboveground biomass from two $0.5\ m^2$ samples per plots . Samples were sorted into dominant species (*L .chinensis* , *C . squarrosa* and *A . eriopoda*) and others , dried at 65℃for at least 48 h prior to weighing . statistical analyses using SPSS 13 .

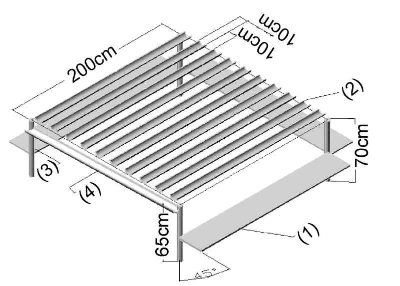

Figure 1 *Transparent Rainfall Manipulation Shelter Note :(1) side shelter (made of transparent plastic film) , length 200cm ,width 30cm , keep angle 45°with brace ; (2) above shelter (made of polyvinyl chloride (PVC) tube) , length 200cm , width 10cm , depth 4 .8cm , distance 10cm , fixed on removable woody shelf ; (3) there are 4 braces , one side two aboveground 70cm hight , the other side two high 65cm , form an inclined plane ; (4) side water guide tube (made of PVC tube) , fixed on the two brace which high 65cm , one point fixed on 60cm place aboveground , one fixed on 55cm place , form an inclined tube .*

Results

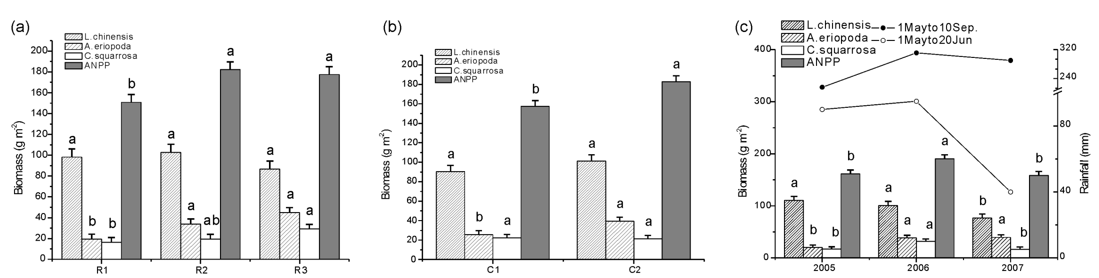

Figure 2 *Variability of ANPP and biomass of* L .chinensis , C . squarrosa *and* A . eriopoda *in (a) rainfall gradient ,(b) clipping gradient and (c) each years with rainfall patterns .*

Conclusions ANPP of R_1 significantly decreased due to direct effects of biomass of *C . squarrosa* and *A . eriopoda* , not *L . chinensis* . The increased ANPP of C_2 came from *A . eriopoda* . To compare with *C . squarrosa* and *A . eriopoda* , *L .chinensis* was more important status for ecosystem's stability , however it is vulnerable when drought happens at the beginning of growing season . Both the amount and patterns of growing season rainfall are important factor for ANPP .

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Impacts of long-term phosphorus fertilization and addition of perennial legumes on a temperate natural grassland : I . Changes in species biodiversity and stability

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Key words : species composition , P fertilization , grasslands , improved pastures

Introduction Grassland improvement with legumes and phosphate fertilizers enhances livestock productivity in Uruguay compared with performance achieved in natural grasslands . The objective of this work was to evaluate long-term impacts of legume introduction and phosphorus fertilization on botanical composition and structure of a temperate grassland .

Materials and methods The experiment was established in 1996 , in a Tipic Argiudol of Uruguay (33°14′58″S , 54° 29′24″W) , in a randomized complete block design with five replicates (2 ha each) . Three treatments were evaluated : a) Natural grassland without legume introduction and fertilization (NG_{0-0}) , improved oversown pasture (IP) with 4 kg ha^{-1} of *Trifolium repens* and 8 kg ha^{-1} of *Lotus corniculatus* and fertilized initially and annually with b) 45 and 30 kg ha^{-1} of P_2O_5, respectively (IP_{45-30}) , or fertilized with c) 90 and 60 kg ha^{-1} of P_2O_5, respectively (IP_{90-60}) . In 2006 , botanical composition was evaluated by species presence and canopy cover in 11 quadrats (50×50 cm) randomly distributed in each plot , adapting the botanal method (Tothill *et al .*, 1992) . The census information richness and Shannon Weaver diversity index (SW Index) were calculated . An F statistic with $P \leqslant 0.05$ (Tukey test) was used to determine the significance of all analyses .

Results and discussion After 10 years , IP showed significantly lower species richness than NG_{0-0} (Table 1) . The SW index was significantly lower in IP_{60} than in NG_{0-0}. Species frequency was significantly affected by legume introduction and fertilization . In IP , the perennial C_4 species were replaced by annual grasses in winter and by *Cynodon dactylon* in summer . A high frequency and ground cover biomass of exotic species (*Lolium multiflorum* and *Gaudinia fragilis*) , the native (*Vulpia australis*) and perennial invasive weeds (*Cynodon dactylon*) were found in IP compared with NG_{0-0}. There were no significant effects of fertility levels within IP in any of the tested parameters . The new community is similar to Mediterranean grasslands with high vulnerability in conditions of drought stress . Changes are in agreement with the fluctuating resources" theory (Davies et al ., 2000) , sustaining that community susceptibility to invasion increases when pulses of a limiting resource occur (e .g . nitrogen and water) .

Table 1 *Species richness (SR/plot) , SW Index and frequency of exotic (FE) and winter annual species (FW) in natural grasslands and improved pastures after 10 years of establishment .*

Treatment	SR/plot	SW Index	FE (%)	FW (%)
NG_{0-0}	60 a	1 .68 a	5 .8 b	3 .2 b
IP_{45-30}	35 b	1 .51 ab	26 .5 a	21 .8 a
IP_{90-60}	29 b	1 .36 b	30 .5 a	24 .4 a
P_{value}	0 .001	0 .012	0 .004	0 .001

Means followed by the same letter within a column are not significantly different ($P \leqslant 0.05$) .

Conclusions The results indicate the importance of developing strategies for managing IP to enhance production and maintain the diversity of natural grasslands .

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Effects of various cattle grazing regimes on vernal pool grassland diversity

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Key words: biodiversity, vernal pools, California, seasonal grazing

Introduction Vernal pools are small seasonal wetlands with a unique flora and fauna that occur throughout grasslands in California, USA. These grasslands have been grazed by livestock for nearly two centuries and the plant community surrounding the vernal pools is dominated by non-native species (Barbour *et al*., 1993). These habitats are decreasing in extent due to housing and commercial development. Government and non-profit organizations are protecting what remains of this habitat and often struggle to determine appropriate grazing regimens. The object of this study was to determine what level of grazing maintains the highest level of biodiversity in vernal pool grassland systems.

Materials and methods This study was conducted on a 5,000 ha parcel located in eastern Sacramento County, CA, USA (38°38′ N, 121°02′W; elevation, 75 m). The climate of this region is Mediterranean with average annual rainfall of 56 cm occurring between the months of October and May. Less than 2 cm of rain falls during the summer months. Four grazing treatments were applied to randomly selected groups of vernal pools during the 2000-2003 grazing seasons. The treatments were: 1) fenced throughout the grazing season (ungrazed, UG), 2) fenced during the wet season (dry-season grazed, DG), 3) fenced during the dry season (wet-season grazed, WG) and 4) unfenced throughout the season (continuous grazed, control, CG). Cattle exclosures ranged in size from 0.33-0.80 ha. Treatments were stratified across two major geologic formations and were replicated six times across the site. Plant diversity was measured using 35cm×70cm permanent quadrats in each of three zones (pool, edge, upland) during the spring. Weekly measurements of vernal pool inundation were recorded.

Results Complete grazing removal for three years (UG) reduced the diversity of native plant species occurring within the vernal pools [Figure 1(a)]. This effect was most noticeable on the pool edges but was also significant in the upland. The cover of grasses (both native and non-native) relative to the cover of forbs increased significantly over the three years in the ungrazed treatments [Figure 1(b)]. The average maximum inundation period in the control pools (CG) was on average 115 (±9) days, whereas ungrazed pools (UG) were only inundated for an average of 65 (±8) days, dry-grazed pools (DG) for 78 (±7) days and wet-grazed pools (WG) for 65 (±8) days ($P < 0.0001$).

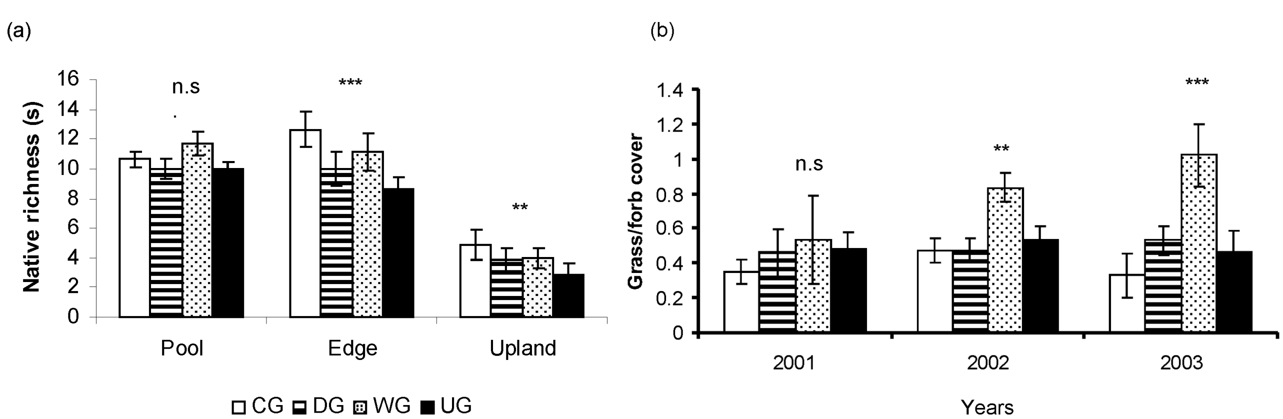

Figure 1 *Effect of four levels of grazing after three years of treatment on (a) native species richness in three pool zones and (b) the ratio of grass to forb cover across three years. n.s., not significant; ** $p < 0.01$, *** $p < 0.001$).*

Conclusions Cattle grazing at historic levels maintained higher native diversity in these vernal pool grasslands than any of the imposed grazing treatments. Complete removal of cattle grazing had the most negative impact on vernal pool systems reducing native richness, increasing grass cover and reducing inundation period within the pools during the wet season. Cattle grazing appears to be an important disturbance for protecting native diversity and pool inundation in these heavily invaded systems.

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Effect of long-term salt stress on antioxidative enzyme activities of NyPa Forage (*Distichlis spicata* var . yensen-4a) and tall fescue(*Festuca arundinacea* Schreb)

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Key words : salinization , ascorbate peroxidase , superoxide dismutase

Introduction Salinization plays a major role in soil degradation . It affects 19 .5% of irrigated and 2 .1% of dry agriculture land existing on the globe , including 38 .5 million ha that are salt-affected to various degrees in China (FAO , 2000) . Na^{+} imposes both ionic and osmotic stresses on plants , while the injurious osmotic effects and ionic toxicity lead to the generation of oxidative stress (Hernandez and Almansa , 2002) . To escape from the toxicity of activated oxygen species (AOS) , plants have developed a complex antioxidative defense system , including antioxidant enzymes such as ascorbate peroxidase (APX) , superoxide dismutase (SOD) and catalase (CAT) .

Materials and methods Two gramineous plants , NyPa Forage and tall fescue , were grown in plastic pots containing fine , white quartz sand . A half strength Hoagland nutrient solution was added daily . Thirty days later , salinity treatments were conducted by adding nutrient solution with 200 mM NaCl (salt stress treatment) or full-strength nutrient solution (control treatment) . Samples were harvested at 0 , 5 ,10 ,15 ,20 days after the start of the salt treatment .

Results The increased SOD activity in leaves was more conspicuous in NyPa Forage while its increase in roots was greater in Tall Fescue . APX activity was much greater in leaves of NyPa Forage than in leaves of tall fescue (Figure 1) . Activity of CAT in the leaf tissue of tall fescue , was not affected by salt stress throughout the experimental period .

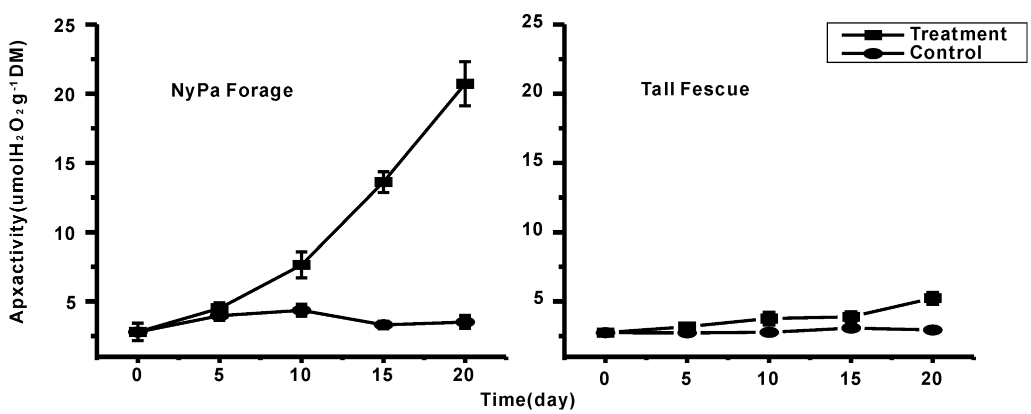

Figure 1 *Time course of total APX activity in leaves of NyPa Forage and tall fescue .*

Conclusion The present findings have suggested that NyPa Forage responded to NaCl stress by efficiently enhancing its antioxidative capacity in both leaves and roots when compared to tall fescue , and the results showed that the antioxidative enzyme activities of leaves and roots may not coordinate on the effect of salt stress . The antioxidative system in leaves was sensitive to salt stress , and may be an important biochemical trait for salt stress tolerance .

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Temporal and spatial variation of arbuscular mycorrhizal fungi spores in seasonally salt stressed grassland using *Medicago sativa* for reclamation in Hexi Corridor, China

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Key words: arbuscular mycorrhizal fungi, depth, *Medicago sativa*, salinity, season

Introduction Soil salinity is a problem of grave concern because it adversely affects growth and development of plants, especially in arid and semi-arid regions. Arbuscular mycorrhiza (AM) are ubiquitous symbionts between the fungus and host plant. This relationship enhances plant growth through increasing nutrient acquisition and carbon cycling, alleviating environmental stresses, and increasing biomass production. The objective of this study was to investigate the seasonally salt stressed affecting AMF spores of taproot systems plants at the reclamation grassland.

Materials and methods This study was conducted in the Linze Ecological Research Area of Lanzhou University (N39°15′, E100°02′), located in Hexi Corridor, Northwest of China. *Medicago sativa* was planted as test materials to reclamation seasonally salt grassland in 2001, 2002, 2003 and 2004, respectively. Rhizosphere soil samples were collected at four different depth as 0-20 cm, 20-50 cm, 50-100 cm and 100-200 cm in April(Shoot), May(Growth), June(Flower), and August(Seed) in 2005. AMF spores were isolated by wet sieving followed by sucrose gradient centrifugation (Daniels & Skipper, 1982). Data were analysed using Univariate Analysis of Variance with SPSS (v13.0)

Results Our results showed that the phenological phase, soil depth, and planted years influence the AMF spores significant (Table 1). (1) The 0-20 cm layer soil has the highest numbers of AMF spores (9.39±0.21/g dry soil), deeper rhizosphere soil reduced the richness of AMF spores. (2) The longer years that *M. sativa* planted, the more AMF spores were existed. (3) To the phenological phase, the largest number of AMF spores was in June (Flower) (4.41±0.21/g dry soil), and the lowest was in May (Growth) (3.20±0.21/g dry soil).

Table 1 *Univariate analysis of variance on the effects of growth stage, depth and plant years on the numbers of AMF spores.*

Source	Sum of Squares	df	Mean Square	F	Sig
Growth Stage (S)	60.459	3	20.153	5.983	0.001
Depth(D)	3538.322	3	1194.107	354.527	<0.001
Planted Year(Y)	145.085	3	48.362	14.358	<0.001
S*D	169.116	9	18.791	5.579	<0.001
S*Y	73.579	9	8.175	2.427	0.012
D*Y	265.222	9	29.469	8.749	<0.001
S*D*Y	227.446	27	8.424	2.501	<0.001
Error	862.252	256	3.368		

Discussion Mycorrhzal symbiosis is a key compent in helping plants cope with adverse environmental condition. In this study, results showed that AMF spores could be used as an indicator to evaluate the degraded ecosystem, and *M. sativa* is a potential materials to reclamation saline soil.

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The effect of environmental factors on plant species diversity and productivity

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Key words: Bayinbuluk grassland, Shannon-Weiner index, Tianshan mountain, CCA ordination

Introduction The analysis of species-environment relationships is a central issue in plant ecology (Antoine, 2000). Productivity is an important index for studying ecosystem function and determining conservation measures. Many studies have focused on the impact of environmental factors on plant species distribution and composition (Campagne 2006). In this paper, we discuss the effects of environmental factors on grassland productivity, species diversity and species diversity-productivity relationships using plant and environmental data from alpine grasslands.

Materials and methods Bayinbuluk grassland is a typical alpine cold grassland (82°27′-86°17′ E, 42°18′-43°34′ N) on the southern slope of the Tianshan mountain region, Xinjiang Province, China. In 2006, nine sites (10 m×10 m) were selected from typical vegetation types at 100 m vertical intervals along an elevation gradient. At each site, seven 1m×1m quadrats were sampled for grass species in late July. Grass species frequency, height and cover were recorded. Aboveground biomass in each 1 m^2 plot was clipped, sun-dried and weighed. Three soil samples were collected at each site. Soils were analyzed for organic matter, pH, soluble calcium, soluble bicarbonate, and water content. HOBO Pro RH/TEMP Data Loggers installed at each site recorded air relative humidity and temperature during the growing season. Soil compaction was measured with a soil compaction meter.

Results Thirty-five indigenous species in 29 genera and 15 families were identified. Values of the Shannon-Weiner index varied from 2.02 to 2.40. Species richness was negatively related to pH (-0.805), Ca^{+2} (-0.81), soil compaction (-0.755), air temperature (-0.742), total salinity (-0.733), and $HCO3^{-2}$ (-0.73) and was positively related to relative humidity (0.77) and soil water content (0.671). Aboveground biomass were negatively related to pH (-0.699), Ca^{+2} (-0.794), and soil compaction (-0.739) and positively related to relative humidity (0.754). A positive relationship was found (R^2 = 0.1847, P < 0.001) between species richness and productivity across the 63 plots. CCA ordination showed that the first axis (Eigenvalue = 0.704) accounted for 66.4% of the variation in environmental factors. Correlation between the first axis and species-environmental variables was 0.993. The second axis (Eigenvalue = 0.349) explained 21.9% of the variation. Axis 1 was correlated to air temperature, relative humidity, $HCO3^{-2}$, total salinity, pH, and Ca^{+2}.

Conclusions Mittelbach(2001) found hump-shaped and positive species richness-productivity relationships at continental scales. Our results are consistent with the positive relationships. The study scale and environmental heterogeneity may effect the species richness-productivity relationships. Ca^{+2}, pH, soil compaction and relative humidity impacted species richness and productivity in Bayinbuluk grasslands. The results of CCA ordination showed there are high correlations between axis 1 and air temperature, relative humidity, $HCO3^{-2}$, total salinity, pH value, and Ca^{+2}.

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Contribution of lucerne and red clover to succeeding cereal crops yield

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Key words : lucerne , red clover , spring wheat

Introduction Nowadays , under the conditions of sustainable or organic farming it becomes very important to use legumes . Introduction of ley/arable rotations could be an effective tool for a significant further reduction of the use of external N-input and an increase of the N use efficiency (Nevens et al ., 2004) . Species of legumes , management of the preceding sward thus greatly influences the yield of the succeeding crop (Høgh-Jensen and Schjoering , 1996 ; Kadžiulis , 2001) . The aim of the studies was to assess the contribution of two year age red clover and lucerne swards on spring wheat yield .

Materials and methods During 2003—2006 a randomized block design field trials were carried out on a loamy *Endocalcari-Epihypogleyic Cambisol* near Dotnuva , Lithuania (55°24′N , 23°50′E) . Soil pH varied from 6.5 to 7.0 , humus content was 2.5% -4.0% , available P 50-80 mg and K 100-150 mg kg^{-1} . Legume/grass mixtures were sown with and without a cover crop of barley (*Hordeum vulgare* L .) or peas (*Pisum sativa* L .) for whole crop or of barley for grain . Red clover (*Trifolium pratense* L .) and lucerne (*Medicago sativa* L .) were sown in mixtures with perennial ryegrass (*Lolium perenne* L .) . Barley and peas as whole crops were harvested at the wax and grain greasy stage , respectively , and for one treatment-barley for grain-at complete ripeness stage . The yields of swards were taken-off at flowering stage of the legumes . The swards were cut twice in the first year and three times in second year . The legume/grass swards in autumn of 2nd year were ploughed-in and succeding crop spring wheat (*Triticum aestivum* L .) for grain was sown in spring . Wheat was harvested at complete ripeness stage . During years of experiments climatic conditions differed : 2003 was dry , 2004 and 2005 were normal , and 2006 very dry and warm .

Results and discussion Lucerne/ryegrass swards were more sensitive to the competitive cover crop than red clover/ryegrass swards , yield formation rate was significantly higher of the swards that grew without a competitive plant , except for drier years (Table 1) . Yield formation rate and size of the red clover /ryegrass swards sown without a cover crop were to counterbalance the benefit provided by a cover crop , although in wetter years the total yield practically did not differ when grown with and without a cover crop . The effect of red clover/rygrass and lucerne/ryegrass swards on the yield of succeeding crop spring wheat and on nitrogen accumulation in grain significantly differed in wetter year due to the sward composition and did not differ due to different combinations of cover crop . In drier years the effect of sward composition on cereal yield was weak .

Table 1 *The yield of different legume/grass swards and their impact on succeeding spring wheat grain yield .*

Swards + cover crop	Yields from Experiment 1 , kg ha^{-1}				Yields from Experiment 2 , kg ha^{-1}			
	a) 2003	a) 2004	b) 2005	c) 2005	a) 2004	a) 2005	b) 2006	c) 2006
R . clover , p . ryegrass	2867	7897	2977	57 .5	6761	10334	2274	44 .4
R . clover , p . ryegrass+Bgr	5461	7486	3092	59 .7	5237	9530	2342	59 .5
R . clover , p .ryegrass+Bwc	6000	7722	3198	61 .7	6387	10887	2121	52 .8
R . clover , p .ryegrass+Pwc	4790	7498	3273	63 .2	6735	10388	2128	54 .3
Lucerne , p . ryegrass	4045	12056	3853	77 .4	6883	9803	2183	57 .4
Lucerne , p . ryegrass+Bwc	4715	10193	3780	76 .0	3993	7848	1866	48 .3
Lucerne , p . ryegrass+Pwc	5329	11805	3810	76 .2	4938	8810	2022	52 ,0
Perennial ryegrass	2025	3607	2092	40 .2	5826	4207	1776	41 .7
LSD_{05}	857 .7	766 .0	211 .9	4 .12	605 .9	771 .0	185 .4	4 .46

Bgr barley for grain , Bwc-barley for whole crop , Pwc-peas for whole crop , a) DM of swards , b) grain yield , c) N in grain

Conclusions The two years' total yield of swards and its formation rate differed due to legume species , different competitive plant and climatic conditions . The effect of legume species on the yield of succeeding spring wheat and nitrogen in grain yield dependet more on the climatic conditions than on other factors .

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Stability , recovery and resilience in piosphere systems in the Kruger National Park

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Key words : grazing gradients , ecological thresholds

Introduction The study aimed to resurvey herbivore utilisation gradients around artificial waterholes (piospheres) described in an earlier study (Thrash 1993) against a backdrop of waterhole closure and biodiversity management in the Kruger National Park (KNP) , to contribute to an understanding of factors governing recovery and resilience in protected areas . Key issues addressed include the response of the plant community and soil parameters to a relaxation of herbivore utilisation pressure at closed waterholes and changes in the same parameters at sites which have remained open . These ecosystem properties were considered in relation to structural and functional ecosystem thresholds (Briske et al . 2006)

Materials and methods Belt transects were laid out at eleven waterholes in the KNP . Transects extended from the waterhole to 5 km from the waterhole , and within that , herbaceous basal cover and species composition were sampled along four parallel transects , using a nearest-plant method . Compressed vegetation height , infiltration and soil compaction were similarly sampled . Soil samples taken at intervals along the distance-from-water gradients were analysed for total nitrogen and phosphorus , organic matter , pH and soil texture .

Results and discussion Basal cover increased significantly ($p \leqslant 0.05$) from 1990 to 2006 at all study sites and in all piosphere zones . There were no significant differences in basal cover between open and closed sites . Changes in basal cover were most closely related to high relative annual rainfall in 2006 compared to 1990 . Herbaceous species composition changed significantly ($p \leqslant 0.05$) from 1990 to 2006 , but with no significant differences in the amount of change between open and closed sites . No general piosphere patterns emerged in 2006 , in contrast to 1990 . Soil analyses (N , P , pH , organic matter , texture) and field measurements (infiltration , compaction) revealed no systematic piosphere patterns , although large increases in infiltration between 1990 and 2006 occurred , independently of waterhole closure . Herbaceous basal cover and compositional changes indicated that the system had crossed a structural threshold , but the lack of significant soil patterns points to this being reversible , as no functional thresholds were approached . Piosphere recovery appears driven largely by climatic factors rather than waterhole closure *per se* , within the time period under examination .

Conclusions Waterhole closure does not contribute significantly to recovery rates in piospheres in the KNP—this appears largely driven by variation in climatic factors . However , changes to the herbaceous composition/basal cover do indicate that a structural ecosystem threshold has been crossed , and ongoing monitoring is required to assess the likelihood of functional thresholds being crossed in the future .

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Impacts of grazing , wildfire and drought on rodent populations in a semi-arid grassland of southwestern north America

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Key words : heteromyidae , Muridae , fire ecology

Introduction Rodents are ecologically important vertebrates in semi-arid grasslands of North America , both for their effects on plant community structure and because they support a wide range of predators . Previous work has indicated the importance of both livestock grazing and wildfire to southwestern U .S . rodent populations , but little is known about their possible combined effects . A 2002 wildfire burned both grazed and ungrazed grasslands in southeastern Arizona where rodent populations were being monitored , providing an opportunity to compare rodent responses to the interactive as well as independent effects of grazing and fire .

Materials and methods The Appleton-Whittell Research Ranch is a sanctuary and research facility managed by the National Audubon Society , in the Sonoita Plain , Santa Cruz County , Arizona , USA . Ungrazed by domestic livestock since 1968 , the Madrean Mixed-grass Prairies" (Bock & Bock , 2000) , of the Research Ranch are surrounded by operational cattle ranches , providing opportunity for cross-fence comparisons (Bock et al . , 1984 ; Jones et al . , 2003) . The Ryan Wildfire of April 2002 encompassed nearly 15 ,000 hectares of semi-arid grassland , including parts of the Research Ranch and surrounding cattle ranches . Widespread drought has impacted the region since 1999 , partially alleviated by above average monsoon precipitation in 2006 and 2007 . Post-fire changes in rodent populations were evaluated by live-trapping (60 traps per site) on six grazed and six ungrazed sites during the summers of 2002 through 2007 , and the results were compared to earlier studies on the Research Ranch (Bock et al . , 1984 ; Jones et al . , 2003) .

Results and discussions Prior to the wildfire of 2002 , rodent communities on the Research Ranch were dominated by members of the Muridae family (i .e . deer mice , cotton rats) . Representatives of the Heteromyidae family (pocket mice) were relatively common on the cattle ranches , where vegetation cover was reduced . After the Ryan Fire , when all cover was reduced , Heteromyidae dominated all trap sites . Through 2005 , the murid rodents had not re-appeared in significant numbers on grazed or ungrazed sites . By 2007 , composition of rodent populations was similar to conditions prior to the wildfire .

Conclusions The size and completeness of the Ryan Fire , such that there were no nearby refugia from which the grass-loving rodents might re-colonize , and the drought conditions that slowed re-establishment of the more dense vegetation habitat preferred by the murid species may have contributed to the lag in re-establishment of pre-wildfire population densities and proportions .

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The Acacia Operation Project: a pilot activity for combating desertification and improving the livelihood of pastoralist in the arid rangelands of Kenya

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Key words: *A. senegal*, poverty, northern Kenya, food security, rural development

Introduction The Acacia Operation Project (AOP) was a pilot project supporting food security and rural development of gums and resins in the African Sahelian countries of Burkina Faso, Chad, Kenya, Niger, Senegal and Sudan (AOP document, 2003). It was a preparatory phase of a 10-year programme in the framework of the Network for Natural Gums and Resins in Africa. The overall objective was to contribute to sustainable development and food security and to combat desertification through the promotion and integration of gums and resins in rural economies. In Kenya, the project was piloted in the Samburu and Marsabit Districts from 2004-2006. The specific aim was to rehabilitate degraded land by planting *Acacia senegal* using novel water harvesting technologies and improving livelihoods through promotion of gum and resin production. This paper reports on outcomes, challenges and lessons learnt and implications for long term programme engagement in Kenya.

Materials and methods Initial work started in 2004 with meetings and participatory rural appraisals (PRAs) to sensitize and mobilize stakeholders about the project and the need to improve natural resources utilization. Local Project Management Committees (PMCs) were set up to assist and manage the project. Thereafter establishment of micro-basins and planting of the basins with *Acacia senegal* trees and drought tolerant crops commenced. Other activities included range-wide collection of germplasm for planting, capacity building for community groups, biophysical characterization of the soils in the sites, protection of planted sites, monitoring performance and survival of seedlings, training on utilization of drought tolerant crops, and evaluation of alternative livelihood systems. Educational tours were also conducted for the PMCs to facilitate technology transfer.

Results and discussion Sensitization meetings encouraged all stakeholders to embrace the project. As a result, the community donated land for project activities. A total of 20 sites totalling 285 ha with 54,000 micro-basins were ploughed and planted with various dryland trees and crops, depending on the site. A total of 1208 individuals were trained on various subjects including tree propagation techniques, seed collection, and crop and tree production. Crop performance was dismal except in Sereolipi where performance for beans, cowpeas, green grams and watermelon was very good in the short rainy season of 2004 and in Laisamis where cowpeas and sorghum did well during the long rainy season in 2005. In all other sites there was complete crop failure exacerbated by the 2005-2006 drought. *Acacia senegal* performance varied according to site with better germination and growth on rocky and sandy sites. Drought resulted in high seedling mortality in all sites, necessitating replanting. Livestock and wildlife interference meant that the plots had to be protected, which increased costs.

Conclusions Results showed that *A. senegal* can be successfully established in the region. However, biophysical characterisation is essential to provide a guide to the suitability of sites for gum-producing trees. Due to climatic uncertainties, project duration should be longer, say 10 years. Although crop production was limited by low rainfall, cowpeas, millet and green grams were promising in years of normal rain. More trials must be completed to provide recommendations on integration of crops into the *A. senegal* areas. Wildlife menace and soil salinity are also important challenges facing farmers in these areas. Cultural bias towards livestock is a major challenge in mobilising the community towards plantation agro-silvopastoralism. Since economic benefits from *A. senegal* are realisable after about 5 years when gum production starts, motivation for local participation can be guaranteed if support is given to the community to exploit existing natural plantations by linking them to markets and providing credit to producer associations. Similarly income-generating activities should be promoted and supported.

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Studies on the autecology of *Astragalus caragana F. et M* in the Esfahan Province of Ira

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Key words: planting, grazing value, semi steppic, vegetative spread

Introduction The genus *Astragalus* is generally considered the largest plant genus of Iran with more than 800 species (Lock and Simpson, 1991). *Astragalus caragana F. et M.* is the most important species of this genus. *Astragalus caragana* is distributed in semi steppic regions of Esfahan province. This paper presents the autecology and grazing value of *Astragalus caragana* in Esfahan province.

Materials and methods The study area is located in the semi steppic region of Esfahan Province in central Iran. The method of research was a standard reconnaissance method including collection of botanical, pedological, phenological, and climatological data as well as examining grazing preference values for the species and developing distribution maps.

Results and discussion The results indicated that the species is distributed over 568,400 ha of the western foothills of the Province at elevations between 1978 and 3320 m with 300 to 750 mm precipitation and 700 to 1300 mm evapotranspiration. It occurs on sandy to sandy loam soils with pH between 7.3 and 7.83 and salinity between 0.054 and 0.22 dsm^{-1}. *Astragalus caragana* covers about 3.8% of the ground in *Astragalus* spp., *Agropyron* spp., *Artemisia aucheri*, *Cousinia cylindlucea*, *Scariola orientalis*, *Euphorbia* spp., *Ferula ovina*, and *Bromus tomentellus* types. Phenological studies indicated that the vegetative growth begins in March when the average temperature is above 0℃ and the minimum temperature for 3 days is above -2℃. The best time for grazing is from 20 May to 5 Jun according to phenological studies. Due to its aromatic and phenolic components, it receives little use early in the season, but it is intensively grazed in mid season.

Astragalus caragana spreads via sexual and vegetative e propagation but most commonly spread occurs through development of rhizomes due to pests. This results in a clumped distribution of the species. Weight of 1000 seeds is about 20.5 g with 21.5% germination and with 58% scarification (does this mean hard seeds that must be scarified?). Interseeding in pitting are the best ways of revegetating the species. Seeds must planted 2.5 cm deep, and germination of 82% can be expected.

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Fire and vegetation change in coastal grasslands, South Africa

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Key words: fire, grassland, savanna, management

Introduction Successional progression from grassland dominated to tree dominated vegetation is common in both arid and humid areas. Factors influencing the successional processes vary depending on environmental conditions, with fire playing an increasingly important role with increasing rainfall. The influences of fire on these successional processes were investigated in the iSimangaliso Wetland Park (IWP), located on the east coast of South Africa. This area experiences annual summer rainfall in excess of 1000 mm, with a mean maximum temperature in January of 25°C and frost free winters with a mean maximum of 18°C in July. Land use (and associated fire regime) in the area has changed in recent decades from rural shifting agriculture to commercial forestry plantations (during the 1950s), conservation areas or wilderness areas. Fire and groundwater have been recognized as the main determinants of the coastal grasslands where regular inundation encourages a sedge rich hygrophilous grassland and above this, exclusion of fire results in succession through to forest scrub savanna and Dune Forest (Taylor 2003; Weisser & Marques 1979; Weisser & Muller 1983). Where large areas have been afforested with *Pinus elliottii*, the use of fire in the surrounding grasslands was prohibited. In the wilderness area, active management has been kept to a minimum, and fires, whether natural or anthropogenic, have not been extinguished. This resulted in regular and extensive fires in the wilderness areas.

Materials and methods Aerial photography from 1937, 1975, and 2000 was georectified, digitized, and analyzed using a GIS to examine broad vegetation changes in the natural vegetation adjacent to the plantations (zero to low fire frequency) and in the wilderness area (high fire frequency). Sites of comparable size and catenal position were located in each area. Vegetation changes, and the direction of change, were quantified on these sites. Vegetation was classified as grassland, scattered trees or dune forest.

Results and discussion In the low fire frequency areas adjacent to plantations, grassland and scattered trees decreased in extent from approximately 266 ha (39%) and 249 ha (36%) in 1937 to 61 ha (9%) and 80 ha (11%) in 2000 respectively, whereas Dune Forest increased from 111 ha (16%) in 1937 to 503 ha (73%) in 2000. Dune Forest and Scattered Trees increased at the expense of grassland up to 1975, after which Dune Forest increased at the expense of Scattered Trees. In the high fire frequency area, grassland was the dominant vegetation category in 1937, however this category decreased in extent from approximately 1615 ha (55%) to 970 ha (33%) in 2000. Dune Forest and Scattered Trees increased consistently from 732 ha (25%) and 537 ha (18%) in 1937 to 981 ha (33%) and 997 ha (33%) in 2000 respectively. Compared with the low fire frequency area where Dune Forest increased to dominate 60% of the vegetation these increases within the high fire frequency area are minimal. In the low fire frequency area Scattered Trees increased and then decreased with a change through to Dune Forest and Grassland decreased drastically. Within the high fire frequency area this change was not as drastic or as large. This difference still indicates a natural progression of these coastal grasslands to a woody dominated vegetation type but in the presence of regular disturbance, largely by fire, this progression is inhibited.

Conclusions The exclusion of fire from these coastal grasslands has a significant impact on the structure and composition of the vegetation, resulting in a complete transformation of the higher lying areas into a predominantly closed canopy dune forest. This transformation varied depending on proximity to higher lying areas and orientation within the catena where west facing sites showed the greatest degree of change. Lower lying sections tended towards scattered trees or a savanna-like vegetation type before ultimately progressing to Dune Forest. This implies that fire can be successfully applied or excluded as a management tool to manipulate vegetation composition and structure.

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Experimental increases in diversity and evenness improve productivity and reduce weed invasion in grassland swards over three years across 12 European sites

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Key words: diversity-function, evenness, persistence of diversity effects

Introduction Increased emphasis on the multifunctionality of European agriculture has called for a re-investigation of the use of mixtures in productive grasslands. Ecological research suggests that increased species diversity in species-poor intensive grassland systems may potentially provide multiple benefits. We present results from the COST 852 multisite Agrodiversity Grassland Experiment, where we test a number of basic questions in agronomic diversity-function research. It was hypothesised that (1) mixtures can outperform monocultures both in terms of productivity and weed suppression (2) the diversity benefits will be persistent through time (3) the diversity benefits will be consistent across a wide geographical scale.

Materials and methods A common experiment was established at 35 sites across Europe and Canada. At all sites, mixtures consisted of two legumes and two grasses. Using a simplex design (Cornell, 2002), 15 experimental communities were sown with varying levels of evenness and the design was repeated at two levels of overall initial abundance. Communities were monocultures, mixtures dominated in turn by each species, mixtures dominated in turn by pairs of species or communities with each species equally represented. For estimation of yield at each harvest, a subplot ($\geqslant 3m^2$) was harvested to a height of 5 cm. Total above-ground biomass for the first three years after sowing and the weed component of that biomass were analysed for 12 sites that used the same mid-European (ME) species (Figure 1). Average monocultures and mixtures were compared in a combined random coefficients repeated measures analysis across the 12 sites. This allowed us to assess whether, in general, mixtures outperformed monocultures across the three years.

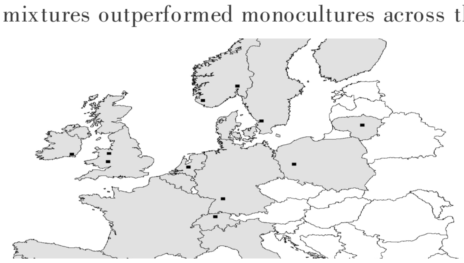

Figure 1 *Location of 12 sites that used the mid-European species.*

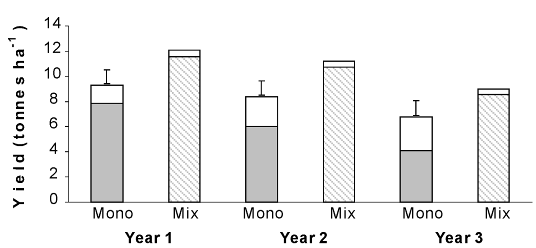

Figure 2 *Average yield of sown (shaded) and unsown (white) species in mixtures (mix) and monocultures (mono) for three years across 12 European sites.*

Results In each of the three years, the average yield of mixtures was greater than the yield of monocultures (Figure 2). While the average weed component of the monocultures increased from 15% in year 1 to 40% in year 3, weeds made up only around 5% of the total yield of the mixtures. By the third year, the average yield of the sown species in mixture was more than double that in monoculture.

Conclusions In Kirwan et al., (2007) we showed that in the first harvest year for 28 sites, there was a positive effect of diversity on productivity and that the effect was related to the evenness of the mixture. Here we show that for 12 of the sites, the diversity benefit persists into the third year both in terms of productivity and resistance to weed invasion. The diversity effect was consistent over a large range of environmental conditions, thus adding generality to our findings. The diversity effect was much greater than expected from previous studies and in the first year the diversity benefits were not only due to a legume effect; the positive interaction between two grass species and two legume species was as strong as that between a grass and a legume (Kirwan *et al*., 2007).

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A model for managing an endangered species in Sandhills rangeland

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Key words : blowout penstemon , endangered species , rangeland

Introduction Blowout penstemon (*Penstemon haydenii* S . Wats .) is an endangered perennial plant species native to the Sandhills region of Nebraska , USA . Populations of blowout penstemon have reached adequate numbers to consider reclassifying its status to threaten as outlined in the Recovery Plan (Fritz et al ., 1992) . Its habitat is disturbed areas of blowing sand in Nebraska rangeland . The survival of blowout penstemon depends on its ability to prosper in current conditions and on our ability to manage for minimum viable population levels . The impact of cattle grazing on this plant will be a key factor in effectively managing its populations . These impacts will be added to a Lefkovitch stage-structured model in later studies to determine its potential for self-sufficiency .

Materials and methods The number of plants remaining and flowering stalks which appear following grazing determine plant survival and productivity . Fifteen pairs of plants were chosen at random from each of two sites in the spring of 2006 . These plants were marked , the stalks were counted and measured , and the number of floral whorls was counted . Flowering stalks were counted again in the autumn after seed set . In order to simulate grazing , all flowering stalks and vegetative material was clipped to within 10 cm . of the ground from half the plants after bloom in mid June . The experiment was repeated on the same 60 plants in 2007 .

Results and discussion None of the clipped plants produced new flowering stalks in the same year after clipping . There was no significant difference in plant mortality between the clipped and unclipped treatments in the first year . For those plants which remained alive , there was no significant difference between treatments , in the mean change in number of flowering stalks from one year to the next (mean clipped = -0 .70 flowering stalks , control = + 0 .35 stalks ; $P = 0.2705$) . Clipped stalks had significantly shorter flowering stalks (28 .08 cm , $P = 0.0494$) in the second year than control plants (31 .43 cm , $P = 0.0494$) . The number of floral whorls in the clipped group (7 whorls) was significantly fewer than the number of floral whorls in the control group (9 whorls , $P = 0.0037$) in 2007 . In the autumn following clipping , there was a significant increase in vegetative shoots among the clipped groups at both locations (mean difference 5 .8 stalks per plant , $P < 0.0001$) . In the spring of 2006 , there was no significant difference in the number of vegetative shoots of clipped plants versus control plants . The mean number of vegetative stalks on clipped plants (6 .7) in the autumn of 2006 was significantly greater (mean dif . = 5 .8 , $P = < 0.0001$) than that of the control plants (0 .9 vegetative stalks per plant) . The number of vegetative stalks was not significantly different in the following spring (2007) .

Conclusions Grazing does not appear to significantly affect the survival of adult blowout penstemon plants after one year . It does cause a loss of production for the year of grazing as well as a reduction in the potential for seed production in the following year , as it produces smaller flowering stalks with fewer floral whorls . These effects in the short-term can be included in the stage-structured model as management events affecting seed production . Grazing events would decrease seed bank potential but not adult plant survival in the model . One recommendation would be to allow animals to graze after seed set , in order to prevent reductions in production potential . If the hoof action of grazing animals can open these blowouts to sand movement , allowing for seedling establishment (Stubbendieck et al ., 1989) , grazing late in the season could actually benefit the survival of the blowout penstemon .

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Sustainable recultivation and land use on karst regions—pasture system

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Key words: legume, pasture grasses, species screening, China

Introduction Karst areas in Guangxi are distributed across the entire Province, including four district cities and 33 counties. Carbonate rock is distributed across 89,500 km^2 of area, and accounts for 40% of the entire district area, making up 17% of the area of China's southern karst. In southern China, the area of karst totals about 540,000 km^2. The karst area of Guangxi is the typical of other karst areas in China and also of tropical and subtropical karst of the world. The karst geography of this project implementation site is a peak clump depression type. Various grasses have been used to establish pasture system in the karst region. Grasses and legumes have been screened for this purpose. Combinations of grasses and legumes, cultivation, soil nutrients and improvement of high-quality pastures have been studied.

Material and methods Mixtures of pasture grasses and legumes were tested in 7.8 ha plots in total. Twelve varieties planted including *Trifolium repens* cv. haifa, *Dactylis glomerata*, *Panicum maxumam*, *Aeschynomene americana*, *Cajamus cajan*, *Paspalum spp*. et al. They were planted in plots with 5 combinations plus a control plot. In April, we choose the ones that performed better to plant two mixed combination pastures with 10 ha for each. These species were *P. wetsteini*, *P. maxumam*, *Setaria anceps*, *Stylosenthes guianenses*, *C. cajan*, Haifa, *P. dilitaton*, *P. notation* and *A. Americana*. Three measurements were made on the Jun 11-17, Aug 29-Sep 3 and Oct. 29-30 in 2006 for height, fresh and air dry yield.

Results The results have shown that some species tested exhibited good emergence and were suitable for the karst area. The highest grass yield was in plot 3, with the fresh yield up to 30t ha^{-1} and the air dried matter field up to 7.7t ha^{-1}. Plot 2 came second with the fresh yield up to 30t ha^{-1} and the air-dried matter yield up to 6t ha^{-1}. The third was plot 4 with the fresh yield up to 26.3t ha^{-1} and the air-dried matter yield up to 5.6t ha^{-1}. The 4th gave to plot 5 with the fresh yield up to23.3t ha^{-1} and the air-dried matter yield up to 5.3t ha^{-1}. The better performing species were *P. wetsteini*, *P. maxumam*, *S. anceps*, *S. guianenses*, *C. cajan*, *A. americana*, *T. repens* cv. haifa, *P. dilitaton* and *P. notaton*.

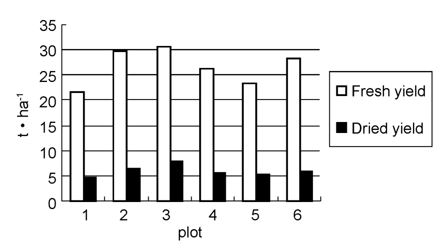

Figure 1 *Total annual pasture yield (t · ha^{-1})*

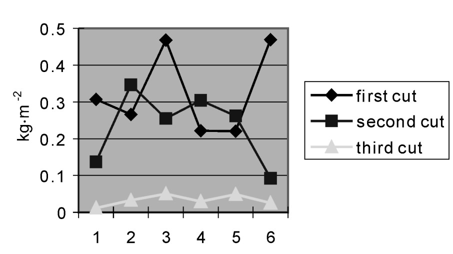

Figure 2 *Distribution pattern of yield (kg · m^{-2})*

Conclusions Based on the study, useful pasture cultivars and grass and legume combinations for establishment in the tropical and subtropical karst region have been identified and the pastures of the karst region are being improved.

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Sustainable recultivation and land use on karst regions—shrub system

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Key words: fodder tree, reforestation, screening, China

Introduction The karst area because of its special geological structure creates a number of environmental problems including water loss, drought, thin soils, desertification, and soil collapse, resulting in a fragile and unstable environment. The karst area in Guangxi spreads across the entire province. Carbonate rock is distributed 40% of and accounts for 17% of China's karst region. Some of it is degrading like the stony deserts, thus it is urgent to select suitable plants for re-vegetating it.

Material and methods We screened a large number of shrubs in order to make selections for re-establishing the shrub system. Nine cultivars have been tested including shrub fodder types, flowering shrubs and fruit trees et al, among them 3 strains of Japanese camellia, 6 strains of Japanese and Chinese chestnut, Japanese peach blossom and including 6 native species, two strains of mountain grapes, *Zenia*, *Morrus*, *Broussonetia*, *Leuceana* and *Cinnamomum*. We used five reforestation methods to plant seedlings only, branches, seedlings with soil, nutrition cup seedlings and directly seeding with seed.

Results Three foreign varieties have shown good adaptability. They are the Japanese prunus and Japanese camellia. Six domestic species did well: *Zenia* grew the fastest, reaching a height of 220cm in 10 months, the large seedlings of camellia planted with the soil grew relatively slowly, only 14cm in height over the same period. Growth rate were in the following order: *Zenia* > *Leucaena* > grapes > *Broussonetia* > *Morus* > *Cinnamomum spp* et al. Reforestation results were strongly influenced by soil preparation. Plowing prior to planting loosened the soil and the young shrubs had adequate water, fertility of soil, sun light, and heat to promote rapid growth. At the same time, the planting-hole method had the poorest results. For example, *Zenia* grew 285cm tall in all ploughed areas and was 2.2 times taller than shrubs placed in planting holes. The basal diameter (BD) of trees was 2.58 cm and 2.1 times bigger when planted on ploughed land. Biomass aboveground was 840 g and 3.8 times heavier, and the belowground biomass was 520 g and 4.3 times heaver for the planting-hole method. For grapes, height was 138 cm in ploughed areas, 2.5 times higher than for the planting-hole method, BD was 0.5 cm, or 7% greater. To chestnut, height was 106 cm in all plough, 1.4 times higher than in planting-hole method, BD was 1.80 cm, 25% bigger than the planting-hole method (Table 1).

Table 1 *Different soil preparation and biomass of trees (cm) (Average for all species).*

Soil preparation	Main root		Side root			Canopy of root	Biomass (g)	
	Length	BD	Length	No	Mean		Branch	Root
Tractor-plough	67	2.2	284	5	1.12	80	840	520
Planting-hole	60	1.2	147	4	0.87	65	220	120

Conclusions The better shrubs for recultivation were *Zenia*, *Leuceana* and *Broussonetia*. The best soil preparation was planting-hole method as it protects the soil surface from eroding and reduces water lose. This method of reforestation is expected to provide better results, even though initial plant growth is not as great as is shown in this research.

Root system ecology of shrubs in Qilian Mountains alpine *rhododendron* shrubland

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Key words : root system ecology , 16 shrub species , alpine *rhododendron* shrubland , disturbance , climate warming ,Qilian mountains

Introduction The Qilian Mountains National Nature Reserve located in the northeastern edge of Qinghai-Tibet Plateau is the key areas for global climatic change research . The alpine *Rhododendron*-shrubland survived above 3 ,000m in protection area has been attracting the attention for its important ecological services function , and is also the summer-pasture for rare white yak and other herbivores . Under global warming background , what or how the impact caused on the shrubland ecosystem by increasing human disturbance are the main reasons of this study . From root system ecology to understand belowground ecological characteristics and response of ecological process to disturbance could provide belowground ecological data and theoretical support for scientific utilization and conservation , however , alpine shrub root system studies were seldom found . The root system architecture and spatial distribution of 16 shrub species existing in alpine *Rhododendron* shrubland were studied , and the relationship with environment were discussed .

Methods The study area was the north slope of the Eastern Qilian Mountains , about 5 km from research station of GSAU . The shrub species existing in alpine *Rhododendron* shrubland were investigated including *Rhododendron thymifolium (R .t)* ,*R . capitatum(R .c)* ,*R . anthopogonoides (R .a)* ,*R . przewalskii (R .p)* ,*Salix oritrepha (S .o)* ,*S . rehderiana (S .r)* ,*S . sclerophylla(S .s)* ,*Lonicera hispida(L .h)* ,*L . rupicola(L .r)* ,*L . ferdinadii(L .f)* ,*Potentilla fruticosa(P .f)* ,*Spriaea alpina(Sp .a)* ,*Caragana jubata(C .j)* ,*Aretous ruber(A .r)* ,*Rubus irritans(R .i) and Hippophae tibetica(H .t)* . Coarse root length and distribution were studied by using traditional skeleton method to expose root systems ,and fine root length and distribution were studied by soil core sampling method and wet-sieving method(Mou P . , 1995 ; Robert ,2001) .

Results The root system of shrubs spread mainly in the 0-30 cm soil layer (Figure 1) . The shallow root dominant species *(R .t ; R .c ; R .p ; S .o)* and subdominant species *(S .r ; S .s ; R .a ; L .f)* form the constructive synusia of the community ; deep-rooted shrubs (*Sp .a ; P .f ; C .j*) are only companion species form the middle synusia ; *L . h ; A . r* compose the low synusia ,other species are rare species in community .

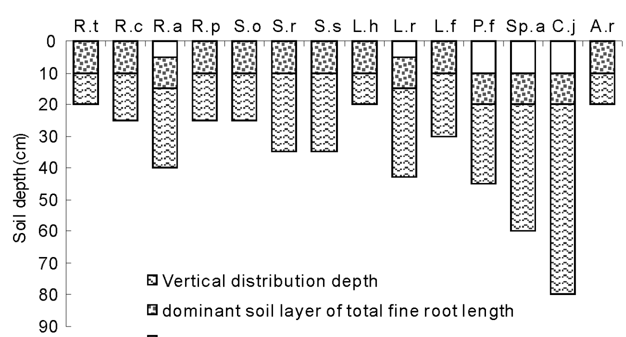

Figure 1 *Overlapping and separation of niche of different shrub roots in soil layer .*

Discussion By using niche overlapping and separating theory , the role of 16 shrubs species in the community and the relationship with environment can be explained . The dominant species and subdominant species adapt to the alpine freezing and humid environment with shallow and dense root distribution , but deep-rooted shrubs only can survived occasionally in community . Global climate warming and human activity disturbance may lead that the deep-root style shrubs replace the current shallow-roots type's constructive species in succession . The hypothesis is consistent with the status of serious damaged Rhododendron shrubland and transitional zone .

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Contribution of vegetative reproduction of *Leymus chinensis* and *Carex duriuscula* to population persistence during restoration succession after flood disturbance in the Songnen Plains, China

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Key words: tillers, rhizomes, meadow vegetation, succession, plant competition

Introduction *Leymus chinensis* is the dominant species and *Carex duriuscula* is a general companion species in *L. chinensis* meadows. Vegetative reproduction is crucial to perennial plant population persistence (Benson and Hartnett, 2006). In the Songnen Plains of China, a periodic flood due to abnormal weather was followed by natural recovery through successional processes (Li and Yang, 2004). Our objective was to quantify the contribution of vegetative reproduction to population persistence and dynamics.

Materials and methods The study was conducted at the Pasture Ecology Research Station of Northeast Normal University, Changling, Jilin Province, China (44°45′N, 123°31′E). Average annual temperature is 4.9°C. Mean annual precipitation is 470.6 mm. From August 1994 to September 1995, the *L. chinensis* meadow was flooded. All plants were dead. In the second year, *C. duriuscula* appeared; *L. chinensis* seeds began germinating after 2 years. In September 2003 and 2004, aboveground and belowground populations of both species were sampled randomly and on areas where the two species with different densities grew together. The collected areas were 0.25×0.25 m^2 with a depth of 0.30 m. Twenty replicates were collected on each date. Potential vegetative reproduction (PP) including that derived from tiller nodes (TPP) and rhizomes (RPP) were counted. The data were analyzed with SPSS statistical software.

Results The density of *L. chinensis* PP increased, but that of *C. duriuscula* decreased from 2003 to 2004 (Figure 1). The average productivity of tillering nodes and rhizomes for *L. chinensis* was about 7.8 and 1.2 times that observed for *C. duriuscula* in the 2 years, respectively. The ratio of the number of PP : the number of tillers was 1.76 for *L. chinensis* and 0.27 for *C. duriuscula* 2003 and 2004, respectively (Table 1). Approximately 76% PP of *L. chinensis* present in 2003 generated established stems in 2004, and while this figure was only 6% for *C. duriuscula*. These results indicate that the competitive ability of *L. chinensis* was much higher than that of *C. duriuscula* in terms of vegetative reproduction during recovery in an early successional stage in a *L. chinensis* meadow.

Table 1 *The productivity of tillers (individuals tiller^{-1}) and rhizomes (individuals m^{-1}) in 2003 and 2004. TPP/T= potential population of tiller nodes/tiller number. RPP/R = potential population of rhizomes/rhizome length. PP/T= total potential population/tiller number.*

Species	Year	TPP/T	RPP/R	PP/T
L. chinensis	2003	0.52	10.04	1.83
	2004	0.96	5.94	1.68
C. duriuscula	2003	0.14	7.22	0.35
	2004	0.05	5.92	0.19

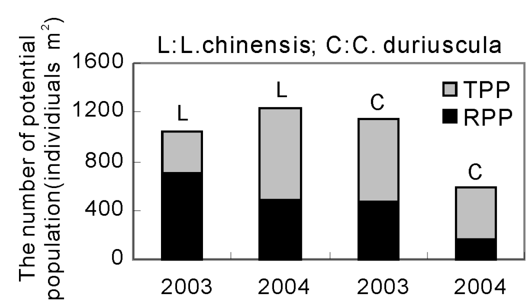

Figure 1 *The density of potential population on vegetative reproduction in 2003 and 2004. TPP: potential population of tiller nodes; RPP: potential population of rhizomes.*

Conclusions *L. chinensis* was superior to *C. duriuscula* in the production of tillering nodes and rhizomes as well as the storage of potential population in vegetative population. PP of both *L. chinensis* and *C. duriuscula* were good predictors of population dynamics of the two species. Consequently, PP played an important role during natural succession after flooding on the natural meadow. *L. chinensis* would the dominant species at a stable stage of recovery.

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Effects of endophyte infection on the response of *Achnatherum inebrians* to water stress and nitrogen fertilizer under controlled growth conditions

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Key words : drunken horse grass ,Xinjiang ,endophyte , tillers , nitrogen fertilizer , growth

Introduction *Achnatherum inebrians* ,locally known as drunken horse grass (DHG) , is a toxic perennial grass found in the western Chinese province of Xinjiang . Recent research shows that DHG is infected by an endophyte that is responsible for the production of the toxic compounds in DHG . It is not clear if this fungus also influences the agronomic performance of DHG . Therefore , an experiment was conducted to test the influence of this fungus , under controlled conditions of different levels of nitrogen fertilizer and water application , on the productivity of DHG .

Materials and methods A factorial experiment consisting of 3 rates of nitrogen (N) (0 ,50 ,100kg N hm^{-2} as ammonium nitrate) , 3 levels of water application (50 ,75 , and 100% field capacity) , and two endophyte (E) infection levels (3% and 94%) were conducted in a glasshouse environment . Six plants were grown in each pot . The aerial dry matter (DM) and tiller numbers of E infected (EI) DHG and E free (EF) DHG were measured .

Results and discussion There were a number of significant ($P<0.05$) inte ractions detected in this study . Although the mean DM production of DHG was not affected significantly by endophyte infection , at the highest level of N fertilizer , EI produced more DM than EF (Figure 1 , bars representing mean values with different letters are significantly different $p<0.05$) . Similarly , at the highest water level (100% field capacity) , EI DHG again produced significantly more DM than EF DHG (Figure 2) . EI DHG also produced more tillers than EF DHG at highest water levels (Figure 3) .

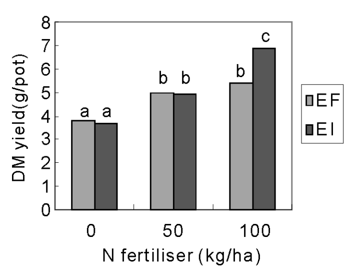

Figure 1 *DM yield of tillers of EI and EF DHG .*

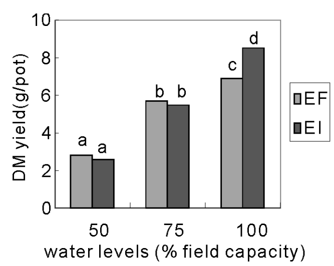

Figure 2 *DM yield of tillers of EI and EF DHG .*

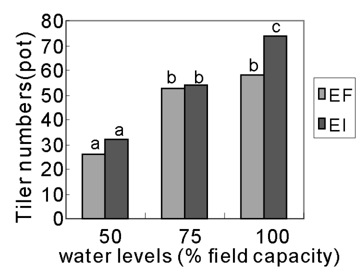

Figure 3 *Tillers Numbers of EI and EF DHG .*

Conclusions There have been few previous reports of the effect of endophyte infection on DHG growth . Studies on tall fescue indicated that the endophyte favors plant growth . However , interactions between the endophyte and other factors such as nutrient status , water and soil type make it difficult to predict a clear response of plant growth to endophyte infection . This study showed that under certain conditions , endophyte infection stimulates host plant growth . More studies are needed to reveal the mechanism of the endophyte-plant interactions .

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Forage potential of alfalfa (*Medicago sativa* L .) for wildlife

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Key words : alfalfa , forage yield , inoculation

Introduction Croatia has 724 hunting grounds with demand to increase the potential for hunting opportunities . To increase carrying capacity for wildlife our objective was to determine the influence of cultivar type of alfalfa and S . meliloti innocula strains on forage .

Materials and methods An experiment was conducted in northwest Croatia on a silt loam soil (Typic Udifluvents) , pH 6 .0 . Total monthly precipitation was 901 mm and average annual temperature is 11℃ . Four cultivars of alfalafa : Mirna , Posavina , OS 88 and OS 66 were seeded in a prepared seedbed in 1 .2 by 10 m plots at the seeding rate of 18 kg ha^{-1} . Seeds were inoculated (20 g peat kg^{-1} seed) with a peat based-commercial *S . meliloti* inoculant (2011) and two isolated indigenous *S . meliloti* strains (OS 6 and C 16) . The experimental design was a randomized complete block with treatments in a split-block arrangement , with four replicates (SAS Inst . , 1997) .

Results and discussions Obtained DM yield was significantly ($P = 0.05$) greater with cultivar OS 66 , while the effect of inocula strain by cultivars was not significant .

Table 1 *Total DM yield (t ha^{-1}) of 4 alfalfa cultivars inoculated by 3 different strains of* Sinorhizobium meliloti , Maksimir 2005 .

Strain/cultivar	DM yield (t ha^{-1})				
	Mirna	Posavina	OS 88	OS 66	Average strain
Control	14 .24	14 .35	13 .56	14 .93	**14 .27**
OS 6	16 .13	15 .77	16 ,01	16 ,66	**16 ,14**
C 16	15 ,97	15 ,82	15 ,41	15 ,96	**15 ,79**
2011	16 ,14	16 ,20	15 ,40	15 ,28	**15 ,76**
Average cultivar	**15 ,62**	**15 ,54**	**15 ,10**	**15 ,71**	
LSD 0 .05					1 ,2 t/ha
Strain x cultivar					NS

Conclusions These results are in accordance to Maćešić *et al* . (2007) , our results suggests there is some advantage in inoculating alfalfa seed when planting in areas where a legume species has not been grown before and that strain of *S . meliloti* bacteria may be an important factor to consider .

Acknowledgments The authors appreciate the financial support received through the project 0147 from the Ministry of science education and sports in Croatia .

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Preliminary investigations on Columbus grass (*Sorghum almum* Parodi) for fodder in semi-arid Nigeria :effects of sowing methods on growth components and herbage yield

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Key words : Columbus grass , semi-arid , sowing methods

Introduction Most of the ruminants in the country is located in semi-arid region , where feed supply is limiting during the long dry season . This research was conducted to investigate the growth and herbage yield of the introduced Columbus grass (*Sorghum almum Parodi*) using different sowing methods in a semi-arid region of Nigeria , where it is being considered for its possible use as fodder plant .

Materials and methods The experiment was conducted during the rainy season of 2005/2006 at the Usmanu Danfodiyo University Teaching and Research Farm (13°1′N , 5°15′E) , using a Randomized Complete Block Design (RCBD) with three replications . Soils were manually prepared using the hoe . The plots were marked out into parallel rows , separated by a 0.5m footpath . They were rectangular , slightly sunken 3m×4m ($12m^2$) basins . Three sowing methods were tested : a) broadcasting (at a rate of 19 .8 kg ha^{-1}) , b) dibbling (at a rate of 16 .8kg ha^{-1} in 50×50cm and , c) drilling (at 16 .8kg ha^{-1} same rate and spacing as for dibbling) . Plant height , leaf length , leaf width , number of leaves , stand establishment count and herbage yield were measured in each plot at intervals of 2 , 4 , 6 , 8 and 10 weeks after sowing to measure crop growth rate (Harper 1983) . Data were compared by analysis of variance , and LSD was used to compare means (SAS 1988) .

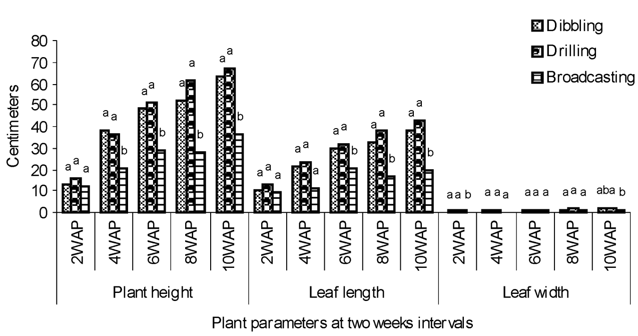

Figure 1 *Plant height , leaf length and leaf width of Columbus grass with different sowing methods at different time intervals .*

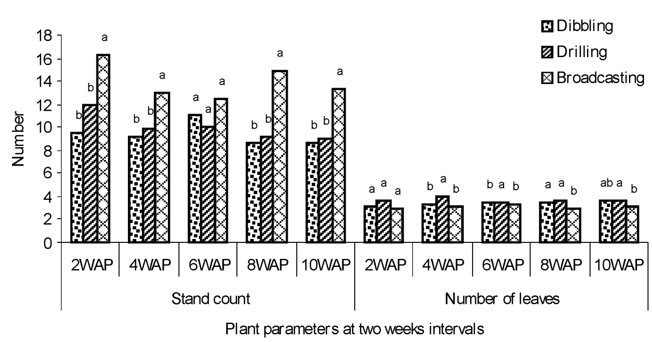

Figure 2 *Stand count and number of leaves of Columbus grass with different sowing methods at different time intervals .*

Results and discussion Plant height and leaf length differed significantly ($P < 0.05$) among treatments from 4 to 10WAP . (Figure 1) . The two parameters also increased with increase in time intervals . Leaf width differed ($P < 0.05$) at 8 WAP . Stand count and number of leaves differed ($P < 0.05$) except at 2 and 6 WAP respectively (Figure 2) . Drilling method required less seeds and produced the highest ($P < 0.05$) DM yield of 3170 kg ha^{-1} , which was however lower than the value of 8180 kg ha^{-1} reported by Muhammad (2004) in the same ecological zone .

Conclusion It can be concluded from our results that drilling greater amounts of seed resulted in greater dry matter production .

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Seasonal dynamics of the rangeland's vegetations of arid zone of Uzbekistan

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Key words: vegetation dynamic, arid zone, livestock, biomass, rangelands

Introduction About 65% of the territory of Uzbekistan is desert. The most important agricultural activity in this region is livestock production. The vegetation of desert and semi-desert rangelands is the most important source of feedstuffs for the livestock industry. The intensity of utilization of natural rangeland grazing resources mandates a program of monitoring of range vegetation condition and trend. The objective of this study is the analysis of intra-and inter-annual variation in biomass, cover, and species composition for the development of grazing plans that protect the forage resource.

Material and methods Comprehensive rangeland inventories were conducted 2-3 times per year for 6 six years on 4 rangeland sites typical of the South Kyzylkum desert: (1) *Artemisia*-annual rangelands; (2) Semi shrub-annual rangelands on foothills; (3) Shrub-semi shrub rangelands in mountainous regions; (4) Shrub-semi shrub rangelands on sandy desert. Measurements included cover, above-and below-ground biomass, frequency and density. Ordination analysis was conducted based on percent relative cover for all years.

Results and discussions The highest values of annual biomass were observed in the semi shrub-annual rangelands, foothills and shrub-semi shrub rangelands, and sandy deserts with 700—1100 kg/ha. Relatively low annual biomass was observed on *Artemisia*-annual rangelands and shrub semi shrub rangelands varying from 200 to 300 kg/ha. In general, our studies show that on properly managed rangelands annual biomass increases from spring to summer between 10 and 30%.

The results of line intercept measurements of cover confirmed the annual biomass analysis. Relatively high values were measured for intercept at all sites in autumn. Where intercept decreased in autumn, grazing pressure during summer was high. This is most likely to occur close to settlements and water sources.

Conclusions Long-term, intensive grazing by livestock has created characteristic plant community patterns along grazing intensity gradients radiating away from villages and water sources. In the fragile semi-arid and arid range sites of Uzbekistan, overused areas close to settlements and water sources can develop into desertification foci. The development of resource-protecting grazing schemes using long-range rest and rotation schemes is important to maintain the integrity of this important agro-ecosystem.

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Grazing summer-active tall fescue in south-eastern Australia

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Key words: tall fescue, tiller, production, persistence

Introduction In the Western District of Victoria, one of the dominant landscape features are valley floors, characterised by heavy clay soils which are prone to waterlogging in winter. Livestock producers could potentially improve pasture production over summer, filling the feed gap, while also reducing groundwater recharge by sowing summer-active tall fescue (*Lolium arundinaceum* syn. *Festuca arundinacea*) in these areas. However, there is little information on the production management and sward dynamics of summer-active tall fescue in this environment.

Materials and methods A summer-active tall fescue (cv. Quantum) pasture was established in November 2004. Two grazing system treatments were imposed in a completely randomised design in September 2006. They are: set stocked (SS), where the sward is maintained at an average feed on offer of 800-1000 kg DM/ha; or rotationally grazed at the 3 leaf stage (RG) to an average feed on offer of 800-1000 kg DM/ha over a 7—14 day period. The survival of tillers is monitored at the beginning of each month by marking all tillers in five fixed 100 mm diameter circular quadrants per plot that were located on tall fescue clumps.

Results and discussion Changes in tiller populations are shown in Figure 1. Tiller appearance rate in early summer (December and January) was low due to dry conditions. Rain in January 2007 (112 mm) prompted rapid tillering. Tiller death rates increased in March when tillers initiated in January died because of little follow-up rain. The autumn break occurred on 27 April 2007, prompting rapid tiller appearance in June. Waterlogging and cold temperatures resulted in few new tillers in July and August. Tillering increased in September in response to higher spring temperatures. Tillering was higher ($P<0.05$) under SS than under RG during July, August and September 2007, indicating SS continued tillering despite adverse growing conditions over winter and responded more rapidly to improving growing conditions in early spring. SS had higher ($P<0.05$) tiller death rates in November 2006 as the season dried off and over 2007's winter in response to low temperatures and waterlogging. These results indicate that SS responded quickly to good growing conditions, but was more sensitive to poor growing conditions.

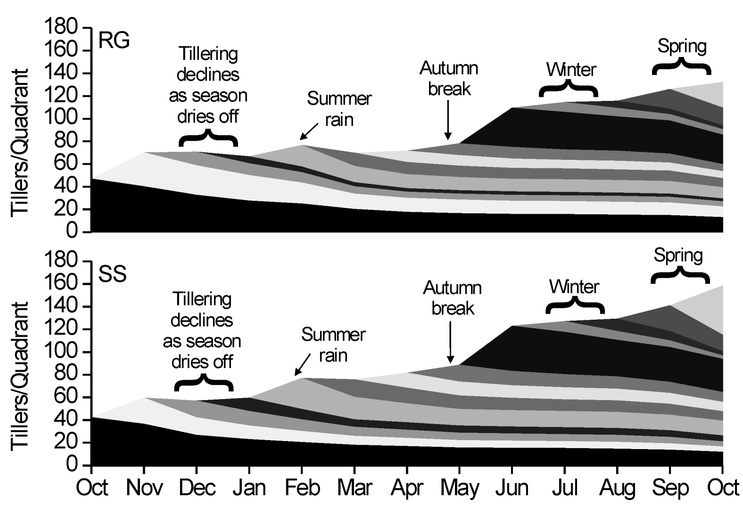

Figure 1 *Changes in tiller population and tiller age profiles for summer-active tall fescue under set stocking or rotational grazing over 2006/07. Shaded sections indicate trends in the population of tillers present at the start of the experiment and those appearing at successive monthly intervals.*

Conclusions A pasture sward consists of a population of tillers, the turnover of which determine pasture production and persistence. The results of this study show that tiller populations are more stable under rotational grazing than under set stocking and are dependent on growing conditions.

Tiller weight versus tiller number in a perennial ryegrass population : a productivity index

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Key words : plant dry weight , productivity index , size-density compensation

Introduction In defining agronomic indicators of sward status , tiller population density is often intuitively linked with sward vigour and presumed to be indicative of productivity potential . However , grass swards are subject to tiller size-density compensation and exhibit considerable plasticity , with shoot size and density subject to genetic variation , and varying with factors such as change in grazing height or seasonal light influx . A productivity index (PI) representing combinations of tiller size and density predicted to result in higher (or lower) sward leaf area index (LAI) and DM productivity (Matthew *et al* ., 1995) has been shown to be useful when comparing genetically similar swards under differing managements , but it is known that the cultivar Grasslands Ruanui has an anomalously high PI when compared with Grasslands Ellett (Bahmani *et al* . ,1997) . Here we report further investigation into factors affecting PI .

Materials and methods 3 clonal replicates of each of 200 full sib F_1 seedlings of a Grasslands Impact x Grasslands Samson cross were cultivated in 10cm diameter plastic bags in a glasshouse at AgResearch Palmerston North from April to July 2003 . Once established , plants were monitored for 4 leaf appearance intervals to determine leaf length (LL) , leaf appearance interval (A_L) , leaf elongation duration and (LED) , tiller number per plant (TN) , and plant dry weight (DW) . Plant spacing was such that the canopy approximated a closed field sward . For measurement units , see Table 1 . Leaf elongation rate (LER) , tiller weight (TW) , and PI (here : $\log_{10}$ TW + 1 .5 $\log_{10}$ TN/pot area) were also calculated for each plant . Data were averaged for clonal replicates and the data matrix of 8 variables for 202 genotypes so obtained , subjected to principal component (PC) analysis (using the covariance matrix) in Minitab version 10 .1 .

Results For each of the 200 genotypes and 2 parents , log (tiller weight , g) and log (tiller population density , m^{-2}) are plotted in Figure 1 . The solid line is an arbitrarily placed 1 :1 compensation line indicating combinations of tiller weight and density giving constant plant DW . The dashed line indicates constant PI (Matthew *et al* ., 1995) . The first 3 PCs (Table 1) accounted for 83% of the data variation . PC1 links high PI , DW and TN with lower LER and long LED . PCs 2 and 3 focus on change in DW and PI associated with TW and TN , respectively , and in both cases linked to high LER .

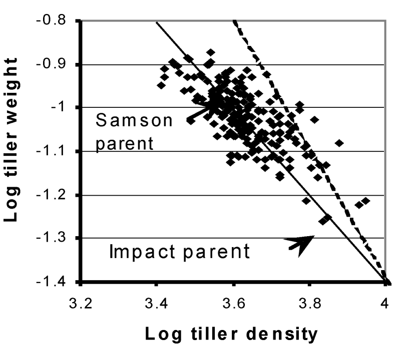

Figure 1 *Tiller size-density compensation within the Samson-Impact F1 population .*

Table 1 *Variable means and principal component (PC) structure for PCA exploring inter-relationships with Productivity Index (PI) . Coefficients less than 0 .2 are suppressed .*

	Mean	PC1	PC2	PC3
LL (mm)	176	-	0 .546	-0 .219
AL (days)	13 .3	0 .357	-	-0 .528
LED (days)	15 .1	0 .341	-	-0 .557
LER (mm day^{-1})	11 .9	-0 .347	0 .404	0 .229
DW (g $plant^{-1}$)	3 .2	0 .300	0 .482	0 .270
PI	4 .4	0 .444	0 .304	0 .338
TW (g)	0 .097	-0 .303	0 .428	-
TN (tillers $plant^{-1}$)	35	0 .493	-	0 .320
% variance explained	-	36 .9	26 .9	22 .8

Discussion and conclusions Means in Table 1 allow the reader to visualise the plant status during the experiment . As is common in PCA , the structure of PCs changed somewhat , depending on the variables entered into the analysis , but relationships between variables common to most PCA formulations were identified even so . PC1 has a strong size/density compensation component with small-tillered plants having high PI , a phenomenon also noted by Bahmani et al . 1997 . PC2 picks out genotypes with an association between LL , LER , DW , and PI , and follow-up study may be of interest to see if scores for this PC provide useful information for plant improvement .

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Biodiversity and structure of subtropical Boliviano-Tucumano mountain forests, depending on disturbance intensity due to forest grazing and selective timber logging

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Key words: agroforestry, Bolivia, plant species diversity, silvopastoral systems

Introduction The *Parque Natural de Flora y Fauna Tariquía*, Department of Tarija, Bolivia is dominated by the *Boliviano-Tucumano subandean semideciduous and seasonal evergreen vegetation* (Navarro, 2004). Theses forests have been used as dry season grazing area of Criollo cattle for centuries. In the last decades, easier accessible parts of the reserve were additionally affected by selective timber logging. The influence of forest grazing and selective timber logging on the plant species composition of the Boliviano-Tucumano mountain forests has not been studied before. This study investigated plant species diversity and forest structure in areas with different disturbance regime. The results can serve as a basis for decisions regarding the future management of the reserve.

Material and methods In three valleys of the mountainous nature reserve *Parque Natural de Flora y Fauna Tariquia*, with an altitudinal gradient of 990 to 1270 m a.s.l., 25 Gentry-type temporary plots each of 0.1 ha (50m×20m) were installed, and divided in 10 sub-plots of 10m×10 m. Plant species, height, diameter, infestation with lianas, and the phenological state of all woody plant species and lianas with≥2.5cm diameter (D.B.H.) were determined. Based on abundance, dominance and frequency, the Index of Importance Value (IIV) according to Mueller-Dombois and Ellenberg (1974) was calculated and used for Detrended Correspondance Analysis (DCA) to group the plots (Kent and Coker, 1992) and Canonical Correspondence Analysis (CCA) was used to determine the importance of the intervening variables.

Results Within the 49 families registered, the most frequently found families were Myrtaceae (17.1%), Solanaceae (9%), Sapindaceae (7.8%), Euphorbiaceae (5.6%), Bignoniaceae (5.5%), Melastomataceae (5.4%), Apocynaceae (4.8%), Rubiaceae (4.2%), Meliaceae (4.1%), Asteraceae (4%), Lauraceae (3.3%) and Fabaceae-Mimosoidae (3.2%). The most frequently found plant species were *Myrciaria delicatula* (10.5%), *Miconia calvescens* (5.3%), *Fosteronia glabrescens* (4.8%), *Sebastiania fiebrigii* (4.5), *Solanum symmetricum* (4.3%), *Psychotria carthagenensis* (3.6%), *Trichilia claussenii* (3.5%), *Vernonia pinguis* (3.4%) and *Blepharocalyx salicifolius* (3%). In total, 123 woody plant species and lianas were found. The Detrended Correspondance Analysis (DCA) of the plant species composition showed that the plots can be classified into five groups, according to the intensity of grazing and timber logging: In the less disturbed Group 1, the species with the highest Index of Importance Value (IVV) were *Trichilia claussenii* (8.1%), *Piper amalago* (5.5%), *Nectandra* cf. *angusta* (4.1%) and *Psychotria carthagenensis* (4.%). Group 2: *Miconia calvescens* (27.1%), *Solanum symmetricum* (8.9%), *Phoebe cf. porphyria* (7.8%), *Piper amalago* (5.7%) and *Amphilophium pannosum* (5.1%). Group 3: *Myrciaria delicatula* (15.5%), *Prunus* sp. (11.7%), *Ilex argentina* (11.4%), *Terminali triflora* (5.8%) and *Blepharocalyx salicifolius* (5.4%). Group 4: *Myrciaria delicatula* (15.5%), *Prunus* sp. (11.7%), *Ilex argentina* (11.4%), *Terminalia triflora* (5.8%) and *Blepharocalyx salicifolius* (5.4%). In the most disturbed Group 5, the species with the highest IVV were *Solanum* aff. *symmetricum* (16.9%), *Acacia aroma* (13.31%), *Vernonia pinguis* (13.84%), *Sapium haematospermum* (8.5%) and *Celtis spinosa* (5.3%). The groups 1 to 5 also differed in forest structure. Group 1 had the highest variability of diameter and height class. This variability decreased with increasing disturbance intensity, and also the mean base area decreased. The latter was 8.9 m^2/ha and 2 m^2/ha in group 1 and 5, respectively. At the same time, the number of plant individuals increased with increasing disturbance intensity. Areas with medium disturbance intensity had the highest cover percentage of lianas (almost 30%). In the Correspondence Analysis (CCA), the disturbance intensity (including both grazing and timber extraction) had a significant ($p < 0.005$) influence on the botanical composition of the different forest sites.

Conclusions The disturbance intensity had a significant influence on the botanical composition of the Boliviano-Tucumano forests. Furthermore, the number of plant individuals increased and both the mean base area and the variability of diameter and height classes decreased with increasing disturbance intensity. Further studies including controlled experiments and direct observations, are necessary to evaluate the influence of different intensities of cattle grazing on plant species composition and forest structure, and thus differentiate between the effects of timber extraction and forest grazing.

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Initial development of dwarf elephant grass (*Pennisetum purpureum* Schum .) clones in the coastal region of Pernambuco State , Brazil

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Key words : average leaf angle , leaf index area , light interception , hybrid

Introduction Elephant grass germplasm is highly heterozygous and presents great variability , which may be exemplified by its large variability in plant height ('T Mannetje , 1992) . Growth analysis of elephant grass clones with different plant heights it is an important tool to understand plant morphological adaptations to the environment and management strategies . This experiment aimed to evaluate physiological responses of elephant grasses clones with different plant heights .

Material and methods The experiment was carried out at the Agricultural Research Station of IPA , located in Itambe , dry forest zone of Pernambuco State , Brazil . It was evaluated eight elephant grass clones . Five of these clones are considered dwarf elephant grass (Taiwan A-146 2 .37 , Taiwan A-146 2 .27 , Taiwan-146 2 .114 ,Merker México MX 6 .31 and Mott) , and one of them (HV-241) is a hybrid with pearl millet . These clones , except Mott , were developed from the IPA/UFRPE elephant grass breeding program . The last two clones are elephant B (or Mercker) and IRI-381 . Elephant B is one of the first elephant grass introductions in Brazil . These two clones are not dwarf and represent the average clones used in the region . Growth was evaluated by measuring the leaf area index (LAI) , light interception (LI) , and average leaf angle (LA) , every 14 d , until 56 d of regrowth after cutting at ground level . For these measurements , it was used a LICOR LAI 2000 . It was used a complete randomized blocks design with four replications .

Results and discussion The relationship between LI and LAI was high ($R^2 = 0.99$) . Differences among elephant grass clones ($P < 0.05$) related to LI and LAI occurred only at 42 d of regrowth (Tables 1 and 2) . It was verified LAI reduction for the elephant grass clones after reaching 95% of LI (critical LAI) , however , time needed to reach critical LAI varied among elephant grass clones . According to Bréda (2003) , any change in the LAI is followed by modifications in the stand of forage plants . No differences among clones ($P > 0.05$) were observed for LA , with averages of 46° , 39° , 30° , and 38° at 14 , 28 , 42 , and 56 d of regrowth , respectively .

Table 1 *Leaf area index along the growth period of elephant grass clones with different plant heights .*

Clones	Growth , days			
	14 days	28 days	42 days	56 days
Taiwan A-146 2 .37	0 .9a	2 .1a	3 .0c	2 .8a
Taiwan A-146 2 .27	1 .2a	2 .4a	3 .7bc	3 .4a
Taiwan A-146 2 .114	1 .1a	2 .5a	4 .0ab	3 .5a
Mercker México 6 .31	1 .3a	2 .3a	4 .1ab	3 .0a
HV-241	0 .9a	2 .4a	3 .7abc	3 .1a
Mott	1 .2a	2 .4a	4 .5a	3 .3a
Elefante B	1 .2a	2 .5a	3 .4bc	3 .5a
IRI-381	0 .9a	2 .6a	3 .7abc	3 .1a
Mean	1 .1	2 .4	3 .8	3 .2
CV ,%	27 .5	19 .5	10 .7	12 .9

Means followed by different letters in the same column are different by Tukey test ($P < 0.05$) .

Table 2 *Light interception along the growth period of elephant grass clones with different plant heights .*

Clones	Growth , days			
	14 days	28 days	42 days	56 days
Taiwan A-146 2 .37	51a	81a	93b	91a
Taiwan A-146 2 .27	61a	89a	95abc	95a
Taiwan A-146 2 .114	57a	88a	96ab	94a
Mercker México 6 .31	60a	84a	97ab	91a
HV-241	52a	86a	96ab	92a
Mott	63a	84a	98a	93a
Elefante B	59a	88a	94bc	94a
IRI-381	53a	89a	95abc	93a
Mean	57	86	95	93
CV ,%	18	7	2	3

Means followed by different letters in the same column are different by Tukey test ($P < 0.05$) .

Conclusions The length of time needed to reach the critical LAI varies with the elephant grass genotype , indicating that management strategy should differ according to the genotype .

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Soil factors affecting the distribution of four salt tolerant range plants in eastern Azarbaijane province (Gharakhlar)

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Introdution Correct management of a range land is on the basis of ecological principals . Understanding the ecological processes is the main term of management Mesdaghi (2002) . Environmental variables consist of complex reactions between environmental variables and plants (canopy cover and density) Jangman (et al , 1987) . Various plant types have correlation with soil types . Zahran (et al , 1992) said that in saline areas salt , soil texture and organic carbon are the most important factors in distribution of plant communities . The results showed that index plants were the presidents of ecological soil factors . Layon and Sagers (2003) in misiyory of United states , by using ordination method (CCA , DCA) , came to the conclusion that there is a little correlation between plant vegetation . The goal of this research is determination of relationship between four saline range plants parameters (canopy cover and density) and physico-chemical soil factors to develop range lands , managing the vegetation and conserving the soil and water .

Materials and methods The investigation was undertaken in the part of sub-basin of Ghatoor Chai River , eastern Azarbaijan state in the north eastern of Iran .Mokhtari (2005) . Plant communities analyzed by topographic map (scale : 1/50000) , then in each community introducer site selected . According to the vegetation changes and the goal of research 10 transect with 50 meters long and 100 meters distance from each other lay down in each community . The way of sampling was random-systematic . In each transect the length of each plant's canopy cover recorded . For measuring the density of plants , the way of point-center quarterwas selected , besides soil sample supplied . In each transect soil dug through the depth of 60 cm , samples were removed from 0-20cm , 20-40cm and 40-60cm . In laboratory soil acidity , Electrical conductivity , sodium in saturated extract , (Ca + Mg in saturated exacted) , ratio of absorbed Na (Na .A .R .) , percentage of saturated salts (PSW) and soil moisture calculated in a way of weight .

Results The results of multiple regression analysis of investigating the relation between four index saline range plants and soil factors showed in Tables 1 and 2 .

Conclusions According to the results , there is a close relation between physico-chemical soil factors and density and cover percentage of the predominant plants . The results of multivariable regression showed that *Halocnemum strobilaceum* had direct relation with moisture of the soil , so distributed in the places that ground water was high . *Salsola .denroides* had direct relation with Na from other soil factors ; this was because of high resistance of this plant to the salt of the soil . pH , clay and Na had effect on the distribution of the *Atriplex veruciferum* . Direct relation of this plant with clay percentage was due to the presence of this plant in the heavy and high PH . The weak or none relation of this plant with soil factors in the first layer may be because of the structure of their roots . *Aeluropus littoralis* had inverted relation with the absorbed Na , this was due to the low resistance of this plant to salt compared to the other species . This result confirmed the results of other researchers (Jafari , 2004) , (Zare Chahooki , 2001) , (Mirmohammadi et al , 2002) .According to the relation between density and vegetation percentage with soil features can determine that predominant plant vegetation of the majority of soils with S .A .R .E .C and Na was *Halocnemum strobilaceum* and *Salsola dendroides* . This result was the same as Mirmohammadi (et al , 2002) and Alakh & Rdif (1988) .

Table 1 *Step by step multi regression of different species density .*

Species	Depth	Soil factor	R^2	Equation
Hal-str	0-20	moisture	75 .4	Y=-187+ 135moisture
	20-40	moisture	70 .2	Y =1154+ 151moisture
	40-60	moisture	46 .9	Y=-977+ 115 moisture
Sal-den	0-20	-	-	-
	20-40	-	-	-
	40-60	Na	84 .9	Y=190+ 0 .824 Na
Atr-ver	0-20	-	-	-
	20-40	Clay , S .A .R	94 .4	Y=2358+122 clay−31 .9 S .A .R .
	40-60	moisture	32	Y= 0 .056 −184moisture
Aelu-litt	0-20	Ca+ Mg	32 .1	Y=311−1 .72(Ca+ Mg)
	20-40	-	-	-
	40-60	Loam , EC , moisture	83 .1	Y=1157+14 .4 silt−2 .6 EC−4 .77 moisture

Table 2 *Step by step multi regression of different species canopy cover .*

Species	Depth	Soil factor	R^2	Equation
Hal-str	0-20	Moisture and sand	71	-Y=-12 .1+56 .1 moisture+0 .381 sand
	20-40	Moisture	29 .1	Y= 5+0 .961 moisture
	40-60	Moisture	21 .2	Y=4 .8+0 .775 moisture
Sal-den	0-20	Na , Ca+ Mg , Clay	73 .4	Y=3 .38+0 .00517Na−0 .132Ca+ Mg+0 .341 clay
	20-40	-	-	
	40-60	Na	79 .5	-Y= 0 .642+0 .00310Na
Atr-ver	0-20	pH	27	-Y= 156+19 .8 pH
	20-40	Clay , S .A .R	97 .3	Y = 2 .58+0 .728 clay−0 .653 S .A .R
	40-60	Moisture and Clay	64	Y= 54 .5−1 .54 moisture+0 .0365 clay
Aelu-litt	0-20	S .A .R , PSW	64 .4	Y =1 .95−0 .109S .A .R+0 .116 PSW
	20-40	pH	17 .6	Y = 7 .25−0 .737 pH
	40-60	S .A .R .	30 .9	Y= 1 .66−0 .00579S .A .R .

Does disturbance similarly facilitate weed invasion within grass , forb , and shrub plots ?

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Key words : growth form , soil resources , safe sites , *Bromus tectorum* , *Isatis tinctoria*

Introduction Big sagebrush communities (*Artemisia tridentata* Nutt .) in the Great Basin have been degraded by the synergistic consequences of chronic disturbance and annual weed invasion (Young and Evans 1978) . Repairing ecosystem function is an overarching goal of restoration efforts , but it remains unclear which species most effectively resist weed invasion and how disturbance mediates weed invasion . We evaluated whether disturbance similarly facilitates invasion in single-species grass , forb , and shrub plots .

Materials and methods Experiments were conducted at Millville , UT (41°39 .44′N , 111°48 .88′W , 1402 m) . The soil is a gravelly loam series . Plots (1 .5 m×1 .5 m , 1 m aisles) were established in May 2003 from transplants reared in a greenhouse , and consisted of 24 plants in a 5×5 square arrangement equally spaced (30 cm apart) , with the center plant absent . Three plot-types were randomly located with 30 replicates : grass (*Agropyron cristatum* [L .]) , forb (*Achillea lanulosa* [Nutt .] Piper) , and shrub (*Artemisia tridentata* var .*wyomingensis* [Beetle & A . Young] Welsh) . A disturbance treatment was applied in mid November 2004 to 15 replications by removing four plants from the 1 m^2 center of plots with a shovel to potentially increase above and below-ground resources and create safe seed sites for the two invasive species . Plots were seeded an invasive annual grass (*Bromus tectorum* L .) and an invasive forb (*Isatis tinctoria* L .) autumn 2004 and 2005 (400 seeds per species) . Total weed seedling density was determined in summer 2005 and 2006 . Total (non-weed) shoot dry mass , soil nitrate and solar radiation (400-700 nm) at the soil surface was determined for plots in summer 2006 .

Results Disturbance significantly increased weed density for all three growth forms except for *Agropyron* in 2006 (Figure 1) . Within a treatment , weed density was less variable in 2005 than 2006 . Weed density also sharply increased between 2005 and 2006 in all plots except *Agropyron* . In fact , weed density declined within disturbed *Agropyron* plots during the study . In contrast , *Achillea* and *Artemisia* plots had 2-3 fold greater weed density than *Agropyron* . Total plot non-weed shoot dry mass (g) of *Achillea* (1957 ±542) was lower ($P < 0.01$) than *Agropyron* (4608±542) , which was lower ($P < 0.01$) than *Artemisia* (14 ,594 ± 542) . The disturbance treatment did not consistently increase soil nitrate (mg kg^{-1} soil) or solar radiation at the soil surface (mol m^2 s^{-1}) . However , *Achillea* plots had significantly greater ($P < 0.01$) mean soil nitrate and solar radiation (5 .2±0 .05 and 382±50) than *Agropyron* (1 .3 ± 0 .05 and 355 ± 50) and *Artemisia* (0 .9±0 .05 and 155±50) plots , respectively .

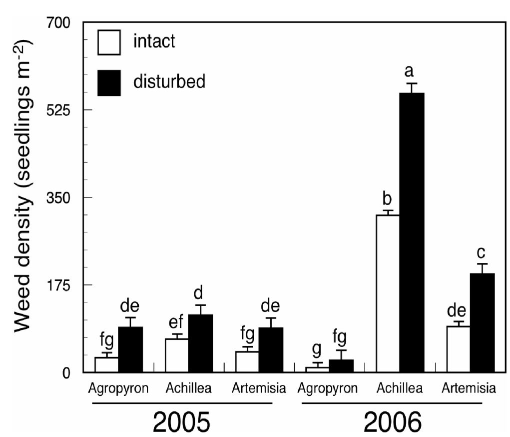

Figure 1 *Mean (+1 SE) weed density in autumn . (Lowercase letters indicate differences ($P < 0.01$) .*

Conclusions The importance of disturbance to mediate weed invasion is clearly corroborated by our results . The capability of the long-lived perennial grass (*Agropyron*) to resist invasion appears to be associated with greater biomass productivity . In contrast , high susceptibility to weed invasion of *Achillea* plots was due to significantly greater amounts of underutilized above and belowground resources (Davis et al . , 2000) . Our results agree with the general contention that disturbance events increase available resources or safe sites for weed invasion . Perennial grasses appear to be a necessary component of minimizing underutilized resources . Our results also emphasize that managerial efforts to reduce the recurrence of disturbance events should be a primary goal to reduce the impacts and prevent continual dominance of invasive annual species in the sagebrush-steppe ecosystems of the Great Basin .

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The effect of annual weather on spring grass phenological development

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Key words: temperate, phenological development, climatic conditions, primary growth

Introduction Phenological development of grasses differ across years, and among species and their cultivars. This study was conducted to compare phonological development among five grass species under field conditions during active spring growth. These temperate C_3 grasses include: *Lolium perenne* L., *Phalaris arundinacea* L., *Bromus inermis* Leyss., *Festuca arundinacea* Schreb. and *Phleum pratense* L.

Materials and methods Pure stands of each species and their cultivars were grown on a highly fertility loam (chernozem); average climatic conditions (last forty years) to the middle of June-precipitation 227.1 mm, T-sum of mean daily temperatures 1244.5℃, sum of sunny hours per day 889.2 hours. Individual shoots of grasses (n=30) were randomly selected from the pure stands and tagged with plastic ribbon. Phenological measurements were made 8 times in 4-8 day intervals during the primary growth between mid-April and early June. Data recorded on each shoot were: extended shoot height (ESH), number of dead leaves per shoot (NDL; a leaf was considered dead if more than half of the leaf lamina from the tip was withered), lamina length (LL) of the live leaves. Calculations include: number of leaves developed per shoot (NL), number of active leaves (NAL) per shoot, sum of active leaf lamina lengths per shoot (SALL), index of leafiness (IL), ratio of SALL to ESH, which is used as an indicator for the leafiness. Data were analyzed using SPSS software.

Results and discussion The climate index for grass growth (Vinczeffy 1991) showed weather differences across years (Figure 1). Annual precipitation had the greatest effect on grass growth differences among years (Nagy 2007). The experimental years may be considered as rainy, somewhat rainy, extremely rainy and reasonably dry for 2004, 2005, 2006 and 2007, respectively. Temperature conditions and the sunny hour accumulation were more balanced than rainfall in the experimental years. However, both sum of temperature and sum of sunny hours were remarkably greater in 2007 compared to the other experimental years. There were great significant differences in the mean phenological development of temperate grasses between experimental years (Table 1). Phenological development of grasses was advanced in 2006, and remarkably depressed in 2007. The highest relative differences expressed as a percentage to the lowest value in the years were 88%, 39%, 43%, 52%, 92% and 41% for ESH, NL, NDL, NAL, SALL and IL, respectively.

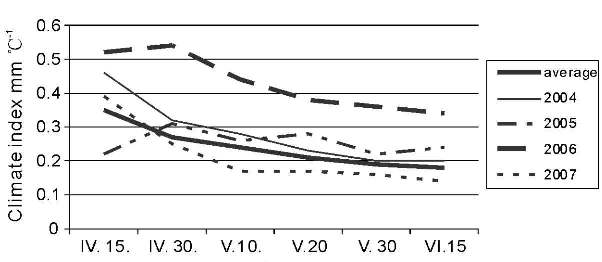

Figure 1 *The climate index for grass growth.*

Table 1 *Results of phenological development.*

Mean	2004	2005	2006	2007	Mean	$LSD_{5\%}$
ESH	67.04	60.08	78.81	41.76	61.95*	4.91
NL	6.86	6.32	7.07	5.08	6.32*	0.43
NDL	1.24	1.27	2.00	1.39	1.47*	0.56
NAL	5.61	5.05	5.07	3.69	4.85*	0.44
SALL	117.26	109.68	105.53	60.86	98.11*	12.59
IL	2.01	1.93	1.42	1.56	1.73*	0.34

* $P<0.001$

Conclusion During the spring grass phenological development is weather dependant.

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Ecology of herbaceous legumes in the Fortescue River valley floodplain , western Australia

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Key words : population dynamics , herbaceous legumes , plant cover , floodplain , rainfall

Introduction In the Fortescue floodplain herbaceous legumes (HL) are mainly taxa of Papilionaceae (with one Mimosaceae) that fail to develop woody stems and branches . Historical data from Curtin University (MRC) studies suggest that vegetation condition is primarily dependent on the unpredictable (though seasonal) influence of cyclonic rainfall and consequential flooding (Fox *et al* . , 2006) . Biomass production is known to increase with the presence of legumes in both pastures and native ecosystems . Holm (*et al* . , 2002) suggests that productivity is more useful than diversity for determining the condition of arid ecosystems/ pastures . Therefore , understanding the role of HL in the productivity of arid floodplains may enhance effective pastoral management .

Materials and methods Between 1992 and 1994 , 60 plots were established across the Fortescue floodplain to record information on vegetation dynamics . These plots were spread across Ethel Creek (22°53′56″S , 120° 01′19″E) , Roy Hill (22°37′18″S , 120° 55′23″E) and Marillana cattle stations (22°38′S , 119°24′E) . The mean annual rainfall (1907—2006) at Ethel Creek is 276 mm . The predominant vegetation types are Coolibah (*Eucalyptus victrix*) woodlands with a grassy understorey and open grasslands , both with cracking clay (vertosols) soils . Plant density and cover have been recorded since studies began in 1992 , at least bi-annually . In 2006 assessments were conducted in May (post summer) and August (winter) . Each plot is 20×25 m with angle iron pickets on each corner . The first transect (0-25 m) runs north-south along the eastern boundary . The second transect (26-50 m) runs parallel to transect 1 through the plot centre . Quadrats of 1×1 m are assessed sequentially . All live plants are identified with density (no . of stems in the m^2) and estimated percentage cover is recorded . The mean cover (%) and density (stems/m^2) are then calculated for each species within each plot .

Results Total biomass of the floodplain is highly correlated to available moisture with an extreme very low mean cover of all plots in April 2005 of <0 .5% and ~65% cover by May 2006 (data not shown) . In total , some 21 taxa of HL have been recorded (1992-2006) . Herbaceous legumes have occurred at all 60 plots , but have not always been recorded at a particular assessment . Early in the study , herbaceous legumes were small contributors and grasses were mainly annual (Figure 1) . *Cullen cinereum* is the most important HL accounting for a mean proportion of 62 .8% of total HL cover for 2006 .

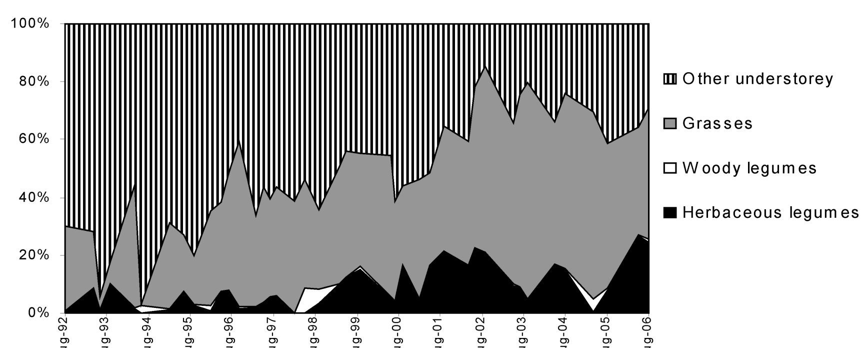

Figure 1 *Proportion of understorey cover (%) from 1992-2006 of all plots assessed .*

Conclusions Increased growth of legumes has followed regionally higher rainfall across the study period . Legume growth may also be contributing indirectly to an increase in grass biomass through nitrogen fixation and increased ground cover . This is assumed to be contributing to overall improved floodplain productivity . It may be concluded that the pasture condition of the Fortescue floodplain has generally improved through the duration of the study . Research into patterns of herbaceous legume growth would confirm if and how these species actively contribute to enhanced productivity .

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Hydraulic lift through the root systems in *Zygophyllum xanthoxylum*

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Key words: arid ecosystem, desert plant, hydraulic lift, water potential, transpiration

Introduction Water is the primary factor limiting plant growth in arid ecosystems. Hydraulic lift may be important in desert ecosystems because this phenomenon may enhance or prolong uptake of water and nutrients through roots during periods of water stress. During hydraulic lift, at night, water absorbed through deep roots in moist soil depths and transported into dry soils in upper portions of the profile, may increase the amount of water available to shallow roots. However, hydraulic lift may not occur in all plants. Our study was designed to investigate the phenomenon of hydraulic lift in *Zygophyllum xanthoxylum* and evaluate the effect of hydraulically lift on plant water transpiration.

Materials and methods The desert shrub *Z. xanthoxylum* were evaluated and two treatments (shaded, unshaded) were applied. Plants were transplanted into a top and bottom split-root apparatus in August 2004. The soil was the mixture of 70% fine sandy loam soil + 30% potting soil. Both top and bottom pots were irrigated regularly. On 2th June 2007, the top pots were irrigated at 25% VWC (volumetric soil water content) and then allowed to dry with the bottom pots continuing to receive water to attain a VWC of 18% (TDR, Germany). The pots were irrigated at 18:30 each day. Thus, when the VWC in top pots was lower than that in bottom pots, soil water potential in the top pots was monitored every 3 hours (PSψPRO, America). Then one treatment was shaded from 18:00 on 7th June to 9:00 on 9th June, the other was not shaded. Meanwhile the top pots were covered with plastic to prevent soil evaporation. Additionally, plant transpiration was measured at 12:00 on 7th June, and from 9:00 on 8th June to 12:00 on 9th June (LI-6400). Shading was provided by four layers of black nylon mesh which reduced solar irradiance by 80%.

Results Hydraulic lift was detected at the top pots for both treatments (Figure 1). Hydraulic lift occurred at night from 21:00 to 9:00 at the next day, hydraulically lifted water remains in the top pots until the transpiration reinstated from 9:00 to 21:00. For unshaded pots, water potential $\triangle\psi_s$ ($\triangle\psi_s = \psi_{max} - \psi_{min}$) was 1.24 MPa, and 1.05 MPa in the shaded pots, significantly smaller than that in unshaded treatment ($P < 0.05$). Before shading and after the shading were removed, the plant transpiration rate increased from 1.39 mmol H_2O m^{-2} s^{-1} to 1.72 mmol H_2O m^{-2} s^{-1} at 12:00, whereas it remained relatively constant for plants in the unshaded pots (Figure 2).

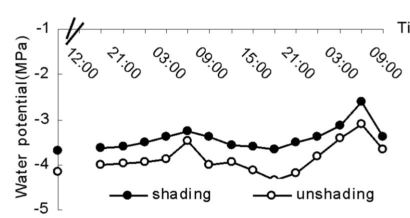

Figure 1 *Water potential in the top pots in different treatments.*

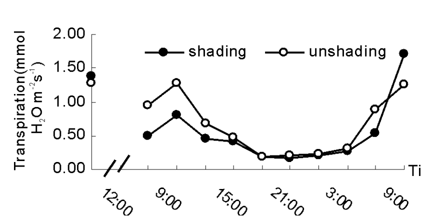

Figure 2 *Plant transpiration in different treatments.*

Conclusions Our results suggest that hydraulic lift was occurring in the desert shrub *Z. xanthoxylum*. The greater plant transpiration after remove of shading treatment may attribute to large hydraulic lifted water by suppression of transpiration. Hydraulic lift may be a plant adaptation to arid environments.

Acknowledgement This study was sponsored by the National Basic Research Program of China (2007CB108903) and China National Natural Science Foundation (30671485).

Effect of sowing and oversowing on species abundance in mountain pastures of central Italy

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Key words : agro-tourism , biodiversity

Introduction Large parts of Central Italy are mountainous and marginal due to climate constraints , shallow soils , steeped slopes and distance from main roads . Pasture productivity is low nonetheless of the agronomic advances , and farmers increase their incomes by offering tourist services . Agro-tourism is favoured by conservation of biodiversity (Uncini Manganelli et al ., 2002) . Under this point of view , farmers seek low input techniques for pasture management that sustain the productivity and at the same time conserve plant diversity (Pardini , 2002) . A trial was done to control what is the effect of sowing and oversowing on productivity and abundance of pasture species . This research has been fund by ARSIA of the Regional Government of Tuscany .

Materials and methods The trial took place from 2004 to 2007 in a mountain pasture (830 m asl , 40% slope) . We compared 3 treatments :
1 .Native pasture (control test , not changed) .
2 .Sown pasture (sown in April 2004 after ploughing at 20 cm depth and then disk harrowing . Sowing mixture *Lolium perenne* (25%) , *Poa pratensis* (25%) , *Trifolium repens* (25%) , *Onobrychis viciifolia* (15%) , *Lotus corniculatus* (10%) , the total seed quantity was 50 kg/ha) .
3 .Oversown pasture (seeded in April 2004 after light disk harrowing . We seeded the same pasture mixture) .
Measurements carried out were the following .
1 .Botanical composition (linear analysis , plus a list of rare species found out of the lines) .
2 .Forage yield (monthly cuts inside cages during the growing period April-October) .

Results and discussion The number of plant species in oversown plots (49) was not significantly higher than in native pasture (52) , but it was lower in son plots (41) , the species missing are mainly short (*Crocus albiflorus* , *Taraxacum officinalis*) , most of them have biological importance and they are known as medicinal plants .

The biomass of the sown plots doubled in 2004 in comparison to the native (Table 1) , it was high also in oversown plots . The positive effect terminated after 3 years in the sown plots and after 2 in the oversown plots .

Table 1 *Biomass in native , sown and oversown pasture .*

	2004	2005	2006	2007	Average
Sown	6 .0 a	5 .7 a	4 .5 a	3 .4 a	4 .9 a
Oversown	5 .0 b	3 .7 b	3 .4 b	3 .2 a	3 .8 b
Native	3 .1 c	3 .0 b	3 .3 b	3 .1 a	3 .1 b

Values that share same letters in columns are not significantly different at $P=0.05$.

Conclusions We conclude that the repetition of sowing practices can reduce the number of species ; on the other hand biomass is increased for 2-3 years maximum . Oversowing did not increase the biomass enough . The good management of native pasture will be cheap and will favour the conservation of plant diversity and , in turn , support the development of the industry of rural tourism . Sowing should be limited only to flat areas where there is only little soil erosion and there is deeper soil , in these areas would be reasonable to repeat the sowing at 4-5 years of distance and to change always sowing mixture introducing several grasses and legumes in order to help maintaining the diversity of plants .

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Genetic structure and AFLP variation of six native *Festuca hallii* (Vasey Piper) populations in the Northern Great Plains of Canada

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Key words : genetic structure , AFLP , *Festuca hallii* , native

Introduction *Festuca hallii* (Vasey) Piper is a dominant native grass species in the Fescue Prairie of Northern Great Plains that has undergone dramatic range reduction in the past century . However , little is known about the genetic diversity and structure of this species . Also , little effort has been made to assess the effectiveness of sampling in capturing genetic diversity in native plant species . The objective of this study was to assess the comparative genetic diversity of plains rough fescue using AFLP markers .

Materials and methods Six *F . hallii* populations were collected from Prince Albert National Park , Batoche National Historical Site , Riding Mountain National Park , Macrorie , Kernen Research Farm and Turtleford . Three AFLP primer pairs were employed to screen 529 samples representing about 30 samples each of reproductive tiller , vegetative tiller and seed collected from each population . The gel images were scored as 1 (present) or 0 (absent) . The scored bands were analyzed for the level of polymorphism by counting the total number of bands and the number of polymorphic bands , and calculating the proportion of polymorphic bands . The within-population variation was calculated with respect to population as the average number of pairwise differences within a population using AMOVA (Excoffier et al . 2005) . Mantel test and PCO analysis were conducted using GenAlEx 6 .

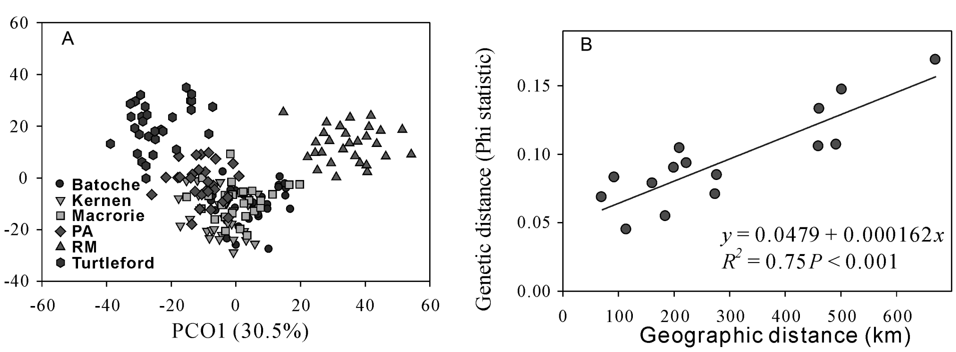

Figure 1 *Principal coordinate analysis of 529 individual plants (A) and the relationships between geographic and genetic distance (Phi statistic) (B) from six* Festuca hallii *population as reflected in the samples of reproductive tiller .*

Results A total of 330 polymorphic AFLP bands were scored for each sample and their occurrence frequencies ranged from 0 .01 to 0 .99 and averaged around 0 .47 . Comparisons of the three sample types in each population revealed more polymorphic bands in the seed samples than the tiller samples , while the mean band frequencies were similar . AMOVA revealed more than 90% of the total AFLP variation resided within natural populations (reproductive and vegetative tillers) and within seed samples . Only 0 .2% AFLP difference was revealed among the three sample types . The tiller samples revealed not only the larger among-population variation than the seed samples , but also the significant associations of AFLP variation with population geographic distances .

Conclusions A large number of polymorphic DNA fragments detected by three AFLP primer pairs show the utility of AFLP in assessments of genetic variability in *F . halli* . Different sampling methods captured different population structures . This finding along with those of Fu et al . (2004) suggests that different sampling methods may differ in the effectiveness of capturing genetic variation . Results from this study are significant for germplasm sampling for ex situ conservation , are useful for the germplasm development for pasture seeding , and should facilitate the management of fragmented fescue populations .

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Drought response of *Trichloris crinita* plants with different aridity history : water use , leaf elongation and senescence

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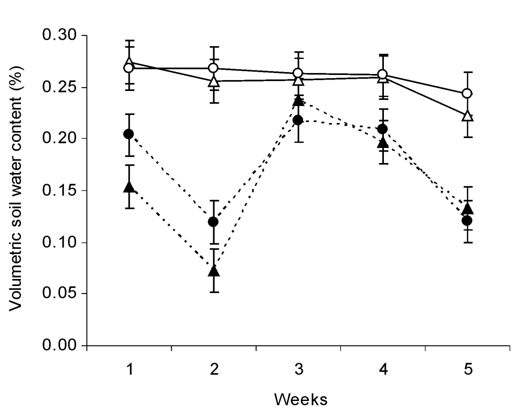
Key words : intraspecific variability , drought resistance , common-garden experiment , Argentina , Chaco Arido region

Introduction An important part of the world presents arid climate . Investigating adaptive responses of plants to drought is central for genetic improvement and for ecological theory (Endler , 1986) . The aim of this work was to evaluate the effect that aridity , as a selective force , imprints over the drought response of plants of *Trichloris crinita* , a forage native grass of the Argentinean Chaco Arido region .

Materials and methods We collected seeds of *Trichloris crinita* plants from two sites with different aridity history : Dean Funes (humid site , H" ; mean annual precipitation = 625 mm) and Chepes (arid site , A" ; m .a .p . = 326 mm) . In September , 2005 , 40 experimental units (two 10-L pots with 1 plant each one = 1 experimental unit) per origin were established in a common garden at INTA La Rioja Experimental Station . Twenty experimental units of each origin were randomly assigned to each drought treatments : high watering level (control , 3-L/pot/week) and low watering level (drought , 1 .5-L/pot/week) . Treatments were imposed from 30 November , 2005 to 4 January , 2006 , in a randomized complete block design . Weekly we measured the volumetric soil water content (SWC) in 6 pots per origin and drought treatment combination , and the leaf elongation rate (LER) of the youngest leaf in a selected tiller per plant , for all plants . The percentage of senesced leaves (PSL) in all the selected tillers was measured on 28 December , 2005 . Data were analyzed using ANOVA models , with the MIXED procedure of the SAS package (SAS Institute , 1996) .

Results In general , drought reduced LER and SWC for plants of both origins . Within the high watering level no differences in LER and SWC were observed for H" and A" plants (Figure 1 and Figure 2) . By contrast , differences were observed within the low watering level : H" plants showed similar LER than A" plants during weeks 1 and 2 , but then H" plants showed lower LER than A" plants during weeks 3 to 5 (Figure 1) . Also , H" plants presented lower SWC than A" plants during weeks 1 and 2 , but no differences were observed between H" and A" plants in weeks 3 to 5 (Figure 2) . PSL of plants from both origins was also affected differentially by drought . Within the high watering level no PSL difference was observed between H" and A" plants (30% vs . 33% , respectively) ; but within the low watering level , H" plants showed a greater PSL than A" plants (62% vs . 42% , respectively) .



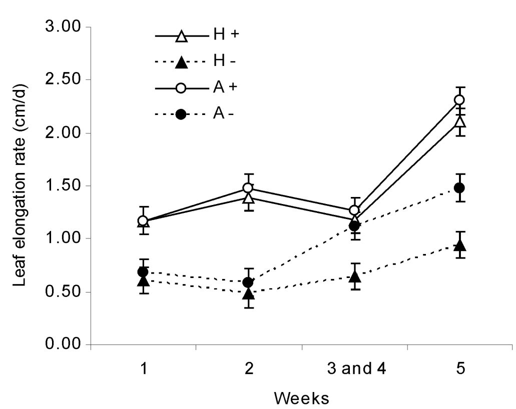


Figure 1 *Weekly variation in LER (mean ± SE) of plants from humid (H) and arid (A) sites , as affected by high (+) and low (−) watering levels .*

Figure 2 *Weekly variation in SWC (mean ± SE) on pots with plants from humid and arid sites , as affected by high and low watering levels (symbols are equal than in Figure 1) .*

Conclusions Aridity , as selective force , conferred a differential drought resistance within the grass *Trichloris crinita* . H" plants were more affected by drought than A" plants (in LER and PSL) . At low watering level , H" plants used water more intensely during the two first weeks , depleting SWC faster than A" plants . This could have contributed to the differences observed in LER and PSL between plants of both origins during the last three weeks .

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Changes on floristic composition of Flooding Pampa rangeland by the use of glyphosate

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Key words : temperate grasslands , basal cover , functional groups

Introduction To increase winter forage production of native rangelands of Flooding Pampa , a technique based on spraying glyphosate herbicide in late summer has been widespread during the last decade in this region . Glyphosate application eliminates green vegetation growing in late summer , improving germination and establishment of cool season (C_3) annual grasses , that enhaces winter forage and meat production . We postulate that this technique would negatively affects plants that vegetate during summer , such as perennial grasses and legumes , decreasing floristic diversity and deteriorating the rangeland .

Materials and methods In a commercial farm located in the Flooding Pampa region , we selected 13 paddocks dominated by native rangeland (30-120 ha each) and used them for cow-calves operation . Five paddocks have never been treated with glyphosate and other 8 paddocks have been treated with glyphosate in late summer from the last 5 years consecutively . In spring (October-November 2006) and summer (January-February 2007) , plant basal cover and species composition were estimated using the step-point method along five 10-m-long transects (200 points per transect) randomly placed in each paddock . Plant species were gathered in functional groups (Jacobo et al ., 2006) . Kruskal-Wallis test by ranks was used .

Results Basal cover of C_3 annual grasses in glyphosate-treated paddocks was significantly higher than that of non-treated ones (Figure 1(a) and 1(b)) , showing the effectiveness of glyphosate application to enhance winter forage offer . Nevertheless , glyphosate-treated paddocks achieved lower basal cover of C_3 perennial grasses and warm season legumes in spring and summer (Figure 1(a) and 1(b)) , which may be consequence of the deleterious effect of this systemic herbicide in late summer over these functional groups , which are growing actively . Basal cover of C_4 creeping grasses was higher in glyphosate-treated paddocks in summer (Figure 1(b)) , consistently with the higher tolerance of *Cynodon dactylon* , the main species of this functional group , to this herbicide . Species richness was significantly lower in glyphosate-treated paddocks respect to non-treated ones (6 .8 vs . 12 , $p < 0.01$) , suggesting the reduction of vegetation diversity .

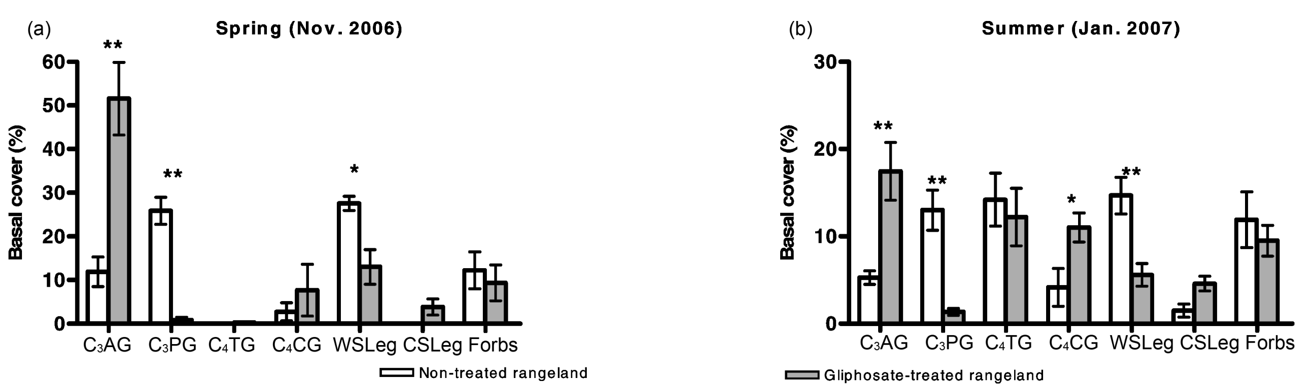

Figure 1 *Basal cover (%) of functional groups growing in spring (a) and summer (b) . Functional groups : C_3AG : C_3 annual grasses ; C_3PG : C_3 perennial grasses , C_4TG : C_4 tussock grasses ; C_4CG : C_4 creeping grasses ; WSLeg : warm season legumes ; CSLeg : cool season legumes and Forbs . ** $p < 0.01$ * $p < 0.05$.*

Conclusions The technique of spraying glyphosate in late summer in native rangelands of Flooding Pampa reduces basal cover of functional groups of great forage value and species richness , deteriorating this resource .

Referene

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Applying multivariate analysis in semi-steppe rangelands (Case study : steppe rangelands of Fars province, Iran)

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Key words: Multivariate, Rangelands, DCA, CCA, TWINSPAN

Introduction This research has been done by using DCA and CCA ordination techniques and TWINSPAN as classification method for determining the most important factors affecting the semi-steppe rangelands vegetation structure in Fars province of Iran through 2400-2800 m and determining ecological vegetation groups distributed in semi-steppe rangelands.

Materials and methods In ILWIS GIS software the slope, aspect and final landforms of studied area were prepared. Vegetation sampling was done in 1 m^2 quadrats along four 300 m. lengthwise transects and eight 100 m. widthwise transects in middle of May in 2006. For soil sampling, we use land form map and Sorenson similarity index. In general parameters such as soil structure, texture (clay, loam, sand), organic carbon, EC, N, P, K, pH, $CaCO_3$ and $CaSO_4$ was measured in 0 to 30 cm. Then all data in Pc-Ord software were imported and analyzed by DCA, CCA, MRPP and TWINSPAN tehniques.

Results Using CCA and Montcarlo test in 2400-2800 meters showed correlation of environmental factors to ordination axes as being shown in Table 1.

Table 1

Altitudinal stratum	Environmental factors	Correlation(%)	Ordination axes
2400-2500	Sand, Nitrogen	84.3	1
2400-2500	Slope, Aspect, EC, Clay, Silt, K, P, Organic Carbon	81.8	2
2400-2500	$CaCO_3$, C/N, Altitude, Slope, $CaSO_4$, pH	61.7	3
2500-2600	Altitude, Slope, Aspect, K, Clay	84.9	1
2500-2600	EC, pH, $CaCO_3$, C/N, Silt	83.3	2
2500-2600	$CaSO_4$, Organic Carbon, N, P, Sand	70.5	3
2600-2700	Aspect, EC, N, K, Clay	95.2	1
2600-2700	Altitude, Slope, $CaSO_4$, EC, C/N, P, Sand	99.3	2
2600-2700	$CaCO_3$, Organic Carbon, Silt	97.3	3
2700-2800	Altitude, $CaCO_3$, Sand	83.1	1
2700-2800	Aspect, EC, Organic Carbon, C/N, P, K, Silt	72.2	2
2700-2800	Slope, $CaSO_4$, pH, N, Clay	60	3

Conclusions The results are shown in Table 2.

Table 2

Altitudinal stratum	Ecological Group
2400-2500	1. *Artemisia aucheri-Astragalus arbusculinus*
	2. *Stachys inflate-Euphorbia sp.*
	3. *Astragalus rhodecemius-Gundelia tournefortii*
	4. *Astragalus arbusculinus-Astragalus cephalantus*
	5. *Astragalus cephalantus-Thymus vulgar*
2500-2600	1. *Astragalus cephalantus-Artemisia aucheri*
	2. *Hertia angustifolia-Astragalus arbusculinus*
	3. *Hertia angustifolia-Astragalus mycranthus*
	4. *Hertia angustifolia-Artemisia aucheri*
2600-2700	1. *Artemisia aucheri-Phlomis orientalis*
	2. *Prangos ferulacea-Stachys inflata*
	3. *Prangos ferulacea-Artemisia aucheri*
	4. *Artemisia aucheri-Ferula ovina*
	5. *Prangos ferulacea-Daphne mucronata*
	6. *Daphne mucronata-Ferula ovina*
2700-2800	1. *Amygdalus lycioides-Daphne muronata*
	2. *Artemisia aucheri-Ferula ovino*

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Radiation use efficiency of alfalfa-tall fescue mixtures in a temperate humid area

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Key words: radiation use efficiency, mixtures, alfalfa, tall fescue, germplasm

Introduction Alfalfa (*Medicago sativa* L.) and tall fescue (*Festuca arundinacea* Screb.) have ecotypes with different responses to temperature. Hypothetically, combination of germplasm with different patterns of seasonal growth might exhibit advantages in radiation use efficiency (RUEfa). In the Humid Pampa region, grass is the main species in these mixtures in winter. However, seasonal transition is crucial to study mechanisms of dry matter accumulation in mixtures with cultivars of different temperature responses. In this work, RUEfa of two alfalfa-tall fescue mixtures are presented.

Materials and methods The experiment was carried out in Pergamino, Argentina (33°52′S; 60°35′W). The soil was typical Argiudol. The treatments were a complementary mixture (C_{ary}): alfalfa moderately dormant and tall fescue Mediterranean ecotype and a competitive one (C_{ive}): alfalfa short dormant and tall fescue north Europe ecotype. In each of two cycles of growth (2005/06 and 2006/07) weekly measurements were taken at the end of winter, summer and autumn. Complete random design was used (n: 2). In each period, leaf area index (LAI), above-ground biomass (AGB), and intercepted photosynthetically active radiation (PARi) were determined. RUEfa (Mj. m^{-2}) was estimated, as the slope of the AGB accumulated on PARi. LAI, AGB and PARi were analyzed by ANOVA Procedure of SAS System ($p < 0.05$). Parameters estimators of RUEfa were analyzed by GLM Procedure.

Results LAI was higher in C_{ive} mixture than in C_{ary} at the end-winter. In autumn, value was higher in C_{ary} than in C_{ive} (Table 1). In autumn, PARi was higher in C_{ary} mixture. RUEfa, was higher in C_{ive} mixture in winter for cycle 2 ($y = 8.3 + 3.3x$, $r^2 = 0.89$, $p < 0.01$ and $y = 0.9 + 1.4x$, $r^2 = 0.86$, $p < 0.001$ in C_{ive} and C_{ary}, respectively). RUEfa was higher for Cycle 2 in summer: C_{ive} ($65.8 + 0.8x$, $r^2 = 0.58$, $p < 0.01$ and $y = 82.1 + 0.1x$, NS, in C_{ive} and C_{ary}, respectively). In autumn, both mixtures had the same RUEfa ($17.7 + 0.6x$, $r^2 = 0.40$, $p < 0.01$ and $-2.8 + 1.6x$, $r^2 = 0.77$, $p < 0.001$, in Cycle 1 and 2, respectively). The seasonal variations in RUEfa have been attributed to changes in the partition of carbon (Browna et al, 2006). For Cycle 2 at the end of winter and in summer, C_{ive} had higher AGB than C_{ary}.

Conclusions At the end of winter and in summer, when alfalfa was the main species in C_{ive}, this mixture had higher RUEfa values than C_{ary}. This was due to a higher LAI and, probably, to a more favorable structure. In autumn, when C_{ary} had higher PARi than C_{ive}, treatments had the same RUEfa. The differences in favour of C_{ive} in RUEfa were associated with higher AGB. In autumn, higher AGB in C_{ary} was related to a higher PARi.

Table 1 *LAI, PARi y AGB in two mixture end-winter, end-summer and end-autumn. Cycles 1 and 2*[1].

Cycle	Season	Date	LAI			PARi			AGB		
			C_{ive}	C_{ary}	P<	C_{ive}	C_{ary}	P<	C_{ive}	C_{ary}	P<
1	Winter	9/19	3.6	2.5	0.05	58	74	NS	153	102	0.05
		9/26	4.6	4.0	NS	91	81	NS	213	194	NS
	Summer	3/6	4.4	4.1	NS	92	91	NS	235	166	NS
		3/13	4.5	5.6	NS	93	91	NS	298	354	NS
	Autumn	5/30	2.7	3.2	NS	88	89	NS	83	106	NS
		6/6	3.2	3.5	NS	93	93	NS	67	110	0.05
2	Winter	9/12	3.2	1.4	0.001	51	62	NS	201	52	0.05
		9/18	4.8	2.0	0.05	80	66	NS	95	344	NS
	Summer	3/6	5.4	4.1	NS	77	82	NS	226	127	0.05
		3/13	5.3	3.8	NS	82	94	NS	203	70	0.05
	Autumn	6/5	3.0	4.2	0.05	35	70	0.01	98	141	NS
		6/12	3.6	3.7	NS	s/d[2]	s/d[2]	—	143	210	0.05

[1] By simplicity, only the last two dates of measurements are shown. [2] Bad weather conditions prevent measurements.

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Productivity and persistence of Kura clover-grass mixtures

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Key words: botanical composition, Caucasian clover, persistence, *Trifolium ambiguum* M. Bieb., yield

Introduction There is currently a need for persistent forage legumes that could be used in permanent pastures of eastern Canada. Species currently used all lack persistence when grazed. Kura clover (KC, *Trifolium ambiguum* M. Bieb.) is a rhizomatous species which potential has been reported in several regions (Laberge and Seguin, 2005). Exceptional persistence and high forage quality are characteristics making KC a good candidate for use in permanent pastures (Laberge and Seguin, 2005). An experiment was established to compare KC and white clover (WC, *T. repens* L.) contributions to total forage yield in post-seeding years when mixed with different grass species and determine if KC could be used to establish desirable legume:grass swards in permanent pastures of eastern Canada.

Materials and methods Plots were established in 2003 and 2004 in Sainte-Anne-de-Bellevue (45°25′ N, 73°56′ W) and Normandin (48°51′ N, 72°32′ W), QC, Canada. Treatments included solo-seeded KC and WC, and mixtures of each clover species with smooth bromegrass (SBG, *Bromus inermis* Leyss), Kentucky bluegrass (KBG, *Poa pratensis* L.), timothy (TIM, *Phleum pratense* L.), orchard grass (ORC, *Dactylis glomerata* L.), tall fescue (TF, *Festuca arundinacea* Schreb.), and meadow bromegrass (MBG, *Festuca pratensis* Schreb.). Total forage yield and clover, grass, and weed yield contributions were determined from 2004 to 2007 inclusively. Plots were harvested approximately every 30 days, resulting in 3 or 4 harvests per year.

Results and discussion Results from a total of 14 sites—years clearly demonstrate KC potential in eastern Canada. In the first post-seeding year, clover and total forage yield of KC and KC-grass mixtures were similar or slightly lower than those of WC (Figure 1). However, from the second post-seeding year, yields were greater for KC and almost all KC-grass mixtures than similar WC treatments. WC contribution to total forage yield in mixtures was often negligible in the fourth post-seeding year, compared to almost 50% for KC. KC performed well with all grasses evaluated, best mixtures varying depending on the site or year.

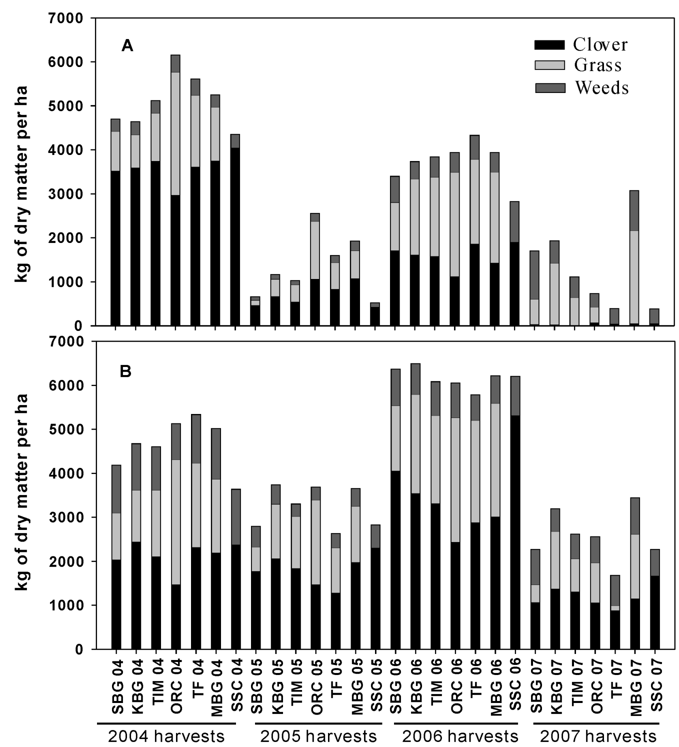

Figure 1 *Forage yield of white clover (a) and Kura clover (b) mixtures with grasses (Normandin 2003 seeding); SBG, smooth bromegrass; KBG, Kentucky bluegrass; TIM, timothy; ORC, orchard grass; TF, tall fescue; MBG, meadow bromegrass; SSC, solo-seeded clover.*

Conclusions KC potential for permanent pastures of eastern Canada has been demonstrated. We recommend the inclusion of KC in the list of forage species recommended for use in permanent pastures locally. KC could be considered an alternative to white clover.

Reference

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The study of salinity and drought stress effects on three range species *Agropyron intermedium*, *Avena barbata* and *Panicum antidotale* from Iran

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Key words: drought, dry matter, salinity, stress, water potential

Introduction Stress is considered to be a significant deviation from optimal conditions of life. The salinity is usually resulted in drought and most of the plants can tolerate a limited amount of salinity and drought, or else it will reduce the function of plant linearly (Jafari, 2000). Salinity inhibition of plant growth is the result of osmotic and ionic effects and the different plant species have developed different mechanisms to cope with these effects (Munns, 2002).

Materials and methods This experiment was carried out in order to study the effects of drought and salinity stress on three range species *Agropyron intermedium*, *Avena barbata* and *Panicum antidotale* using a completely randomized design in 3 repetitions of 36 treatments totaling 108 vessels in the greenhouse. Salinity stress was selected in the form of four salinity treatments, including zero (authentic), 40, 120 and 200 millimolars. Salt solutions of NaCl (60%), Na_2SO_4 (30%) and $CaCl_2$ (10%) were used. Drought stress was selected based on irrigation at an interval of 6, 12 and 20 days. Two months duration of stress was applied. During the test, some characters including: the stem and leaf dry matter, water potential in leaves and the percent of wilted leaves were measured.

Results and discussion 20 days drought and 120 millimolar salinity treatments have the most wilting. Quantity of the wilted leaves of *Avena barbata* and *Pancicum antidotale* species are more than *Agropyron intermedium*, which indicates it's more adaptable in comparison with two other species. The water potential of the leaves is used for the plants tolerance against drought stress. The species under severe drought stress (20 days) in comparison with the species under less stress (6 days) have higher osmotic potential. Figure 1 shows that increasing drought stress could reduce the function and biomass of the stem and leaf. Increasing stress from 6 days to 12 days increases the loss intensity. Enhanced stress more than 12 days is not effective in reduction of function. The most dry matter among the plant species is related to *Avena barbata* in 6 days drought treatment and the least dry matter is related to *Agropyron intermedium* in 20 days drought treatment. In the three mentioned drought treatments, *Avena barbata* has the most biomass and *Agropyron intermedium* has the least biomass. Regarding Figure 2, the salinity treatment doses not affect the oscillation of function significantly. Perhaps the plant can tolerate salinity until 200 millimolar concentration but more research is needed to demonstrate it. The information shows that *Avena barbata* has the most tolerance and function against salinity while *Agropyron intermedium* has the least tolerance and function against the salinity in compared with other treated species.

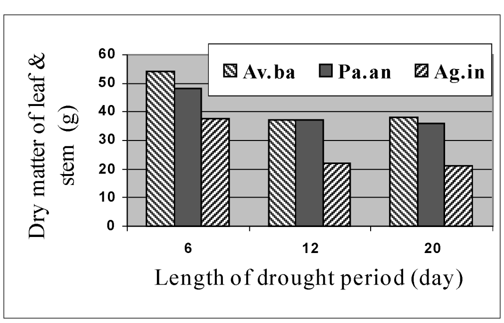

Figure 1 *Effects of drought stress on the dry matter (leaf and stem).*

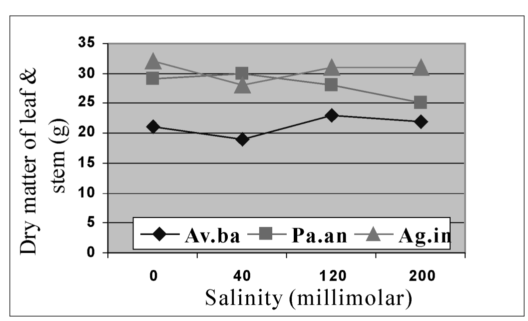

Figure 2 *Effects of salinity stress on the dry matter (leaf & stem).*

Conclusions The drought and salinity could reduce the plant's biomass in short term. The plant would adopt itself with this condition and its growth is reduced. Type and intensity of adaptation are different in species. The stress effect could be observed on the leaves and their wilting increases. The cellular pressure reduction that resulted in water deficiency causes the replacement of water potential with pressure. Thus more resistant plants have the most negative water potential. In conclusion among 3 species, *Avena barbata* is the most resistant species, because it has the most dry matter, maximum of relative humidity and negative water potential of leaves. But *Agropyron intermedium* is less resistant and *Panicum antidotale* is the intermediate one. So *Avena barbata* is the most appropriate plant for cultivating in arid and semiarid areas.

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Effect of soil and subhabitat differentiation on seedling establishment and growth of *Acacia mellifera* subsp. detinens in a semi-arid savanna of South Africa

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Key words: allelopathic, bush encroachment, germination, growth

Introduction *Acacia mellifera* subsp. detinens is commonly viewed as a problem plant. Total clearing of *A. mellifera* is thus a common practice, but re-encroachment often occurs. The objective of this study was to determine the dynamics of *A. mellifera* seedlings grown in soil collected within three subhabitats: two areas under the canopies of mature *A. mellifera* trees, the first close to the main stem of the plant and the second approximately in the middle of the canopy and the third in open areas between the canopies of the trees.

Materials and methods Soil and seeds of *A. mellifera* were collected near the town of Bray in the North-West Province of South Africa. The soil is sandy and extremely low in organic matter and mineral elements. Thirty plastic pots in a controlled environment were filled with soil and three randomly selected seeds were sown in each pot. The height of the seedlings was measured every five days and after three months all the seedlings were harvested and measurements taken (Table 1). A Randomized Complete Block Design was implemented and least significant differences (LSD) were calculated from the appropriate standard errors to estimate the significance of the differences between means.

Results Statistically significant ($P<0.05$) differences in mean plant height, stem thickness and leaf dry mass of the seedlings grown in the soil close to the stem area in comparison to the other two subhabitats were observed (Table 1). In all cases, the growth of the seedlings grown in the soil from the subhabitat close to the stem were more prolific, and this also applied to the other variables that did not differ significantly ($P>0.05$). The higher soil nutrient status, that occurred in relation to a specific spatial gradient from the stem base of the plants (highest) towards the open uncanopied areas (lowest) (Hagos & Smit, 2005), is considered to be responsible for these differences.

Table 1 *Mean values of the various pant growth parameters of the* A. mellifera *seedlings grown in soil collected from the three different soil subhabitats. Values with different letters in brackets differed significantly at $P<0.05$.*

Variable	SH1	SH2	SH3	LSD	P	n	CV (%)
Plant height (cm)	10.7 (a)	8.7 (b)	9.3 (ab)	1.518	<0.05	30	30.21
Stem thickness (mm)	1.859(a)	1.628 (b)	1.604 (b)	0.217	<0.05	30	24.72
Number of leaves	14.0 (a)	12.0 (a)	13.0 (a)	2.434	>0.05	30	36.28
Total root length (cm)	700.0 (a)	562.0 (a)	530.0 (a)	174.1	>0.05	30	56.39
Leaf dry mass (g)	15.4 (a)	10.9 (b)	11.2 (b)	4.0	>0.05	30	64.30
Stem dry mass (g)	11.9 (a)	9.9 (a)	9.7 (a)	3.7	>0.05	30	68.12
Root dry mass (g)	16.4 (a)	12.2 (a)	12.2 (a)	4.6	>0.05	30	67.59
Total plant dry mass (g)	43.7 (a)	33.0 (a)	33.1 (a)	11.7	>0.05	30	61.69

SH1=Soil from close to the tree stems, SH2=Soil from the middle of tree canopies, SH3=Soil from open areas.

Conclusions No allelopathic effect that inhibits the growth of seedlings in soil from under the mature *A. mellifera* trees was found. Due to a higher soil nutrient status under the canopies of these trees, the cleared areas previously overspanned by their canopies will provide the most suitable areas for the establishment and growth of new seedlings. The removal of mature plants may thus promote rapid re-encroachment, provided there are enough viable seeds.

Reference

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Productivity loss due to fire in a semi-arid rangeland of South Africa

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Key words: aboveground phytomass production, fuel load, regrowth

Introduction Accidental, runaway veld fires will not only have a short-term influence on productivity of the rangeland ecosystem, but may also have a major residual effect on the next growing season, depending on subsequent climatic conditions and post-fire management (Snyman, 2003). It was the objective of this study to estimate the short-term impact of fire, which is a normal phenomenon in the semi-arid areas, on the sustainability of the ecosystem.

Material and methods The research was conducted in a semi-arid summer rainfall (annual average—560 mm) region of South Africa (28°50′S; 26°15′E, altitude 1350 m). The study area is situated in the moist, cool Highveld grassland. Soils are mostly fine, sandy loams. The research was conducted on six plots of 3 m×10 m each, re-applied every year on a new area (on the same soil form), over a 10-year period (1995/96—2004/05 season). Each plot was monitored only over a two year period. The treatments randomly applied, consisted of the burning (head fire) of a plot and a control without burning. The burning treatment was applied each year at the end of August by which time the grass fuel was dry. Fuel load included the aboveground phytomass as well as the litter just before burning. Seasonal regrowth was determined at the end of the growing season (April) in each plot by clipping the plants in 10 quadrates (1 m^2 each, randomly placed) to a height of 30 mm. The fuel load before burning and the season's rainfall following the burning were regressed on the seasonal production loss due to burning (seasonal unburnt production minus regrowth of burnt grassland).

Results and discussion The average aboveground phytomass production of the burnt and unburnt rangeland differed ($P \leqslant 0.01$) from each other over the study period and ranged between 1121 and 2614 kg/ha for unburnt rangeland and between 814 and 2110 kg/ha for burnt rangeland. Production losses due to fire, which is also a function of seasonal rainfall (between 412 and 861 mm), varied between 238 and 444 kg/ha. The aboveground phytomass production loss due to fire (kg/DM/ha) is described for one (1) and two (2) seasons after the fire, by the following multiple linear regression equations ($P \leqslant 0.01$):

$$y = -98.18 + 0.44x_1 + 0.04x_2 \quad (n=10);\ r=0.89) \tag{1}$$

$$y = 47.22 - 0.06x_1 + 0.12x_2 \ (n=10);\ (r=0.88) \tag{2}$$

Where y is the production loss due to fire, x_1 is the seasonal rainfall (mm) and x_2 is the fuel load without burning (kg/DM/ha). The equation clearly indicated that the higher the fuel load before burning the greater the production loss due to fire.

Conclusions These significant relationships between effects of fire, rainfall and fuel load on phytomass production, based on 10 years of observations, can serve as a simple empirical model for managers to determine short-term production losses due to fire. This information can also serve as a scientific guideline in estimating production losses in claims for damages suffered in cases of negligent rangeland fires.

Reference

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The rooting depth, root biomass and its vertical distribution regularity of alfalfa in different growing years in Beijing Plain

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Key words: alfalfa, rooting depth, root biomass, root distribution, Beijing Plain

Introduction This research was aimed at finding the rooting depth, root biomass and its vertical distribution regularity of alfalfa (*Medicago sativa* L.) in different growing years in Beijing Plain and providing evidence for the cultivation of alfalfa in this area.

Material and methods The soil profiles method (Chen Bao-shu, *et al*. 1991) was used for determining the rooting depth and root biomass of the Golden Empress alfalfa in different growing years in Beijing Plain.

Results and analysis The results were shown in Tables 1 and 2.

Table 1 *The rooting depth and root biomass of alfalfa in different growing years in Beijing Plain.*

Growing year (year)	0.75	1.2	2.5	3	4	4.75
Rooting depth(m)	1.2a	1.6b	2c	2d	1.8c	2d
Root biomass(MgDM/hm^2)	2.96a	4.74c	6.38d	3.05a	3.78b	10.11e

Note: Different small letters in the same row indicate significant differences at $P<0.05$.

Table 2 *The root biomass rate in different soil layers of different growing years alfalfa in Beijing Plain.*

Soil layer (cm)	Growing year (year)					
	0.75	1.2	2.5	3	4	4.75
0～20	78.38%	70.04%	60.81%	65.57%	69.84%	70.82%
20～40	9.80%	12.03%	13.17%	16.72%	12.96%	13.45%
40～60	7.77%	8.44%	9.09%	6.89%	8.20%	8.11%
60～80	2.70%	4.43%	6.58%	3.61%	4.50%	3.96%
80～100	1.01%	2.95%	4.08%	2.62%	2.12%	1.58%
100～120	0.34%	1.27%	2.82%	1.64%	1.06%	0.69%
120～140		0.63%	1.88%	0.98%	0.53%	0.59%
140～160		0.21%	0.94%	0.98%	0.53%	0.40%
160～180			0.47%	0.66%	0.27%	0.30%
180～200			0.16%	0.33%		0.10%

Discussion and conclusion Combined with the other scholastic's research, we reach the conclusion that the rooting depth of alfalfa growing less than 2.5 years increased annually, and that growing more than 2.5 years were stable in Beijing Plain. With the growing year longer, the root biomass of the alfalfa increased year by year. The reason that the root biomass of alfalfa growing 3 and 4 years were lower should be no fertilization. The rate of the alfalfa root biomass in different soil layer decreased as the depth increased.

Reference

Chen Bao-shu, Fu Yi-kun, Zhang Pu-jin, *et al*, (1991). A Experiment and Practice Guide Book for Rangeland and forage Science. Lanzhou: *Gansu Science and Technology Publisher*. 198-202.

Water requirement and water requirement rate of alfalfa in Bashang area

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Key words: alfalfa, water requirement, water requirement rate, Bashang area

Introduction The research was designed with purpose of revealing the water requirement and water requirement rate of alfalfa (*Medicago sativa* L) in Bashang area to provide scientific support for the water management of alfalfa in this area.

Materials and methods The large scale non-weighing lysimeter method (Cooperation group, 1993) was used for determining the water requirement and water requirement rate of Algonqin alfalfa sowed in June, 2006 with a seeding amount 15 kg/hm^2 and a row spacing 30 cm in Bashang area in 2007. The lysimeter was made of mixed cement and bricks, with a capacity of 3×2×1.6m. Sufficient water was supplied during the experiment period to avoid the alfalfa plants endangered by drought. This process is repeated for three times using three lysimets. The amount of precipitation, irrigation, seepage and water change amount in soil were measured. The formulas for the water change amount in soil, water requirement and water requirement rate are as follow:

$$\triangle W = 10\sum \gamma_i H_i (\theta_{i2} - \theta_{i1}) \quad (1)$$

$$WR = R + I - P - \triangle W \quad (2)$$

$$WRR = WR/T \quad (3)$$

In formula 1 to 3, $\triangle W$, WR, R, I and P stand for water change amount in soil, water requirement, seepage, irrigation and precipitation with the unit *mm*, respectively. γ_i stand for soil bulk density with the unit *g/cm^3*. θ_{i1} & θ_{i2} stand for the soil water content at the beginning and the ending of the calculation time with the unit %, respectively. WRR stand for water requirement rate with the unit *mm/d*. T stand for time with the unit d.

Results and analysis The results were shown in Table 1.

Table 1 *The water requirement and water requirement rate of alfalfa in Bashang area.*

Harvest No.	1	2	1~2
Water requirement(mm)	503.8	180.1	683.9
Water requirement rate (mm/d)	7.8	3.2	5.6

Discussion and conclusion The range of water requirement and water requirement rate of alfalfa around the world is about 400—2250 mm and 3—7 mm/d, respectively (Sun Hongren, *et al*, 2005). Bashang area belongs to the area with low water requirement and high water requirement rate.

References

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Alien plant invasions of Jinfo Mountain National Nature Reserve—identifying and implying

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Key words: alien plant, invasion, identifying, Jinfo Mountain National Nature Reserve

Introduction Jinfo Mountain National Nature Reserve (JMNNR), located in the Range of Dalou and covering an area of approximately 1300 ha and ranging in elevation between 340 and 2251 m, Chongqing, China, contains a diversity of plant species (5900) including subspecies and variation (Han *et al*., 2006). Though many of the plant species in the reserve are native, there are many harmful exotic species which were identified to have been invading the local vegetation. Unfortunately, little attention has been given to prevent and control the of exotic plant species. The objectives of the project were firstly to identify these exotic plant species and then to discover the degree and severity of the invasions, and finally to reveal the way of invasion.

Materials and methods Twenty-four plots were selected randomly at of 840 m, 1340m, 1840m and 2251m elevation, respectively. Each plot was further decided by 3 degrees of serious destruction, light destruction and no destruction in JMNNR. The plots were designed in the area of 400 m^2 (20 m×20 m) for arbor, 25m^2 (5 m×5 m) for shrub and 1m^2 (1 m×1 m) for herbage, respectively. Each main 400 m^2 plot consisted of one 25 m^2 subplot and three 1 m^2 subplots. All subplots were selected randomly. The parameters of elevations, watershed orientation, soil development, history of disturbance of the plots and subplots in which these exotic plant species were found were recorded. And the cover percentage and average height of present vegetation were also recorded. In addition, invasive plant species were investigated through 3 line transects, 100 m long and 20 m wide. The invasive species encountered within each transect were recorded.

Results A total of 62 exotic plant species were identified and in which 9 exotic plant species were found in 15 sampling plots of the total plots investigated, and all of the exotic plant species were found within the line transects. *Miscanthus floridulus* (Labill.) Warb. was discovered to be one of the most seriously invasive plant species, and was discovered at almost all the places where mankind had reached. Fifty percent of the total invading exotic plant species were intentionally introduced (II). Twenty three percent were spontaneous invasion (SI). Aimless introducing (AI) and unknown invasion (UI) invading exotic plant species were nineteen percent and eight percent, respectively (Figure 1). While the most seriously invading plant species-*Miscanthus floridulus* (Labill.) Warb. was UI.

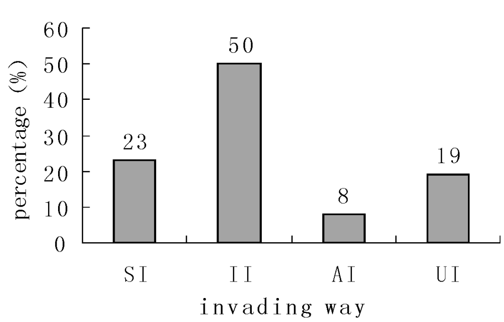

Figure 1 *The invading way of exotic plant species in JMNNR.*

Conclusions Invasions of exotic plant species in JMNNR was seriously, and what is dangerous is that the invasive way of the serious invasive plant species was unknown. Research and sustainable works need to be done in the future.

Reference

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The state of forage germplasm resources in Yunnan province

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Key words : Yunnan, forage germplasm resources, foreground view

Introduction The abundance of forage germplasm resources in Yunnan province was determined by its complicated natural geography. The natural geography and abundance ratio and distributing of forage germplasm resources in Yunnan grassland was described in this paper.

Natural geography, forage germplasm resources and Composing of grass communities of Yunnan Yunnan province was located 21°9′-29°15′ northern latitude and 97°39′-106°12′ eastern longitude. Most parts of it belong to southern of subtropic area and northern of tropic area while little of it belongs to temperate area. Yearly rainfall averages 1100 mm, with over 80% falling in June—October. Total of 15.27 million hm^2 grassland in Yunnan province and 11.87 million hm^2 of the grassland was available, which was about 30% of the land in Yunnan province. Yunnan province was abundant in grassland resources. 11 grassland forms and more than 150 grassland types were involved. There were about 4958 vegetations in Yunnan grassland, with about 3200 vegetations are available forage species. Among of them 320 species belong to grasses, 284 species belong to legumes and 152 species belong to sedges. 94 species and 523 varieties of forage were introduced from foreign countries(Kuang chong-yi et al., 2005). Main grassland forms and the composing of forage communities in Yunnan grassland were shown as follows (Table 1).

Table 1 *Composition of forage communities in Yunnan grassland.*

Forage species & grassland forms	Grasses	Legumes	Sedges	Hybrid forages	Arbor, shrub and undershrub
Hill tussock	13.89	5.56	0	33.33	47.22
Hill and velly tussock	24.73	10.75	9.60	30.11	24.73
Fluvialvelly thicket	24.59	10.66	2.46	25.40	36.89
Mountane thicket and tussock	20.00	4.39	2.44	55.12	18.05
Mountane savanna	21.50	7.89	5.06	45.19	20.35
Mountane meadow	16.67	5.75	5.75	70.10	1.72
Subalpine meadow	14.08	5.63	4.23	74.65	1.41
High and cold meadow	4.76	0	28.57	66.67	0
High and cold moor meadow	12.90	3.23	16.13	67.74	0
Mean	17.00	5.98	8.25	52.04	16.71
Ratio	2.8	1.0	1.4	8.7	2.8

Reference

Kuang Chongyi, Kui Jiaxiang, Xue Shiming & Zhou Ziwei, (2002). The function of forage germplasm resources in development of Yunnan pasture stockbreeding. *Yunnan Journal of Animal Science and Veterinary Medicine*, 23-25.

Rehabilitation of grasslands through perennial grass recruitment within existing swards

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Key words: recruitment, phalaris, seeds, herbage mass, bare ground

Introduction Phalaris (*P. aquatica*) is an introduced C3 grass species, widely sown in southern Australian temperate regions. Phalaris is drought tolerant, can withstand extended periods of heavy grazing, performs well in poorly drained and waterlogged soils, and provides good quality grazing for all types of livestock. Phalaris is known to produce large quantities of seed, but little recruitment within phalaris stands has been reported (Lodge, 2004). When stands thin, encouraging natural recruitment could be more cost-effective than resowing grasslands. The low natural recruitment of phalaris has been attributed to competition from annual grasses and legumes, preventing the weak phalaris seedling from establishing, and to a high level of seed harvesting by ants. The ideal microsites for recruitment are poorly understood. It is often noted that phalaris spreads naturally along roadsides in south-eastern Australia though the mechanisms are not understood. This paper presents findings on the recruitment of phalaris within existing pastures.

Materials and methods A factorial combination of seed delivery mechanisms (A1: uncut, A2: cut & remove, A3: slash & leave), seed addition (B1: nil, B2: + seed, B3: +insecticide) and site preparation (C1: nil, C2: light scarifying, C3: + herbicide) were used. Seedling numbers were recorded 2 weeks after a significant rainfall event (50mm over 2-3 days) and monitored for survival 6, 24 and 48 weeks after first emergence.

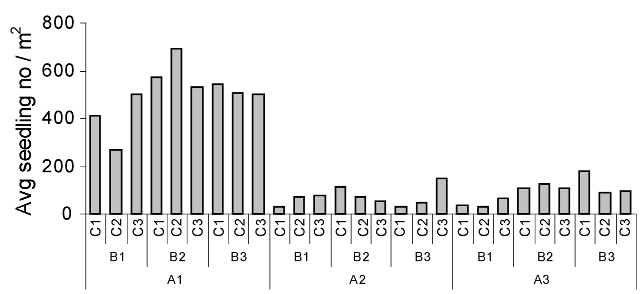

Figure 1 *Initial emergence of phalaris seedling across treatment combinations in March 2007.*

Results and discussion Highest seedling numbers resulted from the nil intervention control, where phalaris was allowed to flower, set seed and to remain standing (Figure 1). Cutting the tall grass and either removing the cut material or leaving it on the soil surface failed to achieve as many seedlings. The uncut treatment could result in slightly lower vapour pressure deficits compared with cutting and leaving the herbage mass on the surface. This suggests that the micro-climate at micro-sites where seedlings establish may be initially more important than competition for soil moisture and nutrients, for this species under dry conditions. That view was supported by regression analysis (assuming Poisson distribution) which showed that less bare ground and greater herbage mass resulted in more seedlings (Figure 2). Seedling survival was though poor due to drought conditions over the next year.

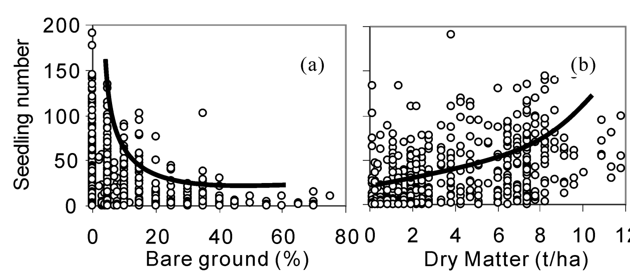

Figure 2 *Effect of (a) bare ground and (b) dry matter on seedling numbers/m². Lines of best fit using all treatments were significant.*

Conclusions Leaving swards undisturbed may be preferable to slashing and building up a layer of litter on the ground for recruitment of new phalaris plants. This affect may arise from subtle changes in humidity at ground level; changes that are very difficult to measure. Conditions for ideal seedling emergence may differ from those for seedling survival.

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Ordination of plant communities at Nazlochai Basin in West Azarbaijan rangelands of Iran

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Key words: Iran, ordination, plant communities

Introduction One of the problems associated with community structure is how the spatial pattern of organisms in the community relates to the interaction of organism with the environment. Ordination is the technique of arranging unites (for example, forest stands) in a uni-or multidimensional order in such a manner that the position of each unit along the axis or axes conveys the maximum information about its composition or relationship with the other units. Ordination is based on the assumption that community composition varies gradually over a continuum of environmental conditions. For this reason community can not be classified in discrete units; rather the form a continuum changing in composition and structure over environmental gradients (temperature, elevation, soil, and so on) (Grieg-Smith, 1983 and Dyksterhuis, 1985).

Material and methods In this study, plant communities distinguished at the rangelands by using of physiogonomic-floristic method (Table 1). The relationship between plant communities determined by using of ordination and calculation of Bray-Curtis index. Location of each plant community on axes, determined by Beal's method and relationship of them has showed in the dimension place (Figure 1).

Table 1 *Communities composition and importance values for species.*

Species	Importance values(IV) ** for plant communities									
	1	2	3	4	5	6	7	8	9	10
Artemisia seberi.	82 4	43 9	73 5	63 5	35 5	93 0	75 4	101 2*	114 1*	110 3*
Kochia prostrate.	33 4	38 5	30 2	0	27 6	42 5*	31 0	41 5*	32 5	39 9
Stipa barbata.	37 9	40 5	37 0	0	28 9	51 9*	39 4	0	36 3	29 4
Bromus tomentellus.	29 7	0	21 5	24 7	0	17 9	30 2	0	30 8*	10 4
Agropyron aucheri.	24 0	32 9	0	31 0	32 9	0	26 7	36 7	0	28 9
Acanthophyllum microcepalum.	36.2	36.8	35.3	14.2	6.7	0	31.2	21.0	37.5*	27.6
Poa bulbosa.	56.3*	51.9	49.7	30.2	0	40.5	57.6*	30.4	59.3*	40.1

** Impotance value is the sum of relative, density, e frequency, and dominance for each species.
* Dominant species.

Results and discussion According to the results; plant community, specially numbers 4 and 5, are distinguished by some different characteristics such as density, frequency, dominance and diversity (Figure 1).

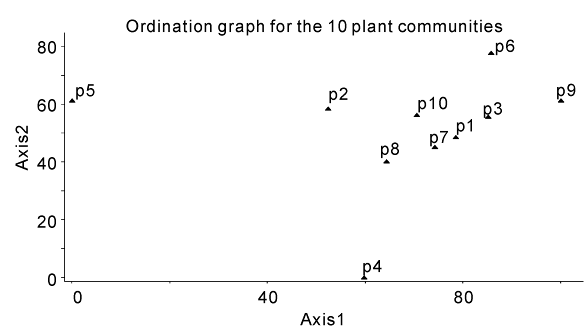

Figure 1 *An ordination graph for the 10 plant communities described in Table 1.*

Conclusions Application of quantitative methods to recognition of plant communities is a one of the most fundamental requirements for management of rangelands. The use of ordination methods are really important due to deficient of range condition methods (Foran, 1986).

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Prescribed burning based on range condition in the Okavango Delta Ramsar site in Botswana, Africa

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The Okavango Delta located in north western Botswana in southern Africa is one of the world's largest remaining inland wetland ecosystems that is protected under the Ramsar Convention. The frequency and severity of fires are perceived to be a threat to the conservation and wise use of the Delta and provided the motivation for the formulation of a fire management plan for the area. The vegetation in the Ramsar Site comprises the *Permanent* and *Seasonal Swamps* and *Burkea*, *Mopane* and *Acacia Woodlands*. The development of simple and practical quantitative criteria describing the ecological condition of the vegetation that could be used to identify areas that should be considered for prescribed burning was an important requirement for the fire management plan and comprised the following guidelines:

1. Burning is ecologically acceptable if the grass sward is in a climax and/or sub-climax stage dominated by Decreaser and/or Increaser I grass species as a means of maintaining the biodiversity and potential of the grass sward to produce grazing for both domestic livestock and wildlife. When in this ecological condition the grass sward is resistant to the negative effects of this extreme form of defoliation. Conversely burning should not be applied when the grass sward is in a pioneer condition dominated by Increaser II grass species in order to allow it to develop to a more productive and species diverse stage dominated by Decreaser grass species (Trollope, 1999).

2. Burning is ecologically acceptable, if the grass sward is in a moribund and/or unpalatable condition, as a means of restoring the vigour of the grass sward and allowing new nutritious regrowth to occur. Field experience indicates that when the standing crop of grass ≥4 000 kg/ha in African grasslands and savannas then the grass sward has become moribund and/or unacceptable to grazing animals and needs to be defoliated by burning or some other means (Trollope, 1999).

While no techniques were available for assessing the condition of the *Permanent Swamps* results of field surveys in the other vegetation types showed that the *Seasonal Swamps* and portions of the *Burkea Woodlands* were the only vegetation units that should be considered for controlled burning, based on the proportion of Decreaser and/or Increaser I grass species. In terms of grass fuel loads, only the *Seasonal Swamps* had extensive areas where the grass sward was in a moribund condition and should be considered for controlled burning.

An assessment of the *Permanent Swamps* dominated by extensive communities of *Cyperus papyrus* (papyrus) and *Phragmites spp*. (reeds) indicated they had extremely high fuel loads capable of generating high intensity fires but were highly resistant to burning because the growing points of the plants are either inundated by water or are growing in moist soil. While it can be accepted that fire is a natural and necessary factor of the environment in this vegetation type, research is necessary to provide information for formulating a fire regime suitable for management purposes in this plant community.

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Forb responses to varying grazing regimes in Australian native temperate grasslands

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Key words: sheep, grazing-rest, exclosures, wildflowers

Introduction Australian temperate grasslands have been subjected to extensive clearing for agricultural and urban development for over 100 years. They are now one of the most endangered ecological communities in Australia. Forbs, non-woody plants other than grasses, sedges and rushes, contribute significantly to the species richness of native grasslands. They have been particularly depleted in fertilised grasslands used as pasture. While livestock grazing has been a major driver in the decline of native grassland quality and extent (Garden *et al.*, 2003), strategic resting from grazing can be used by land managers to target vulnerable or strong life history phases of unfavourable and favourable species (Ash and McIvor 1998).

Materials and methods In July 2003 an open communal grazing design was established at three sites across south western Victoria (Kemp and Dowling 2000). The exclosures were divided into 18 plots (each 15 m×15 m), composed of three replicates of six grazing-rest treatments: *no rest*, *always rested*, removing sheep during the winter (*winter rest*), removing sheep during the spring (*spring rest*), removing sheep in the summer *(summer rest)* and removing sheep in the spring & summer (*spring-summer rest*). In spring 2006 forb richness was measured in each treatment plot by searching for about 30 minutes to produce a forb species list. Responses to treatments were analysed using analysis of variance. We used a multiplicative model which included site and treatment as explanatory variables. We included a site-treatment interaction term as an explanatory variable accounting for when the effect of treatment differed according to site.

Results and discussion Forb richness was most significantly correlated with site (mean +/-s.e., n=18: 17+/-1, 13+/-0.5, 12+/-0.8). The sites had similar management histories of no cultivation, fertiliser or exotic species sowing and had not been burnt for at least 60 years if ever. Although stocking rates were supposed to be similar throughout the experimental period this was not the case. The site with the highest stocking pressure experienced the largest deficit in terms of average rainfall. Perhaps not surprisingly this was also the site with the lowest species richness. The site with the highest species richness had medium stocking pressure, received its typical rainfall in the previous years but most importantly was surrounded by larger remnants of higher quality grassland.

Resting pastures in spring resulted in the highest species richness. This reflects a trade-off between allowing species to grow and reproduce in spring while disallowing over-dominance by a few strong species. Complete rest from grazing resulted in high levels of species richness at only site due to disruption of the treatment at the other two sites by burrowing native rats (*Rattus lutreolus*). Treatment plots that were never rested from grazing had the fewest species.

Conclusions Overall site richness was a result of interactions between landscape factors such as distance to seed sources as well as local factors such as stocking pressure and rainfall. Resting pastures from grazing, particularly in spring, resulted in higher numbers of native forbs species.

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Overgrazing affects arbuscular mycorrhizae diversity and abundance in Patagonian steppe

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Key words: overgrazing, Patagonian steppe, arbuscular mycorrhizae, diversity, abundance

Introduction Arbuscular mycorrhizae fungi (AMF) are critical for survival of most plants in arid ecosystems (Titus et al., 2002). This also might be true in the case of Patagonian steppe, which faces desertification processes mainly as a result of overgrazing (León y Aguiar 1985). AMF diversity is affected by plant diversity; if the latter decrease it is expected that the former would do the same (Johnson et al., 2003). Losses in plant cover and substitution of palatable species by unpalatable ones are overgrazing consequences in the Patagonian steppe. Therefore, the effects of overgrazing on the AMF community were evaluated in the Patagonian steppe.

Materials and methods AMF spore abundance and diversity were evaluated in Patagonian steppe in ungrazed, moderately grazed and overgrazed plots. Soil samples were taken from the rhyzospheric soil of the more conspicuous Patagonian steppe grasses (palatable *Bromus pictus* and *Poa ligularis*, less palatable *Stipa speciosa* and unpalatable *Stipa humilis*) and under bare soil patches. Spores were extracted by the methods of Gerdeman and Nicholson (1863) and Walker et al. (1982). Fungal density was considered as total spore number per 100 g of soil. Fungal specific spore density was quantified to calculate the biodiversity index Shannon-Weaver, H. Trap cultures were made for spore identification.

Results and discussion AMF spore abundance in general was highest in the ungrazed plots and lowest in the overgrazed ones. AMF community associated with *S. humilis* was less affected by grazing and showed a higher AMF spore abundance under moderately grazed conditions. AMF fungal diversity was highest in ungrazed and moderately grazed plots and lowest in overgrazed plots. *Glomaceae* familly was dominant in all sites and *Gigasporacea* family disappeared in the overgrazed sites. *Pacispora sp*. was present in all sites and it was the first time ever it was found in an Argentinian ecosystem.

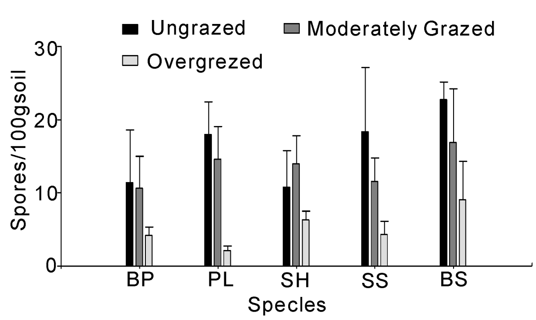

Figure 1 *Number of spores/100 g soil in the rhizospheric soil of B. pictus (BP), P. ligularis (PL), S. speciosa (SS), S. humilis (SH) and Bare Soil (BS); in ungrazed, moderately grazed and overgrazed plots.*

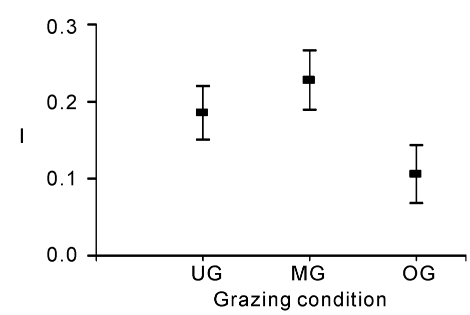

Figure 2 *AMF spore biodiversity index (Shannon-Weaver), H. Under ungrazed (UG), moderately grazed (MG) and overgrazed (OG) conditions.*

Conclusions Overgrazing may alter the ecosystem functioning of the Patagonian steppe not only by reducing the plant cover but also by reducing AMF abundance and diversity, thus increasing the process of desertification

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Studies on transgenic wheatgrass of exogenous CBF_4 gene

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Key words : CBF_4 gene ,transgenic wheatgrass ,southern blot

Introduction After transgenic hybrid wheatgrass (*Agropron cristatu* × *A .desertorum cv* . Hycrest-Mengnong) of CBF_4 has been obtained , the transformation and copy number were detected by Southern blot . The exogenous gene has been integrated into the genomic DNA and inserted into the chromosome of receptor cells by multicopy integration . Exogenous gene fragments have been transferred into ycrest-Mengnong wheatgrass successfully .

Materials and methods The transformed(by gene gun) and non transformed Hycrest-Mengnong wheatgrass plants were used as materials . Plant genomic DNA was sheared by restriction endonucleases . Aim fragments from plasmid DNA which were amplificated by PCR were the templets . The DIG label and detected kit were used to label the probe and to ascertain the transformation of fragments .

Results Figure 1 shows the Southern hybridization map . From Figure 1 , the hybridization band of CBF_4 transgenic plants were obvious and the integration number is 2-5 .

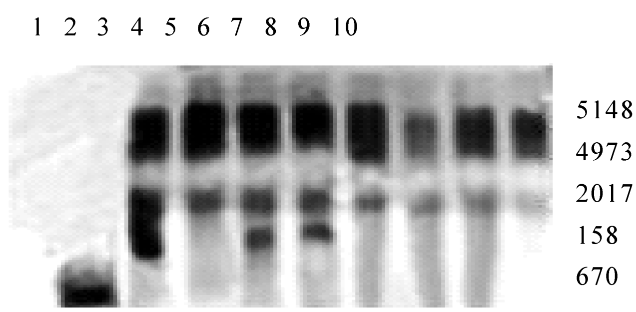

Figure 1 *Southern analysis of digested total genomic DNA from transgenic wheatgrass probed with DIG labeled plasmid DNA (CBF_4) . 1-negative control , 2-positive control ,3-10-transgenic plants .*

Conclusions The CBF_4 gene is a new member of CBF family isolated from *Arabidopsis thaliana* reported by Volker Haake , Daniel Cook . The CBF_4 gene's expression was induced by drought , not low temperature . The resistance of *Arabidopsis thaliana* plants to drought and low temperature will be enhanced if CBF_4 gene expresses excessively . The results of Southern blotting indicated that the exogenous gene CBF_4 has been integrated into wheatgrasses plants and inserted into the chromosome with multicopy .

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Studies of population characteristic affecting senescence of *Elymus sibiricus*

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Key words : senescence , population characteristic , modular , propagation ability , Elymus sibiricus

Introduction Plant senescence is an internally regulated and orderly degenerative process leading to the death of single cells , organs or even whole plants during their life cycle (Deborah , 1993) . Senescence may occur in annual plants and monocarpic perennials abruptly and in iteroparous plants gradually (Silvertown *et al* . , 2001) . *Elymus sibiricus* is a perennial bunchgrass . The objective of this study was to explore the effects of population characteristics on senescence of *Elymus sibiricus* by researching tillering ability , biomass , modular structures and propagation in *Elymus sibiricus* at different ages , in order to supply some evidences and material for forage production and also establishing a basis for more detailed research on perennial senescence .

Materials and methods The sampling sites were selected in places where *Elymus sibiricus* were grown in 2002 , 2003 , 2004 , 2005 , 2006 . The independent tufts of *Elymus sibiricus* population in five sites were large sampled on August 20 , 2007 . The plant number , aboveground biomass , number of sexual plant , weigh of tapering spikes per tuft and so on were measured and recorded . Data were analyzed using an ANOVA modal .

Results The numbers of tillers , sexual tillers and potential population per tuft of *Elymus sibiricus* planted in 2005 (grown 3 years) were the highest . These were decreasing gradually with advancing ages (Table 1) . Also , the weight of tillers and tapering spikes per tuft of *Elymus sibiricus* planted in 2005 was the heaviest . The ratio of sexual tillers to weight of tapering spikes per tuft was the highest in *Elymus sibiricus* planted in 2006 . The number of tillers and potential population presented vegetative propagation ability ; thus the others quantitative characters may present sexual reproduction ability .

Table 1 *Quantitative characters of* Elymus sibiricus *population with different ages .*

Quantitative characters (per tuft)	Planting years				
	2006	2005	2004	2003	2002
Tillers	16 .4±2 .6	39 .0±5 .0**	32 .4±3 .8**	28 .4±4 .2*	20 .4±3 .3
Sexual tillers	12 .4±2 .1 (75 .4%)	26 .0±4 .3** (65 .4%)	18 .0±3 .3* (54 .3%)	10 .8±2 .0 (38 .6%)	6 .6±2 .4 (28 .5%)
biomass (g)	5 .8±0 .9	14 .9±3 .2**	5 .6±1 .1	5 .0±0 .8	3 .0±0 .7
Weigh of tapering spikes (g)	1 .4±0 .3** (22 .0%)	2 .3±0 .9** (14 .2%)	0 .5±0 .1 (8 .3%)	0 .4±0 .1 (7 .4%)	0 .1±0 .07 (4 .3%)
Potential population	8 .2±2 .5	55 .4±10 .6**	49 .6±6 .5**	34 .3±4 .1*	29 .4±8 .2*

* $P<0.05$, ** $P<0.01$, potential population means the total of tiller buds and tiller seedlings .

Conclusions The best time for using *Elymus sibiricus* is after 3 years growth when production and propagation ability are the highest . There was a deteriorative phenomenon observed related to quantitative characters of *Elymus sibiricus* with respect to senescence .

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Testing diversity effects of forage biodiversity in the Karst region of southwestern China

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Key words: biodiversity, selection effect, complementary effect, Karst region, southwestern China

Introduction The relationship between biodiversity and productivity has received wide attention during the last decade. Most of studies have been performed in America and Europe, but rarely in China, especially in Karst region. We investigated the relationships between cultivated forage species diversity and productivity in the Karst region of southwestern China, and anticipated answering the following questions: firstly, how did biomass production respond to forage species richness in our experiment in the Karst region? Secondly, what was the mechanism underlying diversity-productivity in our experiment? Thirdly, did aboveground biomass per plant change with different levels of diversity?

Materials and methods The experiment was carried out at the permanent field site of Huanjiang Experimental Station of Karst Agro-ecosystem of CAS, located in south-west of Guangxi in China (24° 44′N, 108°19′E, 302 m above sea level). The mean temperature is about 20℃, and mean annual precipitation is about 1389 mm. Six forage species selected, including White Clover, Red Clover, Alfalfa, Common Aeschynomene Herb, Green Bristlegrass Herb and Broadleaf Paspalum were included in this experiment. The communities of two, three, four and six species were combined by constrained random selection from the species pool, without any certain composition twice. The analysis was based on the data of aboveground forage biomass and species compositions after a full growing season of each plot. Diversity effect was calculated by the method of (Loreau & Hector, 2001). The data were tested by SPSS 13.0 software using one-way ANOVA procedures, followed by LSD multiple comparison tests to determine the differences among the yields of forage species in monocultures and the differences of RYT, net effect, selection effect and complementary effect among different levels of species-rich communities.

Results Forage species richness had a significant linear increased effect ($P<0.01$) on aboveground biomass. Net effect and RYT of mixture of two species was lower ($P<0.01$) than one, while the other three levels showed diverse trends. Selection effect showed general increase with diversity ($P<0.01$), with the highest value occurring in the community of four species. Complementary effect showed an increasing trend with species richness without significant difference from zero.

Conclusions Our study indicated that biodiversity enhanced the aboveground biomass production in the Karst region because of the selection effect. Selection effect facilitated the growth of forage species with deep roots, and then compensated the growths of other forage species. In addition, our species-rich communities might be in an unstable status, with easilily suffered by disturbance. Increased effective aboveground space utilization might be caused by the increased species richness, and then leaded to the increased aboveground biomass production. The results implied that aboveground species interactions, such as light complementarity, might contribute to positive diversity-productivity. Further investigation should be conducted using empirical field data on light absorption. The presented study revealed production formation mechanism of initial cultivated grassland processes in the Karst region in southwestern China, and was helpful for the grassland building in this area.

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Fractal characteristics of the distribution pattern of *Ceratoides arborescens* populations from Inner Mongolia grassland

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Key words : pattern , fractal dimension , ecological unoccupied dimension , *Ceratoides arborescens*

Introduction *Ceratoides arborescens* is a long-lived , cold-resistant and drought-resistant perennial subshrub , which plays an important role in Inner Mongolia . Traditional approaches to describing and interpreting spatial distributions of *Ceratoides* species have focused on the patterns either of species zonation or of species diversity . In this paper , we discussed the method of fractal analysis , and tried to explain : Whether patterns of *C . arborescens* populations have the similar detail over a range of scales ? To address this problem and to measure the complexity of pattern structure , a fractal approach must be used .

Materials and methods *C . arborescens* is widely distributed along Inner Mongolia grassland . Six study plots , P1 , P2 , P3 , P4 , P5 and P6 are chosen in *C . arborescens* communities of different vegetations on Inner Mongolia grassland . At each plot , eight contiguous 20 m×20 m quadrats are established . Tree height , crown size , and the x and y coordinate of individuals are measured . Fractal dimension (D_b) is calculated using the box-counting method .

Results Figure 1 shows that each log (ε)-log *N* (ε) curve can be subdivided into two sections characterized by different slopes and scale ranges . The scale size of inflexion points is better significance .Table 1 shows that at the significance level of 0 .01 , the fractal dimensions for the distribution patterns of *C . arborescens* populations in P1 , P2 , P3 , P4 , P5 and P6 are 1 .386 , 1 . 377 , 1 .616 , 1 .512 , 1 .087 and 1 .049 , respectively . In the order of P3>P4>P1>P2>P6>P5 .The scale size of inflexion points for P1 , P2 , P3 and P4 are 2. 857 m , 2. 500 m , 2. 857 m and 2. 500 m ,while that for P5 and P6 are 1. 333 m. The mean crown sizes of *C . arborescens* individuals in P1 , P2 , P3 , P4 , P5 and P6 are 1. 432 , 1. 178 , 0. 965 , 0. 601 , 1. 154 and 1. 809 m , respectively . These indicate that the capacities of spatial occupation of different populations are variable .

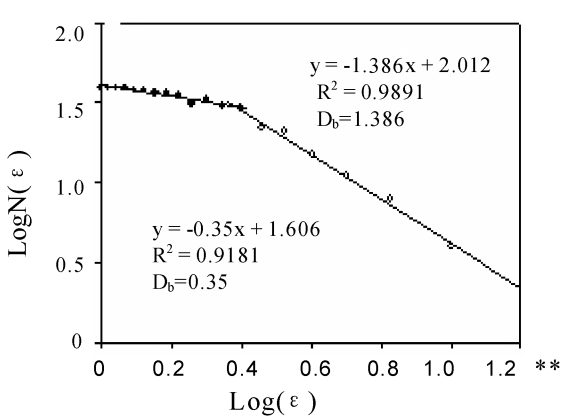

Figure 1 *Box-counting dimension of P1 population .*

Table 1 *Box-counting dimensions of C . arborescens population patterns in different grassland types .*

plot number	box-counting dimension	correlation coefficient	inflection point(m)	mean crown width(m)
P1	1 .386	0 .989**	2 .857	1 .432
P2	1 .377	0 .920**	2 .500	1 .178
P3	1 .616	0 .983**	2 .857	0 .965
P4	1 .512	0 .984**	2 .500	0 .601
P5	1 .087	0 .970**	1 .333	1 .154
P6	1 .049	0 .937**	1 .333	1 .089

** Effects of periods on all variables were significant ($p<0.01$)

Conclusions The patterns of *C . arborescens* populations could be thought of as fractals as they exhibit self-similarity within the range of scale considered . Their fractal dimensions are not integer but fractional , ranging from 1 .049 to 1 .616 . The results showed that the spatial distributions of P3 and P4 were high (1 .616 and 1 .512 near 2) in different types of *C . arborescens* , which reflected the high spatial occupation degrees of the populations as the dominant species of these grassland types . The order of spatial occupation degree was P3>P4>P1>P2>P6>P5 , which reflected the variation of functions and positions of *C . arborescens* population in different grassland types .

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Dynamics of reproductive allocation of reproductive tillers in *Stipa baicalansis* populations on the Songnen Plains , China

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Key words : *Stipa baicalansis* , reproductive tiller , biomass , reproductive allocation

Introduction Reproductive allocation (RA) is the biomass ratio of reproductive organs to total biomass in all assimilative resource of a plant individual . Individual is plastic in size due to the difference of the microenvironment . The plasticity follows certain rules and shows the regulation in growth and allocation at the population level . *Stipa baicalansis* , a perennial grass , is usually the constructive or companion species of communities in meadow steppe regions in China (Li , et al . ,2003) . The objective was to find the rules of the relationship of RA and height , biomass of tiller in different growing stages , which provided scientific accumulation to further research of reproductive ecology .

Materials and methods The study was conducted at the Pasture Ecology Research Station of Northeast Normal University , Changling , Jilin province of China (44°45′N , 123°31′E) which has temperate sub-humid continental monsoon climate . *S . baicalansis* experimental population was planted in 2005 . Each plot had an area of 2 m×6 m with 5 replications . Forty reproductive tillers were sampled randomly in all plots at flowering and ripening stages , respectively . Height , tiller and inflorescence biomass were measured . The ratio of inflorescence biomass to tiller biomass was regarded as reproductive allocation . Relationships between biomass and height of the tiller , and RA and the height , the tiller biomass were evaluated using regression analysis .

Results The relationship between biomass and height of the tillers were positively linearly correlated ($p<0.01$) at flowering and ripening stages , but between RA and both height and biomass of the tiller negative correlation was observed , and only at flowering stage between RA and height of the tiller the correlation was significant ($p<0.05$) (Figure 1) . These indicated best isometric rule of the biomass and height of reproductive tillers . The rule of negative correlations on RA and height as well as biomass was gradually weakening from flowering to ripening stage . These showed RA of the tillers in different size were all tending to the average value of the population with growing stages .

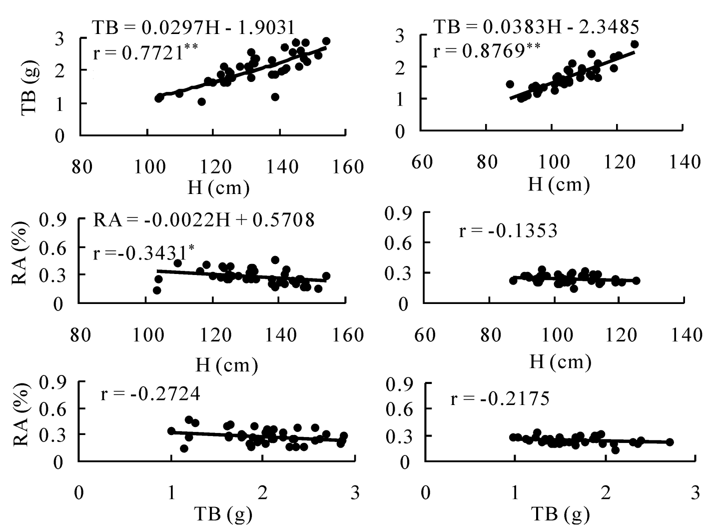

Figure 1 *Observed data and simulated curves on relationship between total biomass (TB) and height(H) of the tiller , RA and both height and total biomass of the tiller at flowering (FS) and ripening (RS) stages .*

Discussions The growth , intraspecies and interspecies competitions of plants shared in limited resource , and appropriate combination of growth and reproduction could form relative predominance in evolution . Taller tillers had good light and more nutrition , so they were advantageous in competition . Positive correlation of biomass and height indicated that increasing height was advantageous to the whole tiller , and an increasing ratio of vegetative growth would decrease RA . The nearly accordant RA in ripen embodied the strategies which *S . baicalansis* population advanced fitness through regulating growth and allocation .

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Dynamic change of production and botanical composition in *Trifolium repens* and perennial grass mixtures over 20 years in the Karst region, Southwest China

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Key words: white clover, mixed pasture, net production, persistence, temporal dynamics

White clover (*Trifolium repens*) use is valued for its ability to substitute for fertilizer nitrogen (N) use and to improve pasture quality (Thomson 1984). It was introduced into the Karst region of China at least 100 years ago; however, its persistence and compatibility with grasses in the mixture still remains unclear.

An experiment was conducted at Zhuopu Demonstration Farm, Guizhou Province, China (104°07′25″E, 27°12′30″N, 2442 m a.s.l.), from April 1985 to November 2005. Four mixtures consisted of white clover plus perennial ryegrass (*Lolium perenne*) (T+L), red fescue (*Festuca rubra* L.) (T+F), Kentucky bluegrass (*Poa pratensis* L.) (T+P) and bromegrass (*Bromus inermis* Leyss) (T+B), grazed with Corriedale sheep between pasture mass of 1800~2500 kg DM ha^{-1} and 900~1200 kg DM ha^{-1}. With N, P and K fertilizer applied in the first four years then yearly application of P fertiliser only.

Results have shown that T+F had the highest mean annual net production and remained stable over 20 years, followed by T+L and T+P, while T+B was the lowest. However, T+L was significantly higher in net yield in the first four years. White clover produced similar yields and was a similar proportional of the sward composition in all mixtures, whereas the four grasses differed greatly ($P < 0.01$), indicating that selection of companion grasses is essential for the production and persistence of binary mixtures (Figure 1).

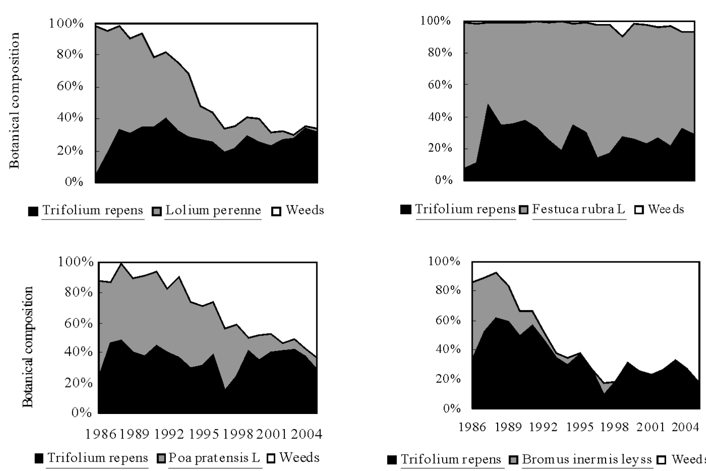

Figure 1 *Botanical composition for each treatment from 1986 to 2005.*

Species of companion grasses had no significant effects on white clover production and persistence, but strongly affected total net yields of the mixtures. These findings are different from many studies, which have found that sheep grazing generally results in a decrease in white clover content (Hodgson 1990; Sheath & Clark 1996), and the companion grass species compete and affect the persistence of the clover (Nolan et al., 2001).

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Study on leaf production of alfalfa at different planting densities

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Key words : alfalfa , planting density , leaf weight , leaf number , hay yield

Introduction Alfalfa (*Medicago sativa*) is a high-protein leguminous forage . Many studies showed that the leaf production of alfalfa was not only related to its nutritional value , but was also related to its hay yields (Frakes *et al* . ,1961 ; Smith *et al* . , 1964) . How to improve the leaf yield of alfalfa has not been reported in the relevant references in the study of alfalfa cultivation . Therefore , the study of leaf production of alfalfa in different planting densities is of great significance to improve greatly its nutritional value and hay yield .

Materials and methods The experimental field was in Gongzhuling city , middle west of Jilin province , located at 43°31′ N and 124°58′ E . The cultivar of alfalfa is *Medicago sativa* L .cv . Gongnong No .1 . Planting density was designed into 5 density grades , the plant distance and row spacings were : A-20 cm×20 cm , B-30 cm×30 cm , C-40 cm×40 cm , D-50 cm×50 cm and E-60 cm×60 cm .The plot area was $12m^2$ (3 m×4 m) , using randomized block design and 5 replicates . The average plant absolute height , shoot number , compound leaf number , stem weight , leaf weight and hay yield of each treatment were measured at the first early flowering stage in the third year(June 10 ,2007) , 5 individual plants from each plot were sampled randomly . Ratio of stem to leaf and hay yield of per square meter were also calculated .

Results and analysis There was no significant difference in the average plant absolute height stem/leaf ratio among all the density grades ($P>0.05$) . However , there were significant differences in shoot number , compound leaf number , shoot weight ,leaf weight and hay yield among some treatments($P<0.05$) (Table 1) ,they were all the highest in the density A and the lowest in the density E . The correlation coefficient(R^2) of leaf weight was 0 .97 for hay yield , 0 .94 for stem weight ,0 .32 for leaf number and 0 .25 for shoot number at the 0 .05 level (Figure 1) .

Table 1 *Significant difference comparison for height , shoot numbers , compound leaf numbers , stem weight , leaf weight , hay yield and stem/leaf ratio in different densities(0 .05 level) .*

	Height (cm)	Shoot number (no/m^2)	Leaf number (no/m^2)	Air-dried stem (g/m^2)	Air-dried leaf (g/m^2)	Hay (g/m^2)	Stem/leaf (%)
A	110 .3a	615a	40170a	900 .2a	479 .9a	1379 .1a	34 .72a
B	118 .9a	440abc	26310abc	759 .2ab	418 .1abc	1177 .4abc	35 .51a
C	125 .9a	444ab	35200ab	801 .6ab	426 .2ab	1227 .8ab	34 .71a
D	114 .4a	388bc	21347bc	468 .3bc	263 .7bc	732 .0bc	36 .03a
E	116 .3a	225c	16716c	350 .8c	213 .8c	564 .5c	37 .86a

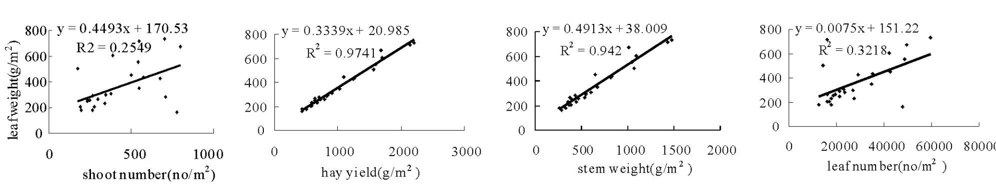

Figure 1 *Relationship between leaf weight and the other characteristics of per square meter .*

Conclusions Leaf weight of alfalfa per unit area was significantly different at differing planting densities , and it increased as the density increased . Leaf weight was closely related to hay yield and stem weight , lowly related to leaf number and not related to shoot number .

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Response of plant species diversity to simulated climate change nitrogen supply in desert steppe

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Key words : species diversity , diversity index , desert steppe , warming , nitrogen supply

Introduction Species diversity plays an essential role in sustaining earth system processes and providing basic goods and services to human society . Stresses from human activities , however , are having a profound effect on the earth system , including loss of species diversity , which is proceeding at unprecedented rates . Such stress is climate alteration and deposition . We investigated the independent and combined effects of experimental warming and nitrogen supply on plant species diversity in Sizhiwang County , a located in Inner Mongolia , China .

Materials and methods The experiment used a paired , nested design with warming as the primary factor and nitrogen supply as the secondary factor . There were six paired of 3×4-m plots , one plot in each pair was assigned as the warming treatment and the other as the control . Each warming and control plot were divided into two subplots (2×3-m) .The subplots were randomly assigned to the nitrogen supply treatment . Nitrogen supply in the subplot is $10 g/m^2$. The warmed plots have been heated continuously since May 2006 using 165×15-cm MSR-2420 infrared radiators (Kalgo Electronics , Bethlethem , PA , USA) suspended 2 .25 m above the ground . In the unwarmed control plot , one dummy' heater with the same shape and size as the infrared radiator was suspended 2 .25 m high to simulate the shading effects of the heater . Thus , there were six replicates for each treatment(control , warming , nitrogen supply , warming plus nitrogen supply) . In each of 24 subplots , we laid out a 1× 1-matrix . We investigated species diversity , cover and height . Margalef (Ma) ,Shannon-Winner (H) ,Simpson (D) and Pielou (JP) diversity indexes were analyzed using SAS 9 .0 .

Results In the study , the main effect of warming plots for H , D , JP was larger than in the control plots both 2006 and 2007 , but Ma was decreased . Comparing 2006 and 2007 in warming and control plots , D index was similar , H and JP were both increasing , respectively 4 .1% and 4 .6% , but Ma decreased 1 .5% . Both 2006 and 2007 , D , H and JP's value in warming× nitrogen supply subplots is higher than other three kinds treatment plots (control , warming , nitrogen supply) . In the same year , these diversity indexes were no significant difference ($P>0.05$) . The reason could be attributable to warming time . If warming experimental was continuously done in the following year , the diversity index difference would be significant . These diversity indexes did not vary in nitrogen-supplied subplots . A similar result has been reported from the Tibetan Plateau (Klein et al , 2004) .

Table 1 *Diversity index (W : warming , N : nitrogen supply , C : control) .*

Treatment	Margalef		Shannon-Winner		Simpson		Pielou	
	2006	2007	2006	2007	2006	2007	2006	2007
W×N	1 .576a+0 .21	1 .453a+0 .14	1 .491a+0 .2	1 .586a+0 .2	0 .695a+0 .07	0 .736a+0 .07	0 .717a+0 .07	0 .772a+0 .1
W	1 .544a+0 .31	1 .437a+0 .14	1 .425a+0 .21	1 .613a+0 .16	0 .642a+0 .09	0 .756a+0 .05	0 .693a+0 .07	0 .784a+0 .06
N	1 .536a+0 .23	1 .477a+0 .24	1 .44a+0 .25	1 .524a+0 .26	0 .653a+0 .11	0 .749a+0 .05	0 .689a+0 .12	0 .716a+0 .08
C	1 .625a+0 .3	1 .495a+0 .22	1 .438a+0 .37	1 .511a+0 .26	0 .642a+0 .16	0 .701a+0 .1	0 .674a+0 .14	0 .716a+0 .13

Conclusions The study , which is the first to explicitly examine the independent and combined effects of experimental warming and nitrogen supply on the desert grassland , suggests that the future species in this region will depend on both climate change and nitrogen supply .

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Changes of proline content in leaves of two alfalfa cultivars with different salt tolerance under salt stress

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Key word: alfalfa, growth, proline, salt stress

Introduction Salinity is the major environmental factor that limit plant growth, productivity and distribution. Proline is generally regarded as a compatible solute involved in cellular osmotic adjustments, whose accumulation increases when plants are in drought and salt stressed conditions. However, Lutts et al (1996) concluded from their studies on rice that proline accumulation contributed little in cellular osmotic adjustments, and that it may have had other functionality not yet discovered in plants.

Materials and methods Seeds of two cultivars of alfalfa (*Medicago sativa* L.), cultivars Zhongmu No.1 and Defor were surface sterilized with 6% sodium hypochlorite solution for 5 min. They were then germinated in humid sand medium on plate in the dark at 25/20℃ of 8 h/16 h, and then four uniform seedlings per cultivar and treatment combination, as a unit, were fixed into the holes of quadrate foam and transplanted into plastic vessels. Every vessel contained 4.4 L of a standard nutrient solution. After 20 days, 6 plants of each cultivar at each treatment were removed and divided into roots, shoots and leaves for the growth parameter and proline content (Tigen et al., 1973) measurements.

Results Root, shoot, and leaf growths (Figure 1) were inhibited by increased salt treatments in both cultivars, but Zhongmu No.1 had significantly higher root, shoot and leaf dry weights per plant than Defor. NaCl treatments led to a significant increase in the leves of proline content in both alfalfa cultivars (Figure 1). The proline accumulation in Defor (low salt tolerance), however, was much greater than in Zhongmu No.1 (high salt tolerance) at 140 and 210 mM salt treatments.

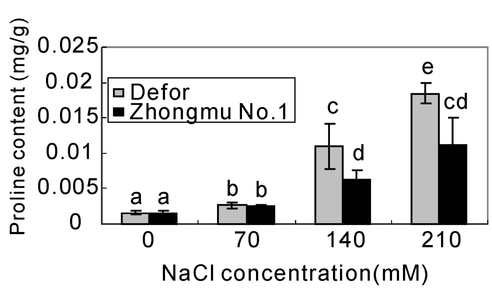

Figure 1 *Effect of NaCl on Proline of leaves of Defor and Zhongmu No.1 at 7 days after salt stress.*

Table 1 *Dry weight (mg / plant) of root, shoot and leaf of Zhongmu No.1 and Defor grown in four treatments after 15 days NaCl treatments.*

NaCl	Zhongmu No.1)				Defor			
	Control	70	140	210	Control	70	140	210
Root	0.035	0.032	0.028	0.023	0.033	0.024	0.019	0.014
Shoot	0.15	0.09	0.08	0.05	0.14	0.06	0.04	0.02
Leaf	0.13	0.11	0.10	0.07	0.12	0.07	0.06	0.03

Conclusions Under high salt treatments, Zhongmu No.1 exhibited better salt tolerance than Defor. Proline accumulation might result in higher salt tolerance instead of causing it. Also, this might indicate that proline was a contributing factor to the inhibited growth of plants under salt stress.

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Study on community β-diversities of different grazing systems in a desert steppe environment

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Key words : desert steppe , continuous grazing , rotational grazing , β-diversity

Introduction Plant community diversity is composed of community composition and dynamic diversification (Xie Yingzhong , 1999) . For the relationships of prairie plant community diversity and grazing , there has been a substantial amount of research conducted (Grimes J P ,1973 ; Huston M . A ,1979) , but there are very few studies on the change process of grassland community plant diversity in different grazing systems . Knowledge about the changes of plant diversity of desert grassland communities under different grazing systems can lay a foundation for further in-depth study on eco-functions of desert grassland community biodiversity .

Materials and methods The study site was located in *Stipa breviflora* desert steppe in Sunit Right Banner of Inner Mongolian (42°16′26″N ,112°47′17″E) .Annual-mean temperature is 6 .2℃ and average precipitation is 209 .12 mm . Dominant vegetation is the community of *Stipa breviflore* and *Cleistogenes songorica* and *Allium polyrhizum* . The experimental treatments were composed of a continuous grazing plot of 340 hm^2 , a rotational grazing plot of 320 hm^2 divided into 8 smaller , equally sized plots and a grazing exclusion plot of 1hm^2 , which has not been grazed since 1999 . Stocking rate on grazing plots was 1 .25 sheep/hm^2 . Plant community β-diversity was measured . Statistical analysis software SAS8 .2 and EXCEL2003 were used to analyze data for this research .

Results and discussion The index of community β-diversity decreased with increasing quadrat size (Figure 1) . Three treatments did not differ significantly with the same sample size on Desert Steppe($p>0.05$) . The highest index of β-diversity was in rotational grazing treatment . This may be because there was certain leisure time in rotational grazing , so the plant growth accelerated and vegetation cover increased . This may have lead to a higher β-diversity index in the rotational grazing plot . The results showed that community structure is relatively complex and stable on a certain extent in rotational grazing system .

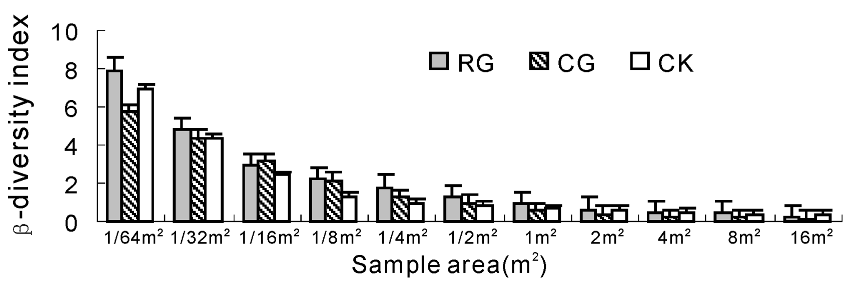

Figure 1 *Community β-diversity under different grazing system .*

Conclusions Community β-diversity index decreases with the increasing quadrat size . The highest index of β-diversity was observed under a rotational grazing system .

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Analysis of fire spread rates between seeded and unseeded areas in the Snake River plains of Idaho, USA using the Behave© fire model

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Key words: fire spread rates, fuel continuity, fire modeling, Behave©

Introduction Wildfire has played an important ecological role throughout the history of the sagebrush-steppe ecosystems of the Snake River Plains of Idaho. In pre-settlement times fires were probably small and spotty, which helped maintain a patchy, heterogeneous landscape (Bunting, 1996). In the post-settlement era, fires in Wyoming Big Sagebrush (*Artemesia tridentata ssp. Wyomingensis*) have been more frequent and larger resulting in the conversion of large areas within the Snake River Plains to exotic annual grasslands of cheatgrass (*Bromus tectorum*). Managers generally reseed a suite of perennial species to reduce erosion and invasive species potential after these wildfires. Seeding with perennial species is believed to reduce the likelihood of future wildfires due to the reduction in cheatgrass. This study examines the effects of revegetation on wildfire spread rates and examines the usefulness of a commonly used fire prediction model (Behave Plus) in predicting fire spread rates in sagebrush-steppe ecosystems. Seeded and unseeded sites have been evaluated for significant differences in fuel continuity, plant canopy cover, fuel load, and fuel bed depth, and rates of fire spread with the Behave Plus© fire model.

Materials and methods Sixteen previously burned sites with seeded and unseeded components were selected in the Snake River Plains of southern Idaho, USA for study. Wildfires on the study sites occurred between June and September from 1987—2002. All study sites were reseeded at least two years previous to the study to allow for community stabilization. Reseeding was primarily accomplished using a rangeland drill in the fall following the wildfire. Common species seeded included *Agropyron cristatum* (crested wheatgrass), *Agropyron sibericum* (Siberian wheatgrass), *Elymus cinerus* (Great Basin wildrye), *Achillea millefolium*, (common yarrow), *Atriplex canescens*, (fourwing saltbush), and *Medicago sativa* (alfalfa). All samples and observations were taken during the months of June August in 2004 and 2005. Fire spread rate estimates were calculated using the Behave Plus 3.1 fire model, with fuel load and fuel bed depth data from seeded and unseeded portions of each site used to provide a comparison of fire spread rate. Fire spread rates were calculated both with and without litter added as part of the total fuel load. A paired sample t-test was used to analyze any differences in fire spread rate, fuel loading, and fuel bed depth. SAS 9.3.1 was used for the analysis. Fuel continuity was measured using the line intercept method for foliar cover. Each gap in canopy coverage along a 100 m transect greater than 5 cm was measured and recorded. A paired sample t-test (Proc Univariate) was performed using SAS 9.3.1 to compare mean gap values between foliar cover of plants for the seeded and unseeded sections. P-values are significant at the 0.05 level.

Results There were no statistically significant differences between seeded and unseeded portions of sites for fire spread rate (p-value: without litter 0.31; with litter 0.11), fuel loading (p-value: with litter 0.69; without litter 0.74), and fuel bed depth (p-value: 0.08). Although there was no significant difference in fuel loading between seeded and unseeded areas, there was a dramatic difference in the composition of plants. Annual forbs and annual grasses comprised 12.5% and 63% of total fuel load in the seeded and unseeded areas, respectively. Mean gap values for each treatment were used to compare sites for fuel continuity. The paired t-test demonstrated statistically significant differences between seeded and unseeded treatments (p-value 0.0084). Average gap size in the seeded areas was 15.78 cm as compared to 12.30 cm in the unseeded areas. On average, there were more gaps in the seeded areas (158) than in the unseeded areas (120).

Conclusions Although no significant differences were found for fire spread rates when using fuel load and fuel bed depth data, there was considerable variation in the plant composition and fuel continuity between seeded and unseeded sites. Fuel continuity is more discontinuous in seeded areas as compared to unseeded areas. Not only are the gaps in canopy cover larger on average in seeded areas, there are also more gaps in the seeded areas than in the unseeded areas. The larger gap size and number of gaps in the seeded areas are indicative of more discontinuous fuels than in the unseeded annual grass dominated areas. This difference in fuel continuity would be influential in reducing wildfire rate of spread although the Behave© model did not substantiate this difference. The Behave© model should be modified to include fuel continuity to better predict fire behavior in rangeland situations.

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Influence of aridity on carbon isotope discrimination in leaves of *Stipa* and other C3 species in central Asian grassland

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Key words: carbon isotope discrimination, *Stipa*, C3 plants, aridity, central Asian grassland

Introduction The carbon isotope discrimination (Δ) of C3 ecosystems is sensitive to water availability. Mean annual precipitation (MAP) is the most convenient and in some cases even the only known property to quantify water availability. The study reports the effects of MAP on Δ of *Stipa* species and other C3 plants.

Material and methods *Stipa* species and were sampled along aridity transects in Inner Mongolia (China) and in the Republic of Mongolia in 2005 and 2006. Δ of *Stipa* was compared with published data of *Stipa* and of other C3 species (including samples collected along the 2005 and 2006 transects and published data) covering several years and regions around Mongolia. Weather data were taken from Climate Source Inc. and the NOAA NNDC network and geostatistically interpolated to obtain temporally and spatially resolved information for the sampling sites.

Results and discussion In 2005 and in 2006 Δ for *Stipa* species increased linearly with MAP. The slope (Figure 1 a) was the same in both years there was an offset of 1.1‰. The latter was caused by a difference of about 0.7 mm day^{-1} of precipitation during the growing season. The Δ response was the same in both years when Δ was related to the year-specific mean daily precipitation during the growing season (Figure 1 b). An unbiased generalized relation of Δ with MAP was derived for *Stipa* species in Central Asian grassland. It has a slope of 0.0063‰ mm^{-1} and predicts Δ for average growing seasons. The effect on Δ of deviations of actual from mean precipitation can be accounted for. The generalized relation of Δ with MAP was validated with published *Stipa* data (Figure 2 a). The same relationship held true for other C3 species (Figure 2 b).

Conclusions The relationships established in this study can be used to estimate the mean Δ of C3 communities from MAP or annual precipitation during the growing period and *vice versa*.

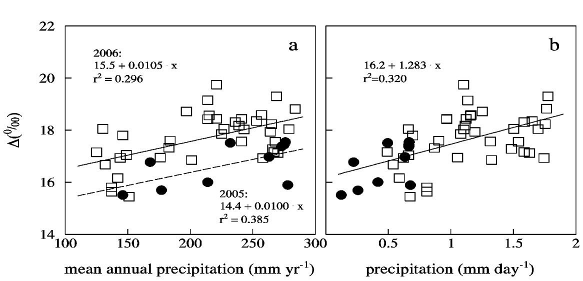

Figure 1 *(a) Relation between Δ and MAP for* Stipa *species for the years 2005 (●, dashed regression line) and 2006 (□, solid regression line). (b) Relation between Δ of* Stipa *sp. and year-specific mean daily precipitation during the growing period (April—August) for the years 2005 (●) and 2006 (□).*

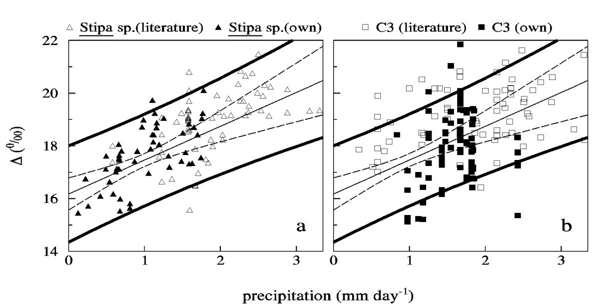

Figure 2 *Relation between Δ and mean daily precipitation (a)* Stipa *sp. from this study and from literature. (b) C3 species from this study and from literature.*
Bold lines denote 95% confidence interval of the individual values, dashed lines 95% confidence interval of the regression and thin line the regression, all calculated from Stipa *collected in 2005 and 2006.*

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Study on the change of micro-relief and plant community in the hulunbuir sandy nature meadow prairie

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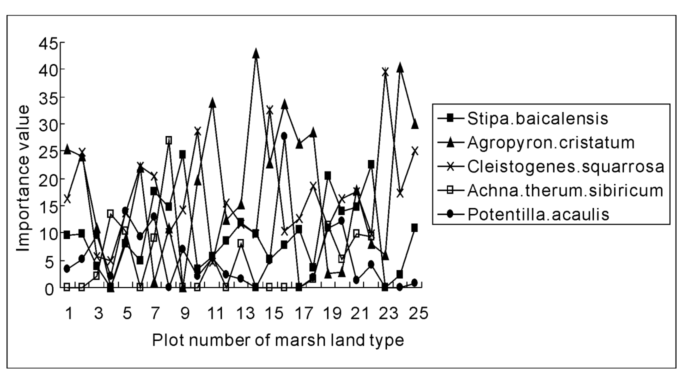
Key words : sandy grassland , micro-relief flora , dominant species , importance value

Introduction It was discovered that sandy grassland vegetation changes in close relation to landscape which could be seen especially well in a morphological depression (Zhang A , 2007) . A morphological depression in grassland is similar to an isolated island in the ocean , which provides an ideal site for studying the relationship between changing of micro-relief and grassland vegetation .

Materials and methods The study site was located in the Hulunbuir Sandy Grassland (49°11′to 49°14 .13′N , 119°34′ to 119°36′ E) , with a length along the W-E axis of 1 .6 km , a length along N-S axis of 1 km , and a relative depth of 19 m . Falling gradients of slopes facing different directions are : W slope 0. 02 , N slope 0. 04 , E slope 0. 03 , S slope 0 .03 . The dominant species were *Stipa baicalensis* , *Cleistogenes squarrosa* , *Agropyron cristatum* , *Achnatherum sibiricum* , *Potentilla acaulis* and *Poa sphondylodes* . The site was lightly degraded . Please entirely revise the following sentence : Establishes 8 types place about background prairie around the marshland to take the contrast . Research quadrat size for the height , density , coverage and the standing crop of plant community was 1 m×1 m . Each treatment was replicated three times .

Results There were 73 kinds of plants in the research type place , 44 kinds in background prairie , and 16 kinds were in 1 quadrate size . 68 kinds in marsh land , 15 kinds were appeared in 1 quadrate size . These types were non-uniformly distributed in the marsh land ; there were significantly differences among species numbers , life type and ecotype . Moreover , it appeared heterogeneity about dominant species and subdominant species in the marsh land and the background prairie , there have the same phenomenon in the different slope position and different slope approaches of micro-relief and flora . There only have 27 kinds of species in sunny slope (Inner Mongolia vegetation , 1985) .

The diagram curves of the main plant species important value change in the marsh land were made .



Conclusions There were stronger reflection ability to the habitat heterogeneity about the terrain factor in the small scale . It will appear soil wind erosion phenomenon if plants were serious disturbed .

The important value as one kind of comprehensive target can reflect the distribution characteristic of plant in small criterion of marsh land , and also point out the most suitable habitat of plants .

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The effect of mycorrhizal fungi on Italian ryegrass in Guangzhou paddy field

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Key words : mycorrhizal fungi , Italian ryegrass , root colonization , phosphorus fertilizer , soil sterilization

Introduction As a feed , Italian ryegrass (*Lolium multiflorum*) has many advantages such as containing more crude protein . Moreover , Italian ryegrass winter cropping can promote the output of succeeding rice . This study evaluated the effect of mycorrhizal fungi on the growth of Italian ryegrass , as well as its performance at different rates of phosphorus fertilizer with or without soil sterilization .

Materials and methods The pot experiment was conducted during the dry season (November 2005 February 2006) with Italian ryegrass (*Loliummu ltiflorum*) , in laterite soil from Guangzhou paddy field , China . A three-factor experiment was designed : the plants were grown in different soil treatments as sterile (S) or non-sterile (NS) , different inoculants as single inoculants (*Glomus mosseae* ,SI) , multiple inoculants (*Glomus caledonium* + *Glomus caledonium* + *Glomus versiforme* , MI) or non-inoculants(NI) , and different concentration of phosphorus fertilizer as 0 mg/kg (CK) , 30 mg/kg(LP) , 60 mg/kg(MP) , 100 mg/kg(HP) . Plants were harvested after 67 days of growth . Roots were assessed regarding root colonization according to Phillips and Hayman (1970) with some modifications . The performance of Italian ryegrass was studied also .

Results The plants inoculated with single fungus had higher root colonization compared with multiple fungus($p<0.05$) , and the plants grown in sterile soil had higher root colonization than in non-sterile soil($p<0.05$) (Figure 1) .When inoculated plants were compared to non-inoculated plants , the mycorrhizal fungi had a positive effect on growth of ryegrass($p<0.05$) (Table 1) . High P fertilizer improved growth ($p<0.05$) , but high levels of P negatively correlated with root colonization (Figure 1) .

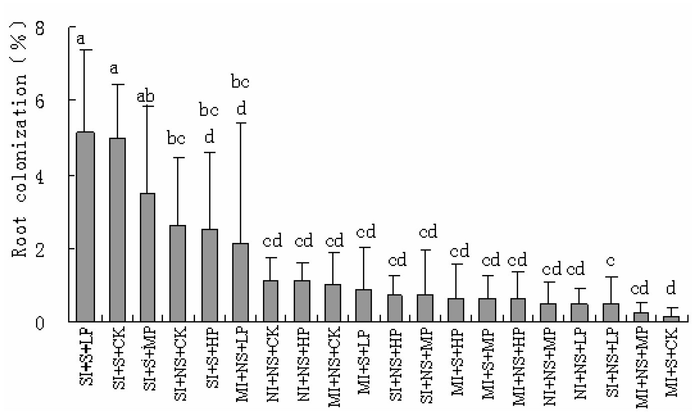

Figure 1 *A M total colonzation of IRG in the pot culture experiment .*

Table 1 *Correlations between AM colonization and growth of IRG (Pearson Correlation , Sig.2—tailed , N= 80) .*

	Root conolization
Above—ground biomass	0.267*
Underground biomass	0.281*
Plant height	0.287**
tillers	0.223*

* : p<0.05 , ** : p<0.01 .

Conclusions Ryegrass was more sensitive to single inoculants (*Glomus mosseae*) , but root colonization and mycorrhizal dependency was universally low , which probably is because ryegrass has well-developed root systems which can uptake nutritions well without mycorrhiza . Plant biomass , height and the number of tillers strongly increased in the presence of mycorrhiza . There seems to be potential to improve the plant growth by inoculating with mycorrhiza . Nevertheless , it is still essential to find the balance between P fertilizer and mycorrhizal fungus . Soil sterilization had a significant positive effect on the root colonization and growth parameters of plants , which possibly resulting from the absent competition of indigenous soil microbes .

Strategy of reproductive allocation of *Stellera chamaejasme* population

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Key words: *Stellera chamaejasme* population, reproductive age, reproductive allocation, module

Introduction Reproductive allocation (*RA*) is the ratio of assimilation products distributed in reproductive organs during plant growth and development, i.e. the amount of organics distributed in reproductive organs. *RA* controls the balance between a plant's reproduction and survival. *Stellera chamaejasme* L. is a major poisonous plant in the grasslands of China. With grassland degrading, the plant's distributed areas are increasing, harming animal production. We estimated *RA* and analyzed the relationships between *RA* and age to offer a theoretical basis for effective control of dispersal.

Study sites and methods The study area was located in the western part of a residential station in Daodesumu village, Inner Mongolia, China (120°24′-120°25′E, 43°42′-43°43′N). The climate in the study area is temperate continental monsoon. The annual average temperature is 6℃ and the annual precipitation is 300 mm. Three study sites were selected and classified into heavy grazing stage (HGS), over-grazing stage (OGS), and extreme grazing stage (EGS) (Xing, 2001). In June 2001, *S. chamaejasme* individuals were randomly sampled in a 1 m×1 m plot in each of the three sites; there were 30-40 plots in each site. The stems, leaves, buds, flowers, and fruits were separated and weighed after being dried at 80℃. The method of identifying the individual age was based on the morphological characteristics (Xing, 2004). The *RA* is a ratio of standing crop of reproductive modules to total aboveground biomass. Analysis of variance was used to test differences among each mean *RA* from the three sites.

Results *RA* values of flower bud, flowering, and fruiting stage were lowest at OGS compared with those at HGS and EGS (Figure 1). The differences of *RA* in during flowering bud and fruiting stage were not significant among the three grazing stages. However, the difference of *RA* in flowering stage was significant ($F=4.961$, $p<0.01$) between OGS and EGS. Therefore, differences of *RA* pattern at the three sites were minimal. At the same grazing stage, *RA* value in flowering stage was higher than that in flower bud stage and fruiting stage. The results showed that the means of total stems, leaves, and reproductive module (*RM*) at the three grazing stages were 42.30%, 49.08%, and 8.62%, respectively, i.e. *Stem*: *Leaf*: *RM*=5:6:1.

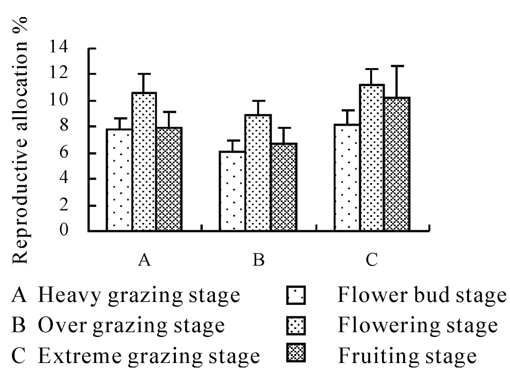

Figure 1 *Reproductive allocation of S. chamaejasme population in different grazing stages.*

Conclusions The *RA* of *S. chamaejasme* population was relatively stable in different grazing stages. *RA* pattern of the plant was probably determined by its genetic characteristics, and not greatly disrupted by grazing. The largest part of aboveground biomass was invested in leaves, the second largest in stems. Our results showed that one of the resource allocation strategies of *S. chamaejasme* is to use resources for vegetative growth rather than reproductive growth.

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Effects of air velocity on eco-physiological characteristics of some common herb species in Horqin sand land, Inner Mongolia, China

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Key words: sand fixing plants, portable wind tunnel, air velocity, photosynthetic rates (*Pn*), water use efficiency (*WUE*)

Introduction Wind is common in nature and poses impact to the development of plants. Wadsworth (1959) and Kitaya Y (2004) reported that there were optimum air velocities for plant growth at 0.2-0.7 m s^{-1}. However, little is known so far about the effect of single wind factor on plants. Information on these studies is required for a better understanding of the effects of air velocity on eco-physiological characteristics of plant species.

Materials and methods The present research was initiated to study effects of different air velocities (4 and 8 m s^{-1}) and blowing duration (20 to 120 min) on eco-physiological characteristics of some common sand-fixing herb species by using the portable wind tunnel to simulate natural wind. The herbs (*Agriophyllum squarrosum* Moq., *Corispermum macrocarpum* Bge., *Digitaria cilliaris* Koeler) in situ were set in a portable wind tunnel (3.5×0.5×0.5 m^3) under field conditions as shown in Figure 1, the sample chamber of which was designed as colorless and transparent toughened glass. The net photosynthetic rates (*Pn*) and transpiration rates (*Ts*) were determined by using Li-6400 Photosynthesis System.

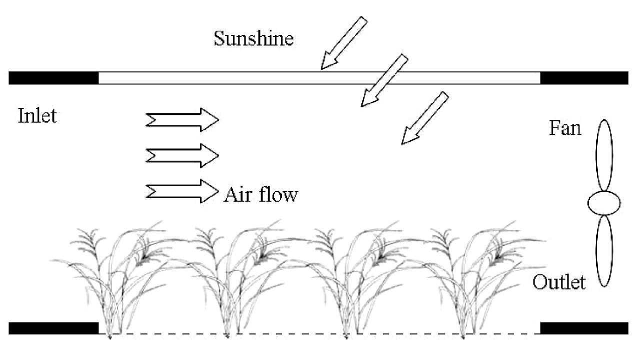

Figure 1 *Schematic diagrarm of wind tunnel simulation experiments.*

Results It was found that the *Pn* and *Ts* of these three herbs decreased significantly with elevated wind levels and blowing duration. At the air velocity of 4 m s^{-1}, the *Pn* and *Ts* of plants inside the wind tunnel were 54.3%-87.6% and 49.6%-84% lower than that outside at the end of measuring time, respectively. The most greatly reduced *Pn* value of 2.1 μmol CO_2 m^{-2} s^{-1} was observed in *C. macrocarpum* as compared to control value of 17 μmol CO_2 m^{-2} s^{-1} outside. In contrast, *Pn* values of *A. squarrosum* reduced from 18.1 to 6.9 μmol CO_2 m^{-2} s^{-1}, while *D. cilliaris* reduced from 15.4 to 8.13 μmol CO_2 m^{-2} s^{-1}. Similarly, photosynthesis and evaporative demand remained lower as a result of 8 m s^{-1} air current, e.g. in *C. macrocarpum*, *Pn* and *Ts* were taken as 1.58 μmol CO_2 m^{-2} s^{-1} and 1.09 mmol H_2O m^{-2} s^{-1}, respectively. Furthermore, water use efficiency (*WUE*) presents evident uptrend at the beginning of wind treatment, suggesting that sand-fixing herbs have adaptability to wind current. However, continuous strong wind event more than 60 min would also cause *WUE* turn to drop.

Conclusions Strong air movement around plants causes considerable effects on plant growth promotion by suppressing the gas and heat exchanges in the leaf boundary layer thereby decreasing photosynthetic and transpiration rates. The inhibitory effect increased with more intensive and longer time wind menace. Considering blown sand is frequent and complex in Horqin Sand Land, the further question arises as to study the effects of wind-sand blow on growth characteristics of some sand-fixing plants.

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Effect of exogenous hormone and explants maturity on callus induction in *Psathyrostachys juncea*

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Key words : Russian wildrye , inflorescences , immature embryos , abscisic acid , casein hydrolysate

Introduction *Psathyrostachys juncea* (Russian wildrye) is a cross-pollinated , long-lived perennial bunchgrass , and is the only species which achieved recognition as an important forage grass in the *Psathyrostachys* genus(Asay .K .H .et al .1996) . It is exceptionally cold and drought tolerant . Only 2 cultivars were released in China , both were selected from natural populations distributed in Xinjiang China . An improved new strain (P8401) have obtained by Inner Mongolia Agric Univ . The parental germplasm was cultivar Bozoisky-select which introduced from USDA-ARS .FRRL . Tissues culture is the basis of somatic embryo propagation and genetic transformation in further breeding . The research aimed to discuss the effect of the sampling time of callus induction , medium screening , hormone regulation and the maturity of explants on the callus induction in *Psathyrostachys juncea* .

Materials and methods inflorescences and immature embryos in 2 varieties (strain) , Shandan and P8401 of *P .juncea* were taken as explants , to inoculate on MS and N6 basic medium with appending different hormones , including containing 0 , 2 , 4 or 6 mgL^{-1} 2 ,4-D ; 0 , 0 .2 , 0 .4 or 0 .6 mgL^{-1} 6-BA ; 0 , 0 .3 , 0 .5 , 1 .0 or 1 .5 mg L^{-1} ABA ; 0 or 500 mg L^{-1} CH . Unemerged inflorescences at booting stage were cut and placed in 4℃ low temperature for 72 hours , divided into 5groups according to their length from 1 cm to 6 cm , then immersion disinfection in 70% ethyl alcohol for 3 min and 0 .1% $HgCl_2$ for 7 min ,wash 4 times with sterile water , cut into 3 mm long sections and inoculate on media . After pollinated the immature seeds were collected from 8thd to 23thd and placed in 4℃ low temperature for 24 hours , immersion disinfection in 70% ethyl alcohol for 30 sec and 0 .1% $HgCl_2$ for 5 min ,washed 4 times . The immature embryos were picked out from scutum of seeds and inoculate on media after glumes were taken away . Explants were Cultivated in darkness for 2 weeks at 25℃ then transfer to 4000 Lx light intensity . Data was recorded after 3 weeks of culture . Embryogenic callus were counted according to Armstrong(1985) .

Results The callus quality induced by 2 kinds of explants and medium , MS and N6 had no obvious difference . The optimum induction medium for inflorescences of Shandan was N6 with adding 2 mg L^{-1} 2 , 4-D and that for P8401 was MS with adding 6mg L^{-1} 2 , 4-D . Adding abscisic acid (ABA) to MS medium could significantly promote the growth of callus . The suitable concentration of adding ABA for callus culture of inflorescences in Shandan was 1 .5mg L^{-1} and that for P8401 was 0 .3mg L^{-1} . Casein hydrolysate (CH) only had the effect of accelerating the growth of callus , its promotion effect on the callus induction of *P .juncea* was little . Taking neonatal inflorescences materials with the length of 1-2 cm as explants for callus induction was most ideal for P8401 and the callus induction rate of more mature inflorescences on MS medium with the length of 5-6 cm was higher than inflorescences for Shandan . The optimum immature embryo age of Shandan was 11-14d , and that for P8401 was 14-17d . The suitable induction medium for immature embryo of both varieties was MS with adding 2 mg L^{-1} 2 .4-D and 0 .2 mg L^{-1} 6-BA .

Conclusions Embryogenic callus could be induced from Both kind of explants , inflorescences and immature embryos in *P . juncea* . Both MS and N6 with adding 2 ,4-D could be used for the callus induction . ABA could promote callus induction of inflorescences and 6-BA with low concentration have positive effects on immature embryos induction in *P .juncea* .The sampling time of explants was key factors in the process of tissue culture . Two varieties with different original area have significantly genetic difference in callus induction .

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Effects of *Atriplex canescens* on planted areas in Iran

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Key words: *Atriplex canescens*, Iran rangelands, planting, soil characteristics, vegetation

Introduction Plantation of favorable species is one of essential achievements for mentioned aims. Before plantation of exotic species in vast areas, they must be tested in small regions. In this research, it was surveyed ecological effects of *Atriplex canescens*. Other researches were done on *Atriplex canescence* by other Iranian researchers (Table 1). Present study surveys some ecological effects in *Atriplex canescens* in land reclamation. There are different opinions about *A. canescens* positive and negative effects on the planted areas environment and vegetation. Some studies dedicate that *A. canescens* planting has lead to positive results in the degraded rangelands, while, others refer to its negative results. Table 1 shows desirable and undesirable results of *A. canescens* planting in Iranian rangelands.

Table 1 *Effects of* A. canescens *planting on soil and vegetation properties.*

Source of data	Study area	Summary of results
Khalkhali (1997)	Shahryar and Gonbad-e-Kavoos	Cover percentage has decreased in planted area compared to control area; Higher diversity in planted area; Low nutrition levels in planted area
Naseri (1996)	Jupar-Kerman	Great number of brushes in control area; More production in control area; Smaller cover percentage in planted area There was no difference between pH and EC in two areas; OM decreases in planted area
Naseri (1998)	Kabutarkhan-Rafsanjan	Relatively equal number of brushes per area unit in both areas; More production in control area; Larger cover percentage in control area; The same diversity on both areas No different between N, P., K, Na, pH, EC, OM, clay and sand two areas
	Abbarik-Gonabad	Smaller density and cover percentage in planted area No difference between PH and EC in two areas; OM decreases in control area
	Abbas-Abad Mashhad	A decrease was observed in mentioned species density and cover percentage in planted area; Increase of *Hultemia persica* was considerable in planted area
	Chah Norooz-Neishabour	Decrease of *Stipa lassiginana* density in planted area
Chalak Haghighi (2000)	Kazeroon-e-Fars	Presence of class I species has decreased in planted area due to favor created microclimate; Increase of% OM in planted area
Henteh (2002)	Aghzi Gang Zarand	Vegetation properties showed better condition in planted area; N, P, K, pH, EC % OM, pH, EC and K have higher levels in planted area compared to control area

Results and discussion Regarding Table 1 results, it is clear that *A. canescens* and *A. lentiformis* planting contain both positive and negative effects on soil and vegetation characteristics of the planted areas. The kind of effects (positive and negative) is mainly influenced by planted area conditions and management. Cutting the aerial tissues (sources of salinity in *Atriplex*) as livestock forage and animal grazing in a season with the least leave and seed falling (which increase soil salinity) are the two favor practices that management should apply in order to prevent soil salinity due to *Atriplex* planting.

To reduce animals illness due to *Atriplex* grazing, suitable grazing season observance using supplementaries and intercropping is necessary. Chisci *et al* (2001) states that cultivating *Atriplex* with legumes produces high quality forage. Totally, a good management is needed to cultivate *A. canescens* in degraded rangelands in arid and semi arid environment in order to get ideal results. This species can be referred as a pioneer species which approves the condition of planted area, sequently can be used in reclamation of degraded ranges or arid environments.

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Changes in content of endogenous hormones in alfalfa leaf under different water stress

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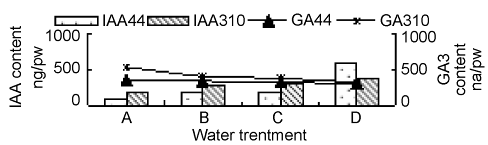
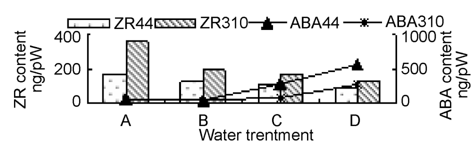
Key words: alfalfa, water stress, endogenous hormones (EHs)

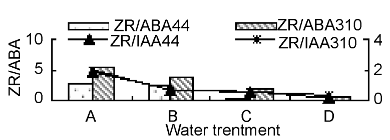
Introduction The study on the different content of hormones and change dynamics of the ratio of hormones under water stress is of great significance to reveal the drought resistance mechanism of the plant (Davies *et al*., 1986). With ELISA method, the object of this study is the main hormones ABA, IAA, GA_3 and ZR in the plant under different water stress.



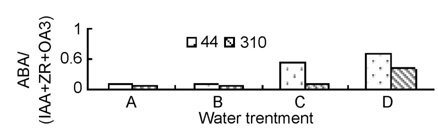
Figurel 1 *The change of IAA, GA_3 content under water stress.*



Figurel 2 *The change of ZR, ABA content under water stress.*



Figurel 3 *The change of ZR/ABA, ZR/LAA under water stress.*



Figurel 4 *The change of ABA/(IAA + ZR + GA3) under water stress.*

Materials and methods Alfalfa materials for test are Argentina germplasm (ZXY04P-44) with strong drought resistance and Libya germplasm (ZXY04P-310) with weak drought resistance, both grown in pot. The test involves four soil water (SW) treatments repeated for thrice. Treatment A (normal water supply), SW: 75% ~ 80%; Treatment B (mild water stress), SW: 65% ~ 70%; Treatment C (moderate water stress), SW: 55% ~ 60%; Treatment D (severe water stress), SW: 40% ~ 45%.

Results and analysis Under Treatment A, the content of EHs in ZXY04P-44 IAA decreased, the increase of EHs in ZXY04P-44 is 1.66 times more than that in ZXY04P-310. Among the treatments, the changes are not significant ($P > 0.05$), compared with Treatment A, the water stress increased significantly ($P < 0.05$), The content of ZR in ZXY04P-44 under Treatment D decreased by 46.26%, the difference is not much compared with the decrease of the content of ZR by 46.33% in ZXY04P-310 under mild water stress, while the decrease is 64.69% in ZXY04P-310 under Treatment D. The variation of ZR/ABA in ZXY04P-44 under Treatment B is not significant ($P > 0.05$), while the variation in ZXY04P-310 among the treatments is significant ($P < 0.05$), the value of ZR/ABA under severe water stress is 0.46. The variation of ZR/IAA value in two kinds of alfalfa is significant ($P < 0.05$). And ZR/IAA value in ZXY04P-44 is on the small side. The value of ABA/(IAA + ZR + GA_3) in two kinds of alfalfa under Treatment B decreased (Figure 1, 2, 3, 4).

Conclusions With the increasing degree of water stress, with the exception that IAA and ABA content gradually increases, indicating the water stress improved the potential regulating capacity of IAA; ABA content increased in ZXY04P-44 under Treatment D, indicating the capacity of alfalfa with strong drought resistance in directly resisting water stress under severe drought condition is stronger than alfalfa with poor drought resistance. Under water stress, alfalfa releases water shortage pressure by slowing growth rate. According to ZR/ABA, ZR/IAA, ABA/(IAA + ZR + GA_3), under water stress, the antagonism of ZR and ABA in two kinds of alfalfa goes towards a stomata closure trend; With increasing degree of water stress, ZR/IAA value in alfalfa gets smaller and smaller, which will benefit the root system growth of the plant, the ZXY04P-44 value is the smallest under severe water stress, indicating benefit to root system growth. ABA/(IAA + ZR + GA_3) value decreased and then increased, indicating four hormones in two kinds of alfalfa coordinate towards direction of inhibiting growth under mild water stress and towards direction of promoting growth under moderate and severe water stress, and the growth promotion trend in ZXY04P-44 is stronger.

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Effects of grazing and mowing on vegetation characteristic in *Leymus chinensis* grassland

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Key words: *Leymus chinensis*, vegetation characteristic, grazing, mowing

Introduction Grazing and mowing are primary methods for utilization of grasslands, but they also greatly influence grassland ecosystem and population characteristics. Grazing and mowing can affect plant-species composition, species richness and productivity (Connell, 1978; Belsky, 1986).

Materials and methods The site was located at the south of the Xilingol-steppe grassland, where grazing and mowing are the principal means of land utilization. Mean annual rainfall was 297 mm and the soil type was chestnut. The site was dominated by perennial native grasses (80%) such as *Leymus chinensis*, *Poa annua* and *Stipa grandis*. Total species quantity (S: species/m^2), coverage (C), dominance (D) and density (D': tillers of grasses, plants of other species/m^2) were measured in August 2005; Community diversity was estimated by species richness (Margale index), diversity (Shannon-Wiener index) and evenness (Pielou index).

Results Mowing was more effective than grazing at increasing perennial herbage coverage and dominance, but mowing decreased total species quantity and density. All annual herbage indices were higher for grazing than for mowing (Table 1). This was mainly due to an increased number of tillers with grazing. Species richness, diversity and evenness were higher after grazing than with mowing (Figure 1). Grazing also increased species diversity but reduced dominance of *Leymus chinensis*.

Table 1 *Species characteristic under different utilized ways.*

life form	mowing				grazing			
	S	C	D'	D	S	C	D'	D
PH	24	94.7	892	94.8	27	88.7	1649	93.7
AH	1	0.7	0.2	0.58	3	7.76	6.9	3.93

Note: PH: perennial herbage; AH: annual herbage

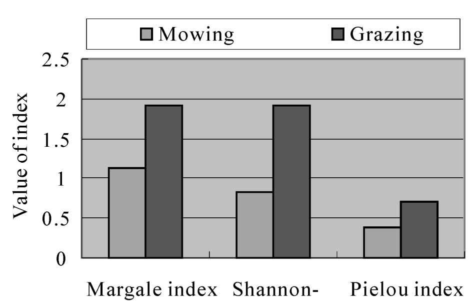

Figure 1 *Diversity of community under different utilized ways.*

Conclusions Effects of different utilization methods of grassland vegetation were described. Mowing led to increased coverage and dominance of perennial herbage compared to grazing, but grazing increased species quantity and diversity. Grazing increased species richness, diversity and evenness when compared to mowing. Grazing also increased the diversity of plant species, and reduced the dominance of *Leymus chinensis*, which lowered overall palatability of these pastures for livestock.

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Studies on formation classification and composing characteristic of helophyte in Maqu meadow, China

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Key words: swamp, plant formation, type, composing characteristic, Maqu

Introduction Swamp vegetation is a kind of plant vegetation, which is mainly made up of helophyte grown under soil moisture saturated. Because this ecological environment occurs in each zone, helophyte belongs to azonal type (Wu 1980). Maqu Meadow is famous swamp distribition and has large acreage. To do this study has any importantance to utilization of swamp vegetation resources.

Materials and methods Maqu Meadow locates in southwest of Gannan Plateau, altitude is 3300 m, the annual rainfall is 650 mm and the annual average temperature is 1-2 ℃. It has 2000 ha swamp and swamp meadow, which accounts for 10.12% of the whole country's pasture. North from Horse Farm of Hequ and through Manrima Town, and south to Cairima Town, it has very large acreage of swamp and rich vegetation resourses.

Results Maqu meadow could be divided into two kinds and four formations.

Cyperus rotundus swamp

Blysmocarex nudicarpa mainly distributed in the altitude of 3000 m waterlogged area such as Huanghe old way, river-along zone and low land area of the first tributary. In this area, C. *melanostachya* was constructive species, *Ophiopogon bodinierii*, *Kobresia kansunensis* were sub-constructive species, and *Triglochin palustre*, *Triglochin maritimum*, *Halerpestes sarmentose* and *Ranunculus hirtellus* were companion species. Coverage was 70% to 90% and forage yield was 1500 kg/ha.

Carex brunnescens mainly distributed in the altitude of 3400 m to 3800 m, which included beaches such as Oulazgaxi, Manermaqiaoke, Caiermawenbao and so on. In this area, *Carex atro-fusca* was constructive species, *Blysmus sinocompressus* was sub-constructive species, and H. *palustris*, *Carex scaposa*, *Sangnuisorba filiformis*, *Cremanthodium plantagineum* and *Triglochin palustre* was companion species. Total coverage was 70% to 80% and forage yield was 7785 kg/ha.

Eleocharis valleculosa F. setosa mainly distributed in seasonnal or year-around waterlogged area, which was 21 km from Maqu county. H. *palustris* was constructive species, *Polygamum amphibium* and *Leontopodium leontopodioides* were sub-constructive species, and *Leymus angustum*, *Potentilla anserina* and *Potentilla bifurca* were companion species. Total coverage was 5% to 65%.

Grass swamp

Polygonum amphibium distributed in waterlogged area of Maqu Dashui. Plant vegetation was mainly Polygonaceae grasses. Total cpcerage was about 5%.

Conclusions Because Maqu meadow belonged to moist area of Qinghai-Xizang Plateau, it similars to Ruoergai Swamp in formation, classification and plant composition. Soil was mostly swamp or slugh, and plant vegetation was those widely distributed species all over the world.

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Structures of the dormancy modules on *Puccinellia tenuiflora* populations in alkalinized meadow in the Songnen Plains of China

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Key words : *Puccinellia tenuiflora* , dormancy modules , dormancy seedling , dormancy bud , population structure

Introduction *Puccinellina tenuiflora* , a perennial grass of tuft , and forms larger area monodominant communities in alkali-patches with loss of surface soil . Its economic value is considerable greater because of better capability of tolerance to the salt and alkali stress in alkalinized meadow in the Songnen Plains of China (Zheng and Li , 1993) . There were some reports about the bio-chemical mechanism , bio-ecological characteristics , the characteristics of production , etc (Yang and Zhu , 1994) . However , the researches of the dormancy modules of *P . tenuiflora* populations have never been reported . Structures the dormancy modules were compared and analyzed on *P . tenuiflora* populations in two pastures for haying and grazing in the Songnen Plains , which may not only accumulate science materials on population ecology of tuff clone plant but also provide scientific evidence to suitable utilization of .alkalinized meadow .

Materials and methods The research was conducted in natual alkali meadow , located at the Pasture Ecology Research Station of Northeast Normal University , Changling , Jilin province of China (44°45′N , 123°31′E) which has temperate half-humid continental monsoon climate . The *P . tenuiflora* populations were sampled in two pastures for haying and grazing on early October , 2004 . The sample area is 25 cm×25 cm with six replications . The number of dormancy buds and dormancy seedlings were counted to each sample , respectively . That was changed from the sample area into the routine unite area of 1 m×1 m (Zhang , et al . , 1993) .

Results The dormancy modules of *P . tenuiflora* populations consisted of dormancy buds and dormancy seedlings in the Songnen Plains at the end of the growth season (Table 1) . The total number of dormancy modules on the populations was more 74 .7% in the haying pasture than in the grazing pasture . Thereinto , the number of dormancy seedlings in the haying pasture was twice in the grazing pasture , the number of dormancy buds is the same in general . That showed the formation of dormancy modules , especially dormancy seedlings of *P . tenuiflora* populations could be promoted by haying using . Though there was larger difference on the number of dormancy modules and its compositions of *P . tenuiflora* in the two plots , there was still the similar characteristic of structures , that's to say , dormancy seedlings held a dominant position . The dormancy seedlings were 5 .9 times of dormancy buds in the haying pasture , while the dormancy seedlings were 2 .8 times of dormancy buds in the grazing pasture .Therefore , that would conclude that were favorable to the formation of dormancy seedlings of *P . tenuiflora* populations by using both haying and grazing .

Table 1 *Structures of dormancy modules of P . tenuiflora populations in different sample plot .*

Sample plot	Seedling		Bud		Total	
	Number/m^2	Percent (%)	Number/m^2	Percent (%)	Number/m^2	Percent (%)
Haying	5254 .4±2568 .1a	85 .6±5 .4a	1011 .2±891 .2a	14 .4±5 .4a	6265 .6±3380 .8a	100
Grazing	2608±1160 .2b	73 .6±11 .3b	979 .2±804 .8a	26 .4±11 .3b	3587 .2±1820 .8b	100

Conclusions In the Songnen Plain , *P . tenuiflora* populations were in the stage of flowering and fruit setting in June , then were the vegetative growth stage after full ripeness . The forming vegetative tillers would not lived through the winter since which would enter the jointing nodes growth stage before the middle of August . But the forming vegetative seedlings would hibernate and continue to grow next year for the reason that would not enter jointing nodes after the middle of August . The phenomenon of top dominance universally existed in plants . The top dominance of all tillers was removed in the haying pasture after early August but the top dominance of part tillers was removed in the grazing pasture , which indicated that the formation of dormancy modules , especially dormancy seedlings would be promoted to *P . tenuiflora* populations by haying utilization .

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A virtual growth model of the whole structure and dynamics of *Lespedeza dahurica*

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Key words : virtual plant model , morphology , root system , shoot system , forage

Introduction The environmental and ecological functions and breeding values of forage rely mainly on their development and growth . The functional-structural plant models (FSPMs) are promising way to quantify the development and growth of plants (Yan et al ., 2004) . This paper presents our new result of building FSPM for forage , mainly describing its whole structure , including shoot and root systems .

Principles of structural model description The whole structural model of forage was described by using of dual-scale automaton (Zao et al ., 2001 ; Zhang & Li , 2006) . According to characteristics of the external morphology and growth processes of *Lespedeza dahurica* , as a special case , the physiological ages (PA) were set 10 , to describe the basic growth unit of *Lespedeza dahurica* , PA 0 represented seed ; PAs ranging from 1 to 6 represented basic growth units of shoot system , and PA ranging from-1 to-3 represented basic growth unit of root system . The relationships between different basic growth units were illustrated in Figure 1 .The whole structural model of *Lespedeza dahurica* was developed by combing basic growth units of different PA with the microstates , macrostates and inter-relationships (Figure 1) .

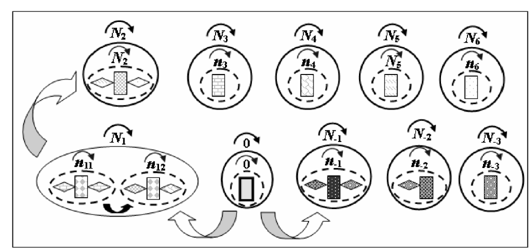

Figure 1 *Illustration of dual-scale automaton model of Lespedeza dahurica . The lowercase and capital letters with subscribing number stand for the iterating cycles of microstate and macrostate , respectively . The arrows between macrostates stand for the transfered direction with finishing its iterating cycles of macrostates .*

Parameterisization of model and simulating results Using the greenhouse potted-experiments , the parameters of structural model of *Lespedeza dahurica* were obtained . These parameters include iterating numbers of microstate and macrostates , growth probabilities of different buds and branch probabilities . Structure *model of Lespedeza dahurica* was used to simulate the dynamic structure of Huzhizi under different growth cycles (Figure 2) . The structures of Huzhizi included the numbers , growth ages of different basic growth units and relationships among them .

Figure 2 *Virtual 3D structure of Lespedeza dahurica under different growth cycles .*

Conclusions A virtual growth model of the whole structure and dynamics of *Lespedeza dahurica* was developed , including shoot and root part at the same detailed scale . By changing the model parameters , the determined and stochastic structure of *Lespedeza dahurica* can be obtained . This is the underlying to complement the function and feedback between structure and function of forage , and to develop the mechanical plant modes which are more faithful to plant growth process .

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Effect of saline-alkali stress on physiological characteristics of grain amaranth seedling

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Key words : grain amaranth , variety ,seedling ,saline-alkali stress ,physiological characteristics

Introduction The stage of seed germination is a sensitive period to salt . According to the actual situation of drought and saline-alkali areas in north , the research treated amaranth seed with mixing salt solutions to discuss that injury and mechanism of adaptation in relation to saline-alkali stress for grain amaranth , and provide theoretical basises to cultivation and selection of seed resisting saline-alkali stress in drought and saline-alkali areas of north .

Material and methods Seedling of red amaranth K112 ,red amaranth R104 and wild amaranth was cultured in outside on June of 2007 ; seedlings were watered with Hoagland solution every three days , other time was used water to spread . When seedlings had five-leaves year old , they was respectively treated with four different concentrations by combining NaCl , Na_2SO_4 , $NaHCO_3$ and Na_2CO_3 with 1 :9 :9 :1 of substance ratio , Per treatment concentration repeated 3 times ; They was randomly arranged . After 15 days treating ,we started to determine physiological indexes .

Results With increase of treatment concentration , the relative conductivity in red amaranth K112 and R104 a little increased , but that of wild amaranth significantly increased under moderate and high concentration of treatment ; From the table1 we also can see clearly that chlorophyll content delined with increasing concentration of treatment , and that in red amaranth R104 and wild amaranth which had high content of chlorophyll itself extremely decreased , it illustrated that saline-alkali stress destroyed chlorophyll in wild amaranth and red amaranth R104 .

Table 1 *Effect of saline-alkali stress on physiological characteristics of amaranth seedling .*

variety	Treatment (mol/L)	Relative Conductivity(%)	Chlorophyll (mg/g)	Proline (ug/ g)	Soluble Sugar(mg/g)
	CK	18 .81bA	1 .40aA	342 .50bB	215 .07bcAB
Red amaranth	0 .1	22 .05abA	1 .35abA	372 .91bB	187 .84cB
K112	0 .2	23 .94aA	1 .34abA	562 .50aA	284 .06abAB
	0 .3	22 .55abA	1 .25bA	322 .91bB	319 .15aA
	CK	22 .04aA	2 .08aA	363 .33bB	120 .71dC
Red amaranth	0 .1	24 .35aA	1 .62bB	383 .33bB	170 .38cBC
R104	0 .2	21 .17aA	1 .39cB	541 .66aA	213 .31bB
	0 .3	21 .65aA	1 .12dC	352 .08bB	304 .94aA
	CK	20 .09bB	2 .59aA	337 .50bA	85 .38bB
	0 .1	19 .39bB	1 .92bB	350 .00abA	136 .03bAB
Wild amaranth	0 .2	29 .64aA	1 .84bB	410 .41aA	139 .25bAB
	0 .3	25 .23aAB	1 .36cC	295 .83abA	268 .45aA

According to the figures in Table 1 ,we can see clearly that proline content of three varieties of grain amaranth first increased and then decreased with increasing treatment concentration and significantly increased on condition of moderate concentration ; Meanwhile this table also shown that soluble sugar content of three grain amaranth increased with increase of treatment concentration ,and significantly increased under high content of treatment . Moreover their content in red amaranth K112 and R104 were more than in wild amaranth .

Conclusions The ability of red amaranth R104 and K112 in relation to resist saline-alkali stress were stronger than that of wild amaranth , so seedling of red amaranth R104 and K112 could normally grow in saline-alkali areas where wild amaranth was distributed . Overall , proline and soluble sugar were osmotic substance of grain amaranth to adjust saline-alkali stress .

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Relationship of soil seed bank and vegetation in Hot-Dry Valley grassland of Jin-Sha River

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Keywords : Hot-Dry Valley , enclosure grassland , soil seed bank , vegetation ,regression

Introduction The soil seed bank means the vigorous seeds existing in the soil surface , or buried in the soil , duff or litter , in the certain period and place (Andreza ,M .M . and Vera ,L .E .2007) . Soil seed bank plays an important role in the community composition and vegetation evolution . Although soil seed bank have been the subject of much recent attention , little is known about the relationship of the soil seed bank and vegetation in Hot-Dry Valley's grassland of Jin-Sha River and understanding of how these interact to determine the importance of soil seed bank to vegetation ecosystem's succession is limited (Luo H . and Wang K .Q 2006) .

Materials and methods The study was conducted in Yongsheng county of Yunnan province . The mean annual temperature is 22℃ and the mean annual rainfall 891 mm . The most rain fall during June to October . The dry season is from November to May . Soil is brown yellow with pH 6 .7 . The grassland is the typical Savanna" . The representative degeneration grassland was enclosed on JinSha River Hot-Dry Valley in 2004 . Soil seed bank was sampled in March 2005 and 2006 . The random sampling was used within each sampling region of enclosure and degeneration grassland (as control) . Nine plots were taken from each sampling region with three replicates square (20 cm×20 cm) . Total soil samples were 243 . The sampling depth was 5cm , total depth 15 cm in every sample square . Soil samples were sorted to eliminate plant fragments and stones and kept in ventilating bags . Seed germination test began in April 2006 . The soil samples were placed in greenhouse that temperatures ranging from 18℃ to 25℃ . Each sample was spread out flowerpots (25 cm) to the depth of 4cm over seedbed soil (the soil was previously sterilized and killed seed by 150℃) . All pots were watered as needed to keep the soil moist . The research of vegetation began October 2005 and 2006 .

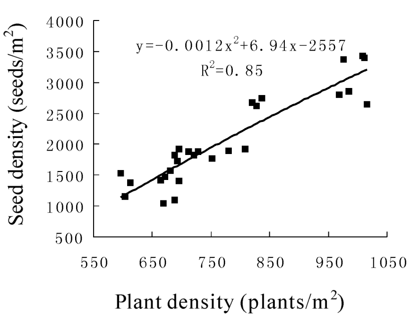

Figure 1 *Relationship between soil seed bank density and vegetation total density .*

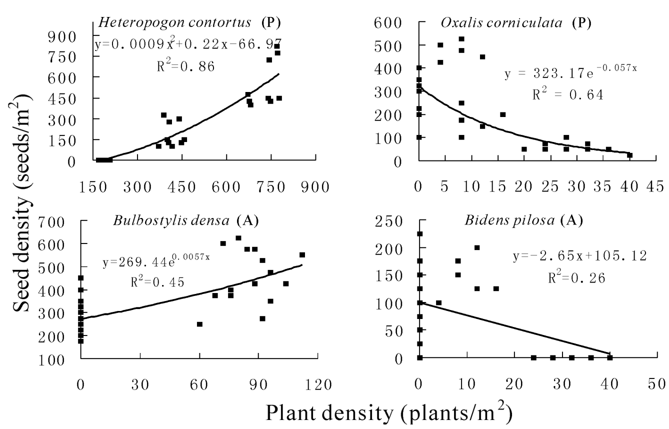

Figure 2 *Relationship between soil seed bank and vegetation density of perennial and annual herbage . (A :annual . P : perennial .)*

Results Seed bank and vegetation density values in this study were found increased significantly ($P<0.001$) compared with other unclosed grassland . Regressions showed a significant relationship ($P<0.01$) between seed bank density and vegetation density when the data of individual species were analysed . Density of the seed bank varied with increasing density of vegetation can be described by a quadratic curve (Figure .1) . The perennial and annual herbage were analysed and the high perennial herbage seed bank density with the vegetation density showed the positive regression ($P<0.01$) , but the short perennial herbage are negative regression ($P<0.01$) . However , the relationship of the seed bank density and vegetation were opposite variation ($P<0.01$) of the annual herbage's seed density compared with the perennial herbage (Figure .2) .

Conclusions The results indicate that both of the soil seed bank and vegetation density have significant positive regression on grassland . The perennial and annual herbage's seed bank and vegetation density have significant regression , which it depend on characteristics of vegetation form .

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The study on the photosynthetic characteristics of three *Melilotoides ruthenica* strains

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Key words: strains, photosynthesis, light response curves

Introduction *M. ruthenica* (L.) Sojak is a relatively new forage crop and may also be a source of genes for the genetic improvement of cultivated alfalfa (*Medicago sativa* L.) for stress tolerances. Many researches about it have been made, but the researches about the photosynthetic characteristics, are few. In the present paper, mathematical modeling was used to calculate the light response curves of three *M. ruthenica* strains to compare their photosynthetic characteristics.

Materials and methods Research was conducted in Zhenglan Banner (42°16′S, 115°57′E) in August 2007. Three *M. ruthenica* strains (90-36, 00-61 and 00-81) domesticated by Grassland Research Institute of Chinese Academy of Agricultural Science. A Li-cor-6400 portable photosynthesis system (LI-COR, USA) was used to measure net photosynthetic rate (Pn) from 8:30 to 11:30 a.m. The leaf was illuminated at the PPFD of 2000, 1500, 1200, 1000, 800, 600, 400, 200, 150, 100, 50 and 0 μmol · m^{-2} · s^{-1}, Pns were recorded and the response curves were estimated through a non-linear regression, using the non-rectangular hyperbola model of Farquhar (1980). Fundamental parameters, such as the apparent quantum yield (AQY), the maximum net photosynthetic rate (Pmax), Light compensation point (LCP), light saturation point (LSP), and dark respiration rate (Rd), were determined according to Guo J.(2005).

Results Figure 1 showed the predicted net photosynthetic rates by the models against the observed values for the three strains. Fundamental parameters of the response curves were given in Table 1. The correlation coefficients (R^2) were statistically significant and above 0.923. There were significant differences in Pmax, LSP, LCP, and Rd among the three strains, and no significant differences in AQY (Table 1). The Pmax varied from 23.760 μmol · m^{-2} · s^{-1} for 00-61 to 12.079 μmol · m^{-2} · s^{-1} for 00-81. The LSP of 00-61 was 42.918% and 105.142% higher than those of 90-36 and 00-81, respectively, while all strains had similar AQY. 00-61 and 90-36 had 106.075% and 96.407% higher LCPs than 00-81, and 76.320% and 46.547% higher Rds than 00-81, respectively. All above mentioned parameters indicated that strain 00-61 performed the best in photosynthesis, strain 00-81 performed the worst, and strain 90-36 was in the middle.

Table 1 *Photosynthetic parameters of three* M. ruthenica *strains.*

Strains	Pmax	LSP	LCP	AQY	Rd
90-36	20.663[b]	537.918[b]	79.314[a]	0.040[a]	3.038[a]
00-61	23.760[a]	768.784[a]	75.593[a]	0.033[a]	2.525[a]
00-81	12.079[c]	374.758[c]	38.488[b]	0.032[a]	1.723[b]

Different letters in the same column mean significance at 0.05 level

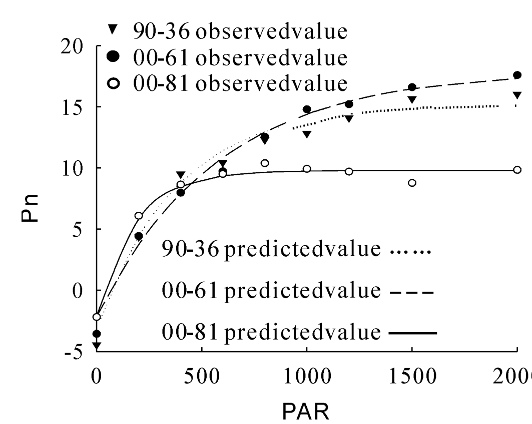

Figure 1 *Responses of net photosynthetic rate in* Melilotoides ruthenica *strains to different light intensities.*

Conclusions The non-rectangular hyperbola model proposed in this study provides a powerful and valuable tool for understanding and predicting the photosynthetic characteristics of *M. ruthenica* strains. We considered that Strain 00-61 with higher Pmax, LSP, LCP, and Rd, which may lead to a high photosynthetic capacity, can be planted in strong light regions, where the environmental conditions favorite it to accumulate more dry matters. Strain 00-81 with lower LSP and LCP, indicated that it was more tolerant to shading than other strains.

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Effects of drought Stress on protective enzymes activities in leaves of *Lespedeza dahurica* seedlings

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Key words: *Lespedeza dahurica*, drought resistance, activities of protective enzymes, SOD, POD

Introduction As forage plant, *Lespedeza dahurica* has high feeding value, a certain extent ability of drought resistance as well. In order to evaluate the drought resistance of *lespedeza* seedlings in Shanxi province, the activities of protective enzymes are studied under drought stress conditions. The purpose of this dissertation is to study the relationship of protective enzymes activities and drought tolerance in two different wild regions.

Materials and methods Seeds from two different regions of Shanxi province are inseminated in the beakers (500 ml) filled with sand to develope. The environmental temperature maintains at 22-26℃ and the relative humidity maintains at 75-80%. Carry out drought stress when the seedings have three small leaves. The relative water content grads are 25%, 40%, 55%, 70%, 85%. Measure the activities of superoxide dismutase (SOD) enzymes and peroxidase (POD) enzymes of the leaves after ten days.

Results The activity of superoxide dismutase (SOD) enzymes of *Lespedeza dahurica* enhance along with the rise of drought stress (Figure 1). The activity of peroxidase (POD) enzymes of two regions increased first then decreased, the Yangquan and Qinyuan regions are the highest at the four grads and the third grads respectively (Figure 2). The drought-tolerant region from Yangquan has higher activities of SOD and POD then the Qinyuan region.

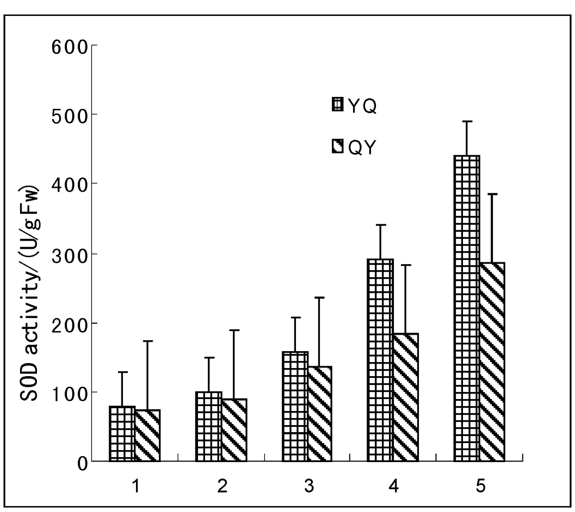

Figure 1 *Effect of drought stress on activities of SOD.*

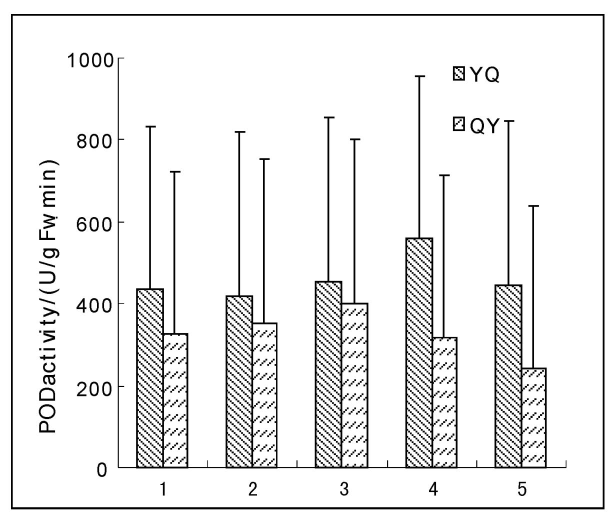

Figure 2 *Effect of drought stress on activities of POD.*

Conclusions The seeds of different regions in Shanxi province represent different drought resistance. The seeds from Yangquan has higher drought resistance because of higher activities of enzymes. SOD enzymes is more sensitive to drought stress than POD enzymes because of the further increase of activities.

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The growth of size on *Cynodon dactylon* clone in Yili River Valley

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Key words : *Cynodon dactylon*, clonal growth, bud, rhizome, stolon

Introduction *Cynodon dactylon* (bermudagrass, bevilgrass) is a typical clonal, perennial, C_4 stoloniferous and rhizomatous grass from tropical and warm-temperate areas (Larry, 1989; Fei *et al*., 1998). It is one of the most important turf grass and valuable pasture grass. It can reproduce vegetatively from both rhizomes and stolons or reproduce sexually by seeds. The extensive network of rhizomes and stolons is easy to become a monodominant community, forming a dense tuft on the surface of the soil. Researches on population growth and modular quantitative characteristics were important and useful for revealing the mechanism of bioecological adaptation as well as enriching the ecological theory and application.

Materials and methods This study was conducted in an abandoned orchard field covered with construction waste and gravel, beside a playground of Yili Normal College, located in Yining city, Xinjiang, which geographically belongs to Yili river valley. In October, thirty wild *C. dactylon* clones were sampled randomly. Their aboveground and underground parts were dug together and maintained the natural integrity. In the laboratory, the radius of each clonal tuft and the length of stolon and rhizome were measured, meanwhile, the number of reproductive ramets and vegetative ramets was counted, respectively.

Results Statistic analysis showed that there was a significant positive correlation between the tuft area and the number of vegetative and reproductive ramet, number of stolon bud and rhizome bud, length of stolon and rhizome ($P < 0.01$). As the tuft area increased, the number of ramet and stolon bud, length of stolon increased gradually by a power function. At the same time, the number of rhizome bud, length of rhizome linearly increased. Their simulated equations and the significance tests were shown in Figure 1. The mean number of vegetative ramet was approximately four times more than that of reproductive ramet as well as the number of rhizome bud was nearly four times more than that of stolon. The mean length of rhizome is 5.1 metres while the mean of solon is just 3.2 metres.

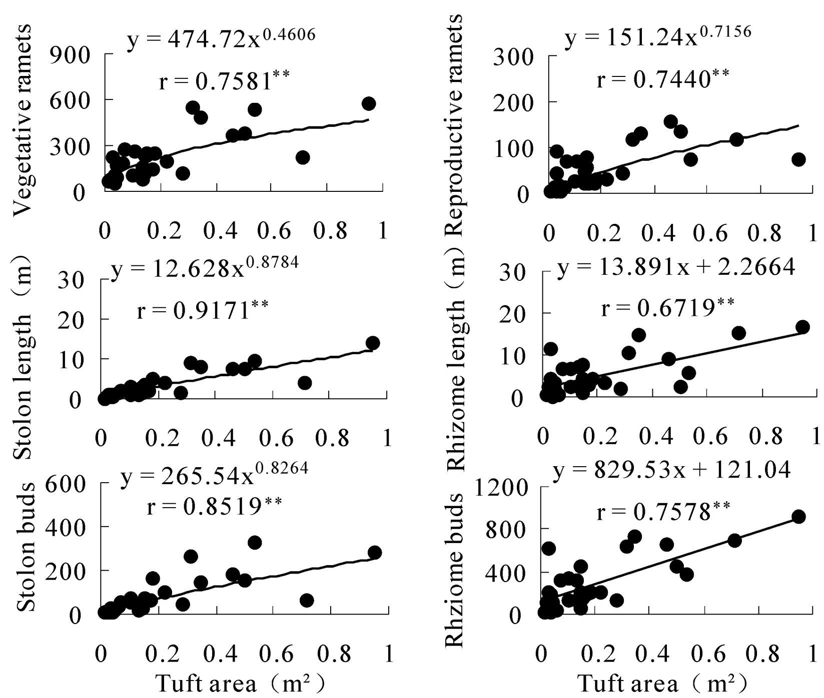

Figure 1 *Relationship between the ramet area and the modules of* <u>Cynodon dactylon</u>. ** $P < 0.01$.

Conclusions When *C. dactylon* clone immigrated to a natural habitat and grew without inter-specific competition, in order to fight for the maximum expansion of space, first of all, the rhizomes elongated as soon as possible to increase its spatial distribution. The elongated rhizomes produced more buds, i.e. the potential population laid a solid foundation for the aboveground spatial expansion. Although as the tuft area increased, the number of ramets and buds, the length of stolon and rhizome increased differently, rhizomatous elongation growth and buds presented the most important contribution to the size of *C. dactylon*.

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Grassland sustainability and livestock production in Taipusi Banner, Inner Mongolia

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Key words: grassland, degradation, grazing, stocking rate, livestock production

Introduction Livestock numbers on north China grasslands have increased dramatically as households seek to improve incomes. However in Taipusi Banner, Inner Mongolia, this has resulted in severe over-grazing and degradation to 70% of the 130,000 ha of typical steppe grassland. Current stocking rates are in excess of those recommended (Houston *et al.*, 2004). Sustainable grassland and livestock production requires a systems analysis of current farm practices and options.

Materials and methods The study region is Taipusi Banner of Inner Mongolia (114°51′-115°49′E, 41°35′-42°10′N, average annual precipitation ~400 mm, elevation 1325-1828 m, chestnut soil). The grassland is typical steppe and dominant species are *Stipa krylovii*, *Aneurolepidium chinense*, *Artemisia frigida*. Farm system models were used to analyse the current feed supply and demand and options for reducing stocking rates (using linear programming). Six farms in a village of 30 were surveyed in detail to construct a typical (synthetic) farm system model (Kemp, Jones and Takahashi, unpublished).

Results and discussion Grassland growth can only meet livestock maintenance demand from July to October (Figure 1) once the grass is frosted animal requirements is not satisfied. Analysis over a range of stocking rates shows that meat and wool production reaches a maximum at ~1 ewes/ha (Figure 2), half that of the current stocking rate of 2.3 ewes/ha. The economic optimum would be between 0.5 and 1 ewes/ha as supplementary feed costs start to increase significantly from that range.

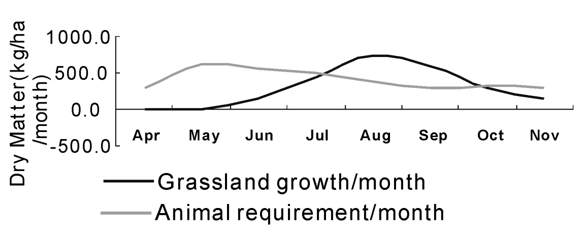

Figure 1 *Feed balance (Dry Matter).*

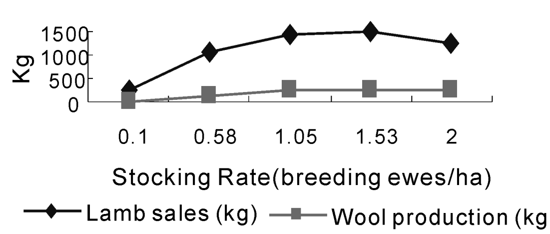

Figure 2 *Lamb and wool production per farm.*

Conclusions Grassland production and livestock demand is out of balance. From the 60 years of stocking rate collected it was found that the stocking rate in Taipusi Banner is now about 2.3 ewes/ha up to 3 ewes/ha. At that level household incomes are less than at 1 ewe/ha. The economic justification to reduce stocking rates supports ecological data.

Acknowledgement Funded by the ACIAR project: Sustainable Development of Grassland in Western China.

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Effect of NaCl concentration on embryogenic callus growth and plant regeneration of *Pennisetum Purpureum* Schumach (Napier grass) *in vitro*

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Key words : *Pennisetum Purpureum* , napier grass , salt-tolerant , sodium chloride , tissue culture

Introduction *Pennisetum americanum*(Napier or elephant grass) and *P .americanum* × *P .purpureum* (Hybrid *Pennisetum*) are important forage and energy crops . In order to guarantee food safety , breeding salt-tolerant napier grass and hybrid *Pennisetum* are of great significance for utilizing plentiful arid and saline land to satisfy need of livestock and production of biomass energy in China . Only one paper reported selection of NaCl tolerant cells from leaf-derived embryogenic cultures of napier grass till now (Stephen and INDRA , 1984) . This report describes effect of NaCl concentration in medium on from immature inflorescences embryogenic callus growth and plant regeneration of *Pennisetum Purpureum* N51 ,which is R line of registered variety Hybrid *pennisetum*"(Tift 23A CMS pearl millet ×N51 Napier grass) .

Materials and methods Embryognic callus was initiated from young inflorescences (1-3 cm in length) of *Pennisetum purpureum* Schum (N51) . Using sterilization and dissection techniques previously described (Zhong et al . ,2007) . A white and compact embryogenic callus pieces obtained from immature inflorescences were transferred to subculture medium supplemented with 1 . 0 , 1 .2 , 1 .4 , 1 .6 , 1 .8 and 2 .0 g/L NaCl . After 45 days healthy embryogenic callus was grown on differentiation medium with same NaCl concentration . All cultures were incubated at 26-28℃ in a growth chamber under 16h of diffused light .

Table 1 *Effect of NaCl concentration in medium on rate of compact callus and rate of regeneration plant .*

NaCl (g/L)	NO . of total callus	Subculture Rate of compact callus (%)	Differentiation culture Percentage of plantlet (%)
0	676	55 .3	8 .4
10	226	49 .3	4 .0
12	337	36 .2	1 .8
14	365	32 .8	1 .6
16	157	32 .2	0 .6
18	304	34 .1	0 .3
20	135	15 .4	0 .0

Results There was a decrease in ration of compact callus and percentage of plantlet with salt concentration increase (Table 1) . The pellet callus became less well organized and more watery appearance and light brown color above1 .2 g/L NaCl . Rate of compact callus and percentage of plantlet was 15 .4% and 0 .0% at 2 .0 g/L NaCl . All compact callus was necrotic after 2 weeks above 2 .0 g/L NaCl . This result showed critical NaCl concentration limit was 20 g/L during subculture of small pellet callus and lethal NaCl concentration was respectively 20 g/L in differential culture .

Conclusions NaCl concentrations in medium have obvious effect on embryogenic callus growth and plant regeneration of Napier grass *in vitro* in this study . Callus cultures tolerant to normally inhibitory concentrations of sodium chloride were 20 g/L in subculture and 18 g/L in differential culture . Salt tolerance of plant regenerated from callus selected at high salt levels need further assessed .

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Somatic embryogenesis and plant regeneration from immature inflorescences of *Pennisetum purpureum* Schumach (Napier grass)

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Key words : *Pennisetum purpureum* (Napier grass) , embryogenic calli , tissue culture , *in vitro*

Introduction *Pennisetum purpureum* Schum .(Napier or elephant grass) is a major fodder and energy crop in tropic and subtropical region . Napier grass N51" was introduced to China from US in 1985 . Although the formation of somatic embryos and plants from inflorescence segments of napier grass was reported (Wang and INDRA , 1982) , there is a number of difficult problem because of different genotype of each species responding optimally in vitro . This paper describes extensive somatic embryogenesis and plant regeneration from cultured segments of immature inflorescence of napier grass N51" , which does not usually set seeds in nature and is principally propagated vegetatively . It will make a possibility of industrial tube seedling production and breed by biotechnology .

Materials and methods Immature inflorescences (1-3 cm in length) of *Pennisetum purpureum* Schum .(N51) were obtained from field in sunny day . After stripping and wiping outside leaves with cotton soaked in 70% ethanol every layer , the inflorescences were dissected out , cut into 1-3 mm segments and placed in trigonal glass bottle on 0 .8% agar medium containing 3% sucrose ad different concentrations and combinations of 2 ,4-D and KT at 3-week intervals . Embryogenic callus was subcultured on the same medium about 4 weeks . Healthy somatic embryogenesis was transferred on differential medium added with 2 , 4-D and 6-BA . 3-leaf plant was grown on root vigor medium supplemented with CPPU and NAA . The basic nutrient media used were MS . The pH of the medium was adjusted to 5 .8 before autoclaving . All cultures were incubated at 26～28℃ in a growth chamber under 16 h of diffused light .

Figure 1 *Calli of dry , compact small pellet .*

Figure 2 *Intact regenerated plantlets .*

Results The frequency of callus of compact , small pellet induction reached separately 79 .0% and 72 .6% in the callus induction medium supplemented with 4 .0 mg/L 2 ,4-D + 0 .05 mg/L KT and 4 .0 mg/L 2 ,4-D + 0 .1 mg/L KT(Figure 1) . During subculture , callus of small pellet were maintained 40 .9% and 74 .0% in the callus subculture medium added 3 .0 mg/L 2 ,4-D + 0 .2 mg/L 6-BA . The rate of green plant regeneration of small pellet callus from subcultures reached 36 .4% and 38 .5% , respectively , in the differentiation medium supplemented with 2 .0 mg/L CPPU +0 .01 mg/L NAA or 0 .5 mg/L KT + 0 .5 mg/L IAA . Green plant of regeneration with three leaves was transferred to root vigor medium added 0 .5 mg/L NAA in 1/2 MS basic culture medium (Figure 2) . The surviving rate of green plant cultured in soil reached above 95% . It was a simple effective method to overcome the obstruction of plant generation by selecting the callus of dry , compact , small pellet in early generation .

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Relationships between veresk rangeland vegetation and environmental characteristic using multivariate analysis methods

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Introduction Interest in how various landscape components affect biotic and abiotic resources has grown over the past 2-3 decades (Brosofske *et al* , 2001) . The distribution and abundance of range species has been correlated with a variety of complex environmental gradients . Environmental factors affect range plant growth and need to be understood and considered by rangeland managers . Plant growth and development are controlled by internal regulators , which are modified according to environmental conditions (Manske 1997) . Of the most ecologically important environmental factors affecting rangeland plant growth and distribution are topography (slope , aspect , and elevation) and soil properties (Jafari *et al* , 2004) . Environmental factor effects on vegetation could be considered as a main ecological subject during last recent decades .

Materials and methods The study was conducted at Zereshkin rangelands , approximately 60 km south west of Savadkouh , in north of Iran (52° 52′58″ — 52°58′5″ E , 35°55′51″—35° 58′40″ N) .Based on field surveys , five vegetation types were identified at the study area . Fifteen 1 m^2 quadrats with 50 m distance from each other were established along each of four 200 m transects . Vegetative sampling method was randomized systematic . Soil samples were taken at the starti and end points of each transect . Data matrix of environmental factors and vegetation types was made . The windows version of PC-ORD (McCune and Mefford , 1997) was used for ordination of vegetation types on a gradient of site factors . Data were analyzed by principal component analysis (PCA) .

Results Figure 1 shows the distribution of vegetative types of Zereshkin rangeland defined by the first two axes of the PCA . As shown in Figure 1 , the location of types in four quarters is different . The distance between the indicator points of the vegetation types along each axis shows the degree of similarity and dissimilarity of types in the environmental factors . In axis 1 , the coefficients of some factors are negative such gravel , thus those types located in quarter 1 , have inverse relationship with this factors . In axis 2 , coefficients some of factors are positive such as silt 30-60 cm , Therefore , those types that are lying in the third quarter have inverse relationships with this factors . For example , as shown in Figure 1 , Da .gl-Br .to . type is relatively equally affected by PC1 and PC2 . Since this type has been located in negative side of axes 1 , therefore , it has a positive tendency to soils with high gravel percentage on top . The distribution of this type is negatively related to nitrogen percentage and OC of soil samples , that is , an increase in N and OC of soil leads to decrease of mentioned type occurrence in the study area .

Discussion Results showed that different vegetation types show different relationships with underlying soil characteristics . It seems that the most important factors affecting the occurrence and separation of vegetation in Zereshkin are texture , OC and nitrogen . Soil texture controls distribution of plants by affecting moisture availability , aeration and distribution of plant roots (Jafari *et al* ., 2004) . Soil organic carbon is an important determinant of soil fertility because of its impact on ion exchange capacities and its near-stoichiometric relationship to nitrogen . Future studies on the vegetation-site factor relationships of rangelands should attempt to study integrated site factors effects on vegetation occurrence and separation .

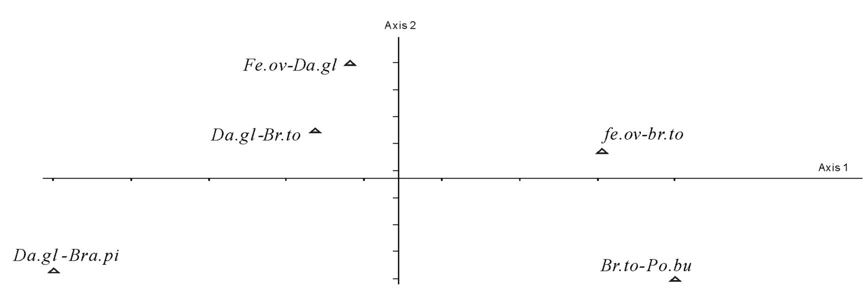

Figure 1 *Distribution of Zereshkin rangeland types defined by the first two axes of PCA .*

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The role of plant richness & diversity on ecological equilibrium of rangeland habitats on Alborz Mountain (north of Iran)

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Key words: plant diversity and richness, ecological equilibrium, habitat, rangeland, soil erosion.

Introduction Ecological equilibrium in rangeland habitat refers to maintenance of vegetation cover and their roots which protects the soil of the ecosystem from erosion. Plant diversity and richness can provide health conditions to maintain an equilibrium ecosystem. Löffler (2004), in his research, has shown that change in the composition of soil and plant species due to high grazing pressure. Continuous overgrazing continuously not only increases erosion (Harden, 1993; Molinillo, 1993). The present paper has the objective of throwing more light on the influence of biotic and abiotic factors on ecosystem equilibrium.

Material and method The area of study has been in the summer ranges of the Ramsar in Mazandaran Province of Iran. The average annual precipitation is about 650-750 mm and the climate, based of Emberger method, can be defined as cool-wet to cool-dry(>2800 m). Since there are two range types, grass and shrub types, on the upland, two amplitude of a crest were chosen. The Daubenmire method was selected to analyse rangeland health conditions as it has certain factors of rangeland like percentage of vegetation, litter, soil conservation, plant regeneration and plant composition. The MPSIAC method was selected to analyze soil erosion. Analysis of the hierarchical datas has been done by regression model. Compare mean between two habitats have been done by T-test method in SPSS software. Plant richness and diversity have been calculated by Ecological Methodology software.

Results Correlation between soil erosion and rangeland condition has been analyzed by simple regression which has shown maximum correlation between them. Rangeland condition in the both habitats of shrubland and grassland has reacted to soil erosion(Table 1). Some vegetation characteristics used for analysis in which there were some differences between two habitats (Figure 1). The regression model for shrubland habitat is as defined in continues: $Y = -0.4(M) - 0.51(S)$; (1) Where, Y is soil erosion, M is Margalef's index and S is Shannon's index. It has been found that soil erosion has been justified by plant diversity (0.51) and richness index (0.41). Model regression in grassland is defined in continue: $Y = -0.18(M) + 0.99(S)$; (2) where, plant diversity (0.99) and richness index (0.18) have justified variance of soil erosion in grassland habitat. Rangeland condition has significantly related to plant diversity and richness indices (Table 1). There is a 97.7% correlation between rangeland condition and indices in shrubland habitat. And about 95% changes of rangeland condition have been justified by indices.

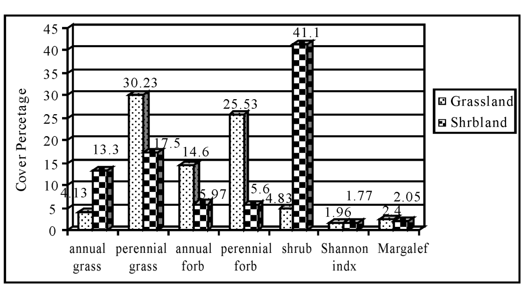

Figure 1 *comparative condition of two habitats based of vegetation status.*

Table 1 *Correlation between Soil erosion with rangeland condition and indices and also rangeland condition with indices.*

Soil erosion*	Predictors**	$R^{(a)}$	$R^{2\,(b)}$	$F^{(C)}$	Sig .(for F)
Shrubland habitat	rangeland condition	87.1	75.8	87.84	0.00
Grassland habitat	rangeland condition	80.9	65.4	52.95	0.00
Soil eresion*					
Shrubland Habitat	Margalef and Shanon	79.4	63.3	23.07	0.00
Grassland Habitat	Margalef and Shanon	90.2	81.3	58.83	0.00
Rangeland conditions*					
Shrubland Habitat	Margalef and Shanon	97.5	95	255.83	0.00
Grassland Habitat	Margalef and Shanon	85.0	72.3	73.4	0.00

* and **: Dependent and independent variables
(a) Person coefficient, (b) Justification coefficient and (c) F-Fisher

Conclusions Based of climatology, annual precipitation is high in study areas. It might theoretically have sufficient diversity and richness, but the results showed both habitats have poor conditions. Climate has a big role to play in the study area as a function component. Therefore, animal grazing causes a decrease in plant diversity and richness. Grazing as an effective component can change plant composition and expanse annual plant. Then it can indirectly influence on soil cover and it also increase soil erosion. The result shows a high degree of relationship between soil erosion and rangeland condition with indices and vegetation factors in which the indices has positively relationship to habitat situation in good condition or negative relationship to soil erosion (as an stability index of ecosystem) in poor condition of rangeland. So, unbalancing between plant species can cause the changing of ecosystem equilibrium as ecosystem stability.

Soil seed bank of three populations of *Capparis decidua* (Forssk .) edgew

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Key words : *Capparis decidua* , seed bank , rangelands , Saudi Arabia

Introduction *Capparis decidua* occurs in isolated populations in Saudi Arabia . Abdel-Mawgood et al . , (2006) reported that a *C . decidua* population near Riyadh , Saudi Arabia apparently did not regenerate for several years . This observation raises the question about soil seed bank status of the species as soil seed bank plays an important role in the composition and conservation of plant communities (Luo and Wang , 2006) . The aim of this study was to asses soil seed bank status of *C . decidua* and companion species in three *C . decidua* populations near Riyadh , Saudi Arabia and the possible influence of wind direction and distance from plant source on soil seed bank size and species richness .

Materials and methods Three populations of *C . decidua* , located in Rawdhat Khuraim RK (25′30 .250 N 47′46 .300 E) , Hawayir Assos HS (25′11 .450 N 48′37 .500 E) and Khor Assos KS (26′59 .75° N 45′33 .353 E) were selected in this study as they are the only population known to exist near Riyadh . Soil in all locations were sandy loam . Population size of *C . decidua* are 183 , 35 and 53 in Rawdhat Khuraim , Hawayir Assos and Khor Assos respectively . Rawdhat Khuraim habitat is in fair condition . However the other two locations are degrading .

Soil seed bank was assessed by collecting soil samples from around five randomly selected *C . decidua* shrubs (replicates) in each site . Two adjacent samples (20×20 cm) from the upper 5 cm of soil surface were taken at 1 .5 and 3 m distances from canopy edge at all main cardinal directions . Because of the concern over the seed viability of *C . decidua* , one set of samples (one of the two adjacent sample units) was used for the assessment of *C . decidua* seeds by soil sieving through 1mm sieve . The other set was assessed for seeds by germination and seedling identification using germination trays (40×40cm and 5 cm deep) in growth chambers . Plant species were classified into functional groups (legumes , grasses , forbs , shrubs and shrublets) regardless of their life form . . The experiment was analyzed as a factorial design (SAS , 1996) .

Results and discussions Results of manual sieving of soil indicated that no significant differences occurred in soil seed bank size of *C . decidua* among the three populations (28 .1 , 33 .8 and 24 .4 seeds/m^2 in RK , HS and KS respectively) . However , all collected seeds of *C . decidua* were damaged by insects beyond viability . This could partially explain the slow regeneration rate of the species in its natural habitats and warrants further investigation . Assessment of soil seed bank by means of germination revealed significant differences among all *C . decidua* populations in all functional groups (Table 1) .Rawdhat Khuraim was the highest in seed bank size in all functional groups (except for shrubs) and species richness . Khor Assos was the lowest among the three populations and was not significantly different from Hawayir Assos except for forb seed bank size and species richness . Rawdhat Khuraim is known for its vegetation density and richness (Al-Yemeni et al . , 2000) and this was reflected here in the present study .

No significant differences were detected in seed bank size or species richness in response to cardinal direction (data not shown) . Distance from shrub edge had only significant effect ($P \leqslant 0.001$) on shrublet seed bank size (73 .8 and 19 .2 seeds/m^2 for 1 .5 and 3 m away from C . decidua respectively) . Over the different *C . decidua* populations , there were 25 species most of them were forbs (17 species) . *Trigonella stellata* (annual legume) , *Pulicaria crispa* (perennial shrublet) and *Lycium shawi* (shrub) were the most abundant species in soil seed bank .

Table 1 *Soil seed bank of plant functional groups in three C . decidua populations (seed/m^2) and species richness .*

Population	Legumes	Grasses	Forbs	Shrublets	Shrubs	Richness
R . Khuraim	349 .4	250 .6	408 .1	113 .1	33 .1	7 .8
H . Assos	82 .5	11 .3 b	218 .8	23 .1	201 .9	4 .3
K . Assos	28 .8	5 .0 b	43 .8	3 .1	23 .8	2 .1
$LSD_{0.05}$	144 .44	39 .307	145 .52	48 .83	128 .29	1 .25

Conclusions Soil seed bank of *C . decidua* and hence its future conservation is likely to be governed by many factors of which insect herbivory plays a major role . Further investigation is needed to determine seed longevity .

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Adaptation benefit two grass coexisting in meadow steppe of northeast China

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Key words : adaptation , coexisting , meadow steppe , soil property

Introduction *Leymus chinensis* and *Phragmites communis* are dominant and sub-dominant species in meadow steppe of Northeast China . They often co-dominate in natural meadow steppe . Important values of both species were used to examine the adaptation of *L . chinensis* and *P . communis* to soil properties and explain their co-existing .

Materials and methods Vegetation characteristics and soil properties were investigated and determined for six pure stands of *L . chinensis* and *P . communis* respectively , and five mixed stands for both species during two growing season . Important value was calculated from height , coverage , biomass and density . Soil properties involving soil moisture , pH value , electrical conductance and nitrogen content were determined .

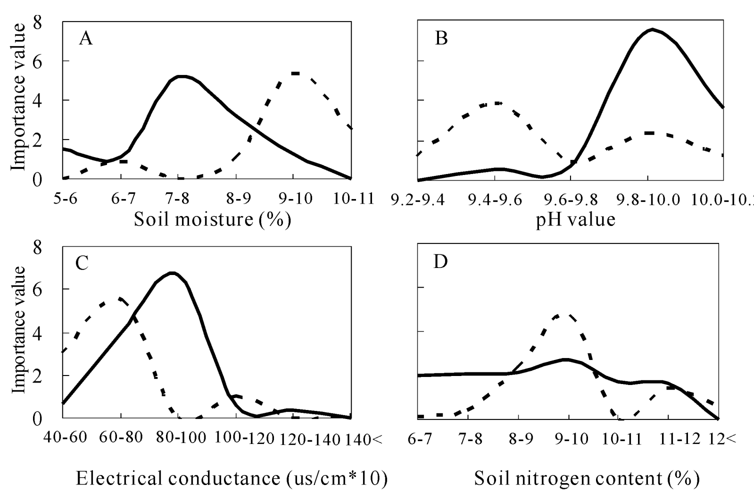

Figure 2 *Different responses of Leymus chinensis (—) and Pragmites communis (---) to the change of soil properties .*

Results Plants in the mixed stands of *L . chinensis* and *P . communis* showed a tendency of having higher aboveground biomass than those in pure stand of *L . chinensis* and *P . communis* (Figure 1 ; P=0 .088) . The important value differed largely in soil moisture , pH value , electrical conductance and nitrogen content for both species (Figure 2A-D) . *L . chinensis* preferred growing in habitats with lower soil moisture , and higher concentration of salt and alkali in soil , but higher soil moisture and nitrogen concentration , low salt concentration favored by *P . communis* (Ba *et al* ., 2006) .

Conclusion *L . chinensis* showed a tolerance to drought , and salt and alkali stress . While *P . communis* adapted to environment with rich soil water and nutrient . Differentiation in niches of soil properties provided the possibility for both species coexisting in the natural meadow steppe of Northeast China (Silvertown , 2004) .

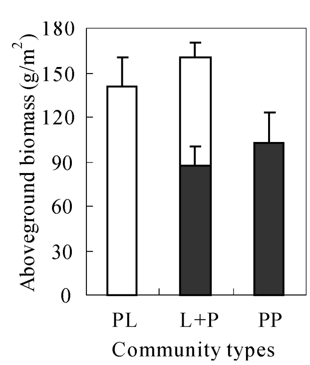

Figure 1 *Production of mixed communities (L + P) is often greater than those of pure Leymus chinensis stands (PL) and Phragmits communities stands (PP) .*

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Profile of water uptake in winterfat during seed germination

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Key words : aquaporin inhibition , Chenopodiaceae , germination , $HgCl_2$, NMR spectroscopy , Saskatchewan , water relations , winterfat (*Krascheninnikovia lanata*)

Introduction Aquaporins are enriched in zones of fast cell growth , expansion and vacuolization (Ludevid et al . , 1992 ; Schäffner , 1998) . These observations suggest that aquaporins are involved in cell elongation and growth , osmotic regulation and resistance to drought and salinity stress (reviewed in Schäffner , 1998 ; Johansson et al . , 2000) . We examined : (1) the role of aquaporins in seed water relations during seed imbibition and early seedling growth of winterfat at low temperatures ; and (2) water distribution and biophysical status within a germinating seed .

Materials and methods Five replicates of twenty seeds (total 100 seeds) were imbibed at 5℃ in darkness . 2 .5 mL of 0 , 30 , 35 , 40 , 50 and 100 (M $HgCl_2$ (aquaporin inhibitor , Sigma , USA) was used . NMR spectroscopy : Bruker Advance DRX 360 WB system (Bruker BioSpin Ltd . , Milton , ON , Canada) , at 360 .13 MHz . ^{1}H microimaging was performed at 20℃ on a single seed mounted in a shortened pipette tip inserted into a plexiglass foot and then placed in a 10 mm NMR tube . Spin-lattice relaxation rates , R_1 $(1/T_1)$, and spin-spin relaxation rate , R_2 $(1/T_2)$, were also measured at each interval .

Results Water migrated first to the embryo then to the perisperm (Figure 1) . Exposure to $HgCl_2$ significantly restricted water flux to the perisperm , which was also associated with reduced germination rate (Figure 1) . Both embryo and whole seed water uptake was reduced in the presence of 30 M $HgCl_2$, a dose lower than the LD_{50} . The impact of restricted water uptake was expressed preferentially in the root during early seedling growth , which was 24 times shorter in the presence of mercury , indicating more dry matter allocation to the cotyledons . Results suggest that aquaporins mediate seed water relations from initial seed imbibition to early seedling growth .

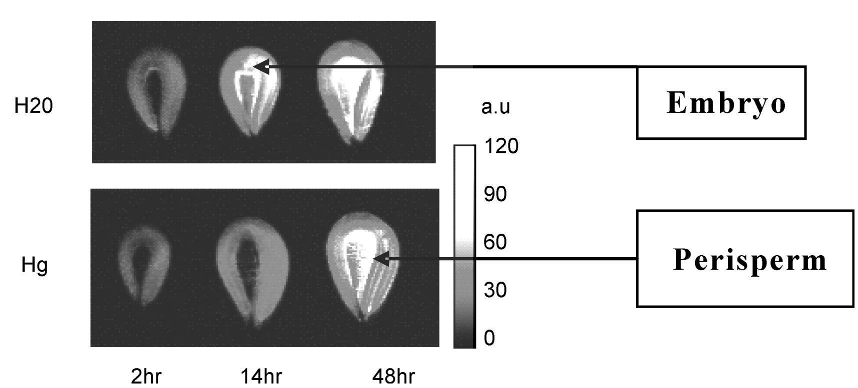

Figure 1 *NMR microimaging of winterfat seeds during imbibition at 20℃ with and without 30 M* $HgCl_2$. *Scale indicates range from no measurable free water (0 , black) to maximum limit of measurable free water (120 , light yellow) .*

Conclusions In winterfat , aquaporins were determined to play a critical role in germinative and early-growth water dynamics . Water entered the embryo in early water uptake and then diffused mainly through cell to cell pathways to the perisperm , reaching the maximum content near embryo protrusion in winterfat .

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Plant energy functional groups and their coupling relationship with the functional degradation of steppe ecosystem

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Key words : caloric value , degradation succession , functional classification system , grazing , Xilin River Basin

Introduction Plant functional group (PFG) is a combination of various plant species with some common functional characteristics , Utilizing PFG can more efficiently reveal the general features of the natural ecosystem compared to studies of individual plant species(Gitay & Noble ,1997) . In this study , we firstly promoted classify functional groups based on the caloric value of plant , and study their dynamics along degradation gradient in three types of steppe of Xilin River Basin in Inner Mongolia . The objective was to investigate the feasibility of this functional classification method and compared the succession pattern of different functional groups with systematic declining at the ecosystem level .

Materials and methods 12 sites were selected along the middle Xilin River Basin in Inner Mongolia of China , including three types of steppe communities consisting the *Leymus chinensis-Stipa baicalensis* meadow steppe , the *Leymus chinensis* typical steppe , and the *Stipa grandis* typical steppe and four degraded intensities sites (undegraded , relatively light , moderate and heavy degraded) in each steppe types . The biomass of each species were determined using quadrate method , aboveground part was clipped and separated by species and caloric vales of each species was determined using a Parr 1281 oxygen bomb calorimeter . Mean caloric value of communities was calculated by weighting caloric value of each plant species according to their relative biomass in each community as follows :

Community cal $(\%) = \dfrac{\sum [B_i \times C_i]}{\sum B_i}$ B_i is i species' relative biomass in a community , C_i is the caloric value of species i .

Results Based on the mean caloric value , the 60 species were divided into three groups : high energy plant functional group (PFG) (caloric value$>$ 18 .00 kJ g^{-1}) , medium energy PFG (18 .00 kJ $g^{-1}$$>$caloric value$>$17 .00 kJ g^{-1}) , and low energy PFG (caloric value $<$17 .00 kJ g^{-1}) . The high-energy PFG has the dominant status , and the medium-and low-energy PFGs are the companion or incidental groups in the primary steppe . There were accordant trends for the three steppe communities , that is biomass proportion of high-energy plant in community decreased gradually , while those of low-energy plant increased with increasing degraded intensities . Moderate-energy plant slightly increased . The aboveground biomass and the mean caloric values of communities showed decreasing trends with increasing degraded intensities at the same time . It is the high-energy plants giving place to low-energy plants that result in degradation of steppe ecosystem function .(Figure 1)

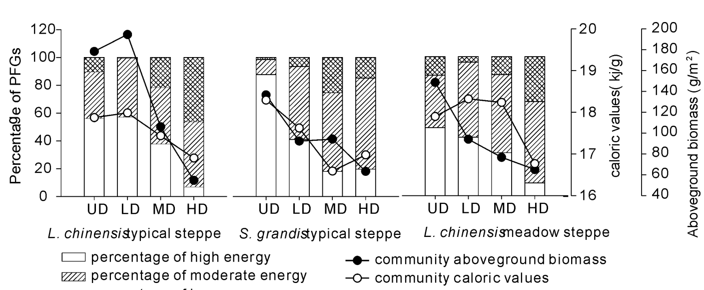

Figure 1 *Proportion of aboveground biomass of three PFGs based on caloric values in 12 sites along 3 degradation gradient .*

Conclusions The substitution of high-energy PFG by low-energy PFG was found to be coupled with the steppe degradation process . A classification system of energy-PFGs was proposed which can provide a reliably approach to characterize the functional status of different plant communities , and explore the mechanisms of steppe degradation at wholesome level .

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The caloric values of main plant species and functional groups in the steppe communities of Xilin River Basin

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Key words: Xilin River Basin, the caloric value, plant functional groups, steppe community, plant species

Introductions The caloric value is a useful parameter which has been broadly employed to measure the energy budgets through an ecosystem (Ren et al., 1999), as well as to assess the photosynthetic efficiency of plants and to identify the allocation of energy storage within different organisms of plants. The objective of this study was to detect variations of caloric value of dominant species and functional groups in total 12 sites in the steppe communities of Xilin River Basin, Inner Mongolia.

Materials and methods Caloric values of main plant population were investigated in Xilin River Basin, Inner Mongolia The study was based on field surveys of the standing vegetation in two typical steppes respectively dominated by *L. chinensis* or *S. grandis* and one meadow steppe dominated by *L. chinensis* including of four degraded intensities sites (undegraded, relatively light, moderate and heavy degraded) in each steppe types Aboveground part was sampled in terms of different species from above 12 sites from 18 July to 10 August 2002, and then oven dried at 60℃ to constant weight. The caloric determinations were made of each sample using a Parr 1281 oxygen bomb calorimeter, The caloric value was analyzed for species grouped according to their life form, family and water ecological types.

Results The mean caloric value of 60 species, taking into account three steppe types and four grazing degraded intensities studied, was 17.25±0.92 kJ g^{-1} with a CV of 5.4%. Among them, a annual forbs, Salsola collina (13.12±1.09 kJ g^{-1}) had a significant lower caloric value than other species (Figure 1). Shrub had the highest value among groups classified by life forms. The mean of perennial grasses was significant higher than that of annuals and biennials ($p<0.05$), the subshrubs and perennial forbs were in the midst. No statistically significant differences were found among the caloric values of the different plant groups based on water ecological types include of xerophytes, mesoxerophytes, xeromesophytes and mesophytes. Different families showed apparent difference in caloric value. The higher caloric values were found in Gramineae, Leguminosae and Compositae, while Chenopodiaceae has the lowest value (Figure 2).

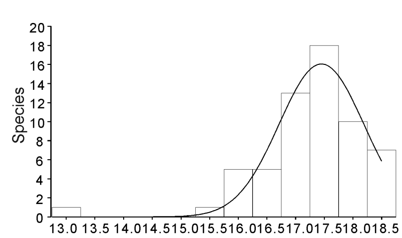

Figure 1 *Frequency distributions of the number of species by caloric value classes of major plant species in the steppe of Xilin River Basin.*

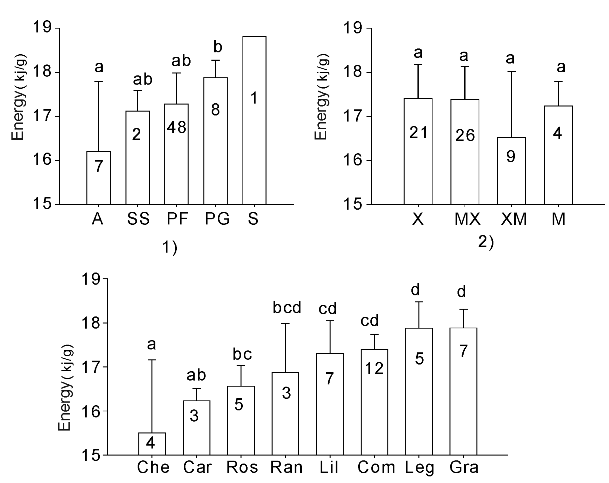

Figure 2 *Mean caloric value (±SD) for different plant grouping in steppe of Xilin River Basin. Different letters represent significant differences among means ($P<0.05$, ANOVA Duncan test). The number in the bar represent the number of species in corresponding grouping.*

1) Based on life form. A: annual and biennials, SS: subshrubs, PF: perennial forbs, PG: perennial grasses, S: shrubs.
2) Based on water ecological types. X: xerophytes, MX: mesoxerophytes, XM: xeromesophytes, M: mesophytes.
3) Based on family. Che: Chenopodiaceae, Car: Caryophyllaceae, Ros: Rosaceae, Ran: Ranunculaceae, Lil: liliaceae, Com: Compositae, Leg: Leguminosae, Gra: Gramineae.

Analysis of photosynthetic characteristics of *Heteropogon contortus* in Arid-hot Valley Areas of Jinsha River

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Key words : *Heteropogon contortus* , photosynthetic characteristics , midday-depress of photosynthesis

Introduction *Heteropogon contortus* , as a dominant species in Arid-hot Valley Areas of Jinsha River , plays an important role for both maintaining ecological environment of grassland and realizing the ecological function . The aim of studying the photosynthetic characteristics in *Heteropogon contortus*' leaves under different circumstances is to figure out the difference of photosynthetic mechanism of *Heteropogon contortus* during various periods , and provide theoretic reference and technological reserve for ecological system restoration of Arid-hot Valley Areas of Jinsha River (Liu Yuhua et al . , 2006) .

Materials and methods The trial field lies in the breeding sheep stud on Renhe Town , Yongsheng County in northwestward of Yunnan Province , which is a kind of the typical Arid-hot Valley Areas . The altitude is 1500m , and the annual average temperature is 18-22℃ . The extremes of high and low temperature are respectively 38 .2℃ and 1 .5℃ . The annual precipitation is about 900mm . The exchange of dry and rainy season is obvious in Arid-hot Valley Areas . The vegetation are mainly *Heteropogon contortus and Fimbristylis dichotoma*(linn .) Vahl ,Enum , mixed with *Salix myrtillacea* Anderss . *Heteropogon contortus* was used in this study , whose photosynthesis was tested by CI-310 photosynthesis system in an open system .Net photosynthetic rate (Pn) , transpiration rate (Tr) , stomatal conductance (Gs) , intercellular CO_2 concentration (Ci) , leaf temperature (Tl) , WUE(Water use efficiency) and LUE(Light use efficiency) were tested in different methods (Tao Hanzhi et al) .The medium size , normal and fully expanded leaves were selected for the experiments . The leaves were sampled with triplicate , and the measurements were made 3-5 times . Data were analyzed by using EXCEL and SAS 6 .12 tools .

Results In this study , the diurnal changes of Pn , Tr and Gs exhibited two-peaked curves with an obvious midday-depress of photosynthesis . The changes of Pn and Gs were synchronous (Figure 1) . The determinations of those in rainy season were higher than those in dry one , however , the difference were not significant ($p > 0.05$) . The diurnal changes of Ci were similar in two seasons (Figure 1) . Figure 2 showed that the diurnal changes of WUE and LUE were expressed as two-peaked and U" curves , respectively .

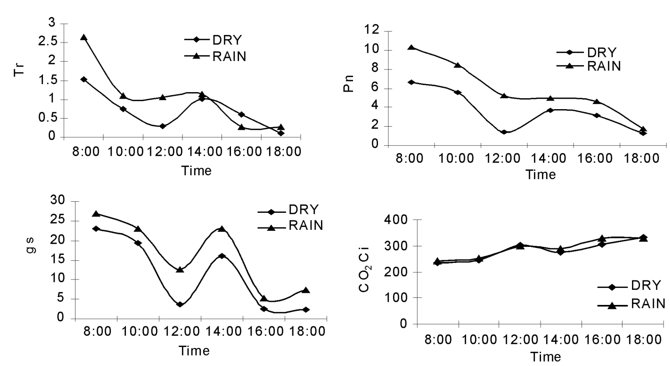

Figure 1 *Diurnal changes of Pn , Tr , Gs , Ci of* Heteropogon contortus .

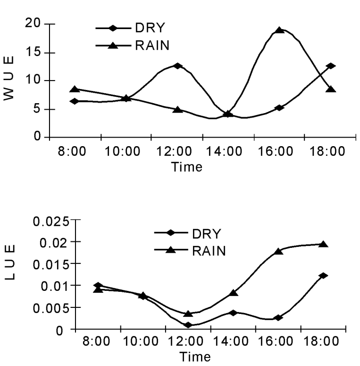

Figure 2 *Diurnal changes of WUE and LUE of* Heteropogon contortus .

Conclusions In specific circumstances of the Arid-hot Valley Areas , *Heteropogon contortus* can avoid water losing and alleviate the damage to photosynthetic organs from high light intensity and drought stress by midday-depress of photosynthesis , maintaining the lower Tr and enhancing WUE . Moreover , the higher values of LUE in the rainy season indicated the rainy season was the important period for *Heteropogon contortus*'s growth and yield's accumulation .

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Effects of different enzyme combination and dissociation-time on the protoplast isolation of alfalfa

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Key words : alfalfa ,the kinds of enzyme ,concentration of enzyme ,dissociation-time ,protoplast

Introduction At present , as donor of protoplast dissociation is different to alfalfa , some factors have influence on protoplast dissociation , such as the kinds of enzyme , the concentration and dissociation-time . Using hypocotyl of alfalfa as tested materials , by setting different the kinds of enzyme , the concentration and combination of enzyme , dissociation-time in this study in order to provide theory and practical guidance for extension of alfalfa biotechnology .

Materials and methods According to the routine methods for inducement cultivating asepsis seedling . After asepsis seedling was cultivated 10d , the hypocotyls were chopped .

Usually 1 .0 g chopped hypocotyls in a CPW-13 solution (Frearson et al . , 1973) were incubated in the dark at 25℃ for 1h then submitted to 10 ml filter-sterilized enzyme solution Ⅰ .The same method was treated in the enzyme solution Ⅱ ,Ⅲ ,Ⅳ as the enzyme mixtures Ⅰ . Chopped hypocotyls were shaken at 60 rpm for 6h in the dark .

Usually 1 .0 g chopped hypocotyls in a CPW-13 solution were incubated in the dark at 25℃ for 1h then submitted to 10 ml enzyme solution Ⅳ ,Chopped hypocotyls were shaken at 60 rpm ,25℃ for 4h ,6h , 8h and 10h in the dark .

The mixture was passed through a nylon sieve (38 .5 μm pore sizes) and 15 ml of CPW9M solution was added . The protoplasts were collected by centrifugation for 5 min at 60 rpm and resuspended in the washing solution . The washing treatment was done twice . Protoplasts , free of debris were carefully removed from the interface of the solutions , and protoplasts were rinsed twice with 15 ml of KM8p medium((Kao and Michayluk , 1975) A small sample of protoplasts in the washing solution was stained with 0 .01% (w/v) phenosafranine .The yield of protoplasts was determined with a Malassez counting chamber .

Results and discussion Even conspecific plant , initiative materials are different , there are different to concentration of enzyme and dissociation-time . Chopped hypocotyls were treated in four enzyme solutions for 6h , it was better the condition of protoplast dissociation in enzyme solution Ⅱ in this experimentation ;In the same condition of protoplast dissociation ,protoplast dissociation production gradual increase along with protraction of dissociation-time ,but dissociation-time is overlong will result in sharp increase of cell debris ,it will affect protoplast culture ,and prior dissociative protoplast is able to occur fracture . It was better dissociation-time that the hypocotyls were treated for 6h , at the same time cell debris was less .

Table 1 *The corcertration and combintin of ensyme .*

Name	Ceihilose (%)	Pectinose (%)	maceroryme R-10(%)
enryme soltion Ⅰ	1	0 .8	0
enryme soltion Ⅱ	1	0 .8	0 .5
enryme soltion Ⅲ	2	0 .8	0
enryme soltion Ⅳ	2	0 .8	0 .5

Table 2 *The effects of different enzyme combintion of alfalfa hypocotyk coprotoplast dissociation for on .*

Name	yield of vinble protoplast (10^6/ml)	cellbreabage
enryme soltion Ⅰ	0 .26	large amount
enryme soltion Ⅱ	0 .95	small
enryme soltion Ⅲ	0 .31	quterare
enryme soltion Ⅳ	0 .40	large amount

Table 3 *The effects of different enzyme dissociation-time of alfalfa hypowtyls onprotoplast dissociztion in enryme solition Ⅱ .*

dissociotion-time(h)	yield($1\times10^6 g^{-1}$)	visbility(%)	yield of vinble protoplast($1\times10^6 g^{-1}$)	cell brealage
4	0 .22	7920	0 .33	quterare
6	0 .96	8690	1 .09	small
8	1 .56	8110	0 .74	small
10	1 .01	9020	0 .56	large amount

Reference

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Grazing behaviors of goats and sheep in winter and spring in a desert steppe

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Key words : *Stipa breviflora* desert steppe , grazing behavior , goat , sheep , winter and spring

Introduction Grazing ecology was to research how the herbivore to produce and realize grazing behaviors and strategies , to utilize and convert herbage resources efficiently , as well as to maintain permanent and productive ecological function of grassland ecosystem . With the development of grazing ecology , grazing behaviors were considered as the most active field in grazing ecology , even in grassland ecology . Meanwhile , grazing behaviors were not only the important factors which influencing the process from primary production to secondary production , determining livestock productivity , but also one of the important indices of evaluating grazing system and grassland conditions , and the important criteria of establishing grazing system and improving the level of grazing management .

Materials and methods The dynamic variation of grazing behavior parameters of grazing goats and sheep in the four flocks with different percentages of goat and sheep in winter and spring were observed in detail with full-time in the *Stipa breviflora* desert steppe in Inner Mongolia (41°47′ N , 111°53′ E , average annual precipitation=280 mm , elevation=1960～2800 asl , soil=light chestnut) . The ratio of goats to sheep of the flocks were 1 ∶ 0 (A) , 1 ∶ 1 (B) , 1 ∶ 3 (C) and 0 ∶ 1 (D) respectively . The goat and sheep for trials in the four flocks with healthy , similar body weight and identical age were observed continuously for two days for each observing time .

Results The dynamic variations of grazing behaviors both for goats and sheep from winter to spring were in the similar trends . Comparing with winter , the ingesting rate in spring increased evidently , intake per bite decreased more than 15% (max 40%) , and daily intake decreased . However , the total bites and walking steps of whole day grazing all increased . Daily intake of goats and sheep in B and C reduced over 10% , the goats' daily intake in A decreased 12% . But the sheep in D held the line . Meanwhile , the behavior indices of goats in winter varied obviously more than sheep . In spring , the behavior indices of goats in A varied more than the sheep in D ; in the B and C , the behavior indices of the sheep varied more than goats , which indicated that in winter and spring , goats in 1 ∶ 0 flock affected the desert steppe greater than sheep in 0 ∶ 1 flock . In the 1 ∶ 1 and 1 ∶ 3 flocks , goats affected the steppe heavier than sheep in winter , and it was opposite in spring . The variations of grazing behaviors of sheep in D were more than in the others , and that of goats and sheep in B varied least .

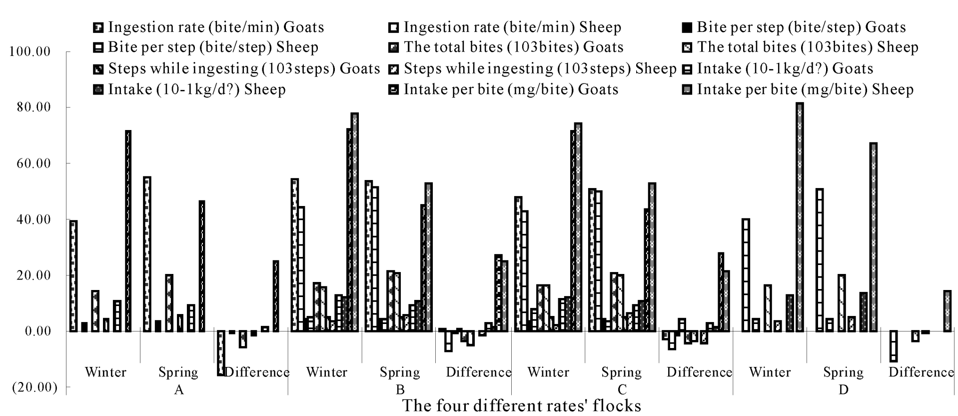

Figure 1 *The dynamics of grazing behaviors of grazing goats and sheep in winter and spring .*

Conclusions Different grazing seasons had a great impact on grazing behaviors . In both winter and spring goats in 1 ∶ 0 flock affected the desert steppe greater than sheep in 0 ∶ 1 flock . The goats in the 1 ∶ 1 and 1 ∶ 3 flocks affected the steppe heavier than sheep in winter , and it was opposite in spring . Comparing spring with winter , goats and sheep in the flock of 1 ∶ 1 gave the least effects on steppe . So the ratio of goats to sheep in 1 ∶ 1 flock was considered reasonable and practicable .

Acknowledgement The study was supported by the national 973" project (grant 2007CB106805) .

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Variation of POD activity in roots of different fall dormancy alfalfa under the autumn cutting

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Key words : alfalfa , POD activity , later autumn cutting , fall dormancy

Introduction Medicago sativa which is the typical leguminous forage is the widest usage in China and the whole world . The regrowth is serious because of chilliness in the north of China . Some factors attached to hard resistance are last cutting time in the autumn , different fall dormancy . So , in the experiment , the research on the change of the POD as the evaluation index are carried on to reveal the relationship between last cutting time in the autumn and different fall dormancy .

Materials and methods Nine cultivars of M . sativa , AC Caribou , Algonquin , WL323 , Amerigraze401 , Sanditi , WL414 ,Hunter River , WL525HQ , Siriver which fall into three classes of autumn dormancy were chose to compared in the experiment . There are 5 treatments (3 replications) . The autumn cutting treatments were applied on the following dates : 10 September , 20 September , 30 September , 10 October , 20 October , and no cutting . Then the POD in the root is measured on 5 Nov , 20 Nov , next 26 Mar and 17 May to observe the change of POD in the root and overwinter rate of different fall dormancy alfalfa by the different cutting time .

Results and Analysis Through analyzing the regrowth rate by different cutting time , the date of 30 September when is 20 days before the first frost is the lowest . There is no difference between the date of 10 October and 20 October without effect to regrowth rate($p > 0.05$) . Through the correlation Analysis , there is high relationship between POD activity and regrowth rate in 5 November at the cutting date of 10 October . 3 . The POD activity rise when the alfalfa regreen , so , there is some relationship between POD activity and regreen but without knowing about mechanism .

Table 1 *The Correlation Analysis on Sep 10th and Sep 20th on POD .*

Cutting date	9 .10			9 .20		
Sampling date	9 .10	11 .5	11 .20	9 .20	11 .5	11 .20
Correlation index	0 .06	0 .57	0 .82	0 .20	0 .37	0 .78

Table 2 *The Correlation Analysis on Sep 30th , Oct 10th and Oct 20th on POD .*

Cutting date	*9 .30*			*10 .10*			*10 .20*		
Sampling date	9 .30	11 .5	11 .20	10 .10	11 .5	11 .20	10 .20	11 .5	11 .20
Correlation index	0 .31	0 .28	0 .54	0 .36	0 .97*	0 .34	0 .28	0 .41	0 .86

Conclusions The POD activity has the relationship with the hard resistance and regreen of alfalfa ; The cutting date of 30 September has the important effect on regrowth rate of alfalfa .

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Experimental study on *stipa bungeana* grassland of enclosed , cutting and grazing succession for 26 years semi-arid region of northwest

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Key words :semi-arid area of northwest , *Stipa bungeana* , use type , succession process

Introduction The study of management of grassland vegetation , successive process of utilization , rules of degraded pasture ecosystem or vanished vegetations , will help to reconstruct the original vegetations and diversity . That is of important guided meaning for cultivated and reconstruction stable community types (Cheng *et al* ., 2002) .

Materials and methods (A) a completely protected area (forbidden grazing) , the time sequence evolution of grass vegetation were observed ; (B)cutting area(cutting twice per year in mid-June and mid-September respectively) , after cutting , changes of community structure were studied ; (C) a reasonable grazing area (rational grazing in middle June , middle August , middle October , 1 .5-2 sheep/hm^2) , influence of grazing on community structure were studied ; (D) uncontrolled grazing area (over-grazing area) . Time sequence evolution of grass vegetation and community structure were studied during the experiments .Each treatment contains 3 fixed plots (1×1 m^2) with 10 replications . Investigations of the vegetation were carried out on 10^{th} April , 10^{th} July and 5^{th} October , respectively .

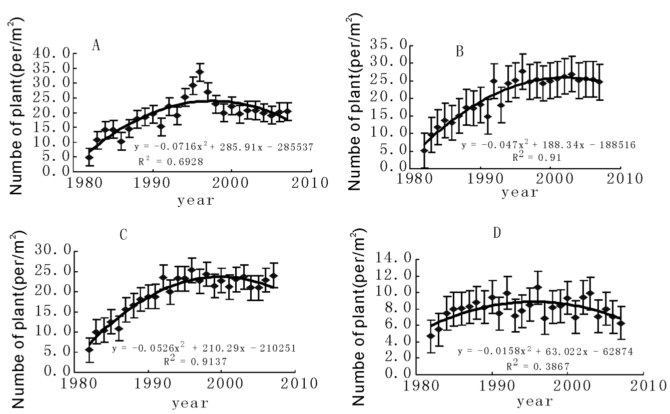

Figure 1 *Grassland population quantity variation .*

Results In district A , plant community density has reached the highest value (33 species/m^2) during the first 15 years . In district B and C , change of population species diversity increased stably , and formed sub-climax community which is mainly composed of *Stipa bugeana* population in the 23^{rd} year . In district D , grassland is usually in serious degradation states . The community biomass has the same change trend as the composition of plant density (Figure 1 and Figure 2) .

Conclusions With time lapsing , great change of evolution process occurred in rational cutting and grazing grassland . It eventually reached sub-climax community by four stages evolution . In 24^{th} year of appropriate utilization , great changes have occurred and individual number of *Stipa grandis* increased sharply , having a tendency of replacing *Stipa bungeana* .

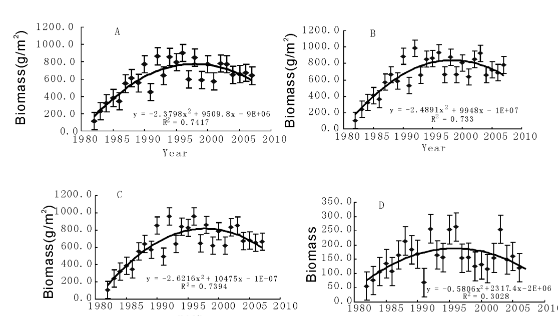

Figure 2 *Inter-annual variability of grassland biomass(A enclosed area B cutting area C reasonable grazing area D unenclosed area) .*

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The effect of hay covered on soil evaporation

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Key words: hay, biological resources, accumulative evaporation, soil moisture, different coverage rate

Introduction In recent years, much work has been done about covered effect and mechanism in preserving soil moisture by domestic and foreign experts (Qiao Hailong, 2006). However, there are few researches on the quantitative observation on the inhibitory effect of soil evaporation. Grass hay production system is an important biological resource. With hay as test material, this paper studied on the effect of soil evaporation by different coverage of hay and explored the mechanism. With a view to restoring grassland ecological environment and providing a theoretical basis and technological support for desertification control.

Materials and methods The test material was typical sandy soil taken from Xilamuren grassland. The soil was air-dried and handled through 2 mm sieve, then stuffed the uniform soil into the flowerpots with diameter 28 cm, high 34 cm. Each flowerpot weight 7.35 kg, A total of five treatments were planned, and the coverage rates were 0, 25%, 50%, 75% and 100%. Each treatment contained five replications. The flowerpots were displayed randomly with interval space of 0.5 m, and the water was added into flowerpots until saturated. In order to simulate natural conditions, 20 g sandy soil was spreaded on the surface of hay, and a preservation membrane was covered for 24 hours. Soil evaporation was measured with Electronic Scale of precision 0.5 g. The observation for every two hours is needed in the first 72 hours time, after that at 9:00 am every day.

Results as table showed, in the evaporation process, the cumulative evaporation of bare soil was the largest. With coverage increasing, the amount of cumulative evaporation reduced gradually. In the first four days (96 hours), the accumulated evaporation of different treatments showed significantly that 100% coverage had a great inhibition on soil evaporation, and the inhibition rate can reach 48%. With the increase of time, the difference between the groups became exiguous. Multiple test results showed that during this period of the 5th to 8th day, the accumulative evaporation of 0, 25% and 50% differed slightly. While the difference of accumulated evaporation of 75% and 100% was significant, and the inhibition rates were 9.3% and 4.8%. This is because after a long procession of evaporation topsoil moisture decreased gradually. As a result, the intensity of evaporation reduced.

Table 1 *The accumulated evaporation of different treatments.*

coverage rate (%)	accumulative evaporation(g)							
	1d	2d	3d	4d	5d	6d	7d	8d
0	361a	572a	664a	737a	750a	783a	807a	821a
25	331b	520b	639b	722b	741b	775a	800a	813a
50	299c	460c	588c	713c	740b	781b	807a	819a
75	239d	385d	514d	635d	662c	701c	728b	745b
100	191e	306e	417e	618e	677d	729d	762c	782c

Note: different letters in same row mean significantly under 0.05 level.

Conclusions Different degrees of coverage can inhibit soil evaporation effectively. 100% coverage had a greatest inhibition on soil evaporation, and the inhibition rate reached 48 percent. With coverage increasing, the amount of accumulative evaporation reduced gradually.

Reference

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Diachronic analysis of vegetation in the Sylvopastoral zone (Senegal) : what lesson to learn from ?

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Keys words : diachronic , sylvopastoral , drought , ecological monitoring , vegetation density

Introduction The Sylvopastoral zone (ZSP) of Senegal has been occupied for several centuries by pastoralists . During this period , frequent bush fires traversed the zone . During the 1950's the installation of boreholes allowed a permanent settlement of an increasing livestock population . Since 1970 , the modifications due to these factors were reinforced with rainfall deficits in particular . To better understand this phenomenon , monitoring was initiated , but discontinued . However , the changes related to these factors continued . The objective of this study was to identify the recent dynamics of the vegetation .

Methods of study An inventory of the woody species (sp) was made in the north at FétéOlé (FO) and in the centre at Dahra (Dh) . FO was studied between 1971 to 1976 (Poupon , 1980) and Dh between 1990 to 1998 . The same experimental designs were used again in 2003 . The study of herbaceous species was done through the exploitation of the data from the Ecological Monitoring Centre (CSE) at three sites according to a north-south axis [Souillène (So) ,Kalossi (Ka) and Ndioumanane (Nd)] from 1988 to 2003 .

Results and discussion Data on woody species at FO (between 1972 and 2003) and at Dh (1996 and 2001) do not indicate variation in the number of species (sp .) but woody density was reduced by 44% and 58% respectively . The number of individuals species has increased in the case of *Boscia senegalensis* and *Calotropis procera* at FO ; but decreased for *Balanites aegyptiaca* , *Commiphora africana* , *Guiera senegalensis* and *Acacia senegal* at FO and *Calotropis procera* and *A . senegal* in Dh . The study of the structure of the settlements shows that some sp have a high number of young individuals at FO and Dh , *Boscia senegalensis* and only at FO , *C .procera* , *B . aegyptiaca* and *G . senegalensis* .

These results show that the environmental conditions in the ZSP are favourable to *B . senegalensis* and less favourable in some sites to *B aegyptiaca* . *C . procera* is maintained with rather old plants in Dh and continues its regeneration in the North . Sp . like *G . bicolor* and *A . senegal* are suffering everywhere . Others sp found only in FO like *C . africana* and only in Dh like *Acacia seyal* and *Acacia nilotica* show the same difficulties of growth . In comparison with studies conducted by Poupon (1982) , the progression of woody sp drought resistance continues , especially in north .

The data for herbaceous sp from 1988 to 2003 indicated that both the north and the center (with low rainfall) have values that are higher than those from the south . This was not expected . Some sp can also be regarded as characteristic of these sites since they were regularly collected : *Aristida mutabilis* and *Chloris prieurii* in So ; *Cenchrus biflorus* and *Alysicarpus ovalifolius* in Ka ; *Schoenefeldia gracilis* , *Zornia glochidiata* in Nd . The relationship between the number of sp/year and the amount of rainfall is not significant as well is the diachronic analysis of herbaceous data . Six year-groups could be highlighted but the discrimination factors were not identified ; the presence of annual sp . depended on several variable factors in the Sahel such as the characteristics of the sp and the environment (Diouf and Lambin , 2001) .

Conclusions The study of the vegetation in ZSP from 1988 to 2003 showed that biodiversity was maintained . A very clear reduction in of the density of some woody sp . , however , was noted , but was compensated by an increase in sp adapted to drought . The number of herbaceous sp did not seem to vary according to rainfall or years and it is very often higher in north or the centre than in the more rainy southern zone .

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Effect of salt stress on the tall wheatgrass at the stage of seedling

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Key words : tall wheatgrass , salt-tolerance , seedling , superoxide dismutase

Introduction Tall wheatgrass (*Thinopyrum ponticum*) is perennial grass that is widely sown on saline land for grazing and soil conservation . It is known to be one of the most salt-tolerant pasture grasses . It is suited to sowing in hard-pan" situations (Smith , 1996) . The effect of salt stress on the tall wheatgrass at the stage of seedling was studied in this experiment .

Materials and methods The experiment was conducted in greenhouse with average temperature of 12—17℃ and relative humidity of 65% —75% . Seeds of tall wheatgrass(*Thinopyrum ponticum* cv . Common) were obtained from Barenbrug Tianjing . Plastic buckets of 25 cm diameter and 20 cm high was lay a bed of small stones in the bottom and inserted a PVC canal each bucket . Each bucket was loaded 7 .5 kg soil and added with four salts (Na_2SO_4 , NaCl , $NaHCO_3$, and Na_2CO_3) and with the concentration of 0% (CK) , 0 .3% , 0 .5% , 0 .7% and 0 .9% . The experiment used completely randomized design with 3 replicates . Twenty plants were reserved in each bucket after seedling . Water was added to each bucket on every other day , according to the water loss to maintain a constant salt concentration . Sample was collected at the height of about 25cm and analyzed in lab .

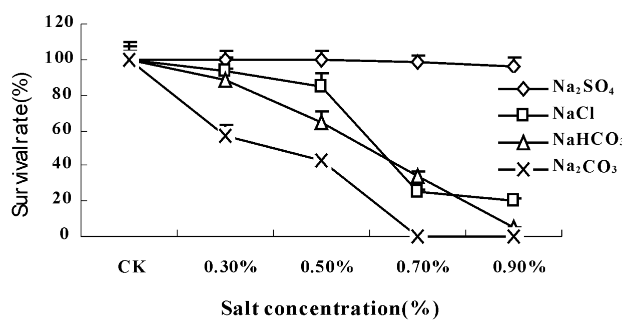

Figure 1 *The effect on survival rate of seedling by different kinds of salt resistance .*

Results Tall wheatgrass can adapt the stress of Na_2SO_4 at the concentration of 0 .3% , 0 .5% , 0 .7% with survival rate no less than 96% (Liu *et al* . , 2007) . The survival rate of other treatments decreased rapidly as salt concentration increased , especially stress of Na_2CO_3 at the concentration of 0 .7% —0 .9% (Figure 1) . Content of SOD at the stress of Na_2SO_4 increased slowly then decreased gradually as salt concentration increased . Content of SOD in other treatments decreased at different level as salt concentration increased (Figure 2) .

Conclusions Tall wheatgrass can adapt the stress of Na_2SO_4 , but not tolerant to stress of NaCl , $NaHCO_3$, and Na_2-CO_3. Survival rate and the content of superoxide dismutase decreased gradually with the increasing of the salt concentration .

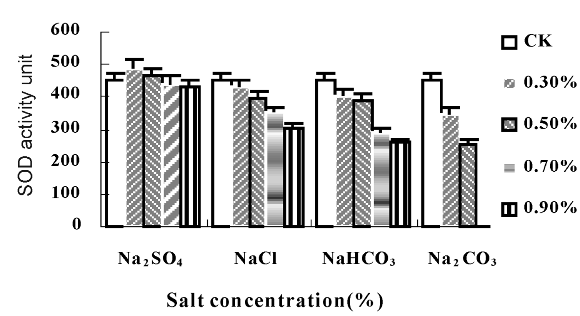

Figure 2 *The effect on superoxide dismutase activity of seedling by different kinds of salt resistance .*

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Photosynthesis and soil respiration from a mixed-grass prairie : effects of grazing and drought

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Key words : rangelands , field plots , measurement , net ecosystem CO_2 exchange , daily rate

Introduction Current objectives of rangeland management include not only concerns of forage production , but also for environmental impacts . The effects of animal grazing on the physiology of rangeland plants have been studied at different spatial-temporal scales and have varied results . In leaf-level studies , it is not easy to account for the spatial-temporal heterogeneity of main ecophysiological parameters . In farm-level studies , it is not easy to manipulate key environmental drivers (such as drought or temperature) . We conducted a field-plot scale study of photosynthesis and respiration of a rangeland considering the effects of both cattle grazing and drought .

Materials and methods The field measurements were superimposed on pastures of a long-term grazing intensity study since 1989 (Patton et al . , 2007) and a study of the effects of drought on rangeland production (Ryan et al . , 2004) . Two pastures with moderate and heavy grazing plus a non-grazing exclosure were used . Within each pasture , three plots of 3m 6m each were chosen from an representative upland area and assigned with natural rainfall , average rainfall and 75% of average rainfall (drought) treatment , respectively , using six automated rain-out-shelters . Drought treatment (Ryan et al . , 2004) was applied from 2003 to 2004 , while ecophysiological measurements were conducted from 2004 (effect of drought) and 2005 (post-drought recovery) . Daily photosynthesis was calculated from measured canopy photosynthesis-light response curves (using a transparent chamber of 44 .5 cm × 44 .5 cm × 60 cm in dimension attached to LI-6400) and hourly solar radiation data . Daily accumulated ecosystem respiration was calculated from measured soil respiration rate (using a 6400-09 soil respiration chamber) and soil water and temperature data . The field measurements were made on 25 clear days from May to Sep .

Results and discussion In both 2004 and 2005 , canopy photosynthesis and net ecosystem CO_2 exchange rates peaked in June . The average daily net CO_2 exchange for 2004 and 2005 is 0 .23 mol CO_2 m^{-2} day^{-1} and 0 .07 mol CO_2 m^{-2} day^{-1} , respectively , similar to the daily rate for a low LAI canopy (Thornley , 1998) . In 2004 , the drought plots had a daily CO_2 exchange rate of 0 .14 mol CO_2 m^{-2} day^{-1} , which was 58% lower than the data for the average rainfall treatment . In 2005 , with the removal of drought treatment , the rangeland recovered accordingly (in terms of ecosystem net CO_2 exchange) . The main effect of grazing intensity on ecosystem CO_2 exchange was not significant for the whole grazing season . However , in June , when the grassland plants were most active in physiology , the moderately grazed grassland showed a more positive net gain than did the idled land .

Conclusions (1) The net ecosystem CO_2 exchange on mixed-grass prairie in North Dakota responded sensitively to drought stress without prolonged post-drought recovery . (2) The benefits of moderate grazing on ecosystem CO_2 exchange were more on the net exchange than on canopy photosynthesis alone .

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Long-term cattle grazing affected specific leaf area and its components in two range plant species

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Key words : *Pascopyron smithii* Rydb . , *Poa pratensis* L . , specific leaf area , cattle grazing , rangelands

Introduction Specific leaf area (SLA) , leaf thickness and density influence plant survival , metabolism and nutritional value . However , systematic measurement of these plant attributes on grazed rangelands is poorly documentedy . We studied 2 dominant cool-season grasses , *Pascopyron smithii* Rydb . , and *Poa pratensis* L . , growing in North Dakota rangelands at 587 m a .s .l . , with continental climate (mean-17 and +20℃ in Jan and Aug ; 458mm rain/yr , with circa 70% during May-Sep) . Grasses dominate ; forbs contribute 20% and shrubs 2% of the peak standing crop . The area has been grazed/exclosed for 15 years under a grazing intensity study (Patton and Nyren , 1988) .

Materials and methods Leaf samples were collected in Jun-Jul and Aug 2002 in 3 non-grazing exclosures , of which 2 are about 10 $\times$50 m^2 and 1 $\times$ 20 $\times$ 20 m^2 , and 3 $\times$ 13ha heavily grazed pastures , stocked at 6 .8 AUM/ha (1 AU = a 454kg cow or equivalent , based on a mean of 12kg forage DMI/day ; 1 AUM = amount of forage consumed by 1 AU/month) (CONFUSING SENTENCE) . A formula , AU = $(LW/454)^{0.75}$, where LW = liveweight when placed on pasture , determined the AU equivalent of each animal stocked . Cattle were removed at the end of the season when 850 kg/ha of forage remained . During each field trip , 6 batches of leaves (12-20 young , fully expanded leaves each) were collected from each of the pastures/exclosures . Leaf area was measured using contact paper and an image analysis system ; leaf volume was measured by water displacement ; leaf thickness was calculated using volume and area data ; leaf density was obtained from leaf volume and dry mass . Data from the 6 batches of leaves from each pasture/exclosure were averaged and regarded as 1 replicate (3 replicates for both the grazing treatment and non-grazing exclosure) . Data for each species for each sampling period were analysed with 1-way ANOVA .

Results and discussion Increased grazing did not change *Pascopyron* SLA but *Poa* increased by 26% in August . The Jun-Jul means were not different (Table 1) . As SLA = 1/(Density(Thickness) , unchanged SLA in *Pascopyron* in Aug may be due to cancellation effects of increased thickness and decreased density . Decreased leaf density was the main cause of the increase in SLA in *Poa* in Aug . Higher SLA usually is associated with higher liquid content and metabolic rate , which is a typical strategy of fast-growing species . However , higher SLA and lower density may reduce leaf resistance to drought .

Table 1 *Effects of grazing on grass leaf properties .*

Species	Leaf property	Jun—Jul 2002			Aug 2002		
		Exclosure	Heavy	Difference	Exclosure	Heavy	Difference
Pascopyron smithii	SLA (cm^2/g)	119 .3	118 .0	NS	134 .5	135 .2	NS
	Thickness (mm)	0 .33	0 .35	NS	0 .22	0 .26	↑
	Density (g/cm^3)	0 .26	0 .26	NS	0 .34	0 .28	NS
Poa pratensis	SLA (cm2/g)	148 .5	170 .0	NS	168 .2	212 .4	↑
	Thickness (mm)	0 .20	0 .18	NS	0 .16	0 .16	NS
	Density (g/cm^3)	0 .35	0 .34	NS	0 .37	0 .30	↓ *

* Significant at $p<0.10$, NS" : not significant , ↑/↓" : significantly increased/decreased ($p<0.05$) ; .(n=3)

Conclusions Pascopyron is well adapted to drought but Poa is not . Prolonged animal grazing may have made Poa more water sensitive ; due to increased SLA , *Poa* may grow faster in high rainfall . However , in drought *Poa* may wilt more easily than grasses that have not been grazed , or are less subjected to long-term grazing .

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Effects of grazing on reproductive characteristics of *Stipa breviflora* in desert steppe

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Key word: *Stipa breviflora*, grazing intensity, reproductive characteristics, seed propagation

Introduction As one of main plants in *Stipa breviflora* Desert Steppe, *Stipa breviflora* turns green in early spring, and has good palatability, and drought resistance. Different grazing intensity affected reproductive methods of *Stipa breviflora* (Zhang *et al*, 2006).

Materials and methods Two grazing and one surrounding plots, which areas were 8.75, 8.81, and 1 hm^2 respectively, were set up in *Stipa breviflora* desert steppe in Siziwang Banner of Inner Mongolia in spring 2002. Stoking rates of zero, light, and heavy grazing plot were 0, 0.686, and 1.477 sheep hm^{-2} a^{-1}, respectively with 2-year old Mongolia sheep of similar body weight. Ten 50×50 cm^2 quadrats at each plot were sampled to investigate seed yields in 2004. Inflorescence, mature seed and reproductive shoot per unit area were recorded. Seed yields were calculated as the multiplication value of bunch, reproductive shoot, and mature seed per unit area. The data was analyzed with step-wised regression method and a General ANOVA mode with SPSS 11.0 software.

Results and analysis Vegetative shoot density in heavy grazing plot was higher significantly ($P<0.05$) than that of zero and light grazing plot (Table 1). There was no difference of reproductive shoot density in different plots. With the increase of grazing intensity, the inflorescence and mature seed decreased. The seed yields were significantly higher with zero and light than that of heavy grazing plot ($P<0.05$).

Table 1 *The seeding comparison of Stipa breviflora under different grazing intensity.*

Treatments	Vegetativeshoot density	reproductive shoot density	Inflorescence perreproductive shoot	Mature seed perreproductive shoot	Seeding ratio	Seed yields(number per unit area)
Zero grazing plot	34.1^a	6.1^a	111.8^a	53.3^a	47.7^a	3044^a
Light grazing plot	31.6^a	5.1^a	90.1^{ab}	36.0^b	40.0^a	2929^a
Heavy grazing plot	48.8^b	4.8^a	80.2^b	37.4^b	46.6^a	2192^b

Note: Different letters in the same column indicate significant differences at $P<0.05$ level.

The correlation analysis of seed yield per unit area and seed yields components showed that the correlation coefficient was the highest between seed yields and reproductive shoot density (Table 2). The regressive equation of reproductive shoot (X_1) as the independent variables and seed yields(Y) as the dependent variable was $Y=801.500X_1-1553.000$ ($R=0.879$).

Table 2 *Correlation between seed yield of Stipa breviflora and correlation factors.*

Correlation factors	Correlationcoefficient R	Significantlevel
Vegetative shoot density	0.063	P>0.05
Reproductive shoot density	0.879	P<0.05
Inflorescence per reproductive shoot	0.404	P>0.05
Mature seed per reproductive shoot	0.425	P>0.05

Conclusions The seed yields decreased with the increase of grazing intensity. Reproductive shoot was the main factor of influencing seed yields in *Stipa breviflora*.

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Testing the neutral theory of plant communities in subalpine meadow

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Key word : neutral theory , biodiversity , subalpine meadow , abundance , Tibetan Plateau

Introduction We tested the neutral theory of biodiversity within the Subalpine meadows on the eastern Tibetan Plateau in areas exhibiting comparatively complicated species composition , Our objective was to explain the species abundance distribution pattern and underlying mechanisms of biodiversity .

Materials and methods We fit the neutral model to random sampled data set obtained in three different types of habitats (north-facing slope , plain field and south-facing slope) . Three methods used to test the fitness of the neutral model to the real community were the confidence interval method , the goodness of fit method , and the diversity index method .

Results The results showed that there was no difference ($P > 0.05$) between the neutral theory predictions and observed data of species abundance distributions in the three habitats according to the goodness of fit method . The observed data nearly completely falls into 95% confidence intervals of the neutral model predictions (only one out of 63 species in plain field communities and 2 out of 75 species in the north-facing slope communities deviate from 95% confidence interval) . There was no significant difference between the neutral theory predictions and observed species abundance patterns , in which the fit of richness predictions was the best ($0.49 < P < 0.56$) and the fitness of evenness predictions were poor . However , for the three different habitats , the fitness of these three indices in north-facing slope communities was perfect , and the p-value varied between 0.49—0.70 . However , the fitness in plain field communities were also relative poor (p-value of the Simpson diversity index is smaller than 0.1) .

Discussion Although the test results of the neutral theory by three different test methods and habitats were somewhat different , the final conclusions were consistent . We concluded that the neutral model can commendably predict species abundance distribution pattern within these three different habitats of Subalpine meadow of the Tibetan Plateau .

Dynamics of *Leymus chinensis* and *Hierochloe glabra* in grassland plantings within the Songnen Plains of China

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Key word : *Leymus chinensis* , *Hierochloe glabra* , vegetative reproduction , population dynamics , series progress , planting grassland

Introduction Two grasses , *Leymus chinensis* and *Hierochloe glabra* are rhizomatous plants distributed broadly within the Songnen Plains of China (Yang *et al* . , 2006 ; Guo *et al* . , 2004) . Because germination rate of seeds is less in *L . chinensis* .than H . glabra there is a successional progression in plantings from H . glabra to L . chinensis . The capability of vegetative reproduction is stronger in *H . glabra* population than in *L . chinensis* population . Therefore *L . chinensis* is a late successional grass and *H . glabra* is an early successional grass . *H . glabra* usually forms many patches of dominant species in the planted grassland at early stage . *H . glabra* is then replaced by *L . chinensis* with successional progression occurring gradually . Eventually , *L . chinensis* would become the dominant species in the community . More compelte understanding of the dynamics of populations of *L . chinensis* and *H . glabra* could provide an improved understanding for management of these reseeded grasslands .

Materials and methods The experiment was carried out at the Pasture Ecology Research Station of Northeast Normal University , Changling , Jilin province of China (44°45′N , 123°31′E) . In the middle of May 2004 , 15 mixed communities with different proportions of *L . chinensis* to *H . glabra* were sampled . Each sample area was 0. 25 m×0. 25 m and the depth was 0. 25 m . Numbers of tillers and buds were counted , the accumulated length of rhizomes was measured and the rhizomes were washed , dried and weighed . Thereafter the quantitative characters of each sample were changed from the sample area into unit area of 1 m×1 m and statistic analysis was regarded , respectively (This is a confusing sentence-please rewrite) .

Results The corresponding quantitative characters in two populations , as the number of tillers (NTLc) , biomass of rhizomes (BRLc) , accumulated length of rhizomes (LRLc) and the number of buds (NBLc) of *L . chinensis* increased , the number of tillers (NTHg) , biomass of rhizomes (BRHg) , accumulated length of rhizomes (LRHg) and the number of buds (NBHg) of *H . glabra* decreased with a pattern of the logarithm function , respectively (Figure 1) . The correlation coefficients (r) between NRHg and NRLc , between BRHg and BRLc and between LRHg and LRLc were different ($P<0.01$) , NBHg and NBLc were different ($P<0.05$) in successional development of the planted grassland .

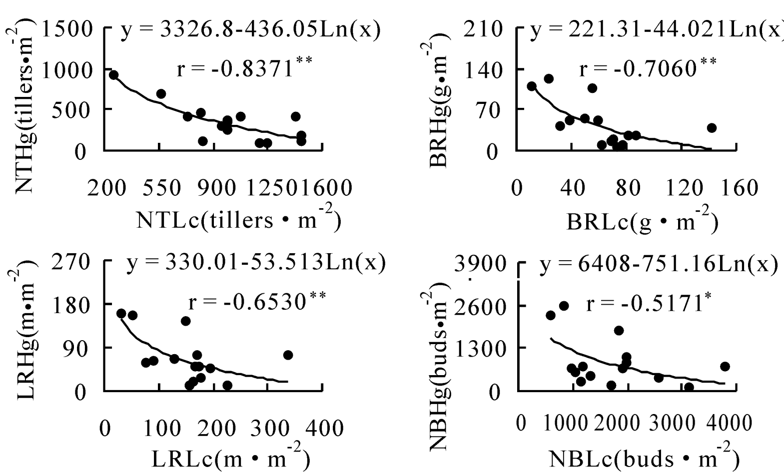

Figure 1 *Observed data and simulated curves of the quantitative characters both Hierochloe glabra and Leymus chinensis in different series progress .*

Conclusions There was a significant negative correlation between NTHg and NTLc , between BRHg and BRLc , between LRHg and LRLc and between NBHg and NBLc in planted grassland . The quantitative characters of *H . glabra* population decreased gradually with increasing presence of *L . chinensis* . Because of their different biologic charactersitics (*L . chinensis* is taller than *H . glabra* in tiller height) *L . chinensis* restrains the photosynthesis of *H . glabra* in the middle and late period of the growing season , which restricts the expansion of rhizomes and the biomass accumulation of rhizomes of *H . glabra* . Thus , bud generation of *H . glabra* was reduced . Although they are both rhizomatous grasses , *L . chinensis* replaces *H . glabra* and becomes the dominant species in these planted grasslands over time .

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Inter-annual dynamics of grassland yields and assessment of herbage supply in the headwater region of three rivers over 18 years

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Key words: grassland yield, herbage supply, dynamic, assessment

Introduction The headwater region of the Yangtze, Yellow and Lantsang rivers is one of the most important ecological function regions in China, and in eastern Asia. In recent decades, because of climate change and excessive human induced utilization, grasslands in the region have degenerated badly (Wang et al,. 2005). Thus, it is necessary to analyze grassland productivity dynamics to assess changing trends of grassland supply. We discuss reasons for observed changes. This analysis will be helpful for establishing effective strategies in grassland conservation and management.

Method Inter-annual dynamics of grassland yield from 1988-2005 were analyzed using the GLOPEM-CEVSA model. The change index of herbage supply was determined by regression slope/mean yield over these 18 years. A stability index was determined by coefficient of variation (CV).

Result The grassland productivity varied with grassland type over these 18 years. In general, grassland yield show increase trend in last 18 years, and increase markedly in alpine desert and alpine steppe of the western part (Table 1).

Table 1 Grasslands yield and assessment of herbage supply from *1988-2005*.

Grassland types	Mean yield (kg/ha)	s.d.	CV(%)	Slope	Changet rend	supply Stability
Temperate steppe	754.32	278.63	36.94	5.58	→	Low
Alpine meadow	529.85	61.00	11.51	3.33	→	Medium
Alpine steppe	144.67	42.83	29.61	3.29	↗	Low
Alpine desert	133.97	56.09	41.87	6.23	↑	Low
Marsh	868.91	139.60	16.07	9.87	↗	Medium

Discussion This study indicated that the grasslands in the western arid areas were affected by inter-annual climatic fluctuation, which resulted in a herbage supply shortage. This will likely lead to grassland degradation. A trend for increased grassland productivity over this 18 year period was mainly driven by climate change. Human impacts were mostly restricted. We should be cautious that any increased herbage supply in these areas are minor compared tp long-term negative impacts of climate change on ecosystem holistic functions.

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Assessment of important environmental factors affecting *Agropyron trichophrum* establishment by using an ordination method

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Introduction Iran is the homeland of diverse plant and animal species. Our knowledge of the environmental factors affecting these species and their distribution will help to develop more efficient range improvement plans. Plants growing in different sites represent the climatic and topographic characteristics of their natural habitats (Elinberg, 1992). Knowledge of these characteristics will help to develop range improvement plans based on ecological demands of different plant communities (Escudero et. al., 2000). For example, Allen et .al., (1995) found a significant correlation between soil and topographic properties. These results indicated that there is a possibility to estimate site potentials from both topographic features and existing plant communities. Similarly, EL-Ghareeb and Shabana (1990) investigated correlations between soil and vegetation cover characteristics. The effective factors on establishment and growth of plant species were classified in two categories. Our studies built upon this earlier work.

Materials and methods

Study area

The study area was located in Karchambu watershed, Faridan, 200km west of Isfahan. The total karchambu watershed area is about 11000 hectares which geographically is located between 49°50′ and 50°36′ eastern latitudes and 32°2′ and 33°11′ northern altitudes. The minimum and maximum elevations from the sea level are 2360 and 3710m, respectively.

Sampling methods

To identify the most important edaphic factors contributing in *Agropyron trichophrum* establishment and distribution in the range, 15 different sites with uniform cover of mentioned species were identified and selected. Quadrat samples of one square meter ($1m^2$) were used to measure percent vegetation cover, species density and soil physical and chemical characteristics on transacts representing the highest diversity of *Agropyron trichophrum* ecotypes (Mueller et al., 1974). The least essential samples number for vegetations cover measurements in each site was calculated by the following equation (1):

$N=\frac{t^2\times s^2}{(x\times k)^2}$ (1) N: number of essential samples, T: t student value with n-1 and $\infty=5\%$, S: standard variation, X: mean vegetation cover

N: primary sample number, K: Precision coefficient (10%). All the soil samples were transferred to the laboratory in separate plastic bags, where the pH value, EC as well as Na, K, Ca and Mg content were measured. Sodium absorption ratio was calculated by the following equation (2) (Miller and keenly, 1986).

$$SAR=Na/[\frac{Ca^2+Mg^2}{2}]^{1/2} \quad (2)$$

Soil texture was measured by hydrometric method (Black, 1965). The relationship among all measured edaphic attributes with *Agropyron trichophrum* establishment and distribution in all 15 range sites was explained by normal ordination grouping of CA categories using CANOCO and PC-ORD software (Ter Braak, 1987 and 1988).

Results The relationship of plant parameters with soil characteristics were identified by RDA (define) method. This method was applied to demonstrate these relationships graphically. The results of these analyses in 15 sites showed that there is strong correlation between two plant characteristic-plant density and percent vegetation cover. The increment of these two parameters is exactly in direction of high density plant sites with over 14, 10, 5, 2, 6 and 12 which indicated the high presence of *Agropyron trichophrum* on these sites. The correlation between these plant parameters (density and percent vegetation cover) are well indicated by the coefficient of correlation values. Soil characteristics like Ca content at soil A layer, sand, Cl, Mg, and Na at B and silt, clay Sp, EC, pH, and OC at A and B layers have no effects on *Agropyron trichophrum* vegetation cover. Parameters like gavel percentage, Mg content and Na at A layer, and Cl at B as well as C/N and Ca content at both A and B layers of the soil have a moderate effects on vegetation cover of *Agropyron trichophrum*. Soil parameters like sand parentage and soil pH at soil a layer have a moderate effect on the vegetation cover while the same factors at B layer were the most effective ones on percent vegetation cover. The most important factors on *Agropyron trichophrum* density were C/N ratio and soil pH at B layer. Among the selected soil parameters, C/N ratio, SAR, sand, gravel and calcium percentage at A layer and SAR, C/N ratio and Cl at B layer had the highest positive correlation while Sp, pH, and EC parameters at A layer had the lowest correlation with plant parameters.

Application of Analytical Hierarchy Process (AHP) in priority classification of utilization measurement methods in *Agropyrun trichophrum* stands in upland grasslands of Iran

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Key words : *measurement methods, percent utilization, Analytical Hierarchy Process*

Introduction Determination of optimum utilization rate for different range species is an important factor in range grazing capacity measurement. The vast rangelands in Iran with diverse vegetation types require an accurate, economic and quick method to determine the optimum utilization rate for different range species. This experiment was conducted to determine the most appropriate method to determine the optimum utilization rate for *Agropyrun trichophrum*, which is considered as one of important grass species in upland grasslands in Iran.

Materials and methods The measurement methods were classified in three categories according to sampling sizes and then for each method the number of samples was determined using the appropriate statistical procedures (Bonham, 1989). The time consumption (in field and laboratory) as well as expenses (equipments and labor) for each sample was measured in each method. To determine the accuracy of the applied methods, the statistical method of Estimating Sampling Sizes was employed (Cook et al, 1986). The collected data were analyzed by AHP statistical method using Expert Choice" software (Asgharpoor, 1998).

Results Stem counting was the quickest and most economic method while paired caging (control) method appeared to be the most expensive and time consuming one (Table 1). There was a significant difference ($P<0.05$) in mean utilization rate of *Agropyrun trichophrum* measured between paired caging method (control) and other methods except for height-weight, before and after grazing and Occular (double sample) estimation methods. The accuracy test showed that height-weight, before and after grazing, Occular (double sample) estimation and paired caging (control) methods with 4.5, 8.3 and 8.6 percent estimation faults (k), respectively, were the most reliable methods among the others. The results of this experiment in respect to high expenses and time consumption of paired caging (control) method corresponds to results reported by Klingman et al. (1943). Stem counting method appeared to be economic and quick in this experiment, however, it was not accurate and trustable which supports the results reported by Pechanec et al. (1937).

Table 1

Methods	Percentage utilization	Time(min)	Budget	Percent estimation faults (k%)	AHP
Paired cage (control)	42.8a	1258	129890	—	0.073b
Before and after grazing	41.87a	938	114890	3.7	0.046b
Occular estimate (double sample)	48.77a	66	35138	5	0.104b
Height-weight	45a	290	29964	0.8	0.154b
Stem count	30.45b	52	11506	11.4	0.186a
Reference unite	27.2bc	275	33080	6.9	0.089c
Production index	20.41dc	345	41075	13.9	0.073dc
Plant count	17.21d	189	24420	18.8	0.023d
Twig length	13.12d	582	62917	20.5	0.041d

Means with the same letter are not significantly different at 5% level.

Conclusions The results obtained by Analytical Hierarchy Process in this experiment showed that the appropriate method (quickest, most economic and most accurate) to measure the optimum utilization rate of *Agropyrun trichophrum* in upland grasslands of Iran is height-weight method.

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Obstacles of determining compensation in grassland ecological values

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Key words : ecological value , compensation , obstacles

Introduction From a theoretical point of view , the Britain scholar Pigou (reference) put forward the very famous Pigou's tax (Need to define this tax) . The US scholar Coase referred to a well-known example of this tax (EXPLAIN HERE) . However , these theoretical examples do not have practical applications . We need to develop pragmatic examples of appropropriate compensations of ecological value . Our objective in this paper is to outline examples of practical estimations of ecological values of grasslands in Inner Mongolia .

Materials and methods The methods in this paper were developed from the authors' investigation in the Xilin Gol League of the Inner Mongolia where grasslands have been damaged by mining activities over XX years (How Long ??) . This paper reports on our adaptations , mainly , of an empirical method , complemented by a theoretical method . This approach combines a number of economics approaches with application at welfare systems (Is this correct ??) .

Results

Although the principal pollution identified , it difficult to enforce .

The pollution-oriented enterprises settled in the Xilin Gol League of Inner Mongolia grassland reject ecological value compensation , even the victim household win the lawsuit , because of their political strength . It can be proved from the James Mcgill Buchanan's public choice theory .

Compared to other types of cases , it is difficult to definitude compensator clearly .

It is difficult to determine compensator . Lots of mining enterprises settled in the Xilin Gol League of the Inner Mongolia , but who are the main bodies ?

It is difficult to determine compensation targets .

A herdsman in Xilin Gol League received compensation of 6 million Yuan because there is coal mine underground his pasture . The collectivity has ownership of grassland , but it did not have any compensation . Some compensation is divided by the ratio of 3 :7 for the collectivity and herdsman in Xilin Gol League . It is no doubt that there are utterly baseless .

It is difficult to define the amount of compensation .

Someone propose it based on the ecological value grassland , but it is very difficult to calculate , almost could not count . The extent and time of pollution are also hard to determine .

Conclusions The aim of pointing out there are obstacles of compensation in grassland ecological value is just for probing into effective approach to solve these problems . In fact , the authors of this paper focus on that the pollution-oriented enterprises settled in grassland should compensate grassland ecological value .

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Analysis of C-banding and karyotype of Chromosome of two *Galega* species

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Key words : *Galega orientalis* , *Galega officinalis* , Chromosome , C-banding , Karyotype

Introduction *Galega orientalis* Lam and *Galega officinalis* Linn are perennial legume forages ,that have gained a place of Practaculture Science importance as new legume pasture species with potential in the former Soviet Union , Northern Europe and Canada . These species have high crop yield , high crude protein content , strong ecological adaptability , and sustainable persistence in pasture . There have been numerous studies on their biology value and cultivation technique , but research about cell biology is lacking . In order to promote the breeding and heredity development of *Galega* , we have condicted investigation on its karyotype and C-banding . This information will have value in understanding the genetic nature of these forage plants .

Materials and methods Karyotype analysis of chromesome was conducted by sqush method . The C-banding analysis was followed by the HBSG (HCl-Ba(OH)$_2$-SSC-Giemsa) method . The description of karyotype and C-banding were performed according to LI Mao-xue(1996) .

Results and analysis

karyotype analysis The results showed that the number of chromosome of *Galega orientalis* Lam . was $2n=2x=16=16m$. According to Stebbins classification , it belonged to 1A type . Its AI(karyotype asymmetry index) was 2 .55 .The number of chromosome of . was $2n=2x=16=12m+4s$, its karyotype was 1A type . Its AI(karyotype asymmetry index) was 1 .77 . Two species have the same chromosome number . The karyotype formula is different ,but they both have nearly median chromosome .

C-banding research The band formula of *Galega orientalis* Lam .was $2n=16=10C+2I^{+}+2CI^{+}+2$ .The band formula of *Galega officinalis* Linn .was $2n=16=8C+2I^{+}+2I_{+}+2CI^{+}+2CT_{+}$.

Discussion Karyotype and C-banding can be used for the analysis of genome and chromosome . *Galega orientalis* Lam .and *Galega officinalis* Linn .were both symmetrical karyotype , which indicated that they were ancient and primal plants . Sometimes arm ratio is inaccurate due to unclear centromere of chromosome related to the degree of pressure . Therefore , it is difficult to obtain accurate results relying solely on the length of chromosome and the arm ratio characteristics to do the matching analysis . But for most plants , the result of C-bangding is relatively steady and valued , so we analyse karyotype combined with the results of C-banding , in order to obtain more accurate result of karyotype analysis .

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Presentation of diversity, life forms and chorology of plant species in rangelands of Jahrom

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Key words: flora, life for, chorology, Jahrom region, Iran

Introduction Plant species and individuals can be grouped into different life-forms classes based on structural and functional similarities. Life-forms have close relationships with environmental factors. Raunkiaer proposed a life-form classification system based on the manner in which plants protect their perennating buds during unfavorable seasons and plant species can be grouped into five main classes: phanerophytes, chamaephytes, hemicryptophytes, cryptophytes and therophytes. Few studies have been devoted to the structure and flora of plant communities in the Jahrom region of Iran. The objective of present study, were classifying plants according to their growth habits by using Raunkiaer's life-forms system to characterize the flora of Jahrom.

Material and methods The study area was located in the Jahrom region in Iran (52°30′ to 54°00′ E & 28°00′ to 29°00′ N). The mean annual rainfall and temperature was 200-500 mm and 19.5℃, respectively. The vegetation of the study area was classified as woodland, shrubland and sub-tropical annual grassland. Specimens were identified according to valid references. Species were classified according Raunkiaer's life-form method and the proportion of species in each life-form class was calculated.

Results A total of 346 species belonging to 234 genera and 67 families were recorded. The families with the greatest number of species were *Papilionaceae* with 52 species, *Asteraceae* with 47 species and *Poaceae* with 36 species (Figure 1). The life-form categories were therophytes with 30.1% of species, hemicryptophytes with 30.1% of species, phanerophytes with 17.6% of species and chamaephytes with 13% of species (Figure 2).

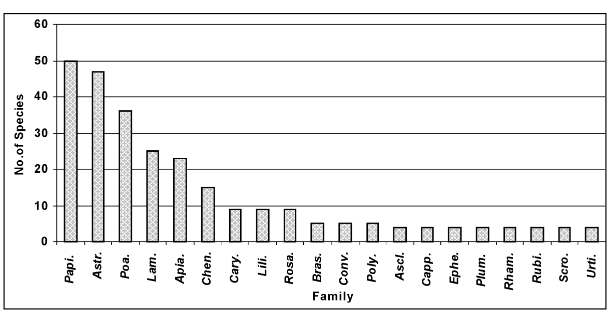

Figure 1 *Important families and number of species.*

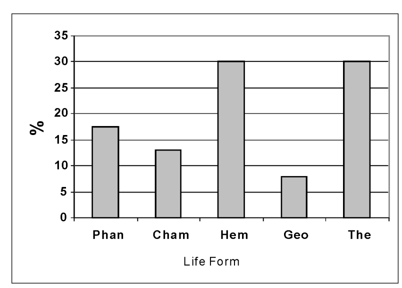

Figure 2 *Spectrum of Raunkiaer's life forms.*

Conclusions This study demonstrates the diversity of herbaceous plants in this area. *Papilionaceae*, *Asteraceae* and *Poaceae* were among the richest families. The chorological studies showed that 81.6% of species were belonged to Irano-Turanian zone and 9.2% were belonged to Sahara-Seindian zone. Also 9.0% of common species were belonged to both zones. Presence of some genera such as *Acantholimon*, *Allium*, *Astragalus*, *Centaurea*, *Alhagi*, *Achillea*, *Cotoneaster*, *Dianthus*, *Echinops*, *Ferula*, *Ferulago*, *Gypsophila*, *Gundelia*, *Lycium*, *Peganum*, *Phlomis*, *Pistatia*, *Prangos*, *Scrophularia*, *Silene*, *Tulipa*, *Verbascum*, and *Zygophillum* are also characteristic of the Irano-Turanian zone. Some genera such as *Citrullus*, *Cenchrus*, *Caloropis*, *Blepharis*, *Priploca*, *Pergularia*, *Onychium*, *Ochradenus*, *Helianthemum*, *Hammada*, *Gallonia*, *Psylliostachys*, *Prosopis* and *Ziziphus* are main elements of the Sahara-Seindian zone. The low low frequency of these genera would indicate that an ecotone zone occurs within the in Jahrom region.

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Which vegetation sampling approach is more efficient for a rangeland inventory ?

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Key words : sampling techniques , canopy cover , precision , accuracy , time/cost consumption , Zagros region

Introduction Iran's rangelands cover about 90 million hectares and provide a wide variety of products and services . Aims of a sampling plan would include maximum efficiency to provide the best statistical estimates with low cost and high precision . It is very important that sampling provides an unbiased estimate of the variance and the mean of the parameters being studied . Designing efficient sampling techniques is a critical processe to all management decisions . On the other hand , the consequences of poor sampling design are loss of both time and money , reduced creditability , incorrect management decisions , and , eventually , rangeland deterioration . The objectives of our study were to compare three vegetation sampling techniques of (1) random (RNDM) , (2) systematic (SYSM) , and (3) random-systematic sampling (RND-SYSM) in terms of precision , accuracy , and time-cost consumption to characterize the vegetation of a mountainous region in Iran .

Material and methods The study area is located in southern part of Zagros mountain in Iran between 52°20′ to 52°23′ E and 29°52′ to 29°54′ N . The mean annual precipitation is 594 mm and mean annual temperature is 14 .9℃ . The study area was stratified based on physical characteristics (slope , aspect , and elevation) by using GIS . In each homogenous unit , three sampling techniques were established to record canopy cover , production , and time/cost consumption .

Results Differences among sampling techniques were significant ($P < 0.01$) for all criteria except for accuracy of production (Table 1) . The efficiency of different criteria was ranked and shown in Table 2 .

Table 1 *Comparison of three sampling methods for different criteria .*

Sampling Method	Time/Cost Consumption (min .)		Accuracy		Precision(Variance)	
	Production	Cover	Production	Cover	Production	Cover
RNDM	3 .31[b]	3 .31[b]	57 .52[a]	33 .9[a]	525 .32[a]	219 .33[a]
SYSM	2 .33[a]	2 .33[a]	61 .64[a]	38 .36[b]	532 .16[a]	283 .24[b]
RND-SYSM	2 .13[a]	2 .13[a]	61 .73[a]	37 .15[b]	701 .19[b]	216 .67[a]

Table 2 *The ranking of efficiency for three sampling methods .*

	Time/Cost*		Accuracy		Precision	
	Production	Cover	Production	Cover	Production	Cover
RND-SYSM	1	1	2	1	3	1
SYSM	2	2	1	2	2	3
RNDM	3	3	3	3	1	2

* For time/cost , accuracy , and precision , 1 was the highest efficiency .

Conclusions The results showed that for cover estimation RND-SYSM had the highest precision and accuracy and the lowest time/cost consumption . On the other hand , the RNDM had the lowest accuracy and the highest time/cost consumption . The highest accuracy for production estimation was belonged to SYSM and the highest precision was belonged to RNDM . The highest time/cost efficiency for production and cover estimations was belonged to RND-SYSM .

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Behavior of medicinal species of *Cichorium intybus* against salinity on different developmental stages

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Introduction Salt tolerance is important in medicinal plants because of the cash value of these crops. The idea of using medicinal plants to treat human beings and livestock is not new, and in many developing countries their use is still in vogue. Despite the fact that in developed countries modern development in allopathic medicine is at climax, there is a renewed interest in using medicinal plants to treat humans, pets and livestock. Medicinal plants are being used for therapeutic purposes in several ways. In modern medicine, many drugs are used that are mainly derived from plants, e.g. digitalis, morphine, atropine, cinchona and vinblastine (Joshi, 2000). Many people are turning to alternative medicine, due largely to the fact that there are frequent side effects to be faced by taking powerful synthetic allopathic drugs (Rojhan, 2003). Because of salinity problems, researchers are trying to get the salt resistant vegetables and medicinal plants on which human's food and healthy depend. The present study was carried out to investigate the extent of salinity on the germination and early seedling growth of *Cichorium intybus* from Compositae.

Materials and methods The seeds of *Cichorium intybus* were used in this study. Experiment was conducted to examine the effect of different NaCl concentrations on germination percentage, germination velocity, root and shoot length and seed vigor. To evaluate salt tolerance during germination, 20 seeds were placed on filter paper (top of paper procedure) and submerged in 5 ml of NaCl. Solutions of NaCl were used at concentrations of 0 (control), 100, 200, 300, and 400 mM. Experiments were performed in a completely randomized design with 4 replicates. Germination counts were made daily and were considered to have germinated when the radicle emerged. At the end of the germination period, the germination percentage, germination velocity, length of the stem and root and seed vigor were calculated.

Results and discussion Table 1 shows the results of NaCl salt effects on germination percentage, germination velocity, length of stem and root and seed vigor. As it is shown in the table, all of understudy characteristics decrease with increase of salinity levels.

Table 1 *Different NaCl salt concentration on early developmental stage in* <u>Cichorium intybus</u>.

Source of Variation	Germination percentage	Germination velocity	Seed vigor	Length of stem (cm)	Length of radicle (cm)
0 (mM)	97a	23.4a	85.84a	1.52a	7.3a
100	96a	22.5a	66.96b	1.22b	5.8b
200	88b	17.95b	26c	0.62c	2.3c
300	46c	3.64c	2.34d	0.32d	0.18d
400	10d	0.09d	0d	0e	0d

Means within a column that have a different small letter are significantly different from each other.

In this study, extension of NaCl resulted in unsuitable condition for seed germination of medicinal plant. Decrease of germination associated with salt concentration increase could be related to accumulation of different ions around seeds which subsequently leads to less water absorption by seeds. Water, as well as temperature is of high importance in seed germination. Grieve and Suarez (1997) suggest that high levels of soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity.

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Effects of different utilization levels on species richness changes in Saral grassland , Kurdistan Province

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Key words : species richness , reference area , key area , critical area , utilization level , Saral , Kurdistan

Introduction Species richness reflects the number of species in a plant community . It is one of the most important plant based evaluation indices for rangeland ecosystems (Cingolani *et al* . , 2005) . The present research was conducted to evaluate effects different utilization levels upon species richness within grasslands of the Saral region of Kurdistan .

Materials and methods Three areas (reference , key and critical areas) were selected from within the Sarel region . Species richness data were collected using Whittaker plots . Ten plots in each area were used to and data were analyzed using regression ($S = \beta + \beta \log x + \varepsilon$) , Where : S :average number of species in each plots , β :intercept ,β : species richness changes per area unit , ε : error amount and x : plot size(0 .1 ,1 ,10 ,100 and 1000) . Finally , regression coefficient (β) and intercept (β) were compared by using t-student statistical method together . Paired regressions showed species richness changes . Minitab13 software was used for this comparing .

Results and conclusion The statistical models for each area (key , reference and critical areas) were obtained as below : $S_{key} = 3.56 + 3.76 \log x$,$S_{Reference} = 3.83 + 4.53 \log x$ and $S_{Critical} = 1.77 + 1.99 \log x$.

The determination coefficients of above equations are respectively 0 .94 , 0 .98 and 0 .98 at 1% level . Regression paired comparing for key and reference area showed that t-calculated (0 .53) was smaller than t-table . Therefore there was not a significant difference between these two areas . The t-calculated value was bigger than t-table in reference and critical areas and in key and critical areas . These results show that both key and critical areas are susceptible to species number changes . Figure 1 , 2 and 3 show regression equations and lines at key , reference and critical areas .

Discussion Key and reference areas were not different . We assumed then that moderate grazing had the same effects as no grazing on species richness . This result is similar to those obtained by Mesdaghi (1980) . With heavy grazing (critical area) there was an obvious reduction of species richness which can be serious risk for rangeland . Utilization based on a key area in each management level is the best approach for rangeland protection and conservation .

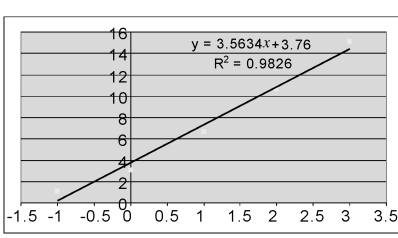

Figure 1 *Regression equation of key area .*

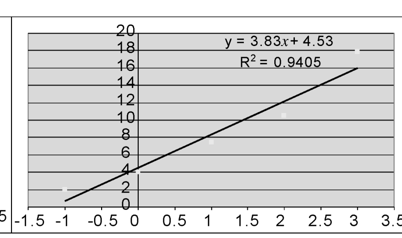

Figure 2 *Regression equation of reference area .*

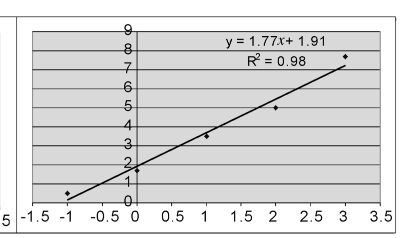

Figure 3 *Regression equation of critical area .*

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Water relations in native trees, Northeastern Mexico

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Key words: water stress, water potential, soil water content, water relations

Introduction Native trees that grow in the semiarid regions of northeastern Mexico are important feed resources for range ruminants and white-tiled deer (Ramirez, 1999). They also provide high quality fuelwood and timber for fencing and construction. Since water stress (González *et al*., 2004) is the most limiting factor in this region, the present work was focused to study how diurnal and seasonal leaf water potentials (Ψ) of native tree species are related to soil water availability and evaporative demand components.

Materilas and methods This study was carried out at the Faculty of Forest Sciences of the Autonomous University of Nuevo Leon (24°47′N; 99°32′W; 350 masl) Mexico. Studied tree species were: *Cordia boissieri* (Boraginaceae), *Condalia hookeri* (Rhamnaceae) *Diospyros texana* (Ebenaceae) and *Bumelia celastrina* (Sapotaceae). Determinations of in the four tree species were at 10 days intervals between July 10 and November 30, 2007 by using a Scholander pressure bomb. Ψ was monitored in five different plants per species at 2-h intervals between 06:00 (predawn) and 18:00 h. Air temperature, relative humidity vapor pressure deficit, precipitation and soil water content were registered throughout. data were subjected to one-way ANOVA.

Results During the wettest period (Sep-10) Ψ ranged from − 0.72 (*C. boissieri*) to − 1.30 MPa (*B. celastrina*), in contrast, during the driest period (Nov-30), varied from − 2.90 (*B. celastrina*) to − 6.10 MPa (*D. texana*) (Figure 1). Diurnal Ψ values were negatively correlated with air temperature and vapor pressure deficit, in contrast, a positive relationship was found with relative humidity. Gravimetric soil water content and precipitation data were linearly correlated with predawn Ψ.

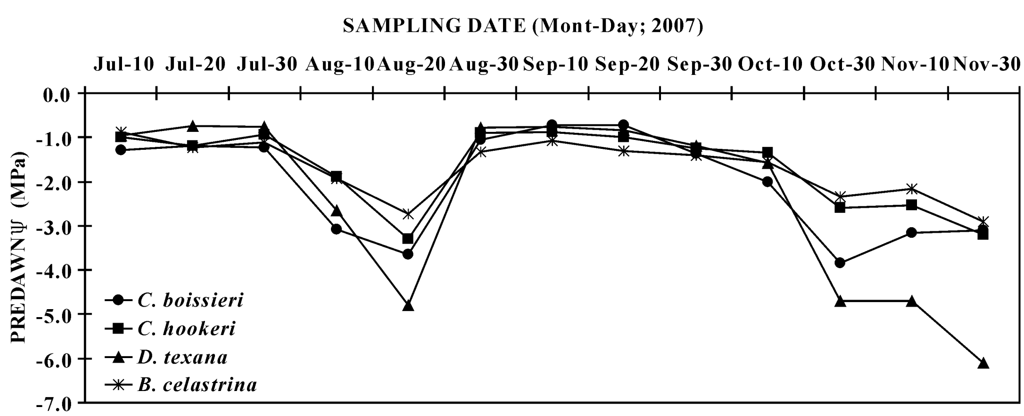

Figure 1 *Predawn leaf water potential (Ψ) in four native tree species, northeastern Mexico.*

Conclusion The ability of tree species to cope with drought stress depends on the pattern of water uptake and the extent to control water loss through the transpirational flux.

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The comparison of photosynthetic physiological characteristics between *Leymus chinensis* and *Leymus secalinus* in the Songnen plains

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Keywords: *Leymus chinensis*, *Leymus secalinus*, responses of photosynthesis to light and CO_2, photosynthetic rate, transpiration

Introduction *L. chinensis* and *L. secalinus* distributed widely in Songnen grassland, they could adapt to the habitats of different salinity and alkalinity gradient. The research of photosynthesis of *L. chinensis* or *L. secalinus* had great progress, but there no report about compare their photosynthetic characteristics. In this study, we tired to find some evidences for comparing and determining their photosynthetic physiological characteristics (Wang *et al*, 2001).

Materials and methods Seeds of *L. chinensis* and *L. secalinus* were planted in the same plot in the Songnen plains in 2006. Photosynthetic rate (P_n) and transpiration (E) through responses of photosynthesis to light and CO_2 were determined by LI-6400 in Sept., 2007. During observation the range of photosynthetic photon flux density (PPFD) was 100 to 1600 (μmol · m^2 S^{-1}) and changing cellular CO_2 concentration (Ci) be controlled by 12 gram CO_2 cylinder between 100 and 1600 (μmol · mol^{-1}) (Chen *et al*, 2006).

Results The daily changes trend of *P*n of *L. chinensis* and *L. secalinus* were similar it shows classical two-peak type. With the light or CO_2 concentration rising, it is clearly see that the *P*n of them was increasing firstly, following reach the peak, and then keep in the same level no matter how the light or CO_2 concentration changed. The CO_2 saturation or compensation point of *L. secalinus* is notable higher than *L. chinensis* in photosynthetic response to CO_2 measuring. But the E of *L. chinensis* is obviously lower than *L. secalinus* both in figures of responses of photosynthesis to light and CO_2 (Figure 1).

Conclusions There were remarkable linear correlation between changes of light use efficiency or transpiration and changes of PPFD or CO_2 concentration in this study. For the plant, the high *P*n could help it accumulate more organic compounds, but it is not the only character for determine the competitive and existent capacity. In the drought and semiarid area, water is one of the most important limited factors for plants lived, so E should be the key character for plant. E of *L. chinensis* is notably higher than *L. secalinus* in this studied, these evidences and data revealed *L. chinensis* has more competitive capacity and adaptive live in the Songnen Plains than *L. secalinus*.

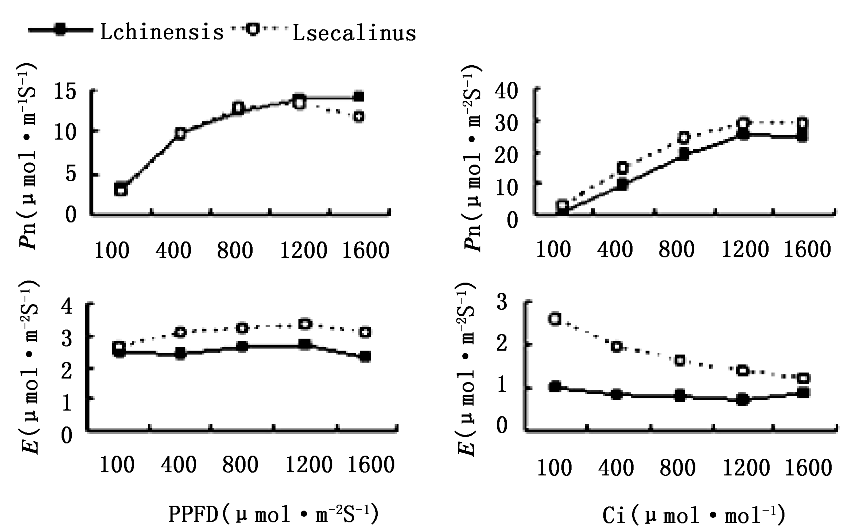

Figure 1 *Effects of Pn, and E induction on response of photosynthesis to light in two spices leaves at 380 μmol · mol⁻¹ CO₂, and comparison of two curves of Pn and E photosynthetic response to CO₂ in leaf, observations were measured at 1200 μmol · m⁻² s⁻¹ photons.*

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Biological soil crust under shrubs and its topsoil properties in the process of dune vegetation restoration in the Horqin Sandy Grassland, Inner Mongolia

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Key words: biological soil crust development, desertification, the Horqin Sandy Grassland, shrub, succession

Introduction Biological soil crust (BSC) is a major structural feature of surface soils and sediments, especially in the arid and semiarid regions, which commonly result from the development of communities of micro-organisms on the surface of physical soil crusts. BSCs are well developed under different shrubs along the vegetation restoration gradient of dunes in the Horqin Sandy Grassland, Inner Mongolia, northern China.

Material and methods The Horqin Sandy Grassland is located in the agro-pastoral transition zone between the Inner Mongolian Plateau and the Northeast Plains of China, and is one of the most severely desertified regions of China. We conducted a field investigation wherein, BSC and topsoil (0-2.5 cm and 2.5-5 cm under BSC) samples were taken under different shrubs in different habitats, and their physicochemical properties, including particle size distribution, bulk density, organic matter, nitrogen, phosphorus, electrical conductivity (EC), pH, and $CaCO_3$ content.

Results and discussion Here in the Horqin Sandy Grassland, due to ecological effects of dune shrubs and their habitats, as the dunes transitioned from semi-mobile dune to semi-fixed dune, fixed dune and interdunal lowland, a succession of physical, algae, lichen and moss crusts developed under dominant shrubs.

Table 1 *Site description of BSC samples in the Horqin Sandy Grassland.*

Sites	Shrub types	Crown diameter (cm×cm)	Crust types	Crust color	Crust Cover
Mobile duen	—	—	—	—	—
Semi-mobile dune	Artemisia halodendron	45×60-70×90	Physical crust	gray and offwhite	30%
Semi-fixed dune	Caragana microphylla	95×110-145×205	Physical crust	gray	50%
			Algae crust	dark gray	60%
Fixed dune	Artemisia frigida	28×30-35×40	Lichen crust	yellow green	80%
			Moss crust	light brown	85%
Interdunal lowland	Salix microstachya	55×70-84×120	Lichen crust	light green	90%
			Moss crust	black green	90%

Simultaneously the value of plant community characteristics increased overall, including cover, richness, aboveground biomass, litter and species diversity. The thickness, water content, fine fraction, and nutrients of BSCs were gradually increased along this successional trajectory. Topsoil nutrients, <0.05 mm particle content in 0-2.5 cm and 2.5-5 cm layers under BSCs increased gradually with the BSC developed from physical to moss crust, and they were higher than that in mobile dune. Moreover, fine fraction, total and available nutrients of topsoil under BSC were decreased gradually from upper to inner layer within 0-5 cm. At a soil depth of 0-120 cm soil layer, water content in mobile dune was much higher than that under BSCs at each layer, owing to shrub establishment and BSC formation which decrease the infiltration of rainfall to the soil.

Conclusions BSC formation and topsoil amelioration can firstly be ascribed to the distinct protection role of shrub establishment, contributing to against wind erosion. No matter what kind of crust was formed, all crusts contained comparatively large amount of fine particles. The more stable the habitat was, the longer the BSC was formed, and the more the finer particle content was contained, as well as the higher values in chemical properties in the BSC.

The successional dynamic changing process of vegetation steppe from Central Asia and Mongolian pasture

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Key words : steppe , pasture , grassland , desert

Introduction Steppes are the most widespread type of plant communities in the Mongolian Republic , that is situated in the easternmost ultra continental sector of the Eurasian Steppe Region . The territories with the steppes vegetation extend from the western up to the eastern frontiers of the country (from 90° up to 120° E longitude) , while in the south they reach 40°20′N latitude-that is much more south then in the neighbouring continental sector-Kazakhstan , where the boundary between steppe and desert region nearly coincides with 48° N latitude (Karamysheva , Lavrenko , Rach-kovskaja , 1969) .

Russian geobotanists traditionally distinguish the following steppe types , which successively replace one another from north to south with increasing aridity of climate , as demonstrated by decreasing precipitation , increase of temperature summations and lengthening of the frost-free period (Lavrenko , Karamysheva , Nikulina , 1991 ; Lavrenko , Karamyshf .va , 1993) :

1 . Meadow steppe , in semi humid climate .
2 . True or typical steppes :
   a) Bunch-grass steppe with many forbs , in semiarid climate .
   b) Bunch-grass steppe with few forbs , in arid climate .
3 . Desertified bunch-grass and dwarf semi-shrub-bunch-grass (semi-desert) steppe , in very arid climate .
4 . Desert dwarf semi-shrub-bunch-grass steppe , in hyper arid climate .

Main zonal and altitudinal types of steppes The list of the main zonal and altitudinal types of steppes is made up on the basis of the legend to the vegetation map of MPR (Karamysheva , Dashnjam , 1990) . The informatior by E . I Rachkovskaja and E . A . Volkova is used for the territories of the Gobi Altai , the central and eastern parts of Mongolian Altai Mts .

The Latin names of plant communities are composed in the following order : Latin names of the dominants and codominants are transfed in the first place . They are united by symbol -" . Further the groups of the so called differential" species with the special ecology and (or) geography are adduced .The Central Asian subregion vegetation is classified in following blocks of Grasslands in Mongolian country .

Cryoxerophytic pasture in mountain :
- Forest pasture
- Steppe pasture
- Dry-Steppe pasture
- Desert-Steppe pasture
- Gobi-Deser pasture
- Pasture of floodlands

Nowadays 75 types of that 7 blocks are mainly preserve their natural conservation . The 9 province region of Northern China Grasslands are about 960 million hectars , 56% of these are used . This is so interresting for us . (According to Grasslands and Grassland sciences in Northern China , Washington , D .C 1992) .

Effect of patch size of metacommunity on species diversity in *Leymus chinensis* meadow in the Songnen plains of China

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Key words : *Leymus chinensis* meadow , Patch , metacommunity , species diversity ,Songnen plains

Introduction The effect of habitat patch size and the spatial distribution of habitat patches have been regarded as important in conservation biology(Fahrig and Merriam , 1994) . Moreover , increasing habitat patch size contributes to species richness in local communities . Patch size is too small to be sufficient for sustaining the generation of population . Therefore , the idea can be extended to that of the metacommunity . There will be also a minimum patch area to maintain high species diversity in metacommunity , a set of apatially separated communities . In the present research , *Leymus chinensis* and *Phragmites communis* communities were studied in *L . chinensis* meadow in restoration succession in the Songnen plains of China . Analysis of Species diversity in *L . chinensis* and *Ph . communis* community patches with different sizes to disclose the changes of species diversity among different patches and the effect of patches sizes on the species diversity , and to offer references for species diversity conservation and grassland management .

Materials and methods The present experiment was carried out in *L . chinensis* meadow in Songnen plains (44°35′ N ,123°30′ E) . Community patches with different sizes both *L . chinensis* and *Ph . communis* dominant in *L . chinensis* meadow in restoration succession were sampled in the middle of August in 2006 , when the plants were in the growing season . . The species abundance and coverage were investigated in 14 habitat patches , which the average size , the minimum and the maximum are 13 .75 m^2 , 1 .32 m^2 , and 56 .5 m^2 , respectively . In order to gain population density ,1-5 smaples were tesed in each patch according to the habitat patch size .The total number of samples was 42 .The indices of Patric richness , Pielou eveness and Simpson diversity were employed in this research (Zhang , 2004) .

Result and discussion Number of species , evenness and species diversity of *L . chinensis* and *Ph . communis* communities increased with an increase in patch area ,and all reached the maximum when the patch area was 10. 24 m^2 when richness , evenness and species diversity were 25 , 0. 66 and 0. 82 ,respectively , and followed by 11. 2 m^2 when number of species , evenness and species diversity were 26 , 0. 45 and 0. 6 . The curve became gentler when patch area was larger than 11. 2 m^2 . It was concluded that the minimum area of *L . chinensis* and *Ph . communis* community patch was 10. 24 m^2-11. 2 m^2 to sustain species diversity in *L . chinensis* meadow in the Songnen plains of China , and abundant species would disappear without certain community environment when patch areas were lower than the ones .

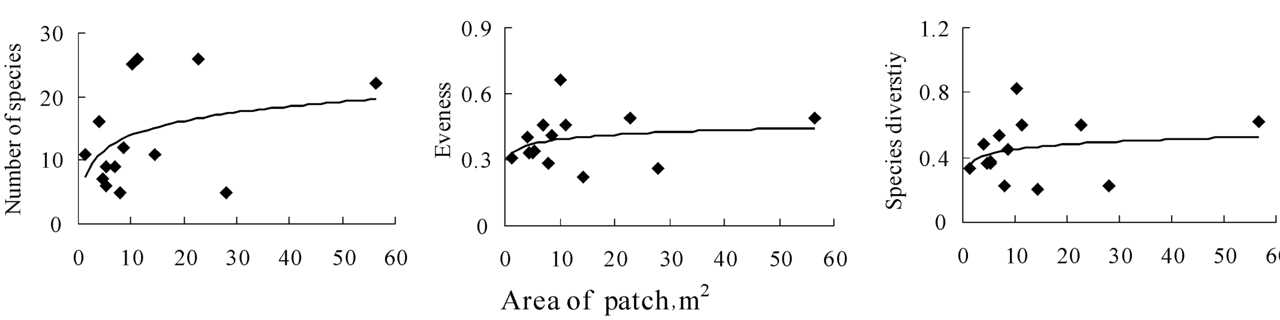

Figure 1 *The relationship between richness , eveness and species diversity and the patch size in metacommunity .*

Conclusions The richness , evenness and species diversity of *L . chinensis* and *Ph . communis* communities increased as the patch area increased , and the highest value of species diversity were in 10 .24 m^2-11 .02 m^2 , which was the minimum area to sustain high species diversity and species diversity would decrease when patch areas were lower than the ones , which offered references for species conservation .

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Response of activated oxygen metabolism to water stress in different drought-tolerant alfalfa (*Medicago sativa*) at seedling stage

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Key words: water stress, alfalfa, activated oxygen metabolism, drought tolerance, response

Introduction Plant growth and productivity are affected by various abiotic stresses such as heat, cold, drought and high salinity and so on. Water stress is considered to be the main environmental factor limiting plant growth and yield worldwide, especially in semi-arid areas (Boyer, 1982). Alfalfa (*Medicago sativa*) is an important legume forage with high drought resistance. However, drought stress is still the main adverse factor limiting alfalfa production. The aim of the present study was to assess response of activated oxygen metabolism to water stress in different drought-tolerant alfalfa at seedling stage in order to provide theoretical basis for drought-tolerance alfalfa breeding.

Materials and methods Plant materials and water treatments. Two Alfalfas varying in their tolerance to drought were used, Longdong with high drought resistance and BL-02-329 with low drought resistance were grown in plastic pots (40 cm in diameter, 30 cm long, ten plants per pot). Each pot had eight plants and each material replicated six times. The plants were divided two groups when the plants were in the ramification periods. One group was control and the other group was treatment. Control was watered normally and the treatment was not watered until the twelfth day when it was rewatered. The O_2 generation rate, MDA, AsA, Car SOD activity and POD activity were tested on the od, 4d, 8d, 12d and the fourth day after rewatering.

Results Under drought stress, the O_2 generation rate MDA content and damage of cell membrane increased. Campared with weak drought-resistance alfalfa there were low O_2 generation rate less accumulation of MDA content and lighter damage of cell membrane in the leaves of strong drought-resistance alfalfa when stressed by drought, and strong drought-resistance alfalfa can recovery faster after rewatering.

POD activity and SOD activity enhanced in the leaves of two alfalfas under drought stress.
AsA content and Car content increased in the leaves of two alfalfas under drought stress.

Discussion From the response of activated oxygen metabolism to water stress in different drought-tolerant alfalfa at seedling stage we can see that there are higher endogenous coordination of antioxidation enzyme system and nonenzyme system in strong drought-resistance alfalfa than that of low drought resistance alfalfa at seedling stage.

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Ecological characteristics of halophytes in the arid areas

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Key words : salt accumulated land , halophytes , pioneer plants , grassland , desertified land

Introduction Scarce water resources in arid areas force people to use highly saline water for irrigation . The practices result in the expansion of areas affected by secondary salinization(Szabolcs 1986) . The countermeasures to cope with the soil salinization problem include the utilization of salt tolerant crops or halophytes .

Materials and methods The field survey was carried out during June to October , 2003 at 5 sampling sites distributed on salt affected areas in Middle to Western parts of Inner Mongolia (Ejinor , Xlingol , Cagnnor ,Wlingsu and Jrndi) . The halophytic plant samples were collected from 1m×1m size quadrats . The scientific names of families and species of plants were identified and recorded . The number of stocks , size of stocks , plant height and biomass of each species were measured .

Results Plant ecological analysis was carried out around salt lakes and salt affected areas in central to western parts of Inner Mongolia . Special attention was paid on the usage of plants . Halophytes of 20 families with 113 species were recorded on 5 sites . Among them , there were 34 medicinal plant species and 41 forage plant species (among them , 11 species have high quality for forage) . Twelve species were common with Japanese flora . Fifty eight species have their close relatives in Japanese flora . Plants with no close relatives in Japanese flora numbered 40 in family level and 3 in species level . *Chenopodiaceae* plants like *Salicornia* , *Suaeda* and *Kalidium* formed colonies as pioneer plants on the salt affected areas in central to western parts of Inner Mongolia . *Phragmites australis* , *Salicornia europaea* , and *Suaeda corniculata* produced high biomass at the central parts of salt affected areas . The biomass of these species was 23 .8 , 8 .9 , and 7 .2 kg/m^2 , respectively . Species diversity calculated by Simpson's index ranged between 0 .000 and 0 .791 . On the plot where salt accumulated more , the index fell around 0 showing the breakdown of diversity .

Conclusions From the experimental results stated above , the following suggestions for the utilization of halophytes were obtained . Halophytes such as *Salicornia* , *Suaeda* and others distribute naturally in the salt affected areas . Their biomass production is quite high . Selecting the proper species , animal feed can be produced . The feasibility expands the options of countermeasures to resume destroyed plant vegetations .

This paper intends to introduce the major plant species , which distribute on the salt affected grasslands in middle and western part of Inner Mongolia , with their characteristics . The utilization of these species was also discussed . The associated objective of the paper is to provide a convenient list of plant species to assist Japanese researchers for their field studies or for their references in the laboratories .

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Responses of photosynthetic rate of lucerne and the mechanisms under cutting at different water availabilities

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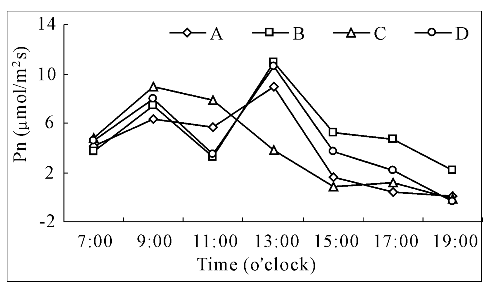
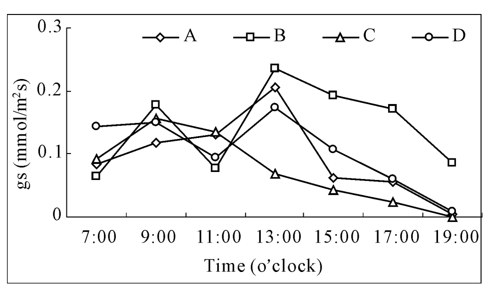
Key words : forage cutting, photosynthesis, regrowth, stomatal character

Introduction The regrowth after cutting (defoliating) is essential to the utilization of forage and grassland. After forage cutting, the residue has to change its original function to adapt new situation. Some clue showed that photosynthetic rate (Pn) of the aboveground part would increase after cutting and would keep higher for a longer period (Nowak and Caldwell, 1984; von Caemmerer and Farquhar, 1984). That might be resulted from the change of light illumination. However, Pn change shortly after cutting was still not clear and the mechanisms under cutting stimulus awaited further exploitation.

Materials and methods Local Lucerne variety (*Medicago sativa* cv. Xinjiangdaye) was chosen as the experimental material. One group of materials was kept 70% field water capacity (FWC) and another was 35% FWC. On a clear day, plant Pn and stomatal conductance (gs) were measured every two hours using LI-6400 after forage cutting. Proline and antioxidases were also measured 5, 10 and 30 h after cutting.





Results and discussions Higher Pn was observed in the residue with cutting, especially 5 h after cutting. Accordingly, greater gs was also measured under cutting treatment. Furthermore, proline content and the activities of SOD (superoxidase), POD (peroxidase) and CAT (catalase) were greater under cutting than without cutting 5 h after cutting. Greater gs promised enough CO_2 supply, thus resulting in higher Pn. The enhanced antioxidases would efficiently clean out free radicals resulting from cutting stimulus and more proline would help to maintain cell osmotic potential, thus maintain cell normal function, including guard cell/stomatal function. Additionally, more water supplies (i.e. 70% FWC) could keep plant more sensitive and efficient in response to cutting stimulus. CAT was found very significant responding to cutting, suggesting that it may play a key role in this stimulus-response signaling. Further investigation concerning regrowing mechanisms is now conducted.

Acknowledgement This work was supported by the grants from 973 Program of China (2007CB106804 and 2007CB108901).

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Citric acid accumulation of *Puccinellia tenuiflora* is a specific adaptive response to alkaline stress

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Key words: *Puccinellia tenuiflora*, saline stress, alkaline stress, organic acid, citric acid, proline

Introduction *Puccinellia tenuiflora* is typical forages found in saline-alkaline habitats of Songnen Grassland. Owing to the special osmregulation, the species could survive in high pH conditions. In order to understand the physiologic characteristic of *P. tenuiflora* alkali tolerance, citric acid accumulation under the alkaline stress was studied.

Materials and methods These treatments were divided randomly into 15 groups (3 replicates per group). One group was used as the control (CK). Five groups were treated with Na_2CO_3 solutions. Six groups were treated with NaCl solutions with concentrations. The remaining 3 groups were treated with 100 mmol l^{-1} Na_2CO_3 solutions, which were neutralized pH7, pH8 and pH9 using 85% H_3PO_4. Proline condentration was determined according to Bates *et al*. (1973). The concentration of total organic acid was determined according to Jing and Ding (1981), and citric acid was determined using the pentabromoacetone method adapted from Shi and Yin (1993).

Results Citric acid concentrations of *P. tenuiflora* increased with increasing stress strength by Na_2CO_3 ($p<0.05$, $R=0.967$). Under NaCl stress, citric acid concentration decreased slightly ($p>0.05$) with increasing stress strength (Figure 1). Changes in the concentration of citric acid and total organic acid with increasing stress strength were almost parallel in the alkaline stressed seedlings of *P. tenuiflora* (data not shown). The proline concentration of *P. tenuiflora* also increased with the increases of NaCl and Na_2CO_3. In neutralization treatments, citric acid concentrations of *P. tenuiflora* decreased with decreasing pH value ($p<0.05$, $R=0.963$). Proline concentration of changed irregularly with pH value decreasing.

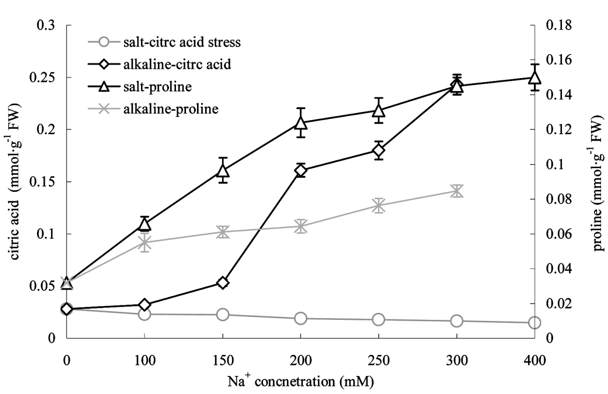

Figure 1 *Comparison of citric acid and proline accumulation between salt stress and alkaline stress in* P. tenuiflora.

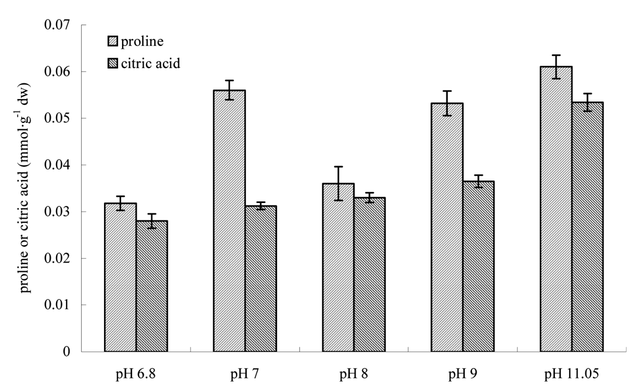

Figure 2 *Effects of neutralization on the concentrations of proline and citric acid in* P. tenuiflora.

Conclusions Under alkaline stress, the organic acid metabolism of *P. tenuiflora* was changed, mainly due to the accumulation of citric acid. The citric acid accumulation was a specific physiological response to alkaline stress. The proline accumulation was physiological response to osmotic stress and the primary physiological significance of proline accumulation was osmotic adjustment.

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Ecological characteristics of 3 salt grasses of saline and alkaline habitats of northern Gorgan , Iran

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Key words : ecological characteristics , salt grasses , Puccinellia distans , *aeluropus littoralis* , Aleuropus logopoides

Introduction saltiness and alkaline phenomenon are the main problems of the arid and semi-arid regions . The extent of such lands are high in Iran and they been increasing under various factors day by day . One of the methods can be using of appropriate plants for such areas . Using of natural flour of the saline areas is one of the main ways to combat against the saline problem so that we use of maximum utilization of these regions by the least interference in the environment . In this direction , three perennial salt grasses as names Puccinellia distans (Jacq .) Parl . , *Aeluropus littoralis* , *Aleuropus logopoides* have been chosen for this study in saline and alkaline habitats Northern Gorgan .

Materials and methods This investigation was carried out in eastern coast of the Caspian Sea . The extent of the rangelands in this area is 100 ,000 hectares . In order to study of ecological characteristic , soil type , forage production , plant cover has been considered . In these habitats forage production measured by clipping and weighting method and to use quadrate 1 square meter , Soil analysis were done by below methods in laboratory : texture by hydrometric , electrical conductivity in saturation extract with electrical conductivity meter .

Results Results obtained from present investigation showed that there have been distributed on the saline and alkaline rangelands of Golestan province .These three species have complete adaptability to the rainfall condition between 250 to 321mm and mean temperature 17℃ , also the climate of the region is semi-arid and on the basis of Gussan method . Forage production *pu .distans* has been between 187 to 800 kg /ha , *Ae . Lagopoides* and *Ae . littoralis* have 50 and 20 kg/ha respectively . The results obtained from soil chemical analysis show that Ec *Ae .Lagopoides* (L .) Trin .ex Thwaites is between 17 .5 to 60 ds/m at the area which are distributed these species but the main distribution of *Ae .Lagopoides* is with the mean salinity 39 ds/m and *Ae . littoralis* (Gouan) Parl . is 31ds/m , also Ec *Pu .distans* is between 39 to 52 ds/m .

Conclusions *Pu .distans* is most suitable for the agricultural areas with 321 mm or more annual rainfall . It Good stands have been grown with lower rainfall but establishment is more risky .To combat the salinity problem , *Ae .Lagopoides* and *Ae . littoralis* send out the salt as salty grains from their various organs (leave and stem) and for this reason they have a considerable resistance to salinity .

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Cytologic observations of sterility in interspecific F1 hybrid from *Leymus chinensis* and *Leymus cinereus*

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Key words : cytologic observations , sterility , interspecific hybrid

Introduction *Leymus chinensis* and *Leymus cinereus* belong to *Leymus* genus of Trib triticeais ,both are allotetraploid (2n=28) rhizomegrass . Cross between two species is known as Geographically distant and the complement of advantages and disadvantages . But the interspecific F1 hybrid is totally sterile . In order to understand the cytologic mechanism of hybrid F1 sterility and fertility restoration further , In this study , the meiosis of PMCs and the development of pollen and embryo sac of *L .chinensis* ,*L . cinereus* and their F1 hybrid .were observed .

Materials and methods *L . chinensis* was collected from north China ,*L . cinereus* was collected from north America . Spikes of *L . chinensis* served as female parent were coverd with parchment paper sleeves following emasculation . Pollination was achieved by shaking pollen-bearing spike of *L . cinereus* in the top of the sleeve . Seedings were established from germinated seed without the aid of embryo culture . Spikes for cytological analysis were fixed in Carnoy's solution for 24h and then stored in 70% ethanol in a refrigerator .Pollen grains were stained with 2% acetocarmine solution to estimate their viability . Florets for analysis of embryo sac development were fixed in FAA and then were dehydrated ,embedded ,sectioned ,stained using standard methods .

Results Data on pairing at metaphase-Ⅰ of PMCs in the parents and their F1 hybrid are listed in Table 1 . Chromosome pairing , pollen stainability and seed set under open pollination in the parents were very high ,and univalents were occasionlly observed . chromosome pairing was also relative high in *L . chinensis* × *L . cinereus* .
And the Chromosome configuration at M Ⅰ was 2 .29 Ⅰ + 12 .39 Ⅱ . Furthermore , most associations was 2 Ⅰ + 13 Ⅱ ,and majority of bivalents were rings . Multivalents were not observed . Pollen stainability were 86 .8 ,12 .0 and 0 .9 % at 1-nucleated pollen stage ,2-nucleated pollen stage and 3-nucleated pollen stage , respectively . The F1 hybrids did not set seed under open pollination . The development stages of embryo sac in *L . chinensis* and *L . cinereus* were observed . But abortive embryo sac observed at meitosis Ⅰ in F1 hybrid turned into trace which was stained darkly(Figure 1) following the megaspore mother cells developing dichod .

Table 1 *Meiotic behavior in the L . chinensis , L . cinereus and their hybrid .*

Materials	No .of chrom .	No .of cells	Chromosome pairing at MI				stainable pollen(%)			Seed sets (%)
			Ⅰ	Ⅱ						
				Rod	Ring	Total	1-nucleated pollen	2-nucleated pollen	3-nucleated pollen	
L . chinensis	28	147	0 .24 (0-4)	2 .73 (0-13)	11 .12 (1-14)	13 .85	97 .3	86 .7	81 .9	51 .2
L . cinereus	28	100	0 .14 (0-2)	0 .20 (0-1)	13 .70 (13-14)	13 .90	97 .9	89 .3	84 .8	64 .9
F1 hybrid	28	151	2 .29 (0-10)	0 .21 (0-4)	12 .18 (8-14)	12 .39	86 .8	12 .0	0 .9	0

Conclusions The lack of stained pollen ,absence of seed set under open pollination ,and high frequency bivalents in F1 hybrid indicated that its sterility was genic rather than genomic . Pollen abortion was mainly occurred between late 1-nucleated pollen and early 2-nucleated pollen in F1 hybrid . Embryo sac abortion in F1 hybrid initiated after the megaspore mother cell developeing dichod .

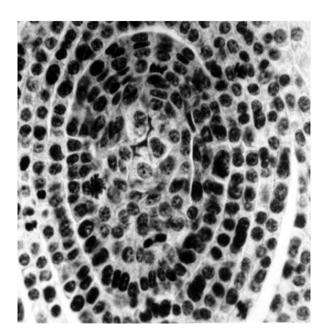

Figure 1 *The abortive embryo sac(indicated by arrow) of F1 hybrid .*

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Distribution of vegetation types in Bayinbuluk alpine grassland

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Key words: Bayinbuluk grassland, CCA ordination, TWINSPAN classification

Introduction In order to better understand and manage grassland ecosystems, it is important to study the relationship between environmental factors and plant (Jafari, 2004). Effects of environmental factors on plant communities have been the subject of many ecological studies in recent years (Campagne, 2006). One of the main components of grassland is vegetation, the absence and presence of which is controlled by environmental variables. Much of the research on species-environment relationships has been carried out in semiarid regions of North America, Australia, and other regions. Our knowledge about interactions of vegetation distribution and environmental factors in arid regions of China is rather poor (He, 2004). The aim of this paper was to discuss how does environmental factors impact on plant distribution and composition in Bayinbuluk grassland, northwest china.

Materials and methods Bayinbuluk grassland is an typical alpine cold grassland (82°27′-86°17′ E, 42°18′-43°34′ N) and located in the southern slope of the Tianshan mountain region in Xinjiang province. The mean altitude is 2400m. The annual mean temperature is-4.2℃. The mean annual precipitation is 263.6mm. In 2006, fifteen sites (10m×10m) were founded from typical vegetation types. In each site, seven 1m×1m quadrats were sampled for grass species in late July. Grassland vegetation frequency, height and cover percentage were recorded. Three soil samples were collected in each site, every soil sample was taken from 0-10, 10-20, 20-30, 30-40 to 40-50 cm layers. Samples were pooled to form one composite sample. Measured soil factors included organic matter, pH value, soluble calcium, soluble bicarbonate, soil water content. In vegetation growing season(from early May to late September), fifteen HOBO Pro RH/TEMP Data Loggers were installed to acquire data of relative humidity and air temperature. Soil compaction were determined by soil compaction meter. The species importance values were calculated using the formula: IV=(Relative coverage+ Relative frequency +Relative height)/300. Vegetation and related environmental factors were analysed using canonical correspondence analysis (CCA). Vegetation types were classified by two-way indicator species analysis (TWINSPAN).

Results A total of 50 indigenous species were identified during this study, belonging to 43 genera and 21 families. fifteen sites of study area were classified into six groups. Group I was dominated by *Stipa purpurea* + *Festuca ovina* and *S. purpurea* + *F. ovina* community types, contained the less soil water content and relative humidity values, but the air temperature value was highest. Group II was dominated by *Kobresia capillifolia* + *Carex stenocarpa* + *S. purpurea* and *C. stenocarpa* + *K. capillifolia* + *F. ovina* community types, soil water content and relative humidity values were relative lower. Group III was dominated by *C. stenocarpa* + *K. capillifolia* + *Polygonum viviparum* and *C. stenocarpa* + *K. capillifolia* + *P. viviparum*. Available potassium, air temperature, organic matter and soil compaction values were relative lower. Group IV was dominated by *C. stenocarpa* + *P. viviparum*, *P. viviparum* + *C. stenocarpa* and *K. capillifolia* + *P. viviparum*. Fertile soil were indicated by relative higher available nitrogen, available potassium and organic matter values. Group IV was dominated by *C. stenocarpa* + *K. capillifolia* + *P. viviparum*, *K. capillifolia* + *C. stenocarpa* + *P. viviparum* and *K. capillifolia* + *Carex melanantha* + *P. viviparum*, Soil water content, relative humidity values, organic matter and available nitrogen values were relative higher. Group VI was a sedge wetland community type dominated by *C. melanantha* + *Triglochin palustre*, relative humidity and soil water content values higher. The results of CCA ordination showed first axis (eigenvalue=0.915) accounted for 34.2% variation in environmental factors data. Correlation between the first axis and species-environmental variables was 0.996. The second axis (Eigenvalue=0.632) explained 57.8% variation in data set. Correlation between the second axis and species-environmental variables was 0.95. Axis 1 was correlated to air temperature, pH value, HCO_3^{2-}, soil water content. Axis 2 was correlated to soil compaction, Ca^{2+}, pH value, HCO_3^{2-}, air temperature, soil water content and relative humidity.

Conclusions According to the results of vegetation classification, quadrats were classified into six groups. Group 1 was an alpine cold steppe type, group 2 was an alpine cold grassland-meadow, group 3, 4, 5 was alpine cold meadows, group 6 was a sedge wetland type. CCA analysis showed that the distribution of vegetation types was most strongly correlated with air temperature, pH value, HCO_3^{2-}, soil water content in Bayinbuluk grassland.

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The photosynthetic characteristics of *Hemarthria compressa* in different seasons

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Key words: *Hemarthria compressa*, Photosynthetic characteristic, Photosynthetically active radiation, Seasonal variation

Introduction *Hemarthria compressa* is very popular in southwest China for hay production and also a potential turfgrass germplasm for low maintenance turf (Yang, 2006). The photosynthetic variation in different seasons was unknown. The objectives of research were to discover the relationship between the photosynthetic characteristics and environmental factors in four seasons, and to find the photosynthetic productive potential of *Hemarthria compressa*.

Materials and methods The hay producing variety Guangyi' was planted in the Teaching and Research Center in Sichuan Agricultural University (38°08′ N, 103°14′ E) for four years. We took photosynthetic measurements from 2006-2007. Measurements of leaf gas-exchange on fully expanded leaves at the top of the canopy were made in situ every two hours through the diurnal period (from dawn until after dust), using an open gas-exchange system incorporating a CO_2/H_2O vapor IR gas analyzer (Li-6400, LICOR, Lincoln, NE, USA.). Net photosynthetic rate (Pn, $\mu molCO_2 \cdot m^{-2} \cdot s^{-1}$), intercellular CO_2 concentration (Ci, $\mu mol \cdot mol^{-1}$), transpiration (Tr, $mmolH_2O \cdot m^{-2} \cdot s^{-1}$), stomatal conductance (GS, $mmolH_2O \cdot m^{-2} \cdot s^{-1}$) and light-response curves were analyzed by Photosynthesis Assistance Software.

Results The daily variation of photosynthetic rate in different seasons presented a single peak curve (Figure 1). *Hemarthria compressa* has a strong photosynthetic ability in spring and summer. The statistical analysis showed that net photosynthetic rate has a distinct relationship with photosynthetically active radiation in four seasons. It also significantly related to intercellular CO_2 concentration, transpiration, stomatal conductance in summer and autumn. In spring all the determined indicators have no relativity. *Hemarthria compressa* has higher light saturation point in summer, it is 703 mol m^{-2} s^{-1} (350 mol m^{-2} s^{-1} for autumn, 125 mol m^{-2} s^{-1} for winter, 318 mol m^{-2} s^{-1} for spring). And in winter, it has lower light compensation point of 3.91 mol m^{-2} s^{-1} (23.4 mol m^{-2} s^{-1} for summer, 10.1 mol m^{-2} s^{-1} for autumn, 34.8 mol m^{-2} s^{-1} for spring).

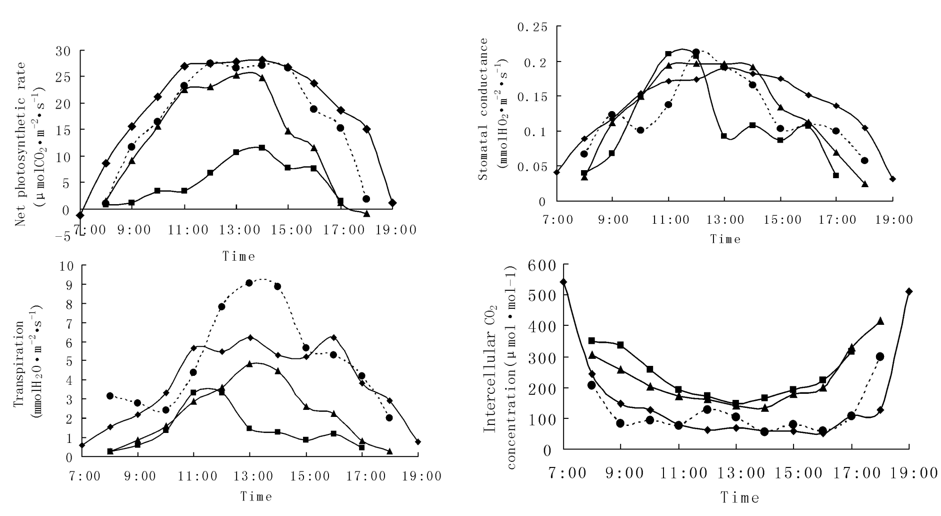

Figure 1 *Diurnal variation of net photosynthetic rate, intercellular CO2 concentration, stomatal conductance, transpiration rate in different seasons.*

Conclusions *Hemarthria compressa* can make the best of the light and heat condition to cumulate organic matter in spring and summer. The low light compensation point in winter could adapt the low light condition. Due to the lower winter photosynthesis of this grass, we can improve the yield and quality of the hay production fields by overseeding other winter-season annual grasses in the winter.

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The dynamic changes of biodiversity in Hongsongwa Nature Reserve

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Key words : grassland , richness index , Shannon-Wiener index , Simpson index , Hongsongwa National Nature Reserve

Introduction Measuring species diversity is critical for ecological research and biodiversity conservation . Using fencing management in natural grassland ecosystems to regulate the grazing intensity of herbivores , plant biodiversity could be maintained (Herrero M et al . ,1998) . Hongsongwa Nature Reserve is marked off three functional areas with fences in which different measures of management are carried out . After enclosed management taken for a long time , monitoring the trend of changes in biodiversity in Grassland Nature Reserve is of great significance .

Materials and methods Hongsongwa National Nature Reserve lies in Weichang County , Hebei Province (N 42°10′～ 42 °20′ , E117°18′～ 117°35′) in China , which is the overlapping zone of the North China , Mongolia and northeast flora (Lianfang li , 1999) . The vegetation types belong to mountain meadow , and the soil is mainly mountain meadow soil and mountain black soil . Experiments were done in core area , buffer area and experimental area in early June , July , August and September from 1999 to 2004 . Five samples were selected in each of the three functional areas in which their natural conditions were consistent with each other . The average value of the five investigated samples was the data that was used to evaluate each area's characteristic .

Results From 1999 to 2004 , Species richness & Shannon-Wiener(H') indices in buffer area were the highest between core area , buffer area and experimental area every year , followed by core area , the two indices in experimental area were minimum (Figure 1 , Figure 2) . Simpson index (C) in core and experimental area was higher than the index in buffer area in the same year (Figure 2) . Mountain meadow , as a nutrient-rich grassland ecosystem has high productivity and is richness in plant diversity . Contrasting the value of the three areas , if it was lacking grazing or mowing its biodiversity would decrease (Figure 1&Figure 2) . The dynamics of biodiversity consisted with the viewpoint that plant species richness increased with high grazing in nutrient-rich ecosystems (M . Proulx & A . Mazumder , 1998) . The results also support the popular viewpoint at present that H' and C are useful to reflect changes of biodiversity .

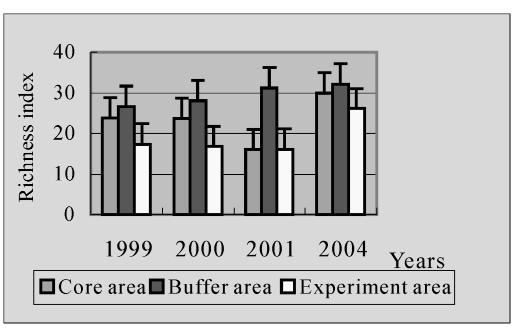

Figure 1 *The species richness index of Hongsongwa Nature Reserve .*

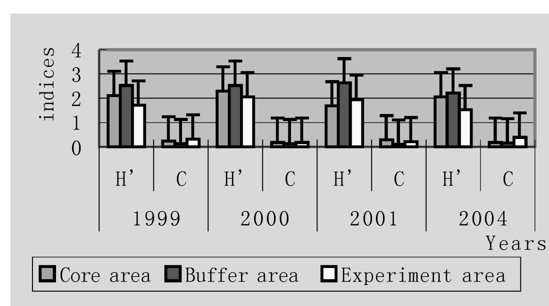

Figure 2 *The species Shannon-Wiener index & Simpson index in Hongsongwa Nature Reserve .*

With the enclosed management carried on , Richness index in core area decreased in 2001 because the average rainfall in summer of 2001 was more than in 1998 & 1999 and interference was lacking . Besides H' achieved its peak in 2001 , not in 2004 because that species distribution in 2004 was less evenness than that in 2001 .

Conclusions Appropriate interference of mowing in buffer area could maintain species diversity successfully . The policy of absolute protection for the core area only applied to the initial stages of degraded grasslands . After the restoration of vegetation , appropriate interference should be taken . Otherwise , biodiversity in the core area would decline along with enclosure for a long time , and the natural landscape of grassland would be changed .

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Classification of herbaceous communities in the subalpine meadow on Mt . Xiaowutai

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Key words : community classification , TWINSPAN , association , subalpine meadow , Mt . Xiaowutai

Introduction Sub-alpine meadows of Xiaowutai Mountain (39°～40°N , 114°～115°E) dominated by *Kobresia myosuroides* are important summer feed resources for grazing cattle and horses (Dong *et al* ., 1994) . However , very limited information about the vegetation compositions of the meadows are available . This study was conducted to classify the herbaceous communities of the meadows , so as to provide basic information for their management .

Materials and methods The sampling site was 9 .6 km^2 in size and located on upper Xiaowutai Mountain . 1 m × 1 m plots were randomly placed along an altitudinal gradient from 2200 to 2800 m a .s .l . at 50 m (±20 m) intervals , Totally 8 transects with 76 plots were set at last . Plant species composition , average height and plant cover of each species in each site were recorded . Species importance value (*IV= (relative height + relative cover)*/2) was calculated . Data sets were subjected to Two-way Indicator Species Analysis (TWINSPAN) (Hill , 1979) for the classification of plant communities .

Results Overall , 97 taxa including grass , herb , fern species were recorded from 76 survey plots . 5 vegetation associations were distinguished according to TWINSPAN cluster analysis (Figure 1) . (1) Ass . *Saussurea chinensis* + *Saussurea iodostegia* + *Ligusticum tachiroei* (cluster 1 , 2 plots) occupied the steep , sunny rocky slopes near the summit , and most species living here were cold-resistant , sun plants . *S . chinensis* was the dominant species and *S . iodostegia* and *L . tachiroei* were subdominant species . (2) Ass . *Kobresia myosuroides* + *Potentilla nivea* + *Hedysarum inundatum* (cluster 2 , 37 plots) were found just below the Asso . 1 , where *K . myosuroides* , *S . iodostegia* , *P . nivea* and *H . inundatum* , the typical species of subalpine meadows were the dominant species , and *Carex coriophora* , *Poa sibirica* , *Anaphalis sinica* , *L . tachiroei* , *Koeleria cristata* and *Trisetum sibiricum* were in the position of subdominant species . (3) Ass . *Kobresia myosuroides* + *Hedysarum inundatum* (cluster 3 , 12 plots) distributed at shady slopes , where the dominate species are *H . inundatum* , *K . myosuroides* , *S . iodostegia* , *Libanotis condensata* and *C . coriophora* , accompanied by those species favor humid environment and are shade-tolerant and cold-resistant , such as *Rumex acetosa* , *Myosotis sylvatica* , *Aster alpinus* , *Ranunculus japonicus* , etc . (4) Ass . *Kobresia myosuroides* + *Polygonum viviparum* + *Carex duriuscula* (cluster 4 , 7 plots) existed at the low altitudinal sites , where *Carex duriuscula* and *Taraxacum platypecidum* were more important , followed by other trample-standing species like *Plantago depressa* and *Ligusticum jeholense*) . (5) Ass . *Kobresia myosuroides* + *Scabiosa tschiliensis* (cluster 5 , 18 plots) located in sunny slopes near valley , and was dominated by light-favoring and dry-standing species , such as *Scabiosa tschiliensis* , *Sanguisorba officinalis* , and *S . iodostegia* , *P . nivea* , *K . myosuroides* .

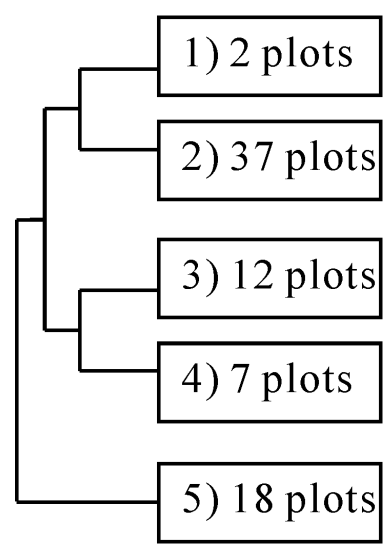

Figure 1 *End-groups of floristic classification (TWINSPAN) for the 76 vegetation samples .*

Conclusions Five herbaceous associations classified by TWINSPAN shows that the vegetation compositions of the sub-alpine meadows on Xiaowutai Mountain vary with the geographic locationd and micro-environment . Therefore , the appropriate management strategies should be applied according to their diversity .

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Effect of intercropping forages on root growth of fruit tree and orchard ecology

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Key words: forages, *Chamaecrasta rotundifolia*, orchard ecology, root system

Introduction Intercropping forages in young orchards not only could fully utilize the land resource to solve a conflict between orchard and pasture, but also could improve the microclimate of hilly orchards (Qi et al, 1993). In contrast, some articles reported that planting mulch grasses in orchard could lead to conflicts of competing water and nutrients between grasses and fruit trees (Catzeflis et al, 1997). This paper investigated the root distribution of forage-orchard compound system and effects of intercropping legume forage *Chamaecrista spp*. on the orchard ecology to provide scientific basis for water and fertilizer management of orchard.

Materials and methods Experiment 1: The experimental materials were five-year Longan trees and *Chamaecrasta rotundifolia* intercropped in Longan tree orchard. Randomized block design was employed. Experiment 2: Four treatments were imposed in a randomized complete block design with 3 replicates. Treatments were: A. Planting *C. rotundifolia* on built contour terraces and Bahia grass and Premier finger grass on the walls of terraces of the orchard; B. No grasses on built contour terraces and the walls of terraces compared with A; C. Planting fruit trees down-slope without building contour terraces, the slope was covered by forages; D. No grasses covered the slope compared with C.

Results (1) 88.2% roots of *C. rotundifolia* were concentrated in 0-20 soil layer, however 71.5% roots of Longan tree distributed in the lower soil layer (lower than 0-20cm) (Table 1), thus the overlapped rate of the root system of two different plants was less than 5%. (2) Compared with the weed-cleaning orchard, runoff amount of the red-earth orchard where intercropped *C. rotundifolia* for 3 years decreased from 2482.4t/hm^2 to 61t/hm^2; the available N, P, K content increased from 47.6, 2.3, 30.4mg/kg to 85.4, 9.0, 95.1mg/kg respectively; and soil porosity and soil moisture increased by 7.1% and 1.2% respectively (Table 2).

Table 1 *Root distribution of 5-year Longan trees (root number/m^2).*

Soil layer(cm)	Distance from the tree base (cm)					Sum	Percentage (%)
	50	100	150	200	250		
0-20	660	550	480	230	140	2060	28.5
20-40	870	800	860	370	180	3080	42.5
40-60	380	550	50	160	100	1240	17.1
60-80	330	120	0	60	70	580	8.0
80-100	130	110	0	0	40	280	3.9

Table 2 *Effect of intercropping* C. rotundifolia *in orchard on soil bulk density and porosity.*

Item	Soil layer(cm)	Treatment A	Treatment B
soil bulk density(g/cm^3)	0-10	0.98	1.05
	10-20	0.97	1.08
Porosity(%)	0-10	25.76	20.1
	10-20	25.70	17.1

Conclusions Planting *C. rotundifolia* outside the crown range of Longan trees had little effect on root growth of fruit trees and could reduce the runoff and sediment, raise soil fertility and improve the microenvironment of orchards.

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Effect on *Artemisia frigida* module under different stocking rates in the desert steppe , Inner Mongolia

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Key words : desert steppe , stocking rate , *Artemisia frigida* , module

Introduction *Artemisia frigida* , a dominant plant in the desert steppe , Inner Mongolia , is a mainly clonal propagating plant . It is quite vegetative growth and new adventitious roots , which is very important to maintain livestock food in the semiarid desert steppe . The stocking rate is an important factor to propagation pattern of *Artemisia frigida* in grazing management in the desert steppe . There are few studies concerning *Artemisia frigida* module change under different stocking rates in the desert steppe . Some available evidence is for livestock production (Han et al , 2000) in the desert steppe and for *Artemisia frigida* module in the typical steppe (Li et al 2002) . Therefore , the effect of stocking rate on *Artemisia frigida* module must be studied to investigated the rule of module change and maintain the sustainable development of desert steppe .

Materials and methods The study was conducted with random paddocks plot method from 2004 to 2005 . There were three plots . A control (4.4 ha) and 3 stocking rate paddocks (4.4 ha each) with three replications were conducted in each plot . Three stocking rates were 0.93 , 1.82 and 2.71 sheep/ha/half yr . The site is on the Inner Mongolian Plateau (41°47′N , 111°54′E , average annual precipitation = 280 mm , elevation = 1450 m asl , soil = Light Chestnut) . The dominant species were *S. breviflora* ,*Artemisia frigida* Willd., and *Cleistogenes songorica* (Roshev.) Ohwi . Sample was separately from early June , early August and late September in 2004 ,2005 . *Artemisia frigida* of one meter square (three replication) was dug with roots in each paddock , then took back to the lab to wash off the soil and statistic the density of vegetative branch , reproductive branch , adventitious root , and rule the length of stolon stem and spacer .

Results The module density of *Artemisia frigida* is different with the growth season and increased stocking rate . The length and density of module except reproductive branch in light stocking rate (0.93) was higher ($P < 0.05$) than in control , moderate (1.82) and heavy stocking rate (2.71) (Figure 1) . The density of reproductive branch was decreased significantly with the increased stocking rate .

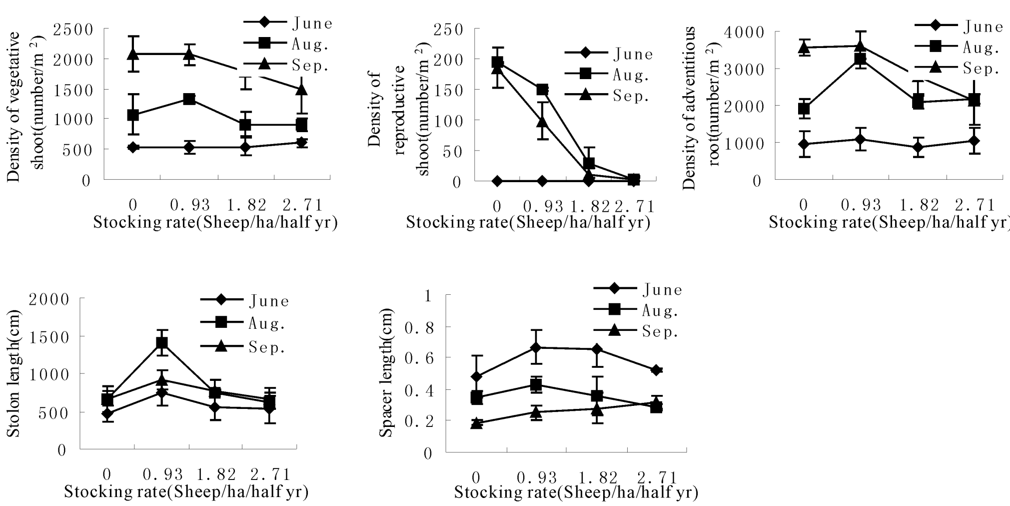

Figure 1 *The module of* Artemisia frigida .

Conclusions The light stocking rate can promote the module of *Artemisia frigida* . Therefore , a proper stocking rate is 0.93 sheep/ha/half yr in moderately degraded desert steppe . The study needs to be continued to assess the long-term effects of *Artemisia frigida* module under different stocking rates in the Desert Steppe , Inner Mongolia .

Acknowledgement This work was funded by the National Natural Science Foundation of China . (30060056 ,30360022)

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Investigation on environmental factors influencing distribution of plant species (case study : damghan region of Semnan province)

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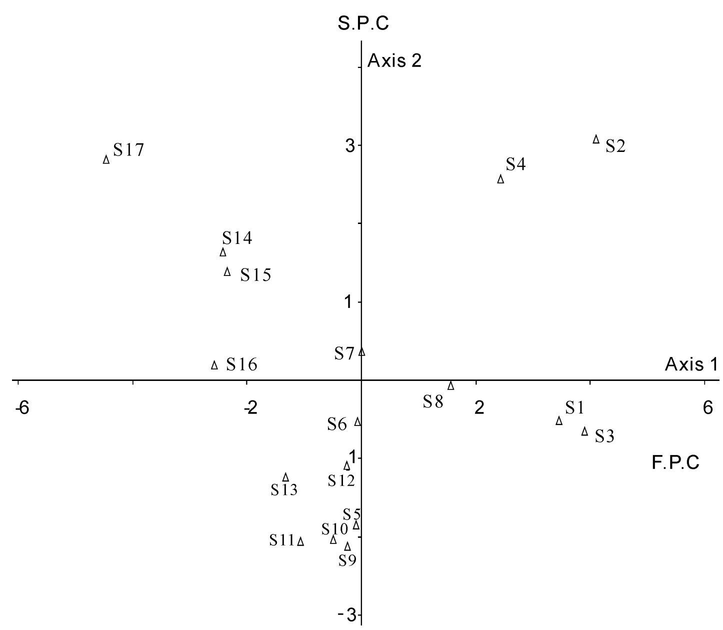
Key words : damghan region , working unit , vegetation cover type , environmental factors , soil properties , principal components Analysis

Introduction The understanding of relationship between plant and ecological characteristics in rangeland ecosystems is very important and it can help the managers to manage the rangelands . Many researchers have proven that plant associations influenced by Environmental Factors such as , soil characteristics topographic factors , precipitation and other factor in ecosystems(Lents , Ro . 1984 ; Aeraz & Zayed ,1996 ; Bruce ,McCune & James Grace ,2002 ; Zare , 2001 ; Jafari , 2004) The purpose of current study is to investigate the reasons of plant species distribution in association with environmental factors to find the most important governing factors in the relation between vegetation cover and environmental factors .

Material and methods The study area includes a longitudinal profile extending from southern slopes of Alborz to Haj Aligholi Kavir of Semnan province . First ,base maps such as geomorphologic facies , lithologic map and elevation was over layed to obtain working units map . Based on the prepared map and field surveys . 10 plots was established in randomized systematic pattern for vegetation cover sampling . distribution of vegetation cover .Floristic list ,canopy cover and density of species were determined in each plot .Furthermore , 5 profiles were sampled within the plots to study soil characteristics in 0-50 cm depth as the effective depth of soil effect on the plant .Consequently , analysis of interaction between soil properties and vegetation cover was conducted by using PC-ORD(Version4) software based on principal components analysis (PCA) .



Results and discussion The results showed that plant type and among environmental factors , elevation , precipitation and slope as the first principal component (F .P .C) and percent of sand , loam and ESP as the second principal component (S .P .C) explain 39 .29% and 20 .5% of the vegetation cover variation respectively . In addition , the mentioned factors explain 59 .79% of vegetation cover variation in Damghan region . The result show that by using PCA analysis we can able to determine the ecological similarity and difference among plant associations and classified them in similar groups as well . The result of this research in Semnan province Explain that there are very important relationship between plant association and unit work(over layed of geomorphologic facies , lithologic and topographic map) , but in erea that influenced by people application(such as agriculture , intense grazing and . . .) we cannot see very significant relation between this cases because of soil disturbance .

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Changes in plant communities by grazing in northern Mongolian grassland and assessment of nomads

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Key words: grazing intensity, grazing management, livestock, pastoralists, vegetation change

Introduction Due to a regime change in 1992, the Mongolian economic system experienced a drastic shift, which resulted in the changes in the life style of nomads. The nomads were concentrated to particular places and became less mobile (Fernandez-Gimenez, 2004). This resulted in vegetation degradation (Okayasu, 2007). Despite warnings of scientists, this is not resolved but is being intensified. One of the reasons is that Mongolian nomads do not recognize imminent threats to the resources or to their future livelihood (Fernandez-Gimenez, 2000). If so, studies on only vegetation are not enough, but need to include evaluations by nomads. We, therefore, studied both grazing effects on vegetation and nomads assessment of plant communities.

Study area and methods The study area is, Bulgan Aimag (Prefecture), located in the forest-steppe zone in the north-central part of Mongolia. We divided the area into three levels of grazing intensities according to ger locations and number of livestock. We examined 6 light grazing sites, 5 moderate grazing sites, and 5 heavy grazing sites. Each site contained five 1m × 1m quadrats. In each quadrat, we recorded the coverage (%) and the height (cm) of all plant species, and clipped the plants to obtain the standing biomass (g). For nomads' assessment, we visited the sites with them and interviewed their assessments of the grassland conditions

Results Total number of species, height of plants, and total standing biomass decreased as grazing pressure increased. Perennial forbs such as *Geranium* spp. and *Galium verum* in heavy grazed sites greatly decreased in cover and in biomass. Graminoids such as *Carex* and *Elymus* kept fairly constant levels of coverage and biomass regardless of grazing pressure. According to interviews, nomads seemed to consider heavy grazing sites were relatively good. They called graminoids thin plants" and regarded them as good forage for livestock. These plants had greatest coverage in heavily grazed sites. These results imply that nomads do not consider heavily grazed sites problematic and this recognition does not stop heavy grazing.

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Genetic polymorphism by RAPD of *Leymus chinensis*

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Key words: genetic polymorphism, DNA, natural variation, RAPD, *Leymus chinensis*

Introduction *Leymus chinensis* (Trin.) Tzvel. is a perennial, rhizomatous species distributed widely in north China. During the long-time adaptation and evolution process, great differentiations in morphology, physiology, biochemistry and molecular biology generated. A better knowledge of genetic diversity of *L. chinensis* could be valuable in the efficient utilization, conservation and management of germplasm collections. The aims of this study were to analyze the genetic diversity of *L. chinensis* selected from cultivars of phenotypic variation.

Materials and methods Thirty cultivars of *L. chinensis* with different phenotype (Liang *et al.*, 2007) were cultivated in green house for 3 months and leaves were sampled for extracting the genomic DNA by the cetyltrimethylammonium bromide (CTAB) method (Puchooa, 2004), and then RNase was added. The yield of DNA was measured using UV-VIS spectrophotometer (Shimadzu). Twenty random primers were used for the amplification. Nei and Kumar's genetic diversity were calculated between accessions. Dendrogram from genetic distance was constructed by Nt-Sys software.

Results and conclusions The results of RAPD products electrophoresis and the dendrogram were presented in Figure 1 and Figure 2 respectively. Thirteen RAPD primers generated 98 bands, of which 88 were polymorphism, and 7 bands were generated by every primer in average. The mean genetic distance was 0.3355. Clustering analysis was performed with NTSYS and 30 clones were divided into 6 groups with threshold of 0.68. These results indicated that the genetic diversity of *L. chinensis* was very high and the cultivars with the same phenotype were not clustered into one group.

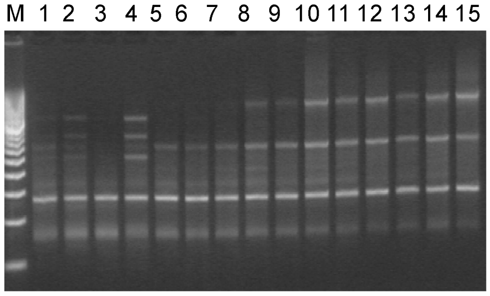

Figure 1 *Electrophoresis pattern of templates L1—L15 with S8.*

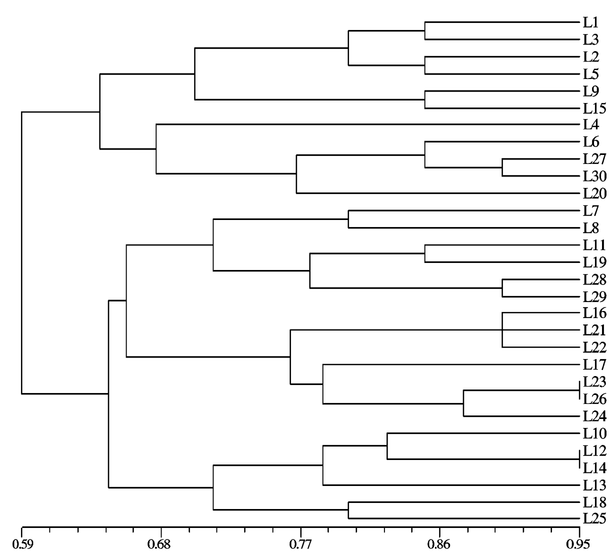

Figure 2 *The dendrogram of L1～L30 constructed by UPGMA cluster analysis revealed by RAPD.*

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Spatial distribution , biomass , and soil seed bank of a naturalized population of alfalfa in native mixed-grass prairie

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Key words : alfalfa , biomass , seed bank , mixed-grass prairie

Introduction The occurrence of naturalized yellow-flowered alfalfa (YFA) (*Medicago sativa subsp . falcata*) on private and adjacent public rangeland in northwestern South Dakota , USA presents a dilemma . The capacity for natural reseeding demonstrates value for rehabilitating depleted rangelands by increasing soil organic C and N and forage production (Smith 1997) . However , spread of YFA in native rangeland potentially threatens native biological diversity and may result in changes in ecological processes and stability . Study objectives were : 1) to describe spatial distribution patterns of YFA , 2) to determine associations between YFA occurrence and species richness and biomass production of native plant communities , and 3) to examine density and viability of seed bank of YFA .

Materials and methods The study was conducted on the Grand River National Grasslands (GRNG) in northwestern South Dakota , USA (45°49′N , 102°33′W) . The climate is semiarid with high inter-annual variation in precipitation and frequent drought . Mean annual precipitation is 386mm and mean annual temperature is 6℃ . Vegetation is dominated by mixed-grass prairie with a variety of native species such as *Pascopyrum smithii* , *Nassella viridula* , *Carex filifolia* , and *Bouteloua gracilis* . Soil types range from sandy loam on slopes and uplands to clay loam in swales . Two sites where YFA distribution has been concentrated were selected and sampled . Two permanent transects were established on each site along environmental gradients . Along each transect , cover by species was recorded in 2m×1m quadrats placed at a 2-m intervals and distinctive plant communities were identified . Three biomass quadrats (1 .45m × 0 .3m) were randomly chosen within each plant community . Aboveground vegetation was clipped and sorted into alfalfa and other species . Three soil cores were randomly collected within each quadrat . Soil moisture and texture were determined . Three soil seed bank samples were extracted using a bulb planter (5cm dia . × 7 .5cm depth) . YFA seeds were removed from soil using a series of soil sieves and counted . Germination and viability were determined using AOSA procedures for alfalfa . Canonical Discriminant Analysis , Principle Component Analysis and Analysis of Variance were used as appropriate for each data set .

Results High density of YFA was highly associated with swale areas and fine-textured soil . As YFA cover increased total biomass significantly increased and native species richness decreased (Table1) . This suggests YFA is a strong competitor with native species on rangelands . Spatial distribution of YFA seed bank was associated with plant communities , which varies with topography , soil texture , and YFA cover . The highest YFA seed density was more than 39 ,000 seeds m^{-2} (Figure 1) . Greater than 99% of YFA seeds was viable but less than 4% germinated under standard laboratory conditions .

Table 1 *Native species richness and total biomass* ($g\ m^{-2}$) *associated with YFA cover . Different letters on the same row show significantly difference* ($P<0.05$) .

Variables	YFA Absent	YFA cover (<50%)	YFA cover (≥50%)
Native species richness	8a	6b	3c
Total biomass	194a	312b	571c

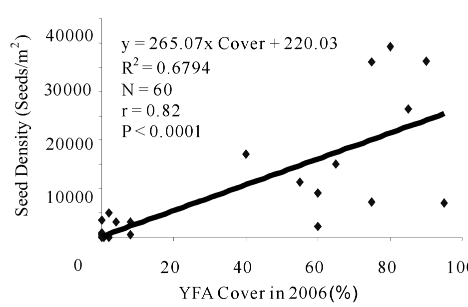

Figure 1 *YFA seed density associated with YFA cover .*

Conclusions Naturalized YFA was not uniformly distributed across the landscape . Densest YFA populations were found in swales . Naturalized YFA increased total biomass production on mixed-grass prairie . However , high density of YFA was associated with reduced species richness and production from native species . Swales that were dominated by YFA contained a large reservoir of viable YFA seeds . Through periodic seed production and high level of hard seed , this population has capacity for maintenance and for expansion onto favorable landscape positions .

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Physiological response to soil drought stress for two ornamental grasses

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Key words : ornamental grass ,drought stress ,physiological response ,*Cortaderia selloana* , *Eragrostis curvula*

Introduction *Cortaderia selloana* and *Eragrostis curvula* are gramineous ornamental grasses with prodigious potential and ability to spread . With the decrease of water resources , it is important to seek drought-resistance ornamental grasses . The objective of this study was to evaluate the drought-tolerance of these two ornamental grasses .

Materials and methods The experiment was conducted in three soil water gradients as 75% ～80% (well water ,ck) ,40% ～45% (moderate water stress ,T_1) ,and 30% ～35% (severe water stress ,T_2) of field water holding capacity . Drought stress was imposed when the grasses were 3-months old by withholding water .The soil water content of each pot was monitored by weighing the pot which was covered with *Rain Out Shelters* to eliminate the effects of rainfall . Physiological indexes were measured on leaves after 14-day treatment(Zhao Shijie ,1998) .

Results With the increasing drought stress , the relative water content and water potential of two ornamental grasses decreased gradually (Table 1) . The relative water content of *Eragrostis curvula* declined rapidly with severe water stress . The change of leaf water potential also showed that the water retention capacity of *Eragrostis curvula* is lower than for *Cortaderia selloana* . f *Cortaderia selloana* , also suffered less plasma membrane damage at all stress levels .

Table 1 *Effects of soil drought stress on water potential , relative water content and relative permeability of plasma membrane of ornamental grass leaves .*

Species	Leaf relative water content (%)			Leaf water potential (-MPa)			Relative electric conductivity (%)			T1 Damaging degree(%)	T2 Damaging degree (%)
	CK	T1	T2	CK	T1	T2	CK	T1	T2		
Cortaderia selloana	98 .1 aA	91 .5 aA	88 .7 aA	0 .74 aA	1 .72 aA	1 .86 aA	18 .5 bA	19 .4 abA	20 .9 aA	1 .06bB	2 .93bB
Eragrostis curvula	93 .6 bA	86 .6 bB	74 .6 bB	1 .04 bA	2 .52 bA	3 .47 bB	19 .2 bB	26 .1 bB	35 .9 aA	8 .52aA	20 .6aA

Note : The same letter indicates no significance , the big and small letter indicates significance at 0 .01 and 0 .05 level separately in the same column .

Conclusion The results indicated that *Cortaderia selloana* is more drought-tolerant than *Eragrostis curvula* .

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Effect of different culture medium on subculture and differentiation of alfalfa anther callus

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Key words: alfalfa, anther callus, tissue culture, hormone, macroelement

Introduction Cultivated alfalfa (*Medicago. sativa. L*) is one of the high quality legume crop, which is wildly planted in the world. Alfalfa is cross-pollination plant, genotype heterozygote and genetics diversity. Method of conventional breeding would not easy to obtain pure line. But pure line can be acquired by the use of anther culture to create double haploid (DH) lines in short time. Combined anther culture with cross-breeding, heterosis utilization, transgenic technology have formed an effective breeding technology and become an important part of breeding. The effects of different medium components, hormone categories and concentrations was investigated in the experiment, to establish foundation for further optimize culture conditions and constructing doubled haploid population.

Materials and Methods The callus were induced from the alfalfa anther cultured on a double-layers medium which contains N6 macroelement, the MS microelement, MS microelement, B5 organic compound, 2,4-D 2mg/l + 6-BA 0.5mg/l. The callus was transferred to the different mediums (Table 1), and growth of the callus was observed. Culture conditions: pH of medium was 5.8, the light intensity was 2 000 lx, time of illumination was 12-14 h/d, the temperature was 25±2℃.

Table 1 *Medium components.*

Medium	Macroelement	Auxin(mg/l)	Cytokinin(mg/l)
S2	MS	0	0
D3	SH	NAA0.05	BA0.5
D4	SH	2,4-D0.05	BA0.5
D5	SH	NAA0.05	KT1
D6	SH	NAA0.05	KT0.5
D7	SH	0	BA0.5
D8	SH	0	0
D18	N6	0	0

Note: other components of medium in the table are MS micronutrients MS microelement, MS organic compound, lactalbumin hydrolysate(LH) 1g/L, activated carbon (Ae) 1g/L.

Results and discussion

The effect of different macroelement of medium on Alfalfa anther callus Fett-Neto etc. think that the growth of the cells depend on NO_3^- as the nitrogen source and inhibit on high concentration NH_4^+. The experiment showed: the effecf of callus culture in the medium containing MS macroelement or SH macroelement was better than in the medium containing N6 macroelement in primary culture, but the medium containing N6 macroelement was the best medium to callus subculture and embryogenic callus induction from the 5th to the 9th subculture.

The Effect of hormone on growing of callus Daipeng Li etc. think that exogenous hormones could transfer development information of dedifferentiate and redifferentiation in plant callus culture, effect of exogenous hormones related with explant, the kinds and the levels of endogenous, hormones of callus, function of exogenous hormone must combined with endogenous hormones. Therefore, it should consider hormone concentration of explant and callus to adding plant exogenous hormone. The experiment showed: callus growth was similar in the D4 (0.05 mg/l 2,4-D + 0.5 mg/l BA) and D6 (0.05 mg/l NAA + 0.5mg/l KT) medium, D4 and D6 were better than D3(NAA 0.05 mg/l + BA0.5 mg/l).

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Pattern of nitrogen integration and its ecological implications in clonal plant *Zoysia japonica*

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Key words: nitrogen, clonal integration, *Zoysia japonica*, isotope

Introduction Clonal integration between ramets of a clonal plant was regarded beneficial for ramet establishment, sustaining stressed ramets, and for resource uptake over large or heterogeneous areas. However, clonal integration may have potential costs, thus, clonal integration may not necessarily exist among physically connected ramets. In natural conditions, *Zoysia japonica* usually forms long-chained and long-lived stolons in various habitats of the grasslands through the way of vigorous clonal growth. We therefore hypothesized that at least one of the underlying mechanisms lie in that the capacity of clonal integration in *Z. japonica* clones must be strong and extensive. Exemplifying nitrogen as an important nutrient element, we carried out an isotopic experiment trying to test the nitrogen integration pattern in *Z. japonica* clones, through which try to explain some of the clonal behavioral performances of *Z. japonica*.

Material and methods The experiment was conducted in the East China Normal University, Shanghai, China. Soil type is clay sand loam. Inorganic N is 209.6 mg/kg. Total soil N is 0.23%. *Zoysia japonica* Steud. as an C_4 perennial herb extensively distributes in China and surrounding countries. The basic morphological unit of *Z. japonica* plant is so-called multiple-node or compound internode, a repeatable sequence of two shortly compressed and one elongated internode. So-called A-and B-tiller successively grow at the bases of two compressed internodes at opposite sides of the multiple-node. The experimental clones were cultivated in the experimental field. Each clone grew from a standardized individual ramets (single multiple-node with two opposite tillers), which cut from a single large clone of *Z. japonica* propagated in the greenhouse before the experiment. A special treatment was given to the middle ramet of each clone: before each middle ramet anchored their roots, plastic cups filled with soil were put under the multiple-node and buried in the field soil, preparing for receiving the ramet roots. At the end of the growth season, two days before harvesting the clones, the plastic cups containing the roots and soil were carefully dig out, and the inside soil were removed, and the inside roots as well as the plastic cups were carefully washed with distilled water and deionized water, then the washed roots were put back into the plastic cups preparing for the isotopic experiment using the ^{15}N-labelled nutrient solution. The nutrient solution used to feed the middle ramet roots was compounded according to the modified ingredients of the Hoagland solution, in which KNO_3 was changed into $^{15}NH_4Cl$ ($\delta^{15}N$ 10.39%) and $K^{15}NO_3$ ($\delta^{15}N$ 10.32%) respectively. Before being fed into the root system of the middle ramets, the nutrient solution containing $^{15}NO^{3-}$ and $^{15}NH_4^+$ respectively, was diluted, resulting in the final concentration 2.5mm/L. Two days latter, each clone was carefully harvested, washed and air-dried. The isotopic experiment replicated tree times with three *Z. japonica* clones similar in architecture. In the experimental period, the mean soil water content was 27.20%. Seven samples of ramets, including leaves, roots and stolons, were taken on each side of the feeding ramets respectively, along the primary, whereas in the case of secondary stolons, less samples were taken due to their short length. Samples were oven-dried and ground into fine powder (approx. 20μm). $\delta^{15}N$ in the samples were detected using a mass spectrometer (DELTAplusXP type), through which the translocation patterns of nitrogen in two forms in *Z. japonica* clones were analyzed. Three statistical indexes, kurtosis, skewness and gradient were calculated.

Result $^{15}NO_3^-$ and $^{15}NH_4^+$ showed acropetal and basipetal translocation patterns in the primary stolons of *Z. japonica* respectively, and more ^{15}N was translocated acropetally, and less basipetally. $\delta^{15}N$ of A-tillers or A-branches were usually higher than those of B-tillers or B-branches, and those in stolons were at middle levels and relatively stable. $\delta^{15}N$ of roots usually showed higher values at the feeding ramets, then degreased quickly. In case of $^{15}NH_4^+$, the gradients of the basipetal and acropetal translocation patterns of ^{15}N in ramets along the primary stolons were greater than the case of $^{15}NO_3^-$. When feeding the middle ramets of *Z. japonica* stolons with same concentration of $^{15}NO_3^-$ and $^{15}NH_4^+$ respectively, $\delta^{15}N$ values of the feeding ramets in the case of $^{15}NH_4^+$, was also greater than in the case of $^{15}NO_3^-$. In any cases, the gradients of the distribution patterns of $\delta^{15}N$ values of A-tillers along the primary stolons were greater than those of B-tillers. The range of $^{15}NO_3^-$ and $^{15}NH_4^+$ translocation in both basipetal and acropetal directions along the *Z. japonica* stolons respectively, was 7 to 15 multiple-nodes. Acropetal translocation of ^{15}N tended to be farther than basipetal, and those of $^{15}NO_3^-$ tended to be farther than those of $^{15}NH_4^+$, especially in the acropetal direction. Acropetal translocation patterns of ^{15}N in the secondary stolons were detected after $^{15}NO_3^-$ and $^{15}NH_4^+$ being fed from the root systems of the middle ramets of the primary stolons, respectively. The acropital translocation patterns of $^{15}NH_4^+$ and $^{15}NO_3^-$ in the secondary stolons were basically similar in form to, but different in quantity from that in the primary stolons, the former was less than latter. In secondary stolons, in the case of $^{15}NH_4^+$, $\delta^{15}N$ of different organs were greater than those $^{15}NO_3^-$, and those in secondary A-stolon were greater than those in secondary B-stolon in both cases of $^{15}NO_3^-$ and $^{15}NH_4^+$. $\delta^{15}N$ of ramets on the secondary A or B-stolons directly connected with the ^{15}N feeding ramets, were usually greater than those of the ramets on the corresponding secondary A or B-stolons grew from the multiple-nodes preceding or after the feeding sites, and $\delta^{15}N$ of ramets on the acropetal secondary A or B-stolons respectively were usually greater than those basipetal.

Conclusions The results at least partially supported the hypothesis that clonal integration in *Z. japonica* clones was strong and extensive, which also at least partially explained the natural performance of *Z. japonica* clone in terms of such as long-chained and long-lived stolons in various habitats and strong capacity of clonal propagation. The extensive clonal integration pattern in *Z. japonica* clone may have some obvious benefits. However, the relevant costs may also be obvious in terms of such as maintenance, inhibiting branching, and facilitation of pathogen infection within the clone, which needs to be revealed in detail through a series of other experiments.

Plant regeneration from in vitro stem explants of *Dianthus spiculifolius*

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Key words : *Dianthus spiculifolius* , Stem , Regeneration .

Introduction *Dianthus spiculifolius* is a charming dianthus that has fine , grassy , blue-green foliage and much dissected flowers , all cleanly snipped as if someone has gone mad with the crimping sheers . The calyces below the flowers are colored pinkish purple . It is low that can be used as a kind of beautiful turf grass .

Up to now , there was no report about the tissue culture and plant regeneration of *Dianthus spiculifolius* . Our aim in conducting the present investigation was to attain an efficient system for regeneration in *D . spiculifolius* . It is suitable for screening gene-transformed *Dianthus spiculifolius* plants .

Materials and methods Plant material came from Beijing Liangxianglvjing Planting Center of Seedling and Wood . Cultures of *Dianthus spiculifolius* were established from young stem collected from greenhouse-grown plants . Murashige and Skoog (1962) medium supplemented with 3% (w/v) sucrose ,

2 ,4-D , 6-BA and NAA in various combination was used for callus initiation . KT in combination with 6-BA and IAA were used for shoot regeneration . Culture media were solidified with 0 .8% agar and adjusted to pH 5 .8 before autoclaving at 121℃ and 1 .2-1 .3 kg/cm^2 pressure for 20 min . Forty ml of medium was dispensed into 100 ml Erlenmeyer conical flasks . Ten flasks were prepared for each treatment and in each flask at least 2 explants were inoculated . Cultures were incubated in a growth chamber at a temperature of 26 ± 2℃ with light intensity of 250 umol . M^{-2} s-1 provided by fluorescent tube lights and incandescent bulbs . A photoperiod of 16 h was maintained with the help of photo thermal controller . Weekly observations were recorded .

Results The best callus initiation medium was MS+ 2 , 4-D (1 .0mg/l) + 6-BA (0 .5mg/l) + NAA (0 .1mg/l) . The callus was maintained by regular subculture every 3 weeks .

No shoot bud induction was observed in the cultures above . That may be the effect of 2 , 4-D . Callus After the 3rd week of subculture ,best response in terms of shoot formation was observed and shoot bud development in the callus became conspicuous on MS medium supplemented with KT (4 .0mg/l) + 6-BA (0 .2 mg/l) +IAA (0 .02mg/l) . The number of shoot buds increased as the culture period progressed to 7 weeks . After 7 weeks , almost the entire callus was converted into shoots . Callus sub cultured on medium containing 6-BA and IAA without KT did not show any organogenesis .

After 8 weeks , plantlets were potted in a soil-vermiculite mixture , covered with film for acclimatization , and subsequently transferred to the greenhouse .

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Characteristic of gas exchange and chlorophyll fluorescence parameters in leaves of *Lespedeza davurica*

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Key words: gas exchange parameters, chlorophyll fluorescence, simulated photosynthetic, CO_2 concentrations, *Lespedeza davurica*

Introduction This paper tests and analyzes the net photosynthetic rate (*Pn*), transpiration rate (*Tr*), stomatal conductance (*Gs*), intracellular CO_2 concentration (*Ci*), minimal fluorescence yield (*Fo*), maximum fluorescence yield (*Fm*), variable fluorescence yield (*Fv*) and electron transport rates (*ETR*) to reveal the physiological and ecological characteristics of *Lespedeza davurica*.

Materials and methods *Lespedeza davurica* belongs to *Lespedeza Michx* of *Leguminosae*. It was measured with LI-6400 portable photosynthesis system and comparative analysis was made. Light intensity was controlled by 2BLED of LI-6400. In a similar way, CO_2 concentration was controlled by CO_2 scrubber and the temperature of leaves was regulated by controller of LI-6400. The leaf area of *Lespedeze davurica* was measured by an area meter (LI-3000A). All of the digital information was analyzed by SPSS 13.0 and Microsoft Excel for Windows.

Results We can know from figure 1 that *Lespedeza davurica* shows evident photosynthetic potentiality for the increase of CO_2 concentration. The figure 2 showed the relaxation rate of *Lespedeza davurica*. When the leaves of *Lespedeza davurica* changed from dark to light, the *qP* and *NPQ* elevated gradually with the increase of illumination time. About 24min later, the *qP* and *NPQ* tended to be stable and quenching. The trend of *PhiPS*2 change was influenced by *ETR*.

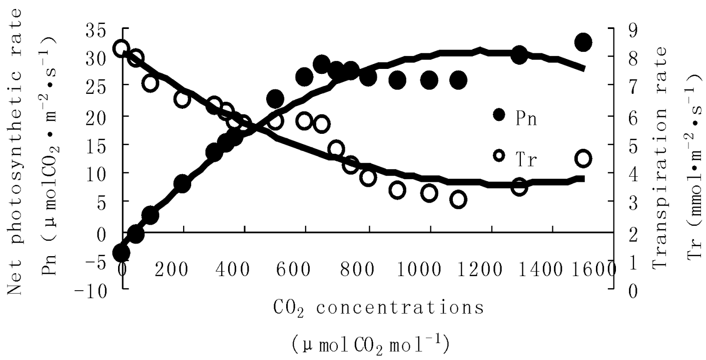

Figure 1 *Responses of photosynthetic rate (Pn) and transpitation rate (Tr) to increasing CO_2 concentrations.*

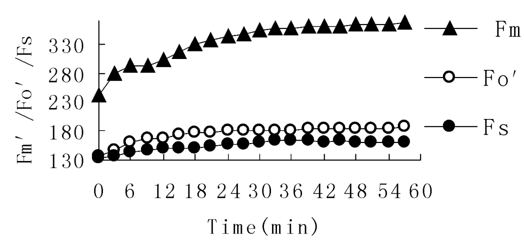

Figure 2 *Chlorophyll fluorescence parameters of leaves of Lespedeza davurica in relaxation.*

Conclusions This experiment showed that water stress is one reason for inhibition in photosynthetic ability after the light intensity over 1600μmol$m^{-2}s^{-1}$. So strong light should couple sufficient water condition and can promote the efficiency of light energy. The significantly positive correlation exists between *Tr* and *Gs* of *Lespedeza davurica* ($P < 0.01$). But there was significantly negative correlation between *Pn* and *RH*. High humidity air may be one reason for inhibition in photosynthetic ability for experiment spot in closure area of Taihang Mountain. The *qP* and *NPQ* of *Lespedeza davurica* gradually increases with illumination time, showing the higher ability of heat dissipation and efficiently avoided the damage of photosynthetic apparatus from excess light energy. The *NPQ* was lower after 27min because of the increase of photochemical quenching. But it may be caused by the interior control of photosystem enzymes, which is a problem of great complexity. The exact mechanism remains to be studied further.

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Phylogenetic relationship of *Leymus chinensis* revealed by the ITS and chloroplast trnL-F sequences

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Key word: *Leymus chinensis*, *Psathyrostachys*, Xm genome, ITS, chloroplast trnL-F

Introduction Based on morphological observation, meiotic chromosome pairing of intergeneric hybrids, DNA hybridization patterns, and variation in repeated nucleotide sequences, previous studies have concluded that one genome in *Leymus* species originated from the genus *Psathyrostachys* (Wang *et al*, 2006). Despite decades of intensive research, the precise phylogenetic relationship of *L*. chinensis is still unclear. The nuclear and chloroplast/mitochondrial sequences was used in many molecular phylogenetic studies for elucidating the origins and evolutionary history of polyploidy in plants, clarified their parental lineages. Particularly, internal transcribed spacers (ITS) and the intergenic spacer of trnL-trnF have been used widely in studying phylogenetic and genomic relationships of the diploid Poaceae genera. With additional abundant available sequences in public databases, ITS and trnL-trnF are the optimal choices in this study.

Materials and methods Two accessions of *L*. chinensis and *Psathyrostachys juncea* were included in this study. They were analyzed together with 18 related genera, consisting of 40 diploid species in the tribe Triticeae. *Bromus catharticus* was used as the outgroup based on previous phylogenetic studies. The aligned data set of the ITS and the *trnL-F* were analyzed using PAUP version 4.0. Heuristic search was implemented with 100 random additional sequence replicates, tree-bisection-reconnection (TBR) branch swapping, MULPARS option, and ACCTRAN optimization. To evaluate relative robustness of the clades found in the most parsimonious trees, bootstrap analysis was conducted using 500 replicates with a simple taxon addition.

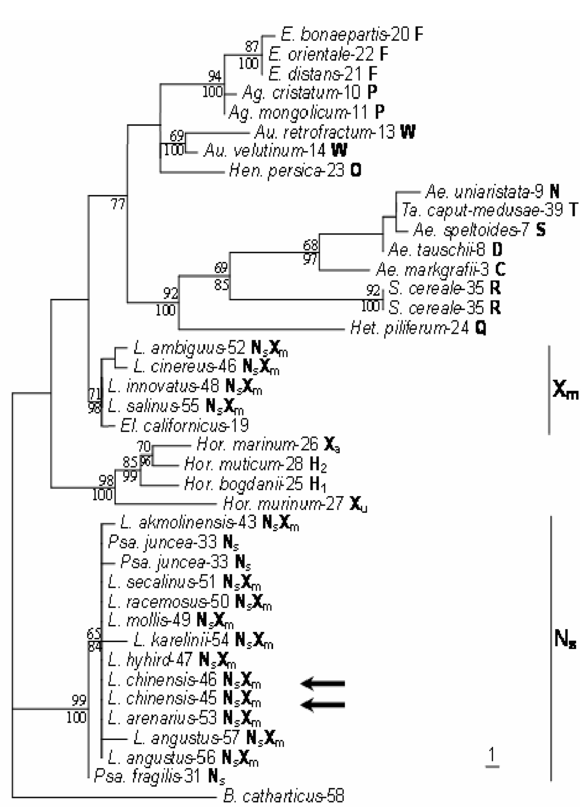

Figure 1 *One of the 500 most parsimonious (MP) trees generated from the* trnL-F *sequences (Tree length = 147, CI = 0.7687, RI = 0.8707). The topologies obtained by Bayesian analysis are identical except for some nodes having different bootstrap values.*

Results It was showed that: (1) The ITS sequences revealed polyploidy *Leymus* have close phylogenic relationships with *Psathyrostachys* and an unknown genus in Triticeae. The ITS tree suggested considerable differentiation among *Leymus* species and recurrent hybridization of *Leymus*. (2) The trnL-F tree revealed especially close relationships of partial *Leymus* species and *Psathyrostachys*, residual *Leymus* species and an unknown genus (Figure 1). The trnL-F tree showed that the mother of *Leymus chinensis* was *Psathyrostachys*, and the father was the Xm genome.

Conclusions The results indicated that it was unlikely that the unknown genome in *Leymus* species originated from a modified version of the Ns genome or any sampled diploid species in present study; The maternal of *L*. chinensis was Ns genome and the paternal genome was Xm.

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Trigonella arcuata responds to *Seriphidium transillense* desert degraded grassland

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Keywords: *Trigonella arcuata*, *Seriphidium transillense* desert, degraded grassland, response, adaptation

Introduction Xinjiang has 5 730 10^4 hm^2 natural grassland including 1083.4 10^4 hm^2 spring-autumn pasture and *S. transillense* is the main spring-autumn pasture which belongs to middle Asiatic climate desert that concentrates in northern Xinjiang plains and low mountains. The grassland has commonly degraded and some places have become over-degradation because of unreasonable use through many years. With the increase of degraded degree, *T. arcuata* replaces *S. transillense* and becoming the dominant species. Fundamental researches have been done but lots of detailed researches are required including some species' strategies and mechanism for adapting natural environment of the degradation.

Materials and methods The study area locates in the middle of the northern slope of the Tianshan Mountains, N43°49′～43°56′, E87°02′～87°05′, which is an open flat alluvial plain and its altitude is 754～942m. The area has middle Asian desert climate characters, annual rainfall of 180～190 mm, evaporation of 1 760mm and drying of 4～10, with an average annual temperature 6.5 ℃, the frost-free period 160～190 days. The soil is gray desert soil and the soil parent material is the loess-like material. *S. transillense* desert is the zonal vegetation in the region, with short-live plants in the spring and annuals forming dominant synusia. In the time sequence, the plant community composition, structure as well as some life-economic traits of middle asiatic climate desert is more complex than that of central asiatic climate desert. In April 2006, 15 samples (1 $1m^2$) are selected in each degraded degree area and the height, coverage and density of every species are recorded and the biomass is measured.

Results The response of *T. arcuata* to different degradation of *S. transillense* desert is shown in the table below. *T. arcuata* becomes the dominant species with the worsening of degradation and it is considered the indicator species, its coverage, biomass and density obviously increase while its height becomes lower.

degraded stage	coverage (%)	biomass (g/m^2)	relative density (individual/m^2)	height (cm)	important value IV=(RC+RY)/2
non-degradation	0.40	0.94	6	1.77	0.01
media-degradation	0.93	0.91	9	0.84	0.04
heavy-degradation	1.55	2.21	16	0.49	0.07
over-degradation	5.12	7.86	60	0.50	0.24

Note: RC means relative coverage and RY means relative yield.

Conclusions *T. arcuata* prevents livestock's eating through lowering its height and inhibits the grassland from completely overwhelming degradation through expanding its population. Through observation we find that it avoids the arid environment of the over-degradation by shortening its life cycle.

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A brief introduction on water conservation and drought resistance technique on desert grassland slope

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Key words : desert grassland ; slope ; water conservation ; water conservation polymer ; drought resistance polymer

Introduction As one of the greatest environmental threats , drought is paid increasingly close attention(zhang H L ,1997) . When it is affected by drought , vegetation on desert grassland s surface will be degenerated much more seriously , once it degenerated , it is difficult to recover . Further more , slope vegetation in desert grassland belongs to a sort of soil water limited ecological system and is a sensitive area in vegetation degeneration . Therefore , desert grassland slope water conservation technique is urgently demanded .

Research method and content Firstly , an experiment area is enclosed on desert grassland slope . Based on slope rainfall-runoff (SRRO) experiment , research on SRRO characteristics on desert grassland is conducted . Based on theory of SRRO hydrodynamics , research on SRRO law is carried out . Runoff energy consuming process is analyzed . The slope soil infiltration and evaporation law is studied . The experiment of how soil structural characteristics have an effect on soil infiltration and evaporation is made . Model Green-Ampt is settled to simulate soil infiltration process . Slope water conservation method experiment is made according to the results mentioned above . The methods include increase on soil surface rough degree ; application of water conservation polymer on loosened slope surface .

Secondly , on the premise of slope water conservation , drought resistance and water economization are studied . Plant population and community characteristics are analyzed . Research on each sort of plant's transpiration rate and osmosis adjustment during onset of drought stress is conducted . Synthesize the above results ,drought resistance method experiment is carried out .

Drought resistance methods mainly include inhibiting growth of fast-transpiration plant ; application of vegetation drought resistance spray etc , which are to reduce the transpiration rate of vegetation community . In the end , a comprehensive system of desert grassland slope is built up .

Result The study on water conservation (WR) and drought resistance (DR) under desert grassland slope conditions is carried out , and WR and DR comprehensive technique measures are put forward . As to slope WR , by method of soil loosening ; application of Handilong (water conservation polymer) ;surface cover in winter , soil infiltration rate is increased . SRRO is increased for 6% under similar conditions . As to slope DR , owing to the application of vegetation drought resistance spray and uprooting of vegetation with high transpiration rate , plant community's transpiration rate is effectively reduced . Thus , the objective of vegetation drought resistance is obtained .

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Forage-livestock industry is a fundamental issue for ecologic and economic win-win in the Loess plateau , China

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Key words :forage-livestock industry , reformulation of agriculture system , Loess plateau , ecologic and economic win-win , industrialized production system

Introduction The Loess plateau , China is a one of the poorest areas by the most severe soil erosion and has the most fragile ecological environment in China . Revegetation , reforming of agricultural system and the development of forage-livestock industry are essential measures for ecologic sustainability .

Material and methods Severe soil erosion , destroyed vegetation , infertile soil and low income could be controlled by developing forage-livestock industry , and reformulating agricultural system , which are the most fundamental measures . In the Loess plateau , forestry vegetation disappeared , soil fertility degradation and low income of farmers were mainly caused due to internal war for a long time , cultivating from forestry and pasture , grain planting system dominant . Thus , transforming traditional grain dominant farming agriculture" , converting grain land into woodland or pasture , restoration of vegetation , to reform agricultural system should be the most fundamental measures in controlling soil erosion .

Acceleration forage-livestock industry can achieve ecology and economic win-win . The adequate agriculture industrial layouts in the Loess plateau should be the favorable farming , protective forestry , commercial forage-livestock industry" . So grain crop planting area should be reduced , reasonable area for forestry is suggested , forage planting area should be enhanced , and all of those provide an alternative choice for ecologic and economic win-win .

Integration Green for Grain to forage-livestock industry : Green for Grain and forage-livestock industry , poverty reduction , development forage-livestock industry and improvement farmers' income will be continuously implemented for ecologic construction .

Alfalfa will be one of important forage to establish forage and feed supply system , producing high quality and high yield forage to meet livestock demand . Sowing pasture establishment , expanding legume pasture area , forage-crop rotation will make up the gap of protein feed stuff shortage . Afterwards , Techniques for alfalfa harvesting time , transportation , processing machinery , silage making in high rainfall area are major issue .

Beef Cattle and sheep are primarily dominant livestock to accelerate for development herbivore and domestic animal of production system industrialization . Establishing forage-meat lamb and beef cattle production system based on local , domestic and international market-oriented and forming industrial development .

Setting up eco-economic system for harmonious development between human and nature in the Loess plateau area by forage and livestock interaction and regional resources coupling : Fully utilizing the neighboring region's resources in livestock , feed stuff and market , a giant , harmonious forage-livestock industry base will be establishing in the Loess plateau through regional advantage compensation and system coupling .

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Research on community dominance and functional groups after Sandy Land enclosed

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Key words: sandy land, enclosure, dominance, aboveground biomass, community functional groups

Introduction Functional groups are usally considered species which have a direct connection with system's function, and the species among functional groups have same effect on system which have a well comparability Therefore, it is a worthy of affirmitive thing that we use functional groups as species diversity index to reseach the relation between species diversity and ecosystem function. (Li Qiu-Nian, 2004) The compartmentalization of functional groups can asertain every species acting character and magnitude in functional groups, which administer to making certain every species' opposite contribution to ecosystem. (Wang Zheng-Wen, Long Rui Jun, 2004)[2] We reseach community functional groups after sandy land enclosed, there is a important significans to making sure ecosystem natural succession and ecological restoration processes.

Natural situation The test spot (Na-Mu-Si-Lai Nature Reserve) lies on northeast Zhang Wu county Liao Ning province, and it situated on south of Horqin sandy land. The test spot was enclosed in 1997. This region is temperate zone monsoon continental climate, and the four seasons change distinct, it belongs to half drought region. The mean annual temperature is 7.1℃, mean annual precipitation is 510.2mm and soil type is aeolian sandy soil.

Materials and metheods All kinds of plant populations' density, coverage, height, frequency and aboveground biomass were mensurated by random quadrat in July, 2006. The quadrat area was one square meter. All items were mensurated ten times. Every kind of population's dominance was mensurated by calculate and compartmentalizd functional groups of life form.

Results The diominance calculational result indicated that the SDR of *Cleistogenes squarrosa* was the maximum among all kinds of populations (Table 1). The perennia grasses, such as *Lespedeza bicolor* Turcz., *Koeleria cristata* (L.) Pers. and *Agropyron mongolicum* Keng also occupied important status. The SDR of annual *Salsola collina* put into second status. This shown that perennial bunch grasses became the dominating population in community by nine years enclosure, the result also suggested that the ecologic quality of grassland has been improved a lot. The functional groups result suggested that perennial bunch grasses took on the most aboveground biomass (97.95 g/m^2) (Table 2) among all functional groups, and this functional group was preponderant group. Undershurbs and subshrubs were one of the main functional groups on ecological restoration and windbreak and sand-fixation, the proportion reached 14.71 percent. There were quite a bit species and quantity of annuals and biennials in community. Moreover, the perennial rhizome grasses had the minimal contribution.

Table 1 *Community dominance.*

Species	SDR	Species	SDR
Cleistogenes squarrosa	21.85	*Delphinium grandiflorum*	5.58
Salsola collina	14.49	*Artemisiasievrsiana* Willd	4.82
Lespedeza bicolor Turcz.	14.46	*Melissitus ruthenica*	5.00
Koeleria cristata (L.) Pers.	12.69	*Dianthus chinensis*	5.10
Agropyron mongolicum Keng	10.10	*Chenopodium aristatum*	4.47
Agropyron cristatum	9.60	*Thalictrum squarrosum* Steph.	0.20
Allium senescens L.	9.30	*Hemistepta lyrata* Bunge	0.10
Ch. acuminatum Willd	9.11	*Koeleria cristata*	0.10
Artemisia capillaries Thunb.	8.68	*Leymus chinensis*	0.10
Herba Potentillae Chinensis	7.54	*B. chinensis*	0.10
P. tenuifolia Willd.	6.27		

Table 2 *Functional group compositions of the life forms.*

Community functional groups	Aboveground biomas (g/m^2)
undershurbs and subshrubs	26.79
perennial bunch grasses	97.95
perennial rhizome grasses	8.86
perennial forbs	14.00
annuals and biennials	34.46

Result Perennial grasses took out a dominant status, but there were large numbers of forbs after nine years enclosure. Sandy land enclosure can redound to ecological restoration. Perennial bunch grasses became the leading functional group.

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Studies on root turion propagation technology of wild hazelnut in Daxing'anling, China

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Key words: wild hazelnut, root turion propagation, length of root turion, substrate type

Introduction Hazelnut distributed mainly in North and Northeast China. Hazelnut has an abundance of nutrition, and it is one of the famous dry fruit. Leaf can be fed to animals. Hazelnut has ecological function and city landscape function. The propagation of Hazelnut mainly depended on seeds, but propagation coefficient was low. Asexual Propagation Technique of Hazelnut are tissue culture and cutting reproduction, and propagation coefficient was also low. The objective of this paper was to improve propagation coefficient, using root turion propagation methods.

Materials and methods The root turion (0.5~2cm) was selected, and cut into segments. Using Carbendazim (1/1000, 50%) soaked, and immersion time was 2mins. Each 20 segments were repeated 4 times. The specific methods are as followed (Table 1).

Table 1 *Different treat methods of wild hazelnut.*

Treat No.	substrate type		length of root turion(cm)
	Thickness of upper: 5cm	Thickness of sublayer: 10cm	
1	fine river sand	vegetable soil	3-4
2	vegetable soil	vegetable soil	3-4
3	fine river sand	fine river sand	3-4
4	fine river sand	fine river sand	1
5	fine river sand	fine river sand	2
6	fine river sand	fine river sand	3
7	fine river sand	fine river sand	4
8	fine river sand	fine river sand	5

Table 2 *The experiment result of wild hazelnut.*

Treat No.	Total No.	1	2	3	4	Rate of seedling(%)*
1	20*4	10	10	9	8	46.25[b]
2	20*4	2	1	3	3	11.25[c]
3	20*4	17	19	16	17	86.25[a]
4	20*4	7	8	7	8	37.5[c]
5	20*4	14	13	15	14	70.0[b]
6	20*4	17	18	16	17	85.0[a]
7	20*4	18	16	17	18	87.5[a]
8	20*4	18	16	17	18	86.25[a]

* Effects of periods on all variables were significant ($p<0.05$)

Results The test lasted about 20 days, and began to do measurement and The main results are showed in Table 2. The Table 2 has shown that the rate of seedling was great impacted because of different seedbed. The rate of seedling was the highest (86.25%) on fine river sand, and there was significant difference from other treats. The rate of seedling was higher and reached 85%, when the length root turion was above 3cm.

Conclusion The best root turion length was 4cm and the best seedbed was fine river sand, which could improve the rate of seedling reached 85%-87.5%.

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Study on AMF in rhizosphere of Vetiver grass in field nursery

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Key words : Arbuscular mycorrhizal fungus(AMF) , Vetiver grass , offset plant , tissue culture seedlings

Introduction Vetiver grass was widely used and even named as the pioneer plant to control soil erosion , stabilize the slope and rehabilitate the ecology in South China , because of its high root tensile resistance and deep penetration . In the application of the vetiver grass , we recently find that it could not only tolerate water submersion and wet condition but also endure a certain degree of drought ; meanwhile it could absorb heavy metal so as to reduce the heavy pollution in soil to some extent . In order to explore the internal mechanism of these good characters of the vetiver grass and find out more plants with the ability to resist stress , we made the sample examination on arbuscular mycorrhizal fungus (AMF) in rhizosphere of vetiver grass to make a further study of its biological function in the restoration from the soil degradation and the dependent relationship with plants .

Materials and methods Collect the vetiver grass in the breeding base of the vetiver grass and in the pond slope in Baiyun District , Guangzhou . Take the fibres with root tip from the soil 5-30cm from the ground and pot for the tissue culture seedlings . Then wash , dry and cut them into 1cm long . Finally put them into the stationary liquid of FAA and get ready for use . In order to observe the AMF more clearly through the microscope , dye the fibres preserved in the stationary liquid in the normal method of Hayman1970 . Use the method of accounting the infected fibres to observe them after treatments through the microscope . To choose 30 fibres from the samplings , 1cm long for each one , put them into the container glass tidily and cover them by the cover glass . Observe the infection of AMF one by one under the condition of 100-400 times of the microscope . Count the infectious and calculate the infection rate .

Results By sample examination on arbuscular mycorrhizal fungus (AMF) in rhizosphere of vetiver grass , at different time and different growing medium treatments in field nursery , the results showed that AMF infection rate in rhizosphere of vetiver grass have no clear relationship with seedling source , but clearly relationship with growing medium . The infection of tissue culture seedlings , at 25 days after planting with the nature forest peat , was up to 93 .33% , infection strength as class Ⅱ . With sterilized forest peat as growing medium , infection rate of the same seedlings was only 20% at 1 months after planting , infection strength as class Ⅰ , and at 20 months after planting , the infection was 53 .33% , infecting strength as class Ⅱ . Infection rates of the offset plants from vetiver grass , at 3 months after planting in natural soil , was 56 .67% , infecting strength as class Ⅰ , at 22 months after planting , infection rate attained most high peak , 80-83% , infecting strength as class Ⅱ , and at 33 months after planting , infection rate was no longer increased , but infection strength increased to be class Ⅲ .

Conclusions Vetiver garss can be infected by the AMF in the natural condition ; The AMF infection rate in rhizosphere of vetiver grass has no clear relationship with seedling source , but clearly relationship with growing medium . ; In the early days of the planting , the infection rate of the AMF in rhizosphere of vetiver grass growed as the time goes by . However after 2 years , the rate climbed to the highest point and stayed still ,but the infection strength was rising .

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Character of canopy apparent photosynthesis and transpiration in *Seriphidium* semidesert under different degradation gradient

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Key words : Seriphidium semidesert , fence , degradation , CAP , transpiration , daily variation

Introduction *Seriphidium* is generally the dominant native plant in semidesert and is extensively distributed in arid regions , especially on the northern slopes of the Tianshan Mountains . It plays an important role in stockbreeding and ecosystems . Photosynthesis and transpiration , which are two of the primary metabolic processes determining plants growth . But research reports about this semi-desert vegetation CAP and TR are relatively few . The objectives of this study were to determine : 1) what changes under different vegetation CAP and TR in different gradient of degradation in a day ? 2) What relationships between CAP ,TR and environmental factors ?

Material and methods The study area is the spring autumn pastures of Sangong village , located on the northern side of the Tianshan Mountains , in Xinjiang , China . The dominant vegetation on the study sites is Seriphidium . , the companion species are , Petrosimonia and Ceratocarpus , but many degraded areas are inhabited by Petrosimonia . We divided grassland into three types according to degree of degradation , moderate , serious and exceeding (MD , SD , and ED) and built fence in all types (inside of fence : IF , outside of fence : OF) , with each plot measuring $40\times40m^2$. Photosynthesis was measured using Beijing Siaidi company's CB-1101 photosynthetic detector within an assimilation box measuring $60\times60\times60$ cm^3 from an aluminum alloy frame and cover of film that allowed light transmittance greater than 85% , within the assimilation box two 12V fans were installed for blending air . Measurements were made from 10 :00am to 18 :00pm , at one hour intervals , three replications were set according fence×degree of degradation . Photosynthetic and transpiration rate were calculated using the apparatus software package . We inspected the relationships between all the variables by means of correlation analysis . All statistical analyses were performed using the statistical software package SPSS 12 .0 .

Results On moderate degraded grassland , with *Seriphidium* as the main vegetation , CAP from 10 :00 to 14 :00 increased slowly . The CAP was 8 $\mu molm^{-2} s^{-1}$ ～9 $\mu molm^{-2} s^{-1}$, and declined rapidly to the minimum from 15 :00～16 :00 , suggesting an obvious siesta phenomenon" , then rose slowly from 16 :00 to 18 :00 . From 10 :00 to 14 :00 , CAP (IF>OF) , but then both have similar trend in CAP after 14 :00 . When *Petrosimonia* was the main vegetation of severe and exceeding degradation of grassland , both inside and outside of fence CAP changed similarly with an obvious single peak curve with a maximum at 14 :00 . Inside of fence the highest average CAP was with severe degradation ,14 .8194 $molm^{-2} s^{-1}$, and the lowest CAP occurred with exceeding degradation outside of fence , only 1. 9639 $molm^{-2} s^{-1}$. This result occurred mainly because with the conditions of exceeding degradation , vegetation is damaged and bare soil increases(Figure 1) . TR value of all vegetation types are a single peak curve , related closely to temperature changes . In all vegetation types TR increased significantly at 12 :00 , both its peak appeared in the afternoon at 15 :00 . This result occurred mainly because the transpiration is closely related to change of temperature , which on average TR is the highest on SDIF , followed by EDIF , and the TR changes are smallest on EDOF as the vegetation is very sparse(Figure 2) .

PAR and temperature changes are typical single-peak curves , the changes of temperature lags behind PAR , the peak of PAR appears at noon 14 :00 , but the temperature in the afternoon at 15 :00 . Inside and outside of the fence (Moderate Degradation) CAP decreased and TR increased with increasing PAR . CAP increased significantly with the rise in temperature in serious and exceeding degradated grassland , changes were consistent with temperature and PAR changes , correlation coefficients are 0.95^{**} ($P<0.01$) and 0.96^{**} ($P<0.01$) and 0.82^{**} ($P<0.01$) , 0.34 ($P>0.05$) , respectively , except with extreme degradation . Due to sparse vegetation CAP did not change significantly with increasing temperature and PAR . Changes of transpiration are closely related to temperature , in the other five cases , the transpiration rate and temperature showed a significant correlation except for extreme degradation , correlation is not significant ; correlation coefficients were 0.80^{**} ($P<0.01$) , 0.68^{*} ($P<0.05$) , 0.87^{**} ($P<0.01$) , 0.62^{*} ($P<0.05$) , and 0.94^{**} ($P<0.01$) , respectively .

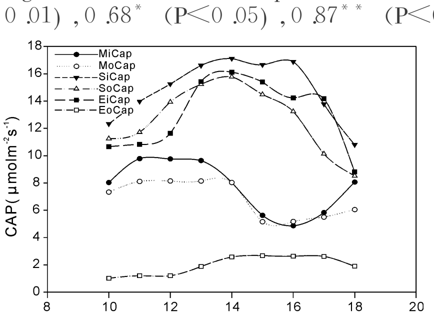

Figure 1 *Variation of CAP .*

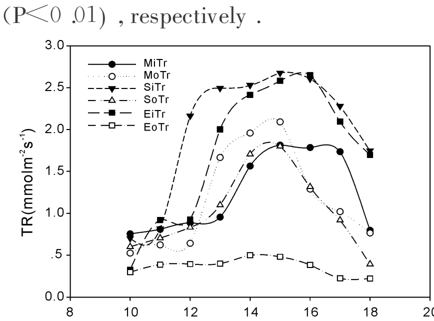

Figure 2 *Variation of Transpiration .*

Study on foliar photosynthetic physiology characteristics of *Setaria sphacelata*

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Key words : *Setaria sphacelata* ; leaf ; photosynthetic physiology ;physiological parameter ;time interval variations

Introduction The origins of *Setaria sphacelata* (*Setaria anceps Stapf* ex Massey) was tropic Africa (L . Jank et al ., 2002) . It was introduced in Lin Chang area of Yunnan province in 1991 and was widely planted as forage in this province . This paper describes the relationship of foliar photosynthetic physiology parameters of *Setaria sphacelata* and environment factors . Reasonable and scientific basis were provided for agriculture production in Yunnan areas of China .

Materials and methods A field experiment was conducted in experiment field of Pasture Science department in Yunnan agricultural university . This area located 21°9′～29°15′ northern latitude and 97°39′～106°12′ eastern longitude . Yearly rainfall was between 1000mm and 1500mm and yearly radiation averages 17 .7 MJ/m^2 . The soil of the field was red soil which pH value was 5 . *Setaria sphacelata* has been planted in the experiment field 3 years and was cut to 5 cm on 8 March 2007 . On 18 may 2007(sunny) , the air temperature(Tar) , air relative humidity (RH) , air CO_2 concentration (ACi) , photosynthesis active radiation(Par) , photosynthesis rate(Pr) , stomatal conductance(Gs) , the intercellular CO_2 concentration(Ci) , transpiration rate (Tr) , the wave length (λ) and the index of reflection (R) were recorded by Ci-310 portable photosynthetic determination system . From the top , the 2nd , 3rd and 6th leaves of healthy and growing well plant was selected for the experiment with 3 replications .

Results The time interval variation of photosynthesis rate was expressed as two-humped curve and reached the top point at around 11 :30 and 13 :56 ,while the time interval change of transpiration rate was a two-humped curve and reached the top point at around 13 :56 and 13 :59 during 11 :00 and 14 :00 point period(Table 1 and Figure 1) .

Table 1 *Variations of environment factors and photosynthetic characteristics during* 11 :30 *and* 13 :59 .

Time	Tar (℃)	RH (%)	ACi (μmol · m^{-2} · s^{-1})	Par (μmol · m^{-2} · s^{-1})	Pr(μmol · m^{-2} · s^{-1})	Gs(μmol · m^{-2} · s^{-1})	Ci(μmol · m^{-2} · s^{-1})	Tr(μmol · m^{-2} · s^{-1})
11 :30	27 .78	24 .03	185 .63	1119 .36	7 .42	16 .64	213 .4	0 .72
13 :21	32 .09	23 .42	194 .43	1134 .87	10 .18	24 .04	202 .8	1 .34
13 :56	33 .00	23 .83	184 .23	1260 .40	11 .63	32 .87	196 .17	1 .77
13 :57	33 .60	22 .58	192 .93	925 .93	7 .97	15 .47	201 .63	0 .97
13 :59	33 .97	23 .23	207 .40	1233 .77	13 .7	31 .2	200	1 .9

Conclusions the leaves of *Setaria sphacelata* significantly affected by environment , the photosynthesis physiology characteristics of *Setaria sphacelata* leaves changed regularly . Stomatal conductance lead the decisive function the environment factor is the atmospheric humidity , but they have the remarkable relevance . The photosynthetic rate's decline is caused mainly by the non-blowhole factor at noon .

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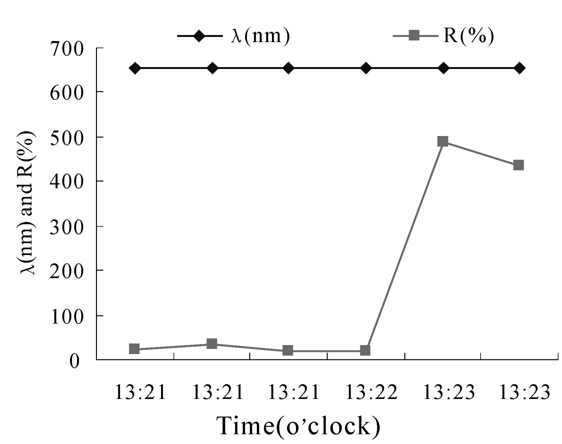

Figure 1 *Variations of photosynthetic active radiation and air CO_2 concentration .*

A study of forage germplasm resources and their utilization in Heilongjiang province China

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Key words : Heilongjiang , forage , germplasm , resource , utilization

Heilongjiang Province has 4 .33 million hectares of grassland of which the Sanjiang grassland is 0 .665 hectares , the grass mountain and grass slope is 1 .8 million hectares , and the western grassland is 1 .865 million hectares , the most importance part of the Songnen grassland . Because of the differences of ecologic environment there are abundant cold tolerant , anti-alkali tolerant , drought and barren tolerant species and biotypes . Identifying germplasm resources and their scientific utilization is necessary not only for the development of animal husbandry , but also for control of the environment .

Forage germplasm resource composition The continuity of the Daxinganling , Xiaoxinganling , and Zhangguangcailing mountains , whose peaks rise and fall along the skyline are natural woodland and these mountain ranges resemble a horse's hoof that encircles the Songnen plain , with interleaving forest and grasslands , temperate zones and cold temperate zones . Therefore , there are three types of plant flora in this area : Mongolia , Changbai and Xingan .In this complicated area , about 2100 species are distributed , and about 1000 of them have an economic value According to investigations there were 11 families , 227 genera , and 796 species . .

Utilization and researching of germplasm resources

Domestication of wild species *Leymus chienesise* (Trin .) Tzvel were domesticated in the 1960s and *Melissitus ruthenicus* C .W . Chang in the 1970's . They were registered by the Chinese Herbage Cultivar Registration in 1988 .

Native species and the new species *Medicago sativa* L in Zhaodong adopted a protection and grow measure , becoming with cold tolerant , drought tolerant for the native species registered in 1989[1] .

The diploid *Melissitus ruthenicuse* C .W .Chang crossing with traploid *Medicago sativa* L cv . zhaodong which was successfully bred [3] using of the artificial inducing method with the 60Co-rwhich increased seed matur of *Astraglus adsurgens* Pall in Heilongjiang .

Introduced varieties The best foreign *Medicago* species is *Medicago varia* Martin .cv .Rambler , and the better domestic *Medicago* species are the Caoyuan No 1 and No 2 , the Gongnong No1 and 2 . The grasses are *Elymus dahuricus* Turcz , *Elymus sibericus* L . , *Broumus inermis* Leyss , and *Agropyron mongolicum* . Keng , *Agropyron cristatum* (L .) Gaertn , Agropyron cristatum (Linn .) var . pectiniforme (Roem . et Schult .) H . L . Yang , *Agropyron trachycaulum* etc .

Utilization and exploitation of forage germplasm resources The collection ,utilization and breeding of forage germplasm . Wild forage domestication for cultivation and their characteristics . Breeding of high yield , superior quality , cold tolerant varieties . The selection of drought tolerant , barren tolerant varieties . The selection of salt-alkali tolerant species .

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Effects of different factors on the hypocotyls protoplast isolation of common sainfoin

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Key words : sainfoin , hypocotyl , protoplast , effect factors , culture

Somatic hybridization which based on protoplast culture has been widely used in forage breeding . In this text , we explore the technology of protoplast isolation , and hope to culture a new pasture cultivars with superior character .

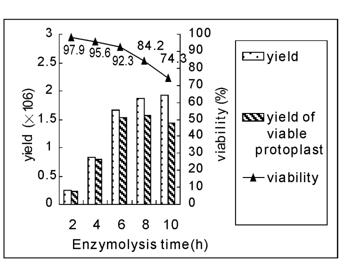
Materials and methods Axenic hypocotyl cultures of common sainfoin . Sainfoin seeds were surface-sterilized with 70% (v/v) ethanol (30s) , then transferred to 0 .1% (w/v) mercuric chloride (15min) , and washed 5 times with sterilized water . Seeds were put on half-strength MS basal medium (Murashige & Skoog , 1962) with 0 .7% (w/v) agar and 3% (w/v) sucrose . and kept in darkness(25±2℃) for 3-4d days .

They were cut transversely into slice (0 .5 mm wide approx .) When the hypocotyls were 2-3cm . The 1-g hypocotyls segments were treated (1 h) in 10 ml CPW salts solution containing 0 .7 M mannitol . ,then transferred into 10 ml filter-sterilized enzyme solution . After 2-10h incubation in the dark (25±2℃) , with gentle shaking (40 rpm) on a rotary shaker , the mixture was passed through a nylon sieve(38 .5μm pore sizes) and 15 ml of CPW9M solution was added . The protoplasts were collected by centrifugation (100×g , 5 min) and resuspended in the washing solution . The washing treatment was done twice . Protoplasts , free of debris were carefully removed from the interface of the solutions , and protoplasts were rinsed twice with 15 ml of KM8p medium((Kao and Michayluk , 1975) A small sample of protoplasts in the washing solution was stained with 0 .01% (w/v)phenosafranine and yield determined using a haemacytometer .

Results and discussion The principle of enzymolysis is getting viable protoplasts with lower concentration of enzymes and shouter enzymolysis time . Mannitol can adjust osmosis pressure of cell in protoplast isolation . If osmosis pressure too high or low ,cell membrane will ruptured . pH not only affect the viability of protoplast , but also the activity of enzymolysis . The result showed that the protoplasts with higher yield and quality were obtained by treating the hypocotyls with an enzyme mixture (pH5 .8) containing 2% cellulose Onozuka R-10+0 .5% Pectinase+0 .3% macerozyme R-10 and 0 .55mol/L mannitol for 6h .

Table 1 *The effects of different enzyme combination on protoplast isolation .*

Cellulase Onozuka R-10(g/l)	Pectin-ase (g/l)	Macerozy-me R-10(g/l)	yield of viable protoplast (1×10^6)
10	5	3	0 .83
10	5	5	1 .18
10	8	3	1 .54
10	8	5	1 .87
20	5	3	3 .20
20	5	5	3 .11
20	8	3	2 .34
20	8	5	1 .96



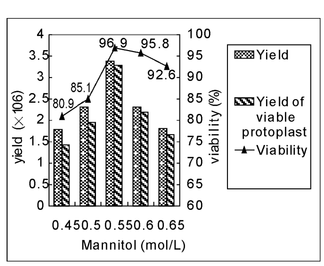


Figure 1 and Figure 2 *The effects of enzymolysis time and mannitol concentration on protoplast isolation .*

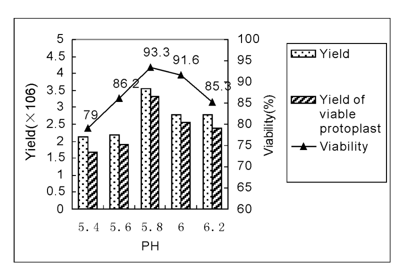


Figure 3 *The effects of pH on rotoplast isolation .*

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A preliminary study of the diurnal dynamics of photosynthetic rate of three grasses

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Key words : *Hodeum brevisubulatum* , *Roegneria turczaninovii* , *Elymus nutans* , the diurnal dynamics of photosynthetic rate , preliminary study

Introduction Herbs Grass has been widely used in grassland ecology construction in China . There are more studies on herbs grass adaptability and productivity . However , there is a lack of information about grass photo—physiology characteristic . The objective of this paper is to compare the diurnal dynamics of photosynthetic rate (Pn) and transpiration rate (Tr) among *Hodeum brevisubulatum* , *Roegneria turczaninovii* and *Elymus nutans* to further understand the photosynthetic characteristics of three grasses .

Materials and methods The experiment was carried out in August , 2007 in Inner Mongolia . The Li-6400 was used to measure the Pn and Tr of two years planted grasses (*Hodeum brevisubulatum* , *Roegneria turczaninovii* and *Elymus nutans*) during fructification . The leaf samples were tested every two hours from 8 :00a .m . to 18 :00a .m . on sunny , and repeated 3 times in each experiment . 3 leaves of each plant were selected in measurement .

Result Seen Figure 1 know , Pn of three grasses exhibited a twin-peaked pattern . The first apex of *Hodeum brevisubulatum* and *Roegneria turczaninovii* appeared at 8 :00 , while that of *Elymus nutans* appeared at 11 :00 . The second apex of *Hodeum brevisubulatum* , *Roegneria turczaninovii* and *Elymus nutans* appeared at 14 :00 , 18 :00 and 16 :00 respectively ; There was noon depression of photosynthesis for *Hodeum brevisubulatum* at 12 :00 . Noon depression of photosynthesis for *Roegneria turczaninovii* and *Elymus nutans* appeared 14 :00 . The diurnal dynamics of Tr was similar to that of Pn (Figure 2) .

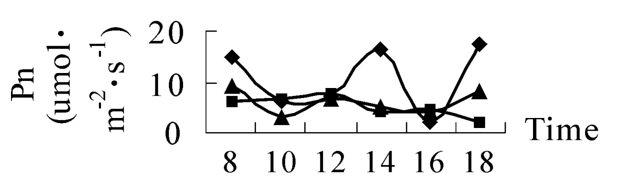

Figure 1 *Diurnal changes of the net photosynthesis rate of three grasses .*

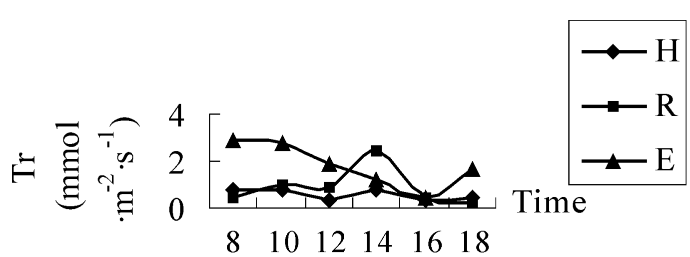

Figure 2 *Diurnal changes of the transpiration rate of three grasses .*

H : *Hodeum brevisubulatum* ; R : *Roegneria turczaninovii* ; E : *Elymus nutans*

Conclusions Pn of the three grasses exhibited a twin-peaked pattern . There was noon depression of photosynthesis for three grasses .With PAR declining after 16 :00a .m . , Pn and Tr of *Roegneria turczaninovii* fell rapidly , while Pn and Tr of *Hodeum brevisubulatum* and *Elymus nutans* rose tardily . This indicated that *Hodeum brevisubulatum* and *Elymus nutans* may be good for using the sunlight of sunset .

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Assessing genetic diversity of *Elymus sibiricus* (Poaceae : Triticeae) populations from Qinghai-Tibet Plateau by ISSR markers

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Key words : Triticeae ; *Elymus sibiricus* ; ISSRs ; Population structure ; Diversity

Introduction *Elymus sibiricus* L . (Siberian wildrye) is a perennial , self-pollinating and allotetraploid grass indigenous to Northern Asia , possessing the StH genome (Dewey , 1974) . In the subalpine meadows with less than 4000m altitude in Qinghai-Tibet Plateau , *E . sibiricus* usually serves as an important forage species . Climate warming , loss of habit by deforestation and excessive gazing at high altitude pastures in the entire Qinghai-Tibet Plateau region now begin to threaten its survival . In the present study , we employed ISSR markers to investigate the genetic structure of natural *E . sibiricus* populations from southeast of Qinghai-Tibet Plateau .

Materials and methods Leaves of 93 individuals of *E . sibiricus* were collected from eight populations in southeast of Qinghai-Tibet Plateau , Sichuan Province , China . Individuals generally 5-10m apart from one another were sampled randomly within each population . Genomic DNA was extracted using the CTAB method . 100 primers (University of British Columbia primer set 9) were first screened for PCR amplification . Eighteen ISSR primers (UBC # 807 , 808 , 811 , 813 , 818 , 825 , 835 , 836 , 840 , 842 , 844 , 845 , 853 , 856 , 857 , 864 , 873 and 880) that generated clear , reproducible banding patterns were selected for further analysis . Polymerase chain reaction (PCR) and electrophoresis were carried out as described in Carvalho et al . (2005) . Unequivocally scorable and consistently reproducible amplified ISSR bands were scored as present (1) and absent (0) , each of which was treated as an independent character regardless of its intensity . The genetic structure of studied populations were calculated by POPGENE , Arlequin and TFPGA software .

Results Of the 100 primers screened , 13 produced highly reproducible ISSR bands . Using these primers , 193 discernible DNA fragments were generated with 149 (77 2%) being polymorphic , indicating considerable genetic variation at the species level . In contrast , there were relatively low levels of polymorphism at the population level with the percentage of polymorphic bands (PPB) ranging from 44 .04% to 54 .92% . The mean gene diversity (H_E) was estimated to be 0 .181 within populations (range 0 .164 to 0 .200) , and 0 .274 at the species level . A high level of genetic differentiation among populations was detected based on Nei's genetic diversity analysis (33 .1%) , Shannon's index analysis (34 .5%) , Bayesian method (33 .2%) and AMOVA analysis (42 .5%) . No significant statistical differences (analysis of molecular variance [AMOVA] , $P = 0.08$) in ISSR variation was found between regions . However , among populations (42 .5% of the variance) and within populations (57 .5% of the variance) , there were significant differences ($P < 0.001$) . Populations shared high levels of genetic identity . This pattern of genetic variation was different from that reported for most of inbreeding Triticeae species reported .

Conclusions The high degree of genetic variation found in present study is probably accounted for the wide distribution of *E . sibiricus* . Owing to the fact that the eight population studied are closed located , the possible explanation for the higher intra-population variation patters revealed in this study is that these studied populations were collected from near the central or founding population .

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Study on the water use of Chicory in Beijing of China

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Introduction Chicory (*Cichorium intybus* L.), a succulent forage needed for the developing cow industry (Dong, 2001), was introduced to Beijing. However, the deficient water resource is a key limiting factor for sustainable development of forage in Beijing. Water use of chicory needs to be studied further before it can be fully utilized in Beijing.

Materials and methods The experimental site, with a mean temperature of 12.2 ℃ and average annual precipitation of 518.3 mm, was located in Shunyi County in the northeast of Beijing. Chicory was planted in spring with a seeding rate of 12 kg/hm^2. The plot area with 3 replications was 5m 10m each, and the space between plots was 2 m. Buffer areas were covered by plastic film to prevent water infiltration. Three different irrigation treatments of 60 mm (CK, 600 m^3/hm^2), 40 mm (MS), and 20 mm (SS) were applied for regrowth after 4 and 5 mowing were applied in 2002 and in 2003, respectively. The yield of chicory and the soil water content of each 10 cm (0～160 cm) were determined. Water content was determined using a 503DR9 Neutron Probe (CPN Co., Ltd., USA) every 15 d. The water use of crops (ET_a) is calculated by the equation: $ET_a = I + P + \Delta W$; where P is the precipitation; I is the amount of irrigation; ΔW is the change of water shortage in the solum; all units are in mm (Yang and Shi, 1997). The water use efficiency is calculated by equation: $WUE = Y/ET$, where Y is the economic yield (Shan, 1994).

Results The irrigation of 20 mm produced a yield of 19039kg DM/hm^2 in 2002 and 22278.9kg DM/hm^2 in 2003, and 60 mm produced a yield of 22508.9 kg DM/hm^2 in 2002 and 27552 kg DM/hm^2 in 2003. The results indicated a yield of 56.7～143.8 kg/hm^2 could be gained with a daily water consumption of 1.88～3.61 mm. A strong positive relationship existed between water use and irrigation over the entire growing period ($R^2 = 0.9689$). The average water use at the second and third-harvests was 25.0%～29.8% more than that of the other harvests. A quadratic relationship existed between water use and yield for the entire growing period. Total water use ranged from 506.7 to 584.2 mm and the WUE from 37.6 to 39.1 kg/hm^2 · mm in 2002, and 517.9 to 643.8 mm and 42.8 to 45.9 kg/hm^2 · mm in 2003, respectively. In addition, WUE increased with an increase in harvest times, and the WUE was the highest with 39.1 kg/hm^2 · mm in 2002 and 45.9 kg/hm^2 · mm in 2003 with the MS treatment (Table 1). The results suggested that irrigation is required for growing chicory in Beijing.

Table 1 *The water utilization efficiency of chicory (kg/hm^2 · mm).*

Years	Treatments	First-harvest	Second-harvest	Third-harvest	Fourth-harvest	Fifth-harvest	Total
2002	CK	33.56	37.91	38.63	44.4	-	38.53
	MS	32.15	38.84	41.24	44.34	-	39.12
	SS	30.22	35.15	40.02	45.04	-	37.57
2003	CK	37.32	41.41	42.48	48.94	45.97	42.80
	MS	37.83	45.57	47.43	51.13	49.32	45.86
	SS	36.24	42.57	43.86	48.04	46.66	43.02

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Photosynthesis and transpiration of Chicory with different irrigation treatments in Beijing

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Introduction Water deficit usually influences photosynthesis, causing stunted growth and development, and futher reduces yield of forage (Flexas et al. 2004). Knowledge gained from studying photosynthesis and transpiration of chicory at different irrigation levels is essential for growing plants in a water stressed area like Beijing.

Materials and methods The experimental site, with a mean temperature of 12.2 ℃ and an average annual precipitation of 518.3 mm, was located in Shunyi County in the northeast of Beijing. Chicory was seeded in spring at a rate of 12 kg/hm^2. The plot area with 3 replications was 5m×10m each, and the space between plots was 2 m. Buffer areas were covered by plastic film to prevent water infiltration. Three different irrigation treatments of 60 mm (CK, 600 m^3/hm^2), 40 mm (MS), and 20 mm (SS) water were applied for regrowth after 4 and 5 mowings in 2002 and in 2003, respectively. The diurnal changes of photosynthesis (Pn) and transpiration (Tr) of chicory were measured for the different treatments and different stages of leaf, bolting, and budding using CIRAS-1 Cassettes Photosynthesis System (PPS Co., Ltd., UK). On sunny days, four mature leaves of chicory in each plot were selected randomly to measure every 2 hours from 08:00 to 18:00 and to calculate the average Pn and Tr.

Results The diurnal change of leaf Pn showed the S" shape with the first peak occurring at 10:00, the second at 14:00, and the trough at 12:00. The diurnal change of Tr was similar to Pn, but peaks and the trough were delayed by 1-2 hours compared with Pn. The average Pn and Tr changes (Table 1) showed soil water content had a great influence on photosynthesis and transpiration of chicory's leaves. A quadratic relationship existed between the Pn and Tr at the different soil water contents. CK: $Pn=-0.3365\times Tr^2+8.4787\times Tr-34.453$ ($R^2=0.5563$, $P<0.05$); MS: $Pn=-0.3287\ Tr^2+7.8767\times Tr-30.757$ ($R^2=0.5415$, $P<0.05$); SS: $Pn=-0.0414\times Tr^2+1.7927\times Tr-3.8072$ ($R^2=0.4274$, $P<0.05$), due to the effects of stomatal movement on both rates and the lag in response of transpiration (Gao 1999).

At low soil water levels, the stoma closed in order to decrease water loss from chicory's leaves. It appeared the response of chicory to the water shortage at the bolting stage and bud stage were more sensitive than that at the leaf stage. The results showed that a quadratic relationship existed between Pn and Tr, and it was essential if normal photosynthesis and transpiration were to occur, plants needed irrigation for regrowth after each harvest in Beijing.

Table 1 *The Pn and Tr of chicory's leaves at different irrigation treatments.*

	treat-ments	leaf stage			bolting stage			bud stage		
		average	peak	trough	average	peak	trough	average	peak	trough
Pn μmol $CO_2\cdot m^{-2}\cdot s^{-1}$	CK	17.93±1.03^a	28.12±0.74^a	19.15±0.81^a	12.83±1.62^a	21.60±1.25^a	12.96±1.49^a	14.07±1.11^a	25.80±0.75^a	14.58±0.84^a
	MS	15.17±0.88^a	26.57±0.63^a	15.93±0.67^b	10.90±1.56^a	19.73±1.14^a	11.55±1.35^a	11.64±0.92^b	23.33±0.67^a	10.72±0.62^b
	SS	7.51±0.43^b	18.05±0.36^b	5.68±0.38^c	6.30±1.04^b	15.24±0.88^b	5.65±0.96^b	6.51±0.33^c	16.55±0.33^b	5.15±0.30^c
Tr mmol $H_2O/(m^2\cdot s)$	CK	10.74±0.62^a	14.68±0.66^a	11.79±0.56^a	11.39±0.68^a	15.88±0.85^a	11.79±0.48^a	11.76±0.92^a	15.93±0.92^a	12.15±0.45^a
	MS	10.27±0.59^a	13.74±0.60^a	10.92±0.78^a	10.38±0.59^a	14.23±0.79^a	10.30±0.39^a	10.31±0.82^a	14.11±0.81^a	9.93±0.52^{ab}
	SS	5.73±0.33^b	8.64±0.40^b	5.38±0.35^b	7.01±0.44^b	10.38±0.50^b	7.01±0.70^b	7.72±0.60^b	11.03±0.64^b	7.34±0.20^b

Note: average-average of Pn from 08:00 to18:00; peak-Pn of 10:00; trough-Pn of 12:00. average-average of Tr from 08:00 to 18:00; peak-Tr of 12:00; trough-Tr of 14:00. Different superscript letters in the same column indicate the significant difference at a $P<0.05$ level.

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Effects of polyethylene glycol(PEG)-simulated drought stress on *Chamecytisus palmensis* seed germination

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(2006BAD26B0102)

Key words : Polyethylene glycol ,*Chamecytisus palmensis* seeds ,water stress ,germination rate , germination potential

Introduction *Chamecytisus palmensis* is a high-quality resource in arid or semi-arid regions . Much work has been done on the characteristics of seed germination of Chamecytisus palmensis seeds , but few studies have compared germination of seeds collected in the same region on different habitats . Thus , this study investigated germination of *Chamecytisus palmensis* seeds with simulated drought stress . These data should aid in selecting drought tolerant species for arid and semi-arid regions .

Materials and methods A total of four kinds of stress were planned with polyethylene glycol PEG(6000) concentrations of 100 , 150 ,200 and 300 g .L^{-1} . These corresponded to the water potentials of about-0 .20 ,-0 .40 ,-0. 60 and-1 .20 MPa (Bailey J D , 2002) . Seeds were placed on filter paper in Petri dishes immersed in PEG solutions . Temperature was controlled at 20～22℃ and light was provided 12 hours a day (test room , natural light scattering) . A few drops of PEG solution were added onto the filter paper everyday and papers were changed every 2d (Ungar . I . A , 1982) . Distilled water was used as CK . Each concentration gradient included 5 replications , each replication contained 50 seeds .

Results Compared with CK , the rate of seed germination in 10% PEG concentration only decreased 8% , while 15% and 20% PEG concentration decreased the rate 24% and 34% , respectively . No germination occurred in 30% PEG . As the stress level increased , seed germination potential of *Chamecytisus palmensis* decreased significantly . Indicating that with PEG simulated drought stress , seed germination declined . Seeds germination potential declined significantly in 10% PEG . The decline for 20% PEG was significant at P=0 .05 . Research showed the germination potential was more sensitive to drought stress than the germination rate .

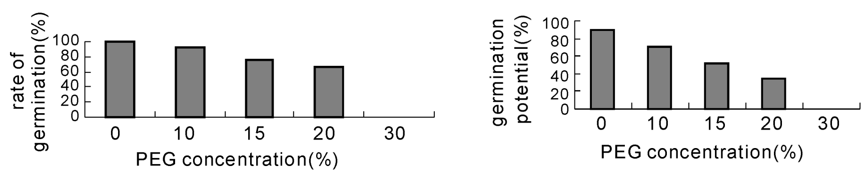

Chart 1 *the effect of PEG simulated water stress on germination rate and the germination potential of* Chamecytisus palmensis *seeds* .

Conclusions PEG retarded the germination of seeds , and the germination rate and germination potential decreased with increasing PEG concentration . The seeds treated with 30% PEG (about-1 .2MPa water potential) did not germinate at all , suggesting that 30% PEG was the threshold for the germination of *Chamecytisus palmensis* seeds .

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Studies on the expression of exogenous p5CS gene in transgenic wheatgrasses

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Key words : Wheatgrasses , Transgenic , p5CS gene , Northern blot

Introduction Transgenic wheatgrasses generated from hybrid wheatgrasses (*Agropyron cristatum* × *A . desertorum cv .* Hycrest-Mengnong) were indentified by PCR analysis and Southern blot . The p5CS gene , which regulates the last step of proline synthesis in plants , was transferred into wheatgrasses . Northern blot was investigated . Results of Northern blot assay displayed that exogenous gene p5CS was expressed at transcription level in transgenic plants . New salt resistance plant lines which are adapted to extensive arid and semiarid areas of west China are expected to breed through these processes .

Materials and methods Plants of Hycrest-Mengnong wheatgrasses with p5CS gene that have been tested by PCR and southern blot were used as materials and compared to non transgenic plants . Plant total RNA was extracted by kit ; after plasmid DNA was amplified by PCR , arm fragments were extracted by kit as templates . They were labeled with DIG High prime DNA Labeling and Detection Starter Kit Ⅰ by the random primer method ; electrophoresed RNA in formol denatured gel ; transferred using capillary blotting ; hybridized and detected by probe labeled with DIG .

Results Figure 1 shows the results of Northern blotting of p5CS transgenic plants and negative plants . The hybridization band of p5CS transgenic plants tested by PCR and Southern blot hybridized with the DIG probe was obvious . It proved that exogenous gene p5CS is expressed at transcription level in transgenic plants .

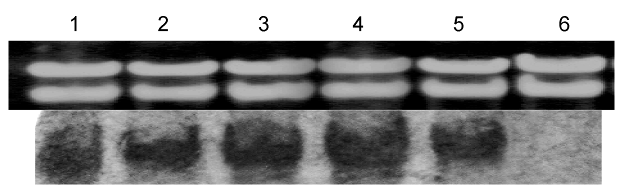

Figure 1 *5 Northern blotting of transgenic wheatgrass plant .*
1～5— transgenic plants ,6— negative control

Conclusions The p5CS catalyse the proline biosynthesis . Its activity , inhibited by proline content , p5CSF129A is a mutant wipe off feedback inhibition of p5CS and it led to a multiple increase of proline content , thus can enhance the protection of plant under osmotic stress . Now it has been transformed into many plant species as tobacco , rice , ryegrass and tall fescue to enhance the resistance to drought and salt . The results indicated that the exogenous gene p5CS was expressed at transcription level in transgenic plants .

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Monitoring of production in the steppes Pre-Caspian Area and open wood (non desert !) and forest of Turan (Middle Asia)

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Key words: Pre-Caspian, Turan, open wood, non desert

Introduction Turan is considered deserts without any reasoning. During 55 years I have studied the vegetation of steppes, mountains, and deserts from Algeria to China and in Central America. I studied the processes of succession, the structure of coenoses, the productivity, of superstructures I (trunks, branches, green organs) and roots, the ecological and biological properties of plants, their biochemistry, the contents of macro-and microelements of 200 dominants in various regions.

Materials and methods In various countries I created experimental plots of 2-10 hectares and compared the dynamics of vegetation, crops, etc. on fenced and unfenced plots (a fence prevents a plot from being grazed). These and other studies of mine brought me to revisiting the adopted concept that Middle Asia is desert, which turned out to be wrong. Deserts occupy only a small area in Middle Asia to the south of the Aral (80-100 mm of precipitation), 41-44 degrees L.N., 57-62 degrees L.E.

Results I arrived at the conclusion that in Kara-Kum and Kysyl-Kum (150-190 mm of precipitation per year) specific types of vegetation prevail rather than desert ones: highly xerophilous open woods with white saxaul (ass. Haloxylon persicum). All superstructural phytomass is 2-2.9 tons/hectare (dry), green mass of Hal.pers. is 0.3-0.6 and that of shrubs is 0.2, sedge (Carex physodes) is 0,15 tons/hectare (dry). The structure of Hal.pers plus shrubs occupies 25-30% of the area, with carex growing among them, which. creates a layer of rhizomes 30 cm thick with a mass of 8,3 tons/hectare (dry). In lowlands with the level of subterranean waters 8-12 m black saxauls (ass.Haloxylon ammodendron = H.aphylla) is well dispersed. After cutting down, with demutation they become sparse (xeroph. open woods) [with shrubs and sedge (Carex)]; however/at the phase of climax they become arid woods, the tops of black saxaul (Hal.amm.) taking 90-100%. At the climax phase the production of trunks and roots of Halox.amm. is 105 tons/hectare (dry), and that of green organs is 4.3-4.6 tons/hectare (dry), that of Ammodendron argenteum is 4.2 tons/hectare (dry) near the lake Aral. This is much more than the mass of leaves in the woods of Europe, where it is 2.1-3.2 for oak trees, 2.8-3.3 for conifers, and 2.9-3.7 tons/hectare for pines (dry). In the Sahara deserts the green mass is 0.001-0.03, and in Goby it is 0.01-0.2 tons/hectare (dry).

Conclusions I consider that xerophilous open woods with trees Haloxylon amm., H.pers., Ammodendron con., Amm.argent. and others and with shrubs in Turan represent extreme arid chains of a specific type of vegetation-sparse woods in ecological series which go from subhumid sparse woods in mountains. Therefore, high productivity, complete density in superstructural and underground spheres, stability of coenoses—all this demonstrate absence of deserts in Turan (except for a small spot) and presence of specific xerophilous open woods and thick arid woods.

However, even absinthes (Artemis) decreased substantially in 10 years—they were replaced by uneatable plants-spurges Euphorbian Ceratocarpus arenaria, then Peganum harmala and others. Certain researchers defended the concept that absinthes of Seriphidium belong in deserts, that absinthes are typically desert kind of plants. This severe error is based on absence of studies of successions, so a border line of deserts was drawn up to Volgograd and to the north, up to latitude 52° North in these deserts" (Artemisia) observe 300-450 mm of precipitation per year, hay stations produce hay on hundreds thousands of hectares, and somewhere wheat is cultivated without watering.

The adopted but erroneous statement (that Middle Asia is a desert) should be revisited in the light of existing data on high productivity, complete crown density of ceonoses, successions XKboth rehabilitative and digressive), etc. The geographic maps should be corrected, and the Pre-Caspian area and Northern Turan should be denoted as steppes (original, coming of Stipa, Agropyron, Helictotrichon, Koeleria, and secondary ones with Artemisia, Festuca, and others), and the Southern Turan (Kara-Kum) should be denoted xerophilous open woods rather than deserts.

Productivity in open wood on mountaine = 109 t/hec, in arid mountaine (rain 350 mm) prod. = 44 t/hec, in open wood of Kara-Kum prod. = 105 t/hec.

Descartes wrote: Refine your terms, and you'll get rid of errors". Kurochkina argues that there are no deserts in Turan (1995, IRC, USA).

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Grazing impacts on natural steppe community of eastern Mongolia

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Key words : Grassland , overgrazing , productivity , community , succession

Introduction Grasslands are estimated to cover 125 million hectares (ca 80%) of the total land area of Mongolia , and make up 2 .6% of the global grassland vegetation (World Resources Institute , 2003) . Currently about 122 million hectares of Mongolia is devoted to nomadic pastoralism , with 28% of which lying in the steppe zone . A primary cause of low and declining productivity is land degradation . Mongolian grasslands are partly overstocked , particularly in semiarid region of Mongolia . In order to prevent further degradation and rehabilitate degraded areas , it is necessary to study the impact of grazing on this grassland .

The present work (monitoring study) was done on the territory of Bayantumen sum in East Aimag , Mongolia in 2001-2003 and were compared the dynamics of productivity , species composition and vertical structure in vegetation with different levels of grazing pressure .

Materials and methods We chose two grasslands in the Kherlen river valley for our monitoring study . There used trancekt metod . Main criterions by which distinguished the vegetation into levels are : cover of dominated species in vegetation , mean height of plant , productivity and quality (ratio between the biomasses of palatable and unpalatable species) . (1) *Artemisia adamsii* overgrazed grassland is situated within the 5 km range from the Kherlen river were altitude is 764 m , plants are exposed to overgrazing , plant mean height is very low (approximately 6 cm) , vegetation cover is 10 .2% and very sparse , species richness is poor due to permanent grazing of livestock . There dominated by woody or unpalatable by livestock or steady to grazing species such as *Artemisia adamsii , A . frigida , A . scoparia* . (2) *Stipa* light grazed as control grassland is situated within 15 km range from the Kherlen river , were plants are exposed to very light grazing , plant mean height is 45 cm , vegetation cover 62% , species richness is very high , in are dominated by Stipa grandis , S .krylovii .

Study results We conducted vegetation surveys on grassland sites in steppe zone that were subjected to different livestock grazing intensities in eastern Mongolia . In this paper representing light and overgrazing were situated 5 and 15 km from the Kherlen River . The main characteristics of vegetation such as vertical structure , species composition , vegetation cover and productivity were measured and analyzed in relation to two levels of grazing pressure . We found that the total biomass decreased and the proportion of woody plants increased with increasing grazing pressure compared with Light grazing . The lightly grazed grassland exhibited high heterogeneity , the highest species diversity and richness and a high productivity due to occurrence of *Stipa* , whereas the overgrazed grassland exhibited low species diversity and a higher occurrence of *Artemisia adamsii* of poor feed quality . Based on study , we suggest immediate and full protection of the overly grazing grasslands until the vegetation was restored to a healthy state . It is necessary to implement a strategy of rotating between rests and to prevent the grasslands from further degradation .

Conclusions The features of grassland community is closely related with the grazing pressure .
Under overgazing of livestock the *Stipa* steppe community was replaced by *Artemisia adamsii* dominated community and overgrazing leds to the reduction of productivity and it's quality .
To prevent further degradation necessary to rest and rotate the vegetations on the light grazing and on overgrazing necessary fence to exclusive from livestock for their restoration to original vegetation conditions

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The study on growth and yield changes dynamic laws of Xinjiang small Reed (Phragmites australis)

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Key words : Reed , growth and developing period , leave number , cutting height , cutting period

Introduction Reed(Phragmites australis (Cav .) Trin .ex Steud) is most Important natural growing grass in Xinjiang grasslands and animal husbandry production . It has important functions to protect and improving ecosystem ,to fully utilize low , damping and salty area . Engaging in experiment on the reed land formed naturally , distinguishing its excellent plant height , leaf number , cutting in different growing period and different cutting high etc . , provided scientific basis for effective using , and achieve better economic results at the animal husbandry production .

Materials and methods The experiment field is choosing at side of the rice field . test design is used as split-plot design , main plot is designed cutting in different growing period , respectively at heading stage , flower stage , fructicative stage and mature to yellowing stage , 3 times , in each period , and plot area is 20m^2 . Main plot is dividing into 4 equal parts as split plot . Split plot is designed cutting height in 0cm , 5cm 10cm and 15cm , 3 times . Split plot area is 5m^2 . Observing growing and developing period is standardized as 50% plant into that period , and measuring length between nodes by selecting the longest on the stem ; counting leaf number by selecting middle length stems , and calculating main data from 20 observed stems number . Measuring dry wet ratio and leaf stem ratio is done on the 500g wet grass drained in the lab .

Results The test result shows that from regrowing to ear , reeds growing speedily , and the variation of length of knot are large , particularly new shaped nodes , after earing , it becomes to slower . From the regreening , the reed leave number is increasing in different degrees . After flowering , its leaf numbers is not increasing . When turned to yellow , some leaves on the lower part of stem are defoliated , so its number decreases . Each plot production has some differences because of reeds growth . If it is growing in moist condition and thicknesses are enough , hay produced is much increased . To compare main yield of each growing period and different cutting height , mostly the high yield cutting is at fructifcative period , cutting at flower period is second , and then is cutting at ear stage . Cutting at mature to yellow is reducing in the yield . To comparing effects of different cutting height with yield , the cutting height at 0cm is significantly high . Other cutting height .in proper order is 5cm , 10cm and 15cm .Through variance analyzing make known that , it has significantly variability between different cuttings height 0cm 5cm and 10cm 15cm . There is no significantly variability between other treat methods . Comparing dry wet ratio , in birthing nodes has less dry hay percentages , in the ear is higher , and at fructicative stage is mostly high . Comparing leaf-stem ratio , in birthing nodes cutting at 0cm height is the highest rate ; in proper order is 5cm , 10cm , 15cm . leaf components higher than stem between 2 .36～2 .52times . In the ear , it is no significantly variation among all the different cutting height , average leaf-stem ratio is 209 .59% , leaf components are more than twice the stem .at the flower period , their ratio is about 1 .4 :1 . At the fructicative and mature to yellow period , their ratio are almost the same .

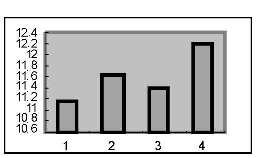

Figure 1 *Measuring result length of a knot* .

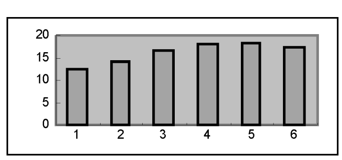

Figure 2 *Measuring result of leaf number variation in different growing period* .

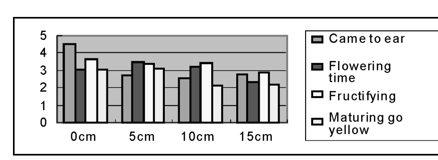

Figure 3 *Measuring yield result of different cutting height* .

Conclusions According to the different length of a knot and leaf numbers variation is in different growing period , before the ear period is reed growth very fast , it has very big variation between length of a knot and average leaf number on per stem , especially during birthing new nodes . Hereafter , nodes number has almost shaped , so there are no more changes about them . There are 16～23 leaves average on each stem . Based on reed productivity cutting in different growing period and different cutting height , any times are good for harvesting after ear stage , and there is no significant variation among them . However , there are many leaves defoliate after turned to yellow , thus to consider the regrowth hay yield and nutritious changing among the components , it is better cutting at the heady period .

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Impact of grazing on vegetation of *Artemisia*—annuals rangelands in semi desert of Uzbekistan

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Key words: grazing, rangelands, semi desert, sagebrush, livestock.

Introduction Grazing pressure is the most important factor impinging plant community composition and biomass in natural grasslands. Excessive stocking is the main reason for rangeland degradation worldwide.
The semi desert foothills region of Uzbekistan covers about 4 million hectares (Gaevskaya et al. 1975). This region is the most densely populated area of the arid zone of Uzbekistan. Karakul sheep husbandry is the most important livestock production sector in this region. The objective of our study is to measure the impact of grazing on plant community composition and productivity of the dominating *Artemisia* communities. The research focuses on the effects of grazing on plant productivity, floristic composition and the determination of stages of rangeland degradation as a result of overgrazing around settlements and wells.

Material and methods Field studies were carried out on *Artemisia*-annual sites of the Karnabchul semi-desert. The Karnab study site represents the sagebrush-ephemeroid arid rangelands of the foothills of Central Asia and located about 150 km NWW of Samarkand. An annual average air temperature of 14.6 C and precipitation of 169 mm characterize the macroclimate of the sagebrush-ephemeroidal semi-desert at Karnab. The annual distribution of precipitation is characterized by a maximum of precipitation in winter and spring, followed by drought during June-October. The soil is classified as loamy serozem with an occasional gypsum horizon in the soil profile (Saliendra et al. 2004).
Two study sites are located near the settlement of Tim; the third study site is located around a well near the village Tutli, 50 km from other two sites. The dominant species at all sites is sagebrush (*Artemisia diffusa H. Krasch. ex P. Pol.*), while the herbaceous layer is dominated by *Poa bulbosa* and *Carex pachystylis*. *Peganum harmala* is dominant on degraded sites. Vegetation was sampled along a grazing gradient extending from settlements or wells. Biomass production, density, cover and plant composition were measured.

Results and discussions Significantly high grazing pressure was observed in the site around the well. *P. harmala* was found as an indicator plant of degraded rangelands as a result of high grazing pressure. Along the grazing gradient, distinct stages of succession could be identified. Plant population density of *P. harmala* with amount of 13000 per hectare had full dominance in plant composition in the area of 1 km from the well. The value of density with 233 per/ha was decreased in the distance areas as a result of moderate grazing. Plant productivity confirmed the density values and ranged from 892 kg/ha to 25 kg/ha during spring season. Biomass production of *A. diffusa* on the sites most distant to settlement was 132 kg/ha, whereas closer to villages, under high grazing pressure, plant productivity decreased to 95 kg/ha. Major and consistent changes in plant community composition were observed.

Conclusions Livestock grazing heavily impacts the natural rangelands of arid zones around settlements and wells. We conclude that grazing intensity is the most important factor shaping productivity and plant community composition on the Karnabchul *Artemisia*-annuals sites. There is no evidence for the presence of a non-equilibrium plant community dynamics in this system.

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Changes on seed bank composition of Flooding Pampa rangeland by the use of glyphosate

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Key words: temperate grasslands, rangeland deteroration, herbicide use

Introduction To increase winter forage production of native rangelands of Flooding Pampa, a technique based on spraying glyphosate herbicide in late summer has been widespread during the last decade in this region. Glyphosate eliminates green vegetation growing in late summer, improving germination and establishment of cool season (C_3) annual grasses, that enhaces winter forage and meat production. We postulate that annually application of glyphosate would reduce the seed bank of species that vegetate during summer, like perennial grasses and legumes, decreasing floristic diversity and deteriorating the rangeland.

Materials and methods In a commercial farm located in the Flooding Pampa region, we selected 13 paddocks dominated by native rangeland (30-120 ha each) and used for cow-calves operation. Five paddocks have never been treated with glyphosate and other 8 paddocks have been treated with glyphosate in late summer from the last 5 years consecutively. During the warm season (November 2006-February 2007) 3 soil samples ($17\times13\times10$ cm.) of each paddock were extracted and put in plastic pots. The pots were watered periodically to register emerging seedlings until no more germination was observed. Each seedling was identified by genus and species and afterward were gathered in functional groups (Jacobo et al., 2006). Kruskal-Wallis test by ranks was used.

Results and discussion Seed bank of C_3 annual grasses (*Lolium multiflorum*, *Bromus unioloides*) in glyphosate-treated paddocks was significantly higher than that of non-treated ones (Figure 1), showing the effectiveness of glyphosate application to improve winter forage offer. Nevertheless, glyphosate application significantly reduced seed bank of sedges, warm season legumes (such as *Lotus glabe,r*) and C_4 tussock grasses (such as *Paspalum dilatatum*) (Figure 1). This may be related to the interruption of seed formation dispersal when this systemic herbicide is applied in late summer. The higher seed bank of C_4 creeping grasses in glyphosate-treated paddocks (Figure 1) is consistent with the higher tolerance of *Cynodon dactylon*, the main species of this functional group, to the herbicide. Species richness was significantly lower in glyphosate-treated paddocks respect to non-treated ones (8,75 vs. 12,67, $p<0.01$), suggesting the lost of several seeds species form the rangeland seed bank when the technique is applied.

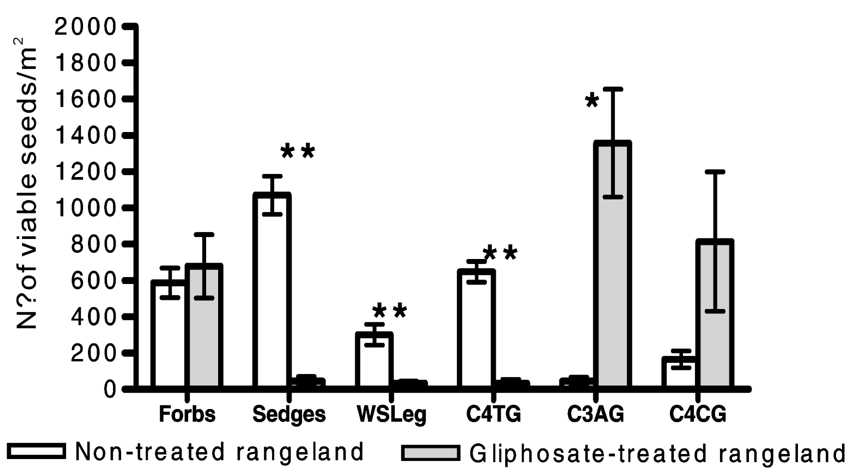

Figure 1 *Number of viable seeds/m2 gathered by functional groups: WSLeg: warm season legumes; C4TG: C_4 tussock grasses; C4CG: C_4creeping grasses; C3AG: C_3 annual grasses.* ** *$p<0.01$* * *$p<0.05$.*

Conclusion The technique of spraying glyphosate in late summer changes seed bank composition of rangelands of Flooding Pampa and reduces seed availability of valuable forage species, leading to deterioration of this resource.

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Investigation of LFA model application for determination rangeland's function in exclude and open range in Hamadan province , Iran

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Key words : landscape function analysis , soil surface characteristics , exclusion , grazing , functional attributes .

Introduction Soil indicators are the main index to recognize the function of natural ecosystems , and to evaluate their potentials . Landscape function analysis (LFA) method was used to evaluate management effects on soil surface characteristics and rangeland functional attributes (Tongway , D J . , Hindley , N . , 2004) .

Material and methods In this method for determination of three functional attributes of stability , infiltration and nutrient cycling 11 soil surface indicators were considered (Tongway , Dat al 1989) . They are soil surface cover (soil protection from erosion) , perennial canopy/basal cover , litter (cover , origin , degree of decomposition) , cryptogam cover , crust brokenness , type and severity of erosion , deposited material , soil surface roughness , soil surface resistance to distribution , slake test (soil stability test) and texture were used . Based on results land cultivation reduced functional attributes .

Results By increasing grazing intensity in open rangelands leave out palatable species and dominate annual in heavy grazing area . Vegetation and soil surface layer degradation increased soil erosion , created gully and reduced functional attributes . In relict excludes area because of reestablishing homogenous annuals , soil indicators and functional attribute were improved . by increasing grazing intensity , perennial vegetation cover and soil surface resistance reduced . Also in open rangeland breaking soil crust created bare soil .

Table 1 *Comparison among stability Index in exclude and open grazing treat .*

index	P value
Litter Cover (simple)	0 .076^{ns}
Cryptogam cover	0 .001*
Crust broken-ness	0*
Erosion type & severity	0 .046*
Deposited materials	0 .004*
Surface resist . to disturb .	0 .014*
Slake test	0 .011*
Litter Cover (simple)	0 .008*

^{ns} : insignificant * :significant(0 .05)
** : significant (0 .01)

Table 2 *Comparison stability index in exclude and open grazing treat .*

index	P value
Per . basal / canopy cover	0 .011*
Litter cover , orig & incorp .	0 .892^{ns}
Soil surface roughness	0 .046*
Slake test	0 .011*
Texture	0*
Surface resist . to disturb .	0 .107^{ns}

Table 3 *Comparison am stability in exclude and open grazing treat .*

index	P value
Per . basal / canopy cover	0 .011*
Litter cover , orig & incorp .	0 .684^{ns}
Cryptogam cover	0*
Soil surface roughness	0 .019*

Conclusion Finally rill , terraces and pedestal erosions increased we found that LFA method able to show changes of management effect at last consumption a few money and time shows the capability of this method .

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Irish grasslands 2010 : a sustainable environment ?

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Introduction Irish agriculture is currently undergoing rapid changes in response to new economic and environmental drivers of change . These drivers offer both challenges and opportunities . A holistic approach to the new economic and environmental climate is required to avail of these opportunities and address these challenges . The objective of this study was to review the economic and environmental drivers of change and identify knowledge gaps that must be addressed in order to derive such an integrated approach .

Economic drivers Currently , under Cross-Compliance , the Single Farm Payment requires compliance with current environmental legislation . However , following WTO reforms , in the long term direct income support can only be sustained as compensation for public goods , such as environmental services , over and above legislative requirements .
Following EU Common Agricultural Policy (CAP) and World Trade Organisation (WTO) reforms and the abolition of milk quotas , agricultural production is increasingly market driven , with increases in milk prices and the abolition of milk quotas expected to favour intensification in productive agricultural areas , based on low-cost , grazed grass system with extended grazing .
Dramatic worldwide increases in grain prices , fuelled by demand for bio-fuel , are presenting opportunities for tillage farmers , but challenges for livestock farmers reliant on cereals .

Environmental drivers The Nitrates Directive (ND) was implemented last year (S .I . 06/378) , aimed at reducing the risk of loss of nutrients to groundwater and surface waters . The Nitrates Directive is now superseded by the Water Framework Directive (WFD) , which demands good quality status" of all water bodies by 2015 . Most of the challenges posed by the WFD have been anticipated in the ND , though the economic drive to extended grazing may continue to pose local challenges to groundwater . At societal level , drinking water is an increasingly scarce commodity ; with the construction of a pipeline from the Shannon to Dublin , agricultural areas are expected to play a key role in providing this public service , with requirements over and above current legislation .
Before the ND , reduction of risk of nutrient loss to water , along with the protection of existing biodiversity and farm habitats , was one of the main objectives of the Rural Environment Protection Scheme (REPS) . Now that protection of water quality is required on all farms under the ND , REPS payments can only be sustained for environmental services over and above the requirements set by Cross-Compliance . Therefore , REPS4 payments are aimed at *enhancing* biodiversity on farms . Recent willingness-to-pay" studies show significant public monetary support for such measures .

The impending Soil Framework Directive (SFD) places soils on an equal footing with air and water , and requires abatement strategies for 7 threats to soil quality . For Ireland , compaction , loss of organic matter and contamination have been identified as the most relevant threats to agricultural soils . We have identified two types of abatement strategies : 1) prevent deterioration of soil quality and ensure compliance with legislative requirements , e .g . prevention of contamination , and 2) improve soil quality , which in most cases is expected to be synergistic with productivity , such as reductions in compaction and loss of organic matter .
The current debate on greenhouse gas (GHG) emissions and the Kyoto protocol are significant drivers of change : with Irish agriculture accounting for 30% of national GHG emissions and 5% of GDP , it is potentially an easy target for reductions in GHG quota . However , GHG emissions from the agricultural sector have in fact declined since baseline 1990 levels , and can not be held responsible for the large increase in national GHG emissions , well above Kyoto targets . Any further reductions in GHG emissions from agriculture should therefore be considered as environmental services to other sectors of society . Future GHG emissions are difficult to predict : while the projected increase in dairy production may add to methane and nitrous oxide emissions , this may be easily offset by planting of farm-forestry , with a government target of 1% of farmland planted per annum .

Conclusions In summary , we have identified three types of environmental drivers : 1) halt deterioration of environmental quality (EQ) ; 2) improve EQ in synergy with productivity ; 3) improve EQ as a service to other sectors of society .
So far , policies such as the Nitrates Directive , Cross-Compliance and REPS3 merely required a halt to deterioration of the aquatic and biotic environments and compliance with relevant legislation . Such legislative compliance alone can no longer be rewarded by income support .
Most of the new policies , e .g . REPS4 , SFD , WFD and Kyoto are now aimed at actually improving EQ . In cases where these measures are synergistic with productivity , e .g . reduction of compaction , these are of direct interest to farmers . However , in cases where these measures are aimed at either servicing (e .g . WFD) or compensating for (e .g . Kyoto) other sectors of society , this provision of additional public environmental services should be recognised in monetary terms , which we expect to positively incentivise and facilitate an integrated approach to agricultural land use and environmental quality .

Forests , steppes and grasslands in Morocco : diversity , ecological importance and socio-economic role

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Key words : Morocco , flora , forest , steppes , grasslands , diversity .

Abstract Forests , steppes and grassland in Morocco : Diversity , ecological importance and socio-economic role . With its geographical situation (crossroads between Europe and Africa , Mediterranean Sea and Atlantic Ocean) , with the diversity of its climate and habitats , Morocco shelters a particularly varied natural vegetation by its structure and aspect , as well as by the diversity of the species . The floristic richness of the country is related to the biotopes heterogeneity . From the desert to the high mountains and the littoral to the most continental borders , Morocco offers very varied ecological conditions which allowed installation of various stocks species .
The main vegetal formations are forests , matorrals , steppes , lawns and grasslands . Forests cover approximately 5 million hectares , followed by steppes of *Stipa tenacissima* , with nearly 3 millions hectares .

Forest

Steppe

Grassland

Moroccan vascular flora counts about 4 500 species and subspecies distributed among 930 genera and 130 families . Rare , threatened and/or endemic flora represents a significant part : 951 are endemics , 463 rares , 1284 threatened and 36 vulnerable .

Biogeographic analysis shows that the Moroccan flora is mainly mediterranean , enriched by taxa from the North (holarctic elements) , the South (tropical or Saharan elements) , the East (irano-touranian elements) or the West (macaronesian elements) .

Effect of water stress and rehydration on the physiological and biochemical indices of alfalfa

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Key words: water stress; physiological and biochemical characters; *Medicago sativa*

Introduction Alfalfa (*Medicago sativa* L.), which has high adaptability, a well developed root system, and high yields, is often called the king of forage crops" (Bai *et al*., 2003). The goal of this study was to gain insight into the physiological and biochemical responses of alfalfa to prolonged water deficit and rehydration.

Materials and methods Three varieties of alfalfa, WL323, Aohan, and Lumu NO.1, were planted in plastic pots (made from 32 cm lengths of 25 cm diameter plastic). The percentage of relative water content (RWC) of soil in pots was maintained at 75% (the control), 60% (light water stress), 45% (moderate water stress) and 35% (heavy water stress). Treatments were replicated three times. Plants were grown in stress for 25 days and then rehydrated. Plants were sampled once after five days of rehydration. Free proline, osmotic potential, SOD and POD activity of alfalfa leaves were measured (Li, *et al*., 2000).

Results The content of proline in three alfalfa varieties increased at the beginning, and then decreased after a maximum on the 20th day of water stress. The rates of change of proline content in Aohan and Lumu NO.1 alfalfa were greater than WL323. Content of proline decreased after 5 days rehydration. The osmotic potential of three alfalfa varieties decreased with the increase in water stress, but increased after 25 days of stress. After rehydration, OP in all the treatments recovered well except for WL323 and Aohan alfalfa with heavy treatment. SOD and POD activity in three alfalfa varieties changed similarly increasing with increasing water stress. With stress, SOD activity increased gradually and was maximum on the 25th day. The rate of change of POD activity in Aohan alfalfa was greater than others, and WL323 was the least, and Lumu NO.1 was intermediate. SOD and POD activity decreased after rehydration (Figure 1).

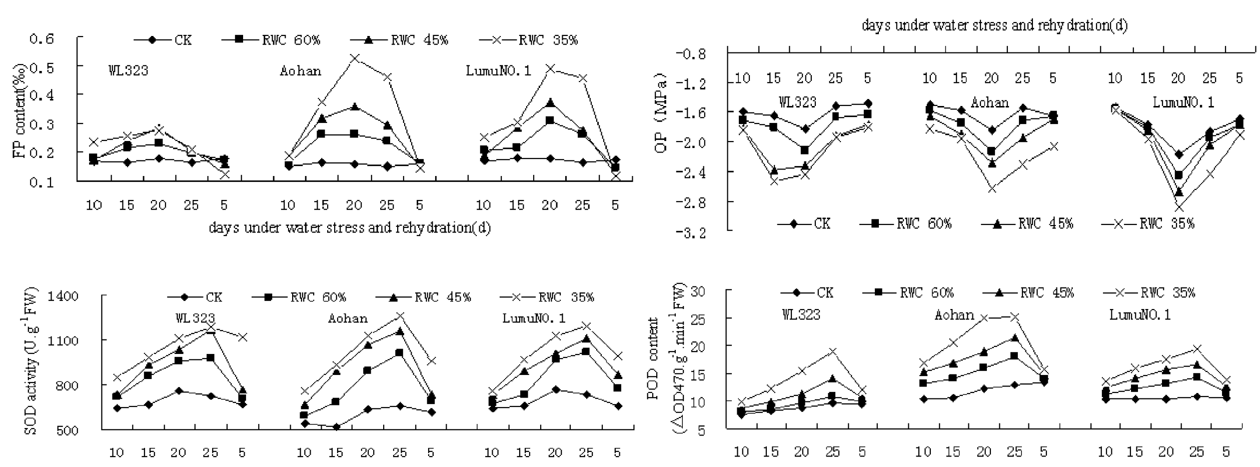

Figure 1 *Effect of water stress and rehydration on free proline, osmotic potential, SOD and POD activity in alfalfa leaves.*

Conclusions Data in this study show the differential antioxidative responses among three alfalfa varieties, which had high levels of an antioxidative enzyme system and free proline accumulation. In conclusion, selection of alfalfa varieties with genetic traits like antioxidants and proline accumulation might be useful in assessing the adaptive responses of alfalfa to water stress.

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Effect of topography on utilization from mountain rangelands of Mazandaran Province —case study : rangelands of Babolrood Basin , IR-Iran

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Key points In mountain rangelands , due to topographic variations , animal grazing in whole areas is not equally distributed . Based on dissemination of grazed animal in range lands is more influenced by topography . This factor is affecting to the percentage of utilization . After study of aerial photography and topographical map , and field surveying the requirement maps was created . In order to suitable tools , selection of grazing distribution in mountain rangelands was investigated by topographical impact on vegetation . In order to determine relation between percentage of utilization and topographic factors correlation and multiple regressions was used . Result shows that slope was the most effective on the utilization factor and aspect was less effect to utilization .

Key words : Topography , Animal Distribution , Utilization , Stepwise Regression Method

Introduction In mountain rangeland percentage of utilization is affected by topography , stage of plant growth and distribution of water . Therefore , mixed use of parameters is usually the most effective way to grazing management . In order to choose of suitable instrument , on grazing distribution in mountain rangeland evaluate of topography effect on percentage utilization is necessary . Type of vegetation , relief , season and kind and age of animal's effect on utilization was studied (Mesdaghi , 2000 , Gholami , 2004 , Delcurto et al . , 2005) and showed that the topography is one of the most important factors that affected to the distribution of animals to use of plants , as extremely slops and mountains are inhibited to animal grazing . The objective of this study was to determine topographic effective factors on non-homogenic grazing distribution of Babolrood watershed at the Mazandaran province that utilization of animal is uncorrected .

Materials and methods The study area was located in Babolrood Basin at the Mazandaran province of IR-Iran . After survey of map topography and the aerial photograph of study area overlaid and with finding field operation slope , high stratum and vegetation map were provided . Pay attention to coral five utilization unite that view of topography , kind of animal and type of vegetation were homogenic chosen in each of utilization unit with use of high to weight method , the percentage of utilization were measured . Comparison of means was done by LSD method ($p < 0.05$) and table of matrix simple correlation was computed .

Results and discussion Matrix correlation of different variables at five utilization units showed that , in utilization units of first , second and fourth , greatest correlation value was found between utilization percentages and slope . The final results showed that a regression model in fourth unit was the best (Table 1)

Table 1 *Regression characteristics of the best model .*

Dependent variable	Independent variables	R^2	Regression equation
UT Unit 4	Slope , height and interaction of slope & height	0 .97	$Y = 102.0 - 0.60X_1 - 0.01X_3 - 2.60X_1X_3$

The result of this study showed that in the amount of topographical factors , the slope was highest affected on utilization factor . Relationship between slope and utilization was inversely , when slope increased the utilization decreased . This is due to decrease of animal activity and movement in sharp slopes . Height factor was less effective on the amount of unitization . This was probably due to chief effect to the other parameters of plants . Some research in Haraz basin in the North of Iran showed that with increasing of height and UV ray and decreasing of temperature , was decreased plant diversity and grazing intensity (eg . , Ebrahimi , 2003) .

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Yield and quality of whipgrass mixed with different levels of White Clover

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Key words : Hemarthria compressa ;Trifolium repens *L . ; Overseeding ratio ; Yield ; Quality*

Introduction Development of grass legume pastures is one of the recognized strategies in many countries for enhancing both the quantity and quality of feed resources . Forage quality and seasonal distribution of biomass of grass legume pastures have proved superior to those of grasses or legumes alone . Therefore , this study assessed the effect of different mixture of white clover (*Trifolium repens* cv . Chuanyin Ladino) levels on seasonal yield , crude protein (CP) and neutral detergent fiber (NDF) of whipgrass (*Hemarthria compressa* cv . Guangyi) .

Materials and methods The forages were grown in the 2005 crop season in Agricultural Research Centre of Sichuan Agricultural University , Ya'an , Sichuan province , China . Whipgrass (WP) and white clover (WC) were selected and propagated using sprigs and seedlings , respectively . Treatments included three levels of white clover (25% , 50% and 75%) mixed with correspondent amount of whipgrass . Whipgrass and white clover alone were used as controls . The experiment was carried out in a randomized complete block design .

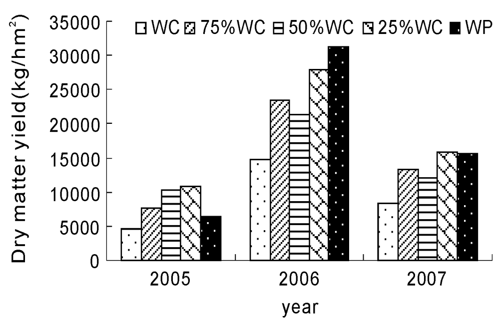

Figure 1 *The average of dry matter yield in 2005-2007 .*

Results The average dry matter (DM) yields of three years harvests were higher in the treatment of 75% WP-25% WC (yield 18217 kg/hm^2 DM) than the other treatments (14554 kg/hm^2 for 50% WC +50% WP , 14793 kg/hm^2 for75% WC+25% WP , 9 2 kg/hm^2 for WC only , 17813 kg/hm^2 for WP only) .The CP contents of the mixture increased as the proportions of white clover increased . Comparing to WP only , the total CP contents of the treatment of 75% WP-25% WC , 50% WC-50% WP and 75% WC-25% WP increased 26 .5% , 4 .6% and 11 .0% ,respectively ; whereas NDF content decreased 9 .6% , 10 .3% and 10 . 9% , respectively (Tab .1 , Figure 1) . Perennial tropical whipgrass mixed with three levels of white clover contributed to high pasture quality through increased CP contents and reduce NDF contents of the mixture . The advantage of prerennial legume white clover in the mixed whipgrass pasture is the higher protein value compared to whipgrass alone .

Table 1 *The content of CP and NDF of different treatments in 2005~2007 .*

treatments	CP(%)				NDF(%)			
	2005	2006	2007	average	2005	2006	2007	average
100% WC	18 .90	17 .50	18 .60	18 .33	30 .10	27 .00	28 .70	28 .60
75% WC+25% WP	14 .20	14 .50	15 .00	14 .57	37 .70	39 .60	36 .50	37 .93
50% WC +50% WP	13 .90	13 .90	14 .20	14 .00	38 .80	40 .00	36 .90	38 .57
25% WC+75% WP	13 .60	13 .30	13 .80	13 .57	39 .70	40 .70	37 .50	39 .30
100% WP	11 .30	10 .80	11 .00	11 .03	47 .60	52 .80	42 .70	47 .70

Conclusions The amount of white clover in the whipgrass-white clover mixture affected DM yield , CP and NDF characteristics . There was an increase in CP and reduction in NDF of whipgrass as the proportion of white clover in the mixture increased . All whipgrass-white clover mixture could supply the required nutrients for maintenance and production of livestock , 75% WC+ 25% WP provided best potential in nutrient management of hay cropping systems .

Studying physiological-morphological chanages of *Agropyron cristatum* against water deficiency

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Introduction Water is the principal constituent of plant cells, usually composing over 80% of the fresh weight of herbaceous plants. Water is the primary solvent in physiological processes by which gases, minerals, and other materials enter plant cells and by which these materials are translocated to various parts of the plant. Water is the substance in which processes such as photosynthesis and other biochemical reactions occur and a structural component of proteins and nucleic acids. Water is also essential for the maintenance of the rigidity of plant tissue and for cell enlargement and growth in plants (Brown 1995). During periods when rainfall is lower than evapotranspiration demand, a water deficiency exists. Under water deficiency conditions, the rate of water loss from transpiration exceeds the rate of water absorption by the roots, and plants undergo water stress. Water stress can vary from a small decrease in water potential to the lethal limit of dessication. Range plants have mechanisms that help reduce damage from water stress. This research focuses on mechanisms (changes) of *Agropyron cristatum* when facing water stress.

Materials and methods The study was carried out at the greenhouse condition. Under study species was *Agropyron cristatum* from Gramineae family. The experimental plan was completely randomized design (CRD). The mentioned species seeds were planted in plastic pots with three irrigation treatments; 3 (control), 6 and 12 days intervals in four replications. During the study period wilting percentage and water potential were assessed. Shoot and root weight in addition to root:shoot ratio were measured at the end of study period. A Duncan Test was used to compare the means.

Results and discussion Results showed that wilting percentage of understudy species increased with increment of drought stress. Also, it was shown that 12 days irrigation treatment had the highest leaf water potential. Shoot dried weight of species decreased during the study, while root dried weight and root:shoot ratio increased. When plant encounters the drought stress, lessens the volume of the aerial part to reduce the amount of transpiration. But, at the same time expands the root system to absorb water from depths of soil. In this case the volume of root might be ten times more than what is in wet condition (Larcher 1995). The studies of Saeedian (1997), Sharifi Kashan (2000) and Jafari & Firouzabadi (2001) showed that the growing up of stress causes the decrease in shoot dried weight and increase in root dried weight and root:shoot ratio.
Totally, abovementioned changes help *Agropyron cristatum* to tolerate watre stress successfully. Regarding this, mentioned species could be used in reclamation of semi arid rangelands with more confidence.

Table 1 *Comparison of understudy characteristics means using Duncan test ($P<0.05$).*

	Water potential (bar)	Shoot dry weight (gr)	Root dry weight (gr)	Shoot/root
3 days (control)	−21.5a	1.53a	0.76b	0.48c
6 days	−21.25a	0.95b	0.87b	0.92b
12 days	−16.5a	0.52c	1.25a	1.93a

Means within a column that have different capital letter are significantly different from each other.

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Study of environmental factors effects on vegetation , case study : Iran

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Abstract The distribution of plant species under environmental factors effects was examined in Veresk rangelands of Iran . Six vegetation types were recognized in the study area . Canopy cover percentage of plants in different types was estimated based on randomized-systematic vegetation sampling procedure within 1 m^2 quadrates . Soil sampling was performed from 0-30 and 30-60 cm depths . The characteristics of soil samples in addition to slope , aspect and elevation of quadrates locations were considered to test their relations with distribution of vegetation using multivariate analysis . The results showed that separation of understudy types was mainly affected by texture , gravel percentage , N , OM , pH , and Ec .

Key words : Vegetation , Environmental factors , Soil , Multivariate analysis

Introduction Interest in how various landscape components affect biotic and abiotic resources has grown over the past 2-3 decades (Brosofske *et al* , 2001) . The distribution and abundance of range species has been correlated with a variety of complex environmental gradients . Environmental factors affect range plant growth and need to be understood and considered by rangeland managers . Plant growth and development are controlled by internal regulators , which are modified according to environmental conditions . Of the most ecologically important environmental factors affecting rangeland plants growth and distribution are topography (slope , aspect , and elevation) and soil properties . Various studies have been done in this case (El-Sheikh and Yousef ,1981 ; de Blois *et al* , 2002) .

Materials and methods Based on field surveys , six vegetation types were identified at the study area . Fifteen 1 m^2 quadrats with 50 m distance from each other were established along each of four 200 m transects . Vegetative sampling method was randomized-systematic . Floristic composition and canopy cover percentage related to each quadrat was recorded . To examine the relationship of topography to vegetation , aspect , slope , and elevation of quadrats was recorded , too . Soil samples were taken from 0-30 and 30-60 cm depths . Texture , gravel percentage , pH , Ec , OM , N , CO_3^{2-} , and HCO_3^{2-} of soil samples in addition to slope , aspect and elevation of quadrates locations were considered to test their relations with distribution of vegetation using multivariate analysis (PCA technique) .

Results and discussion Results from PCA showed that PC1 and PC2 together accounted for approximately 73% of the total variance in data set . It was shown that the overriding factors of PC1 are gravel percentage , Ec , N , and OC in the first soil layer (0-30 cm) and gravel percentage , clay , silt , N , and OC in the second layer (30-60 cm) . It can be noted that PC2 is correlated to pH , sand and clay at depth 0-30 cm and sand at depth 30-60 cm . According to the correlations between site factors and components , it seems that PC1 represents soil characteristics of salinity and nutrient while PC2 is related to texture and pH properties . Results showed that different vegetation types show different relationships with understudy soil characteristics while no relationship was recognized between topography and vegetation types . According to small area of the study region (2650 ha) , topography changes is very tiny (aspect is steady , elevation ranges between 2050 and 2850 m a .s .l . , and slope 21%) , therefore no strong relationship was considered between topography and vegetation . It seems that the most effective factors on the occurrence and separation of vegetation in Veresk rangeland could be soil characteristics including texture , N , and OC . Soil texture controls distribution of plants by affecting moisture availability , ventilation and distribution of plant roots (Jafari *et al* . 2004) .The role of soil moisture , as a key element in the distribution of plants is described by El-Sheikh and Yousef (1981) . Soil organic carbon is an important determinant of soil fertility because of its impact on ion exchange capacities and its near-stoichiometric relationship to nitrogen . According to high cover percentage of different types and existence of livestock during grazing season , N and OC of study area soil is large which in turn , causes a noticeable positive correlation between most vegetation types and mentioned soil characteristics .

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Effect of frequency and time of cutting on the production of three strains of tropical forage legume *Aeschynomene americana* L. in drained paddy field and upland field

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Key words: cutting frequency, drained paddy field, dry matter production, tropical forage legume

Introduction In Japan the rice production control has been continuing since the 1970's, and some parts of the paddy fields are laid off into forage production. However, in the ill-drained fields or the fields with high ground water table forage species of higher wet endurance are required. Tropical forage legume *Aeschynomene americana* cv. Glenn has a high wet endurance (Bishop *et al*., 1985; Tobisa *et al*., 1999) and shows high dry matter productivity (Skerman *et al*., 1988; Tobisa *et al*., 1999). The objective of this experiment was to investigate the effects of two levels of cutting frequency and time on the dry matter productivity of *Aeschynomene americana* L. grown at both drained paddy field and upland field in southern area of Japan.

Materials and methods The experiment was conducted in the drained paddy field adjoining rice paddy field at the Kyushu University Farm. Three strains of *Aeschynomene americana* (cv. Glenn, Lee and CPI93556) were sown in spacing of 50 cm×15 cm on June 1. Two levels of cutting frequency were (1) two times cutting (the first cutting on August 19th, the second cutting on October 3rd) and (2) three times cutting (August 4th, September 4th, October 3rd). Two levels of the first cutting were (1) early time (August 3rd) and (2) late time (August 18th), followed by the second cutting on October 9th. Measurements were made for dry matter yield (DMY), *in vitro* dry matter digestibility (IVDMD) and crude protein (CP). Digestible dry matter yield (DDMY) and CP yield (CPY) were calculated.

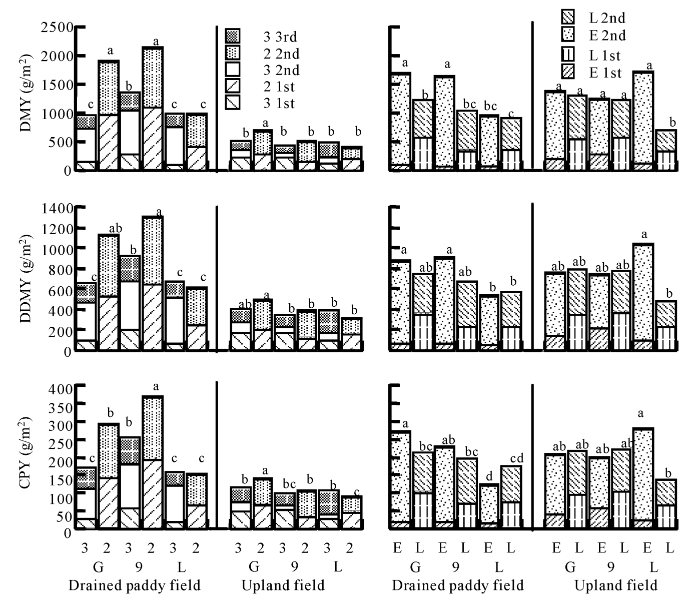

Figure 1 *Effect of frequency and time of cutting on the dry matter yield (DMY), digestible dry matter yield (DDMY) and crude protein yield (CPY) of Aeschynomene in drained paddy and upland fields.*
G: Glenn, 9: CPI93556, L: Lee, 3: three times cutting, 2: two times cutting, E: early time cutting, L: late time cutting.
The total values followed by different letters are significantly different at $P<0.05$.

Results Total DMY, DDMY and CPY for the two times cutting treatment of Glenn and 93556, annual forages, were higher than the three times cutting treatment in the drained paddy field and upland field (Figure 1). As for Lee, total DMY, DDMY and CPY in the drained paddy field did not show significant differences between the two treatments of cutting, but in the upland field they showed slightly higher values for the three times cutting. Total DMY, DDMY and CPY for the early time cutting treatment of Glenn and 93556 were higher than the late time cutting treatment in the drained paddy field, but in the upland field they showed similar values between the early and late time cutting treatments.

Conclusions The results of the present study suggested that Glenn and 93556 showed higher total DMY, DDMY and CPY at two times cutting and longer period of regrowth in the drained paddy field.

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Statistic of psammophyte in Otindag Sandy Land

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Key word : Otindag Sand Land, Psammophyte, Statistic, Plant resources, Dominant population

Introduction Otindag Sandy Land, located in the middle of Xinlin Gol Plateau, is the largest sandy land in dry steppe zone of China. Recently, a series of environmental problems such as activation of fixed dunes, desertification and sandstorms, has already aroused widely attention by the ecologist. psammophyte constitution, dominant population and initial plants were surveyed and analyzed in Otindag Sandy Land to understand it's psammophyte resources and to provide a foundation for vegetation recovering and ecological system protection in Otindag Sandy Land.

Materials and methods By the method of random sample, psammophyte in ZHENGLAN Banner, XIANGHUANG Banner, ZHENGXIANG BAI Banner of Otindag Sand Land was surveyed using GPS in august 2006 and 2007, especially in serious desertification area. Shrub sample was 10m×10m, Herbs, 1m×1m, In addition, reference was collected and Psammophyte resource was analysed with the guiding of botany theory.

Results Although psammophyte has 424 species out 1083 of Otindag Sandy Land, they distributed widely, can be find all over of this zone, It's made a key function to the whole ecological system of Otindag Sandy Land. The first ten families are *Compositaea*, *Gramineae*, *Rosaceae*, *Leguminosae*, *Cruciferae*, *Scrophulariaceae*, *Cyperaceae*, *Ranunculaceae*, *Labiatae*, *Chenopodiaceae*, and others 51 families have 87 genera, 167 species, respectively 37.84% and 39.39% of total. *Compositaea* and *Gramineae* have a very high number of plant species. *Compositaea* has 31 genera and 64 species, respectively 13.47% and 15.09% of total. Gramineae has 34 genera and 51 species, respectively 14.78% and 12.03%. Further survey indicated that there is lot of initial and dominant palnts witch always appear on zone of succession from moving dune to half-fixed sand. Initial plants included *Agriophyllum pungens*, *Corispermum candelabrum*, *Bassia dasyphylla*, *Artemisia scoparia* etc. Dominant plants included *A. intramongolica*, *Cleistogenes squarrosa* etc. And other species included *Thymus serpyllum Thalictrum sp. Potentiplla* spp., *Saposhnikovia divaricat* etc. Also the dominant population was surveyed, main species were *A. desertorum*, *Bassia dasyphylla*, *C. candelabrum*, *Setaria verticillata*, *Lappula myosotis* in sunny slope, formed *A. desertorum* + xerophytic herbosa communities. Arbors + lochmium formed in shady slope, main species were *Caragana micropyhlla*, *Spiraea aquilegifolia*, *Salix microstachya*, *Ulmus pumila* etc. There has less water in sand deposited slope and wind hollow, so it has simple vegetation, It formed *C. candelabrum*+ *Setaria verticillata* dominant communities in Sand deposited slope and formed *S. verticillata* + *C. candelabrum* + *A. intramongolica* dominant communities in wind hollow. *C. candelabrum* monodominant community(63%), other species less than 13% was formed in dune top (Chen Yufu, Dong Ming. 2002 The vegetation and soil space Patten and their relantionship in Eerduosi Acta Phytoecol. Sin. Journal, 26, 501-505.).

Conclusion and discussion Psammophyte of Otindag Sand Land has only 39.15% of total, but they widely deposited in the whole area, play an important role as initial, dominant plants. However its dimonant plant and population we know is not so complete, so we should make an efforts to study more.

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Molecular characterization of bermudagrass germplasm using sequence-related amplified polymorphism markers

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Keywords: SRAP, *Cynodon dactylon* (L.) Pers., cultivars, molecular characterization, UPGMA

Bermudagrass [*Cynodon dactylon* (L.) Pers.] germplasm has a broad resource of genetic diversity that can be used for turfgrass, forage and conservation. bermudagrass is widely distributed in world, but genetical information is lacking on DNA molecular variation in geographically disparate forms. Accordingly, this study was conducted to assess molecular genetic variation and genetic relatedness among thirty-five *C. dactylon* var. *dactylon* accessions and twenty-one public cultivars originating from 4 countries (China, Australia, USA and India). The objectives of this study were to use sequence-related amplified polymorphism (SRAP) markers in the evaluation of genetic diversity in a diverse collection of 56 bermudagrass germplasms. Thirty SRAP primer combinations were used. It is the first report of home and abroad bermudagrass germplasm resources relationship by using SRAP markers. Cluster analysis by the unweighted pair-group method with arithmetic averages (UPGMA) based on 268 (in total of 274) polymorphic bands indicated that there were six clusters (Figure 1). The coefficients of genetic distance among the genetypes ranged from 0.57 up to 0.97 and averaged 0.77. The genetic diversity estimate, *He*, average 0.27. Both Principal Coordinate Analysis (PCA) and UPGMA analysis indicated the similar results that the ecological varieties were clustered in different groups. The Australia cultivars, some USA cultivars, Xinjiang cultivars, and so on, were distinctly differentiated. This shows there is a wide genetic diversity among genotypes within *C. dactylon*. Ferriol et al. (2003) reported that the information obtained from SRAP markers was more concordant with the morphological variations and the evolutionary history of the morphotypes than that found with AFLP markers. The use of PCR-based technologies such as SRAP is an effective tool for estimating genetic diversity, identifying unique genotypes as new sources of alleles for enhancing turf characteristics, and for analyzing the evolutionary and historical development of cultivars at the genomic level in a bermudagrass breeding program.

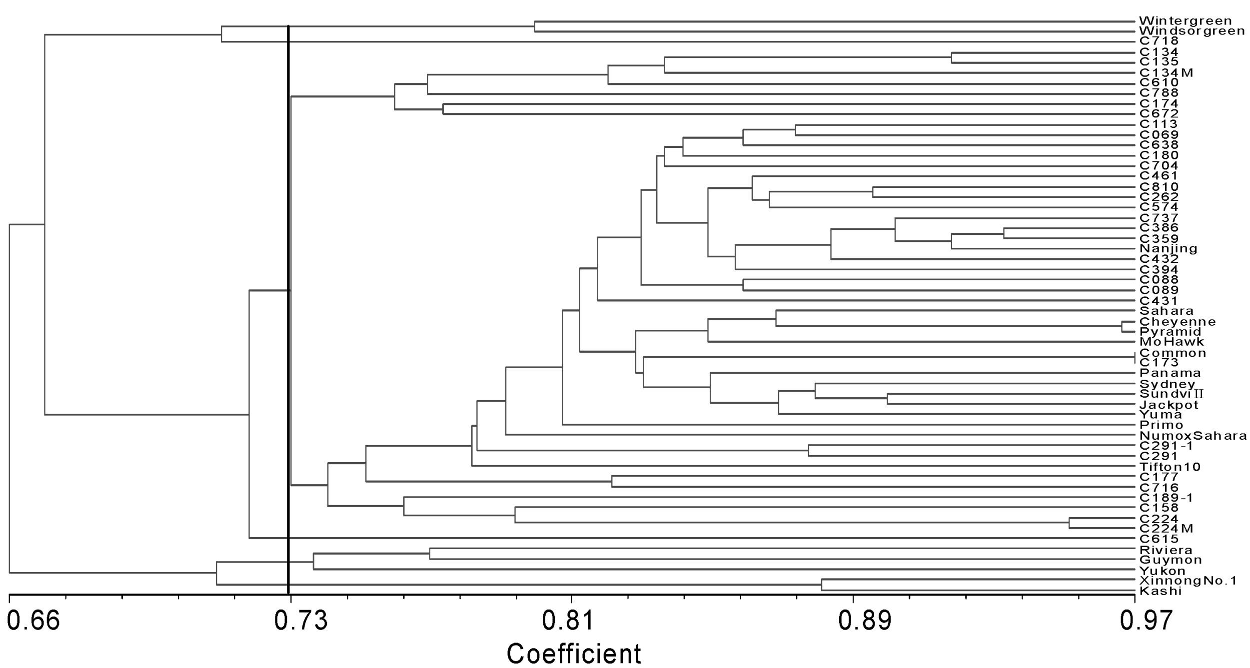

Figure 1 *Dendrogram of 56 Cynodon dactylon (L.) Pers. produced by UPGMA clustering method based on the genetic similarity matrix derived from 268 SRAP markers.*

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Comparison of the production performance between two populations of *lespedeza davurica*

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Key words :*Lespedeza davurica* ; Population ; Production performance ; Cultivation ; Domestication

Introduction *Lespedeza davurica* is important subshrub in Northern China . It is drought tolerant , warm season plants . It is grown for hay and pasture , soil improvement , erosion abatement , and benefit to wildlife (Delectis florae reipublicae popularis sinicae agendae academiae sinicae edita , 1995) . The purpose of this study was to compare production performance between two populations of *Lespedeza davurica* from Henan(HN) and Shanxi(SX) provenance in China .

Materials and methods Two population (HN and SX) of *Lespedeza davurica* were studied using randomized complete experimental design , and were sowed three replicates in plots in field without irrigation at Jinzhong of Shanxi . , Growing height of plants , length of main stem and yields were measured .

Results The *Lespedeza* population from Shanxi could grow well in the growth period and produce mature seed , but the growing season of the population from Henan is longer than that from Shanxi , 80 percent of seed matured when the plants were dead . There was the maximum growth speed from jointing stages to heading stage while the growth speed of slowed down from blooming stage . The height of plants and length of main stem of the population from Henan is higher than those from Shanxi at the bearing stage (Figure 1) . The yields (air-dry basis) was the highest at the bearing stage , 18730 .29kg/hm^2 and 10521 . 90kg/hm^2 from Henan and Shanxi , respectively (Figure 2) .

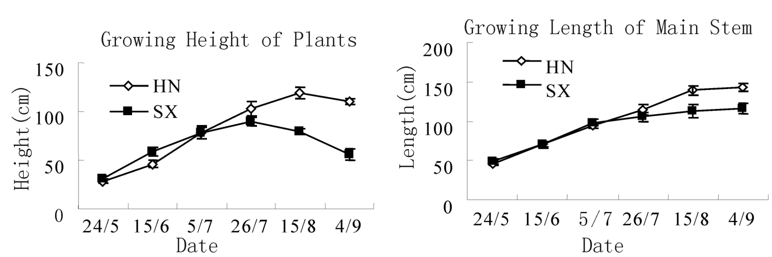

Figure 1 *Growing height of plants and length of main stem from different population of* Lespedeza davurica .

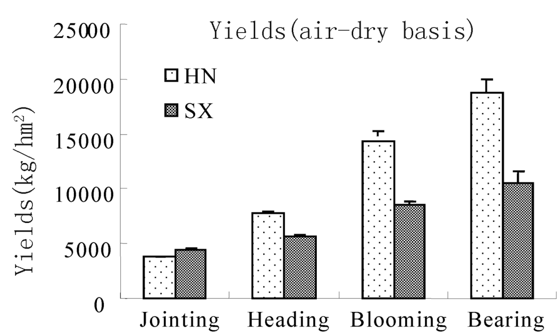

Figure 2 *Yield of* Lespedeza davurica *at different stages* .

Conclusions *Lespedeza davurica* from Henan is better than that from Shanxi based on height of plants , length of main stem , and yields . *Lespedeza davurica* from Henan is better than that from Shanxi as a forage with their erection and high yields . One from Shanxi is used for soil improvement and erosion control because the plants are slightly spreading on the ground .

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The effect factors on regeneration system of tissue culture using mature embryo of wheatgrass

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Key words : wheatgrass , genotype , tissue culture , mature embryo , ABA

Introduction It is the development trend that breeds new variety with good quality , high yield and multiresistance by transgenic technology in modern wheatgrass breeding . It is precondition of transgene that found a highly-effect and stabilized regeneration system for tissue culture . Through the experiment on tissue culture using mature embryo of differentials genotype wheatgrass to select excellent genotype of wheatgrass that was suitable for transform exogenous gene . The effect factors of callus induction and regenerated frequency were studied in the regeneration system .

Materials and methods The seeds of *A . cristatum* cv . Fairway(Fairway) , *A . desertorum* cv . Nordan(Nordan) , *A . mongolicum* Keng and *A .cristatum* × *A .desertorum* cv . Mengnong(Mengnong) were choosen to sterilize and embryos of them were embedded culture medium to induced the callus . Cultures were incubated in the dark at 26℃ for 14 days followed by a secondary culture for 20 days that repeated twice or thrice . Then the good callus was picked out and cultivate in differential medium in the light for 16 hours . The cultures were switched to enrooting medium until the seedlings could survive perfectly .

Results Effect of different genotype wheatgrass on inducing callus from mature embryo :All materials for experiment could be induced to form callus in same medium . The time on appearing and forming of callus were little different . But there were much different in inducing rate and morphology of callus among 4 materials . The percentage of callus induction for *A . mongolicum* Keng was higher 20% than others . The percentage of callus induction for Nordan was 67 .5% , lowest among 4 materials . In addition , the morphology of callus of *A . mongolicum* Keng . possessed compact and dense structure were best than others possessed soft and clearing structure (Table 1) .

Table 1 *Effect of different genotype wheatgrass on inducing callus from mature embryo .*

Varieties	Inoculate No .	Time of appearing callus(d)	Time of forming callus(d)	Callus No . (piece)	Percentage of callus induction (%)	morphology of callus
Fairway	400	4	10	307	76 .8	white ,soft ,water
Nordan	400	4	10	270	67 .5	white ,soft ,water
A . mongolicum Keng	400	3	8	380	95	White ,compact
Mengnong	400	3	9	296	74	white ,soft ,water

Differentiation and enrooting ability of callus from mature embryo for different genotype wheatgrass : There are remarkably different in percentage of differentiation callus from mature embryo among 4 materials . The seedlings were appeared after the inducted callus of *A . mongolicum* Keng switched to differentiation for 15 days , but to Mengnong and Fairway , its need 20 days . The seedlings were appeared after the inducted callus of Nordan switched to differentiation for 30 days . And the Differentiation percentage of callus of *A . mongolicum* Keng , Mengnong , Fairway and Nordan were 72% , 58% ,52% and 41% respectively . When the seedlings is 2-3cm , its were inoculated in enrooting medium . The roots of all materials could be growed and they were robust .

Effect of ABA on morphology and differentiation ability of callus from mature embryo of wheatgrass : The secondary culture was done in medium appended ABA . The result showed that ABA can improve the morphology of callus and enhance the differentiation ability on 4 materials . There were different effects to morphology of different callus by different ABA concentration . When ABA concentration was 0 .1mg/L , it was little effect to callus . But when the ABA concentration was 0 . 5mg/L , the quality of all callus was decline . The optimal ABA concentration was 0 .3 mg/L , it could improve the quality of callus evidently .

Conclusions The callus from mature embryo of *A . mongolicum* Keng was higher than others in the percentage of callus induction and differentiation callus . *A . mongolicum* Keng was a perfect host to transgene . The ABA (0 .3 mg/L) can remarkably improve the quality of callus .

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Ecological genetic study on flowering phenology in red clover

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Key words : red clover , SSR marker , flowering traits , local adaptation

Introduction Red clover (*Trifolium pratense* L .) is an important forage legume and adapted to a wide range of environments . Much genetic variability within this species has been characterized by genetic analyses using isozymes as well as DNA markers . In red clover , genetic linkage maps of some segregated populations were constructed with a few thousands DNA makers including SSR , EST , and RFLP . The purpose of our study is to clarify the mechanism of local adaptation of red clover populations . In this study , we focused flowering habit because red clover was thought to divide two ecological groups with different maturity in previous studies . We used SSR markers associated flowering time to assess genetic differentiation for flowering traits .

Materials and methods Three red clover cultivars ; Natsuyu , Corvus and Nordi were used in this study . Natsuyu and Corvus are early maturing cultivars bred at Japan and Switzerland , respectively , while Nordi is late maturing one bred at Norway . The experiment was carried out with 2×2 factorial design for each cultivar , with day length (14 hs or 18 hs) and vernalization (first mature leaf stage or second true leaf stage) as the factor . Each treatment was represented by 20 or 25 plants . The total of 90 plants of each cultivar were analyzed by eight SSR markers which was chosen from the public DNA databases (http ://www .clovergarden .jp/) and developed by K lliker *et al* . (2006) . All markers located at the vicinity of QTLs for flowering traits in individual linkage group (Harrmann *et al* . 2006) . Four SSR primer sets were used to detect polymorphism .

Results After 29 weeks from seedling , all plants in Natsuyu and Corvus were flowered , but almost plants of Nordi grown under 14 hs day length didn't flower . In all cultivars , flowering date was earlier 18h than 14h and vernalization at second true leaf than at first mature leaf (Table 1) . It indicated that day length is main factor of flowering in red clover ; while vernalization accelerates it , but not absolute factor . It confirmed five to eight alleles in each primer set (Table 2) . A difference among cultivars was observed for allelic frequency in each primer set . RCS0131 and RCS4430 loci showed different pattern of allelic frequency between early maturing and late ones .

Table 1 *Effect of day length and vernalization of flowering date in each cultivar .*

Leafage at vernalization	First mature leaf		Second true leaf		ANOVA		
	14h	18h	14h	18h	Day length(A)	Vernalization(B)	A×B
Natsuyu	53.3	46.8	43.9	37.0	* *	* *	ns
Corvus	53.5	47.6	38.6	33.2	* *	* *	ns
Nordi	—	76.06	—	64.28	—	ns	—

Table 2 *Allelic frequency was used in each cultivar .*

Locus	Cultivar	Allelic frequency Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ	Ⅷ
TPSSR16	Natsuyu	0.29	0.28	0.13	0.21	0.01	0.07	—	—
	Corvus	0.25	0.08	0.17	0.28	0.14	0.08	0.01	—
	Nordi	0.30	0.30	0.10	0.20	—	0.10	—	—
TPSSR23	Natsuyu	0.25	0.49	0.20	0.03	0.04	—	—	—
	Corvus	0.43	0.21	0.14	0.07	—	0.04	0.09	0.02
	Nordi	0.08	0.40	0.38	0.08	0.01	0.01	0.02	—
RCS0131	Natsuyu	0.26	0.28	0.17	—	0.13	0.16	—	—
	Corvus	0.23	0.23	0.16	0.06	0.08	0.13	0.09	0.02
	Nordi	0.17	0.17	0.33	0.03	0.10	—	0.10	0.10
RCS4430	Natsuyu	0.55	0.19	0.14	0.06	0.06	—	—	—
	Corvus	0.57	0.21	0.11	0.11	—	—	—	—
	Nordi	0.71	0.14	0.14	—	—	—	—	—

Conclusions Red clover had a wide range of variety of sensitively to day length and requirement for vernalization between and within cultivars . It was confirmed that different allelic frequency was observed among cultivars . SSR loci having different pattern of allelic frequency between early maturing and late ones could be useful in monitering population dynamics in red clover population to clarify the relationship between local adaptation and flowering phenology .

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Allelic share among two taxonomically related *Elymus* species , hexaploid *E . nutans* Griseb and tetraploid *E . burchan-buddae* (Nevski) Tzvelev

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Key words : *E . nutans* , *E . burchan-buddae* , ploidy , allelic frequency , genome , AFLP

Introduction Two taxonomically related *Elymus* species , *E . nutans* Griseb and *E . burchan-buddae* (Nevski) Tzvelev , are among the most abundant perennial grasses and widely distributed across the north western China . The two *Elymus* species are very similar in their morphology , although the important character that distinguishes them with certainty is chromosome number and genomic constitution (L ve , 1984) as *E . nutans* is hexaploid ($2n=6x=42$, StStYYHH) and *E . burchan-buddae* tetraploid ($2n=4x=28$, StStYY) . Effects of different ploidy genome on the plant genetics have been paid more attention . This study is to test the consanguinity between two *Elymus* species with different ploidy through shared AFLP (amplified fragment length polymorphisms) allelic frequencies , and induce the causal genome of .

Materials and methods Seed samples (30 seeds of each population used for DNA preparation) of fourteen populations of *Elymus nutans* Griseb ($2n=6x=42$, StStYYHH) and eight populations of *Elymus burchan-buddae* (Nevski) Tzvelev ($2n=4x=28$, StStYY) were collected from the Qinghai-Tibetan Plateau in Maqin County (N34°29′-34°33′ , E100°23′-100°31′ , altitude from 2800m to 4100 m) , Qinghai Province , China . Fluorescent AFLP was amplified using IRDye® Kit on the DNA sequencer LI-COR-4300 (LI-COR Biosciences Inc . , Lincoln , NE , USA) . We have used the Structure software (V .2 .1) described in detail by Falush et al .(2003) , which records the allele frequencies in a hypothetical ancestral" population .

Results and discussion

Above 5% probability of allele frequency as a criterion , 84 . 29% of all allele were shared by two different ploidy Elymus plants . The rest unshared were rarely found in tetraploid *E . burchan-buddae* , however the alleles shared were common detected in hexaploid *E . nutans* (Figure 1) . Comparing the allele frequency and base pair for two different ploidy *Elymus* species separately , it was found that hexaploid *E . nutans* with St , H and Y genomes had the 1 .45 times of alleles frequency and more bands of large size than those of tetraploid *E . burchan-buddae* with St and Y genomes . The results demonstrated that tetraploid *E . burchan-buddae* contained a few rare alleles and large bands that were commonly present in hexaploid *E . nutans* . A slightly higher allele number per locus and frequency had been detected in hexaploid *Triticum aestivum* compared to the tetraploids (Alamerew et al . , 2004) . This confirmed our hypothesis before experiment which higher genetic variability in hexaploid *E . nutans* than tetraploid *E . burchan-buddae* . In *Elymus* genus , Y genome may have similar genera origin and evolution history to St genome (Lu and Bjφrn , 2004) . It seemed that extra H genome had brought complexity to the whole genetic pool of hexaploid *E . nutans* .

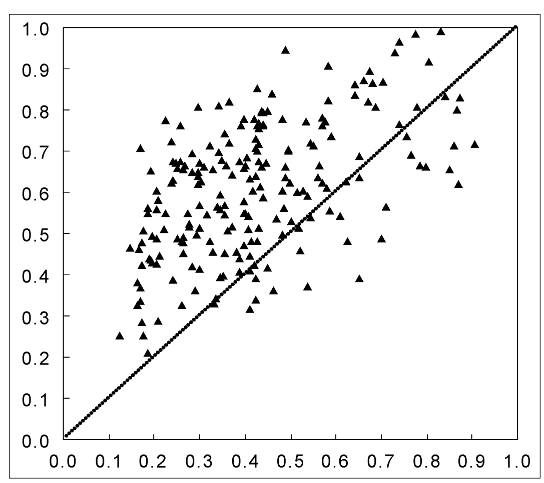

Figure 1 *Comparisons of each allele frequency between tetraploid* E . burchan-buddae *and hexaploid* E . nutans . *X axis represents the frequency of one allele in tetraploid* E . burchan-buddae . *Y axis shows the frequency of the same allele in hexaploid* E . nutans .

Conclusions We can deduce that it is H genome that leads to resultant difference in allele frequency and richness among two taxonomically related *Elymus* species , hexaploid *E . nutans* and tetraploid *E . burchan-buddae* .

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Root colonization by arbuscular mycorrhizal fungi in plants of Lhalu Wetland

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Key words : Arbuscular mycorrhizal colonization , Mycorrhizal status ; Fens plants ; Wetland

Introduction As a typical highland marshland type wetland , Lhalu wetland is the highest and biggest urban wetland in the world . It plays an important role in the improvement of Lhasa's ecological environment and is regarded as the lung of Lhasa City"or its kidney . But in the past , it was strongly disturbed by human activities .Arbuscular mycorrhizal fungi (AMF) have been proved to have potential of increasing plant diversity (van der Heijden et al ., 1998) , and it is also ubiquitous in wetland habitats (Cooke and Lefor , 1998) . It follows that mycorrhizal associations forming might be an essential part of wetland biological functions . We undertook this study as an initial survey of AMF colonization in fens plants of Lhalu wetland .

Materials and methods The survey was conducted at Lhalu wetland (91°03′48 .5″~91°06′54 .4″E , 29°39′46 .3″~29°41′05 .5″N) , which is located in the northwest of Lhasa city . Soil cores (6-cm diameter) were collected to a depth of 20-30 cm from 16 most common plant species within the wetland on August 10th , 2006 . Three individuals of the same plant species were randomly selected . Healthy (white , turgid) roots were picked from each of the soil cores for AM fungal colonization .

Results and discussion Of the 16 species surveyed , 10 formed fully developed arbuscular mycorrhizas , with arbuscules (and/or coils) and vesicles in at least one individual . An additional three species hosted aseptate hyphae and vesicles characteristic of AMF , but contained no arbuscules or coils . Three species (*Hippuris Vulgaris* , *Polygonum hydropiper* , and *Phragmites australis*) contained no AMF structures . Total colonization ranged from 0 to 82 .6% ,and arbuscular colonization ranged from 0 to 55 .6% . In this survey , plants in the wetland belong to Cyperaceae , Polygonaceae and Juncaceae , which were presumed to be nonmycorrhizal or rarely mycorrhizal (Muthukumar et al . 2004) , were colonized at different level . This result is similar to the report of Cooke and Lefor (1998) .

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Studies on geographic distribution of wild *Poa pratensis* population and its community type in Yangtze ,Yellow and Lancang river source region

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Keywords : *Poa pratensis* ,geographic distribution ,community type ,Yangtze ,Yellow and Lancang river source region

Introduction *Poa pratensis* belonged to herbage plant ,which originated from Europe and northern Asia .*P .pratensis* distributed widely temperature zone of northern hemisphere .*P .prantensis* whose rhizomes are very strong is a kind of rhizome plant ,the ability to usurp on others space is much better(Ma ,2003) .Nowadays ,*P .pratensis* plant was used to pioneer plant seed to grazing lands ,being artificial rangeland and rebuild deteriorated grassland .But the study report on geographic distribution and plant community in Yangtze ,Yellow and Lancang river(short for YYLR) source region is much less .The objective of this study was to provide scientific reference value for further study .

Materials and methods Our study site was in YYLR source region(31°39′～36°16′N ,89°24′～102°23′E)of the east and southeast of Qinghai province . The administrative area include Yushu Tibetan Autonomous Prefecture ,Guoluo Tibetan Autonomous Prefecture ,Zeku County and Henan County of Huangnan Tibetan Automonous Prefecture ,Tongde County and Xinghai County of Hainan Tibetan Autonomous Prefecture and Tanggula Township which are 16 county and 1 township ,and total land area in this region is 366400km^2 .The climate in this region is dominated by Southeast monsoon and high pressure of Siberia and soil is alpine meadow coarse-loam . The mean annual air temperature is-4℃～3℃ ,and annual precipitation is 260～770mm . We choosed primarily six principal samples and six associated samples of typical distribution of wild *P .pratensis* population with three replications in every sample .The height ,coverage ,density and underground biomass were measured by 50×50cm^2 square frame in principal sample within 50×50m^2 area ,and height and coverage measured in associated sample within 50×50cm^2 area . Meanwhile ,the altitude ,longitude and altidude were recorded with Global Positioning System ,and slope direction and degree were measured by compass instrument .

Results The wild *P .pratensis* distributed from 96°30′24 .96″ E to 100°57′31 .2″E of longitude ,between 33°07′29 .34″ N and 34° 46′12 .9″ N whose span were 4°24′6 .24″of longitude , 1°38′43 .56″of latitude ,respectively .The range of altitude is 3365m～4500m .There are twelve plant community types that were P .pratensis＋Geranium spp . , P .pratensis＋Elymus nutans , Potentilla , anserina＋P .pratensis ,Ligularia , virgaurea＋P .pratensis , P .anserina＋Aconitum , tanguticum＋P .pratensis , Deyeuxia spp＋P .pratensis , E .nutans＋P .pratensis , Carex moocroftii＋P .pratensis , P .pratensis＋Capsellabursa-pastoris , P . anserina＋L .virgurea , P .pratensis＋Polygonum , sibiricum ,P .fruticosa＋Scirpus , distigmaticus(Table 1) . The important value of *P .pratensis* is 34. 63 ,24. 25 ,26. 12 ,13. 46 ,8. 97 ,18. 27 ,6. 08 ,11. 40 ,47. 40 ,3. 74 ,29. 56 ,3. 69 respectively in every community .

Table1 *Grassland type of each site .*

site	grassland type
Jimai Township ,Dari County	*P .pratensis＋Geranium spp .*
Jianshe Township ,Dari County	*P .pratensis＋Elymus nutans ,Potentilla*
Manzhang Township ,Dari County	*Potentilla anserina＋P .pratensis*
Mulong Gama ,Kequ Township ,Gande County	*Ligularia virgaurea＋P .pratensis*
Mulong Wanma ,Kequ Township ,Gande County	*P .anserina＋Aconitum tanguticum＋P .pratensis*
Longge mountain ,Suohu Rima Township ,Jiuzhi County	*Deyeuxia spp .＋P .pratensis*
Zhang'e vally ,Suohu Rima Township ,Jizhi County	*E .nutans＋P .pratensis*
Dawu Township ,Maqin County	*Carex moocroftii＋P .pratensis*
Hebei Township ,Tongde County	*P .pratensis＋Capsellabursa－pastori*
sJielong Township ,Yushu County	*P .anserina＋L .virgurea*
Jielong Township ,Yushu County	*P .pratensis＋Polygonum sibiricum*
Jielong Township ,Yushu County	*P .fruticosa＋Scirpus distigmaticus*

Conclusions Based on preliminary investigation on the field ,the wild *P .pratensis* is a kind of wide ecological spectrum species . It could be suitable for growing in the shrub meadow ,river bank ,mountain slope and under forest .*P .pratensis* population were basically dominated species and secondary species in each plant community .So we can rehabilitate degraded alpine meadow by scattering seeds of *P .pratensis* in order to change community succession stage that reached sub-extreme community or extreme community .

Reference

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The effect of growth age on alfalfa's aboveground biomass

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Key words: alfalfa, aboveground biomass, community structure

Introduction Alfalfa in different growth ages has different dynamics of growth (Wu *et al*., 1997). Growth rate, biomass accumulation and so on of 3 year and 5 year alfalfa were tested in this experiment.

Materials and methods Fixed 10 plants, measuring absolute height every 10 days. Choosing 3 plants, using harvest method, observed single plant weight and leaf-stem every 10 days. Using harvest method, choosing $1\times1m^2$ plot with 3 replications every 10 days, observed forage yield and calculated fresh-dry ratio and growth rate. Choosing 10 representative plants, and cut every 20 cm from root to top, obtained the community structure.

Results Plant height, growth speed, single plant weight, forage yield of 5 year alfalfa was higher than 3 year alfalfa, the leaf-stem and fresh-dry ratio of 5year alfalfa was smaller than 3 year alfalfa (Table 1). The change tendency of absolutely and relatively growth rate was increase at first and then decrease. The distribution form of alfalfa aboveground biomass was a rhombus structure, which was big in the middle and point in both ends (Table 2).

Table 1 *Plant height, single plant weight, leaf-stem ratio, fresh-dry ratio and yield of different growth age of alfalfa.*

Date	Plant height(cm)		Single plant weight(g)		Leaf-stem ratio		Yield (g/m^2)		Fresh-dry ratio (F:D)	
	3 year	5 year	3 year	5 year	3 year	5 year	3 year	5 year	3 year	5 year
3.10	6.4±1.14	7.1±0.70	11.08±0.28	12.89±0.26	2.42±0.06**	1.67±0.03	443.2±6.75	515.6±4.65**	7.26±0.02**	6.69±0.02
3.20	7.3±1.16	8.3±0.70*	17.13±0.10	18.76±0.57	2.32±0.04**	1.47±0.03	685.2±4.00	750.4±6.08**	6.96±0.02	6.40±0.02
3.30	13.9±1.24	15.7±0.71**	23.93±0.62	25.25±1.30	1.76±0.04**	1.20±0.04	957.2±8.26	1010.0±7.07**	6.49±0.02**	6.22±0.29
4.09	31.8±1.30	36.0±0.80**	39.47±0.06	42.50±3.46	0.97±0.05**	0.74±0.02	1578.8±7.16	1700.0±5.77**	6.12±0.04**	5.88±0.03
4.19	51.6±1.40	60.1±0.78**	55.16±1.53	61.46±2.77**	0.74±0.04*	0.65±0.04	2206.4±8.29	2458.4±7.53**	5.73±0.01**	5.38±0.01
4.29	78.8±1.50	90.9±0.62**	77.82±1.56	110.33±4.05**	0.70±0.01*	0.62±0.04	3112.8±7.82	4413.2±5.45**	5.14±0.03**	4.89±0.02
5.09	98.5±1.37	119.6±0.60**	100.14±1.43	151.43±6.84**	0.58±0.05*	0.43±0.04	4005.6±6.24	6057.2±8.28**	4.79±0.01**	4.14±0.01
5.19	109.9±1.46	132.5±0.64**	102.32±2.05	152.47±1.86**	0.61±0.03	0.61±0.03	4092.8±6.89	6098.8±7.23**	4.26±0.01**	4.14±0.01
5.25							4097.0±7.62	6170.0±7.76**	4.12±0.03**	4.01±0.02

Note: * significant at the 0.05 level, ** significant at the 0.01 level in same line.

Table 2 *Biomass and pattern of production of different growth age alfalfa's layer.*

Height(cm)	Biomass(g/plant)		Leaf-stem ratio		3 year(g/plant)			5 year(g/plant)		
	3 year	5 year	3 year	5 year	Stem	Leaf	Flour	Stem	Leaf	Flour
140—160		6.8		1.54±0.05				2.2	3.4	1.2
120—140	7.2	54.1	3.33±0.36**	1.17±0.06	0.6	2.0	4.6	17.5	20.5	14.4
100—120	51.2	191.1	1.81±0.05**	1.02±0.08	15.0	27.3	8.8	72.4	74.0	44.7
80—100	174.1	348.4	1.51±0.05**	0.93±0.02	68.3	103.1	2.4	168.8	157.7	21.9
60—80	254.0	324.7	0.78±0.03**	0.57±0.04	143.0	111.0		206.6	117.4	0.6
40—60	207.9	260.4	0.32±0.04	0.28±0.07	157.7	50.2		202.9	57.5	
20—40	168.0	186.0	0.05±0.01	0.04±0.01	160.5	7.5		178.4	7.6	
0—20	161.8	170.8			161.8			170.8		

Conclusions Cutting at full bloom, the average height of 5 year alfalfa is 132cm, higher than 3 year alfalfa 109cm. The growth speed of 5 year alfalfa was higher than 3 year in each stage ($P<0.01$). The single plant weight of 5 year alfalfa was 152.47g, heavier than 3 year 102.32g ($P<0.01$). The leaf-stem ratio of 3 year alfalfa can reach 0.58～2.42, higher than 5 year alfalfa 0.43～1.67 ($P<0.05$). The forage yield of 3 year alfalfa can reach 4.10 kg/m^2, heavier than 5 year 6.17 kg/m^2 ($P<0.01$). The fresh-dry ratio of 3 year alfalfa can reach 4.12～7.26, higher than 5 year 4.01～6.69 ($P<0.01$).

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Storage and output of bud banks on rhizomes of different age classes of reed population in the dry land habitat in alkalinized meadow in the Songnen Plains of China

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Key words : reed , rhizome , age class , bud bank , alkalinized meadow , dry land habitat

Introduction Reed (*Phragmites communis*) , a rhizome clonal grass , has extensive ecological adaptability and distributes broadly worldwide (Ekstan , 1995) . Regeneration and renewal of wild reed populations mainly depend on vegetative propagation . Reed is a fine foraging grass and its protein content is higher than that of other grasses in dry land habitats at vegetative growth stage . However , reed usually exists as a companying species into different patches of communities on alkalinized meadow in the Songnen Plains of China .

Materials and methods The rhizomes of single dominant reed community were all sampled three times , in July , August and September , respectively . All rhizomes within the 1 m^3 space which was 1 m wide and 1 m deep to reach the deepest rhizomes of reed were dug every time . The color of reed rhizomes became darker with ageing . Furthermore , the combining with else characteristics , the age of each rhizome could be judged (Yang et al . , 1998) . According to the current state of the rhizome node buds , both dormant and bourgeoned buds were counted . The relative ratios of the dormant and bourgeoned buds were counted in term of age classes and statistics analysis was regarded , respectively .

Results The changing trends of dormant bud ratio and bourgeoned bud ratio were obviously contrary to each other in bud banks of 6 age class rhizomes at the three growth stages . The buds in different age classes all had an output course of accumulated bourgeons . Further statistic analysis showed that the dormant bud ratios and bourgeoned bud ratios were both linearly correlated with age classes at extremely significant level at three growth stages . Their simulated equations as well as significance tests were in figure 1 . The a value of dormant bud ratio in equations decreased gradually with the change of growing season , but that of bourgeoned bud ratio increased gradually . These results indicated that in the late growing season , some dormant buds of 1st age class rhizome bourgeoned and outputted one after the other . Although the parameter b did not show regular seasonal changes , the absolute values that were b value of dormant bud ratio decreased or b value of bourgeoned bud ratio increased with age class remained the same on the whole . This indicated that both decrease of dormant bud ratio and increase of bourgeoned bud ratio had great consistency .

Conclusions Reed rhizomes usually live for 6 years and distribute in depths along the one meter range below soil surface in dry land habitat in the alkalinized meadow . The storage of bud banks of the rhizomes every age class was a steady output course of accumulated bourgeons . The dormant bud ratios decreased and bourgeoned bud ratios increased gradually with the age classes . The quantitative relationships were all linear equations between ratios both the dormancy buds and the bourgeoned buds and age classes in the reed rhizomes at three growth stages .

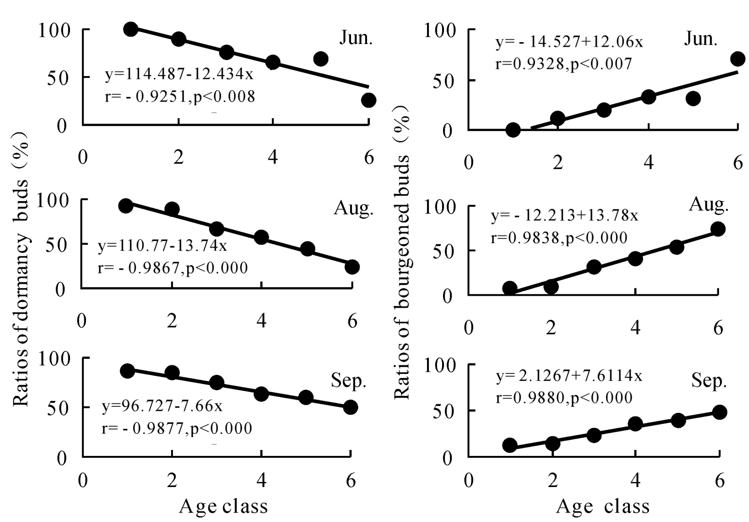

Figure 1 *Simulated linear equations and significance tests on relationships between bud ratios (y) both dormancy and bourgeoned and age classes(x) in the bud banks of reed rhizomes .*

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Changes of CAP of creeping bentgrass as affected by light intensity during summer stress

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Key words: turfgrass, creeping bentgrass, light intensity, shade, photosynthesis

Introduction There is no report on colony photosynthesis of creeping bentgrass (Agrostis stolonifera) under different light intensity. The objective of this study was to provide reference for variety selection and heat resistance regulation of evergreen turfgrasses of transitional climate zone by discussing response pattern of the colony apparent photosynthetic rate of creeping bentgrass under different light intensity in high temperature season in Nanjing.

Materials and methods The site was on farm of Nanjing Agricultural University (119°11′E, 32°08′N). Mean temperature in hottest month was 28.1℃. From Sep 2004 to Nov 2005, treatments were orderly imposed in 4 split blocks with sprinkler irrigation system. Treatments were natural lighting, slight shading, medium shading and heavy shading, maximum daily light intensity were approximately apart 1900, 1100, 550 and 90μmol.m^{-2} · s^{-1}. The grass was creeping bentgrass L-93 design with 3 replicates. Area of every plot was 1.3×2.0m^2. The plots were shaded all-day with black PVC shade net. The colony photosynthesis indexes were mensurated with LI-6400 portable photosynthesis system. Colony apparent photosynthesis(CAP) was calculated with the formula:

$$CAP = \triangle C/106 \times V \times 360/\triangle M \times 273/(273+T) \times 44/22.4 \times P/760 \times 1000/L \quad (1)$$

Where $\triangle C$ was concentration difference of carbon dioxide, V was volume of assimilation box, $\triangle M$ was mensuration time, T was temperature in assimilation box, L was land area which assimilation box occupied, P was atmospheric pressure (Li Shaokun, 2000).

Results Diurnal process of photosynthesis of creeping bentgrass could be generalized five modes under different light intensity in high temperature season in Nanjing area, namely typical single peak, table single peak, siesta single peak, typical double peak and atypical double peak. CAP of creeping bentgrass on the last ten days of Jul was lowest, the value was lower ($P<0.05$) or extremely lower ($P<0.01$) than that in Jun, Aug and Sep. The phenomena of light saturation happened from Jul to Sep under natural lighting and slight shading, in Jun under medium shading (Figure 1).

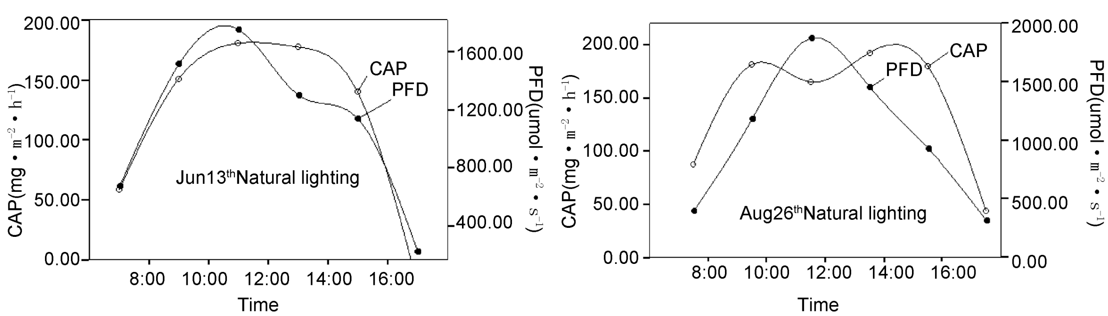

Figure 1 *Light saturation point of photosynthesis of creeping bentgrass under natural lighting.*

Conclusions In high-temperature season, CAP of creeping bentgrass decreased with monthly temperature rising and shade density increasing. As months and shade density increasing, light saturation point from Jul to Sep falled, but the saturated CAP falled with light saturation point reducing. When light intensity was less than 412.87μmol · m^{-2} · s^{-1}, light saturation phenomena disappeared.

Influence of different sampling strategies on the relationship of biodiversity and grassland primary production

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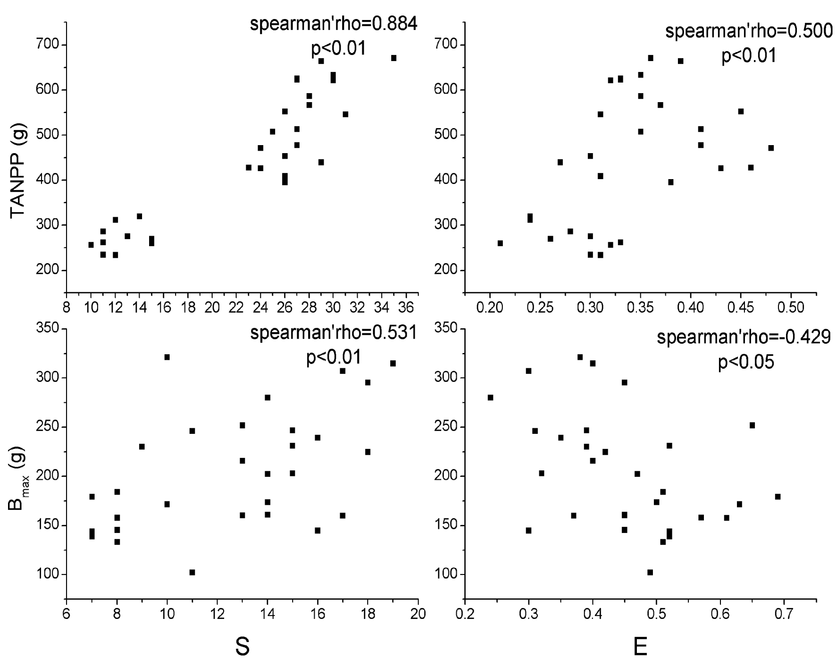
Key words: sampling strategy, species richness, species evenness, production, phenological separation

Introduction The relationship between biodiversity and ecosystems function (primary production shown in most studies) is a key issue for ecologists. The maximum community biomass in August was used as production in almost all studies. Some researchers suggested that a multi-harvest sampling strategy may be better in grassland communities (Hooper and Dukes, 2004). A three-year study was conducted in a natural grassland community to test the influence of the sampling strategy on the relationship between biodiversity and grassland primary production.

Materials and methods Three plots were selected, and fenced in different years. From May to September, all live grass was clipped every two weeks for three years. The maximum biomasses for each species during the growing season were summed as the total annual primary production (TANPP), while the maximum biomass of the community in lateAugust was indicated B_{max}. Both species richness (S) and independent species evenness (E) were used as diversity indices.



Results and discussion Species richness had a positive relationship with both TANPP and B_{max} in all three years. Species evenness had a positive relationship with TANPP in all three years while it had a negative relationship or non correlation with B_{max}. These results showed that complementary effect and sampling effect were confused with different sampling strategies (Mulder et al., 2004). This may suggest that phenological separation is an important factor for interpreting the relationship between diversity and production in seasonal grassland communities.

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Response of dominant species population importance value to different grazing systems in Stipa breviflora steppe

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Key words: desert steppe, population, importance value, rotational grazing, continuous grazing

Introduction The impact of grazing on the vegetation is an important field of grazing ecology. Most of that rational grazings can improve forage growth and livestock production. It can also improve grassland and prevent grassland degradation (Martin SC, 1988; Wei Zhijun et al, 2003). Studied on dominant population importance value of desert grassland communities under different grazing system may explore reasonable grazing system and provide a theoretical basis for the sustainable use of grassland resources.

Materials and methods The study site is located in *Stipa breviflora* desert steppe in Sunit Right Banner of Inner Mongolian (42°16′26″N、112°47′17″E). Annual-mean temperature is 6.2℃ and average precipitation is 209.12mm. Dominant vegetation is the community of *Stipa breviflore* and *Cleistogenes songorica* and *Allium polyrhizum*. The experimental treatments were composed of a continuous grazing plot of 340hm^2, a rotational grazing plot of 320hm^2 divided into 8 smaller, equally sized plots and a grazing exclusion plot of 1hm^2, which has not been grazed since 1999. Stocking rate on grazing plots was 1.25sheep/hm^2. The height, density, coverage of plant community were measured.

Results and discussion Throughout the grazing season, the importance value of *Stipa breviflora* in continuous grazing was higher than that in rotational grazing (Figure 1). With continuation of grazing, the importance values of *Stipa breviflora* in rotational grazing plot and the banning grazing plot showed downward trends, in contrast to the upward trend in continuous grazing plot. The importance values of *Cleistogenes songorica* and *Allium polyrhizum* in rotational grazing plot were higher than those in continuous grazing plot.

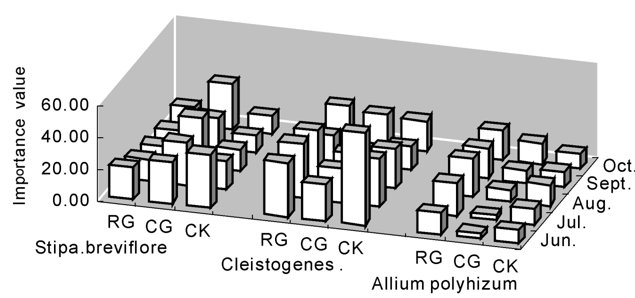

Figure 1 *Importance value of dominant population under different grazing systems.*

Conclusions *Stipa breviflora* of grazing tolerance poor palatability forage was enhanced in continuous grazing. Rotational grazing increase the role and status of *Cleistogenes songorica*and *Allium polyhizum* of better palatability forage.

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Clonal morphology of *Artemisia frigida* in the grassland with different degradation

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Key points: Artemisia frigida population, degraded grassland, clonal architecture, clonal growth, patchiness of resource

Introduction Overgrazing caused the degradation of grassland and affected the structure of plant communities. Grazing-induced degradation leads to the essential resource for growth and reproduction of plants are heterogeneously distributed. Clonal growth enables chonal plants to vigorously spread in horizontal space in many stoloniferous and rhizomatous plants, the connections (i.e., stolons and rhizomes) between the ramets may occupy patches differing in resource supply. Phenotypic plasticity is assumed to be a strategy for clonal plants to cope with resource heterogeneous environments. Clonal plants through clonal growth and chonal morphology to acquiere heterogeneously-distributed resource efficiently. *A. frigida* is a native perennial shrub that occurs primarily on degradated rangelands. It has the ability to produce offspring through clonal propagation and sexual reproduction. in degradated grassland. through its clonal growth it not only to acqire resource but also play important role in sand fixation and wind erosion control.

Materials and methods The study area locates near the national grassland ecosystem research station (116°14′E, 41°37′N, and 1430m in altitude). According to the communities types, divided four degeneration gradations. There were 10 subsamples for the *Artemisia frigida* in each plot. In order to identify the branches, plants were sampled with shoots and roots connected. Other species were disposed of. For the target species, the number of modules (including genets and ramets) per sample was counted. Internode lengths were measured. The combined data from each degeneration gradation, subsamples were subjected to a one-way ANOVA for degeneration and Duncan Multiple range test.

Table 1 *The basic situation of plots.*

Degradation Gradation	Communities types
Light Degradation	*L.chinensis + Agropyron cristatum + A.frigida + tussock grass*
Middle Degradation	*L.chinensis + S.grandis + A.frigida + tussock grass*
High Degradation	*A.frigida + Cleistogenes squarrosa + P.acaulis + tussock grass*
Extreme Degradation	*P.acaulis + A.frigida + small tussock grass*

Table 2 *Clonal morphology of A.frigid.*

Degradation Gradation	Spacer Length (cm)	Branching Intensity (indm^{-1})
Light Degradation	3.40[a]	1907.2[a]
Middle Degradation	2.63[b]	2184.5[a]
High Degradation	1.15[c]	2675.6[b]
Extreme Degradation	1.07[c]	2850.4[b]

NOTE: Treatments with different letters in one column are significantly different at the $p<0.05$ level.

Results ANOVA results showed highly significant effects of degeneration on internode length of stolons and branching intensity, indicating that internode length of stolons and branching intensity responded to each habitat. Internode length decreased in *A.frigida* and branching intensity increased with the aggravation of degradation

Conclusions Clonal growth and clonal morphology of *A. frigida* responded markedly to degradated grassland, in different habitats, the species responded differently. The plasticity of *A. frigida* of clonal growth and clonal morphology in response to resource heterogeneity corresponds partially to the alternations of the number and magnitude of modules

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Dynamics change of Water-Soluble Carbohydrate contents in roots system during greening stage of *Leymus chinensis* populations in Saline-Alkaline Soil on the Songnen Plains of China

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Key words : Leymus chinensis *populations* , Water-Soluble Carbohydrate , contents , greening stage , roots system , Saline-Alkaline soil

Introduction Water-soluble carbohydrate(WSC) plays an important role in metabolism of the plant . It is reported that it is indispensable for plants to turn green and to endure stresses . In spring , the growth of plants strongly depends on the reserves accumulated during the previous seasons . In late April , *Leymus chinensis* began to turn green , during the process , a considerable amount of WSC from its roots system (including rhizomes , tilling nodes and adventitious roots) must be consumed to growth . The dynamics change of WSC contents in roots system can be used as an indicator of its growth .

Materials and methods The experiment was conducted in a large area with single dominant *L . chinensis* populations in saline-alkaline soil in Daqing city , in Heilongjiang province (125°09′E ,46°35′N) . The chemical characteristics of the saline-alkaline soils have been measured first (Figure 1) . During late April and Mid-May(no rainy days) , A sampling every 3 days ,excavated up to a depth of 0 .2m below the ground in the same area($25\times25cm^2$) .Contents of WSC were determined quantitatively using the colorimetric anthrone method . Each sample was tested three times . The WSC content was obtained using the flowing formula : $C=(SC\cdot SV\cdot DSR/SM\cdot 10^{-3})\times100\%$,where *C* is the content (%) , *SC* is the sample concentration (mg/L) , *SV* is the solution volume (mL) , *SDR* is sample dilution ratio , and *SM* is sample mass (mg) .

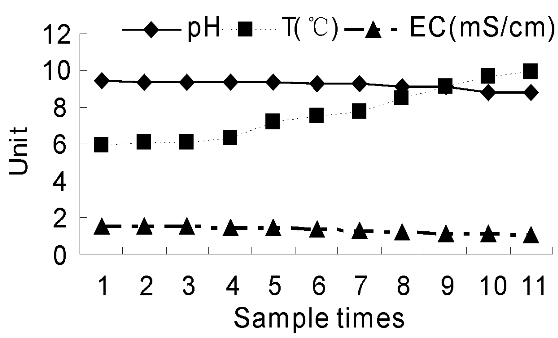

Figure 1 *The chemical characteristics of the saline-alkaline soils (0-20cm) .*

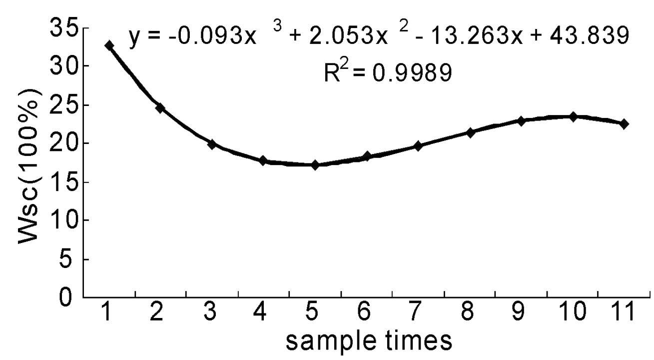

Figure 2 *Dynamic change of water-soluble carbohydrate contents in roots of L .chinesis .*

Results WSC contents in roots system of *L . chinensis* significantly decreased at first , then slowly to increase from germination period to greening growth(Figure 2) ,The trend of changes in WSC contents shows the regression equations : $y=-0.093x^3+2.053x^2-13.263x+43.839(R^2=9989)$.

Conclusions From germination period to greening stage , abundant stored matter was consumed . WSC stored were continuously supplied to the aboveground for growth . So the contents significantly decreased . With the growth of plants , the species can get certain photosynthetic products which prevent WSC from continuing to decrease , but weaken to store and almost balance between growth and decline . Besides in response to initial growth , the contents of WSC still need to resist the adverse conditions , such as low soil temperature , high pH and salty stress . The experiment confirmed that the *L . chinensis* population environmental adaptability and can improve the Saline-Alkaline soil .

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The study on the inflorescence differentiation of *Bromus ciliatus* L .cv . Xilinguole

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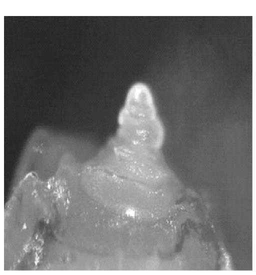
Key words : *Bromus ciliatus* L .cv . Xilinguole ,inflorescence differentiation , growth cone

Introduction *Bromus ciliatus* L .cv Xilinguole is a good and important forage . In this research the inflorescence differentiation of the varieties and the difference of three lines (9701 ,9708 , 9714) which are chosen from the *Bromus ciliatus* L .cv Xilinguole were studied . It provides the theoretical basis for production and reasonable utilization of *Bromus ciliatus* L .cv . Xilinguole . It is also important for breeding the new varieties .

Materials and methods The materials were planted in the Experimental Station of Inner Mongolia Agricultural University .
The differentiation process of nutrition growth cone and reproductive growth cone 50 plants which have the similar heftiness and height with *Bromus ciliatus* L .cv Xilinguole were chosen from first ten days of April . Observe the plants every one day . We should observe from the buds of tillering , when the spikelet pumped , and take the buds observed .When the inflorescence can be seen , paying attention to the inflorescence . After heading , taking the top of spikelet studied . When floret begins developing ,taking the first and second spikelet studied . Take photos by Olympus .

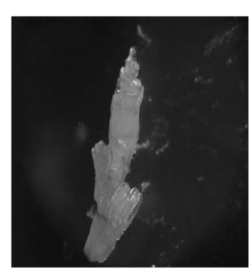
Comparis inflorescence differentiation of different lines of *Bromus ciliatus* L . Take three lines of 9701 , 9708 , 9714 go public . Observing anatomy and take photo the plants every two days .

Results Tip meristem is Hemisphere ,when it is at the stage of the vegetative growth phase . New leaf primordium produces from the basal of growth cone continually . The plant which is at this stage has 1-3 leaves . The growth cone elongate . ,when it is at the stage of the single edge phase . Bract primordium can be found . The plant which is at this stage has 4-5 leaves . Spikelet primordium produces from the leaf axil of Bract primordium , when it is at the stage of the double edge phase . Spikelet primordium and Bract primordium compose the double edge , spikelet primordium produces top-down process . The plant which is at this stage often has 6-8 leaves . At the stage of spikelet differentiation stage , floret primordium produces from the leaf axil of the lemma primordium . It starts from below . The plant which is at this stage has more than 8 leaves . The stamen primordial differentiated earlier than the pistil primordial , when it is at the stage of floret differentiation .The floret which is at the bottom develops faster than the top one . Stamen and pistil develop and maturate at the same time .



Vegetative growth phase

Double edge phase Spikelet



Spikelet differentiation stage

Floret differentiation stage

Conclusions The growth cone of these three kinds is hemispherical , when they are at the tillering stage . The kind of 9714 whose processes of growth cone is more obviously than the other two kinds , when it is at the booting stage . The kind of 9714 develops fast , when it is at the previous booting stage , for it stays longer at the single edge phase and double edge phase . At the floret differentiation stage , stamen of 9708 is more mature , at the same time lemmas of 9714 are lagging growing .

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Grassland resource in Hebei province of China

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Introduction Hebei Province is located in the northern part of the North China Plain extending into the Inner Mongolian Plateau. Beijing, the capital of China, and Tianjin, the important trading port in north China, are all situated at the center of the province. The total area of the province is 190,000km^2, 26.3% of them are grassland which equals to 5 million hm^2

The province has a temperate continental monsoon climate, which varies greatly due to its vastness, and most of the territory has clear-cut seasons. Its annual sunshine time is 2400-3100 hours, annual frost-free period 120-200 days, annual precipitation 300-800mm, and annual average temperature is from 0 centigrade to 13 centigrade.

The distribution characteristics and types of Hebei grassland resources According to the vegetation characteristics and the difference of distribution, grasslands of *Hebei* can be divided into 5 regional patterns. They are Bashang (highland) area, mountainous area of north Hebei, basin and mountainous area of north-west Hebei, mountainous area of west Hebei, Hebei plain terrain. The grasslands are classified into 6 types: temperate meadow-steppe type, temperate steppe type, lowland meadow type, high-cold meadow-steppe type, warm-temperate herbosa type, warm-temperate shrub herbs type.

The forage yield and carrying capacity of Hebei's grassland

Forage yield Grassland in North West region (Zhangjiakou and Chengde) of *Hebei* with good hydro-thermal conditions and 5-7 months of growing period has the high forage yield in Hebei Province. According to the *Hebei* Provincial Grassland Management Station's monitoring data(2007), the forage plants ratoon easily and the grass coverage of the grassland is more than 65-75%. The height of the herbaceous layer is over 30-45 cm. The average yield of hay per unit per year is 1592.4 kg/hm^2.a, the output amounts to 5.93 million tons per year.

Carrying capacity The carrying capacity is 24.66 million Sheep equivalent units of the whole Hebei Province, nature grassland 48.5% and crops stallks 51.5% of that total.

Utilization, conservation, improvement and construction The positive efforts made by the *Hebei* People's Government for ecological improvement and biodiversity protection in the past five decades have acquired signal success. A number of eco-construction projects are initiated, such as reforestation, natural forest protection, Beijing-Tianjin sand-source control, natural grassland restoration and consummate more grassland family contracting system and etc. It execute that the pasture enclosure feeding, forbiding breed, building man-made grassland feed basement properly, persue breeding in house or fold. Since 2000, planted or improved grassland has reached 833000 hm^2. The grass industry and the husbandry in Hebei province are achieving gradual development, becoming more large-scaled and stronger.

Comparison on water-stress tolerance of three alfalfa varieties

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Key words : alfalfa , water stress , betain , ABA , net photosynthesis rate , stoma conductance

Introduction Alfalfa (*Medicago stivia* L .) is a legume forage with high production and excellent quality , and is cultivated in the most world . In China , alfalfa mainly is plants in the arid and semi-arid zones . So it always suffers water-stress which effected alfalfa performance . The study compared three alfalfa varieties on the change of drought physiological indexes and their drought tolerance (Xing , Rajasheka , 2001) .

Materials and methods Three alfalfa varieties were planted in pots in greenhouse . Water-stress treatment was controlled by weighing pot every two days . In this experiment , there were four drought levels , including CK , LS , MS and SS . Leafe betain content , ABA content , net photosynthesis rate (NPR) and stoma conductance were measured .

Results Zhongmu1 and Aohan had higher betain content than Queen under water stress (Figure1) . There had two change models of ABA content , double-apex model and single apex model respectively . ABA accumulation of double apex varieties was earlier than that of single apex variety . Among the alfalfa varieties , Aohan' NPR was highest under water stress . The main factor of alfalfa NPR was stoma closure in this experiment But under SS treatment , Queen's stoma conductance significantly increased , extra-cell CO_2 concentration also increased (data not show) , so the main factor of Queen's NPR was non-stoma effect (Gunaselera , Berkowits , 1992) .

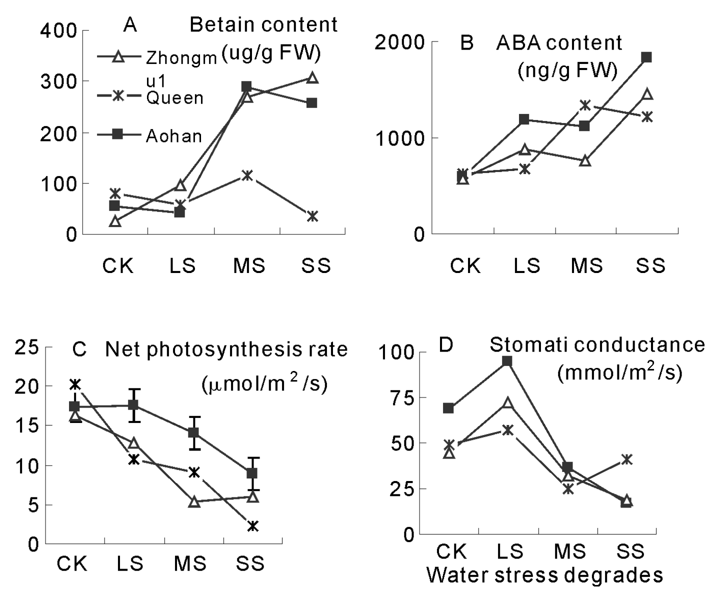

Figure 1 *The change of betain content , ABA content , NPR , stoma conductance of three alfalfa varieties under different water stress degrades .*

Conclusions Based on the change of three alfalfa varieties on betain content , ABA content , net photosynthesic rate and stoma conductance under water stress , betain osmoregulation and ABA stress inducement are the most important mechanism of alfalfa water-stress resistance and acclimation . Queen is less tolerance to drought than Aohan and Zhongmu1 ,and has different water-stress tolerance formability .

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Technique of plant regeneration from immature inflorescence of *Pennisetum Purpureum in Vitro*

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Key words: *Pennisetum Purpureum*, immature inflorescences, *in vitro*, callus, plant generation

Abstract Immature inflorescences of *Pennisetum Purpureum* and MS improved and were used for explant and basic culture medium. Effects of development period of immature inflorescences and hormone compositions of different kinds and ration on callus induction and plant regeneration were studied. Results indicated that 2～5 cm immature inflorescences was optimum. The frequency of callus of compact, small pellet induction reached separately 79.0% and 72.6% in the callus induction medium supplemented with 4.0mg/L 2,4-D+ 0.05 mg/L KT and 4.0mg/L 2,4-D + 0.1 mg/L KT (Figure 1). During subculture, Callus of small pellet were maintained 40.9% and 74.0% in the callus subculture medium added 3.0mg/L 2,4-D + 0.2 mg/L 6-BA. The rate of green plant regeneration of small pellet callus from subcultures reached respectively 36.4% and 38.5% in the differentiation medium supplemented with 2.0mg/L CPPU +0.01mg/L NAA or 0.5mg/L KT + 0.5mg/L IAA. Green plant of regeneration with three leaves was transferred to root vigor medium added 0.5 mg/L NAA in 1/2 MS basic culture medium (Figure 2). The survivor rate of green plant cultured in soil reached above 95% (Figure 3). It was a simple effective method to overcome the obstruction of plant generation by selecting the callus of dry, compact, small pellet in early generation.

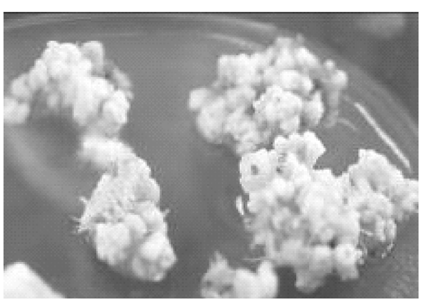

Figure 1 *Calli of dry, compact, small pellet.*

Figure 2 *The intact plantlets from immature inflorescences of Pennisetum Purpureum.*

Figure 3 *Regenerated plant transplanted in soil.*

Influence of stress on physiological-biochemical characteristics of three *Atriplex* L plants

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Key words : *Atriplex* L ., physiological , biochemical , stress , NaCl

Introduction The *Atriplex* L . plants are the typical plant in arid and semi-arid regions of the world . It is reported that many *Atriplex* L plants have more strengthen of drought stress and salt-resistance (ASLAM *et al* . ,1986 ;Jos e Ramos *et al* . ,2004) . We introduced 3 kinds of *Atriplex* L plants to improving atrocious environments , especially in salina and less rainfall areas . Therefore , to understand the physiological-biochemical characteristics of 3 plants is very important .

Materials and methods The experimental materials are yearold seedlings of *Atriplex canescens* ssp . *Aptera* , *Atriplex canescens* ssp . *canescens* var . *laciniata* Parish and *Atriplex canescens* (Pursh) Nutt which were placed in greenhouse and tested the inorganic ion content beforehand . Three plants above signed as A ,B ,C . Drought stress contains 4 levels which signed as D1 , D2 ,D3 ,D4 , corresponding is 60% ,45% ,30% ,20% of saturated soil water content , using TSC-V moisture teller to supply losing water everyday . Salt stress ($NaCl : Na_2SO_4 = 1 : 1$) contains 5 levels as S1 ,S2 ,S3 ,S4 ,S5 , which corresponding is 0 .1% , 0 .3% ,0 .5% ,0 .7% ,1 .0% of soil weight . Set no stress as contrast (CK) and 30d for test , 5 repeats . Indexes included SOD , POD , MDA , and Water holding capacity of leaves .

Results Along with the increasing of drought stress , SOD of plant A was increasing from CK (268 .58u/g) to D1(483 .63u/g) , and then gradually decreased from D2 to D4(from 306 .13 to 233 .26u/g) . However , plant B and C was decreased . Under salt stress , SOD of 3 plants was all decreased . POD of three testing plants were all decreased under drought and salt stress , in which plant C were significantly different to other 2 plants ($p < 0.01$) . MDA was the product of plasmalemma that under stress , it is all increased under drought and salt stress , in which D4 of A ,B and C owned the highest value as 36 .49 , 32 .65 and 28 .33(μmol/g) . Water holding capacity of 3 plants is B>A>C (Figure 1) .

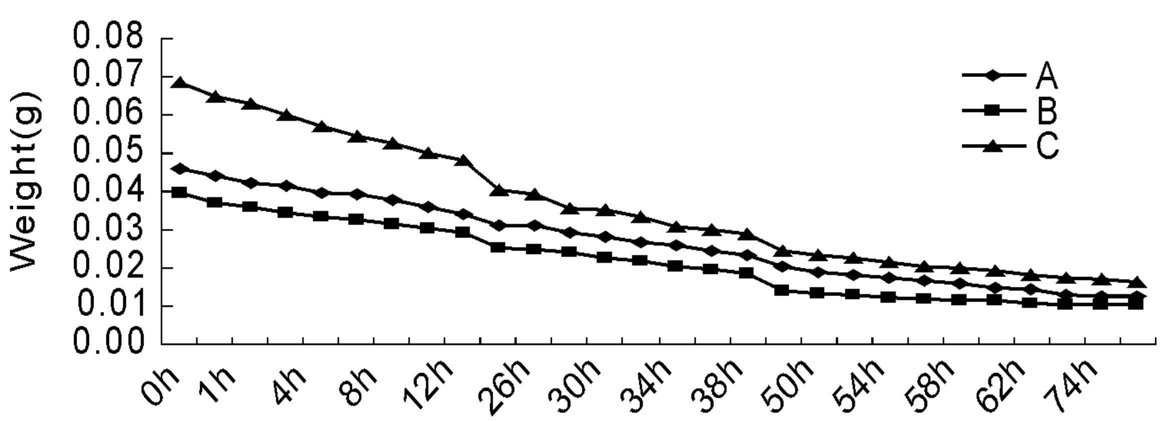

Figure 1 *Leaves waber holding capacity of* 3 *test plants* .

Conclusions Under drought /salt stress , three *Atriplex* L plants exhibited a good resistance in a smaller change between CK and low-grade stress . At high-grade stress , the growth of three plants was all repressed seriously . Meanwhile , 3 plants showed more repressed along with the increasing of stress grade . SOD and POD were protector of plasmalemma . Under adversity , 3 plants can rapidly increase the content of these substances to resisting stress .

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Quantitative classification of subalpine grassland under degenerate succession in northwest Sichuan

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Key words : subalpine grassland , degenerate succession , TWINSPAN , association , north-west Sichuan

Introduction The northwestern Sichuan is located at eastern margin of Qinghai-Tibet Plateau , in which the vegetation is typical subalpine meadow . Two-way Indicator Species Analysis (TWINSPAN) , which was adopted to conduct the multi-analysis of the florae , was used to study the distribution patterns of subalpine grassland communities under degenerate succession in the region .

Materials and methods The pathway expedition on subalpine grassland in Hong-Yuan County was carried out for three years from 2005 to 2007 . The marsh , shade slope , flat and sunny slope were chosen to set up research sites . On base of those terrain , 45 sampling plots were investigated in non-degraded , lightly degraded , moderately degraded and severely degraded subalpine grassland . Using Importance Value as the measuring index , the 45×71 matrix was formed . Then through analyzing with the software PC-ORD , Two-way Ordered Table was obtained .

Results 45 sampling plots were divided into 13 groups by TWINSPAN . And in combination with the ecological characteristics , they were classified into 12 associations (Figure 1) : (Ⅰ) *Poa annua* + *Plantago asiatica* + *Thlaspi areven* , (Ⅱ) *Carum carvi* + *Elymus dahuricus* , (Ⅲ) *Carex alrofusca* + *Plantago asiatica* + *Ranunculus tanguticus* , (Ⅳ) *Kobresia pygmaea* + *Anemone rivularis* , (Ⅴ) *Kobresia setchwanenesis* + *Polygonum vivparum* + *Stellera chamaejasme* , (Ⅵ) *Kobresia setchwanenesis* + *Potentilla discolor* , (Ⅶ) *Kobresia setchwanenesis* + *Saussure japonica* + *Geranium pylzowianum* , (Ⅷ) *Festuca rubra* + *Aster alpinus* + *Deschampsia caespitosa* , (Ⅸ) *Elymus nutans* + *Deschampsia caespitosa* , (Ⅹ) *Carex muliensis* + *Kobresia setchwanenesis* , (Ⅺ) *Kobresia setchwanenesis* + *Carex muliensis* + *Sanguisorba parviflora* , (Ⅻ) *Caltha scaposa* + *Blysmus sinocompressus* + *Deschampsia caespitosa* .

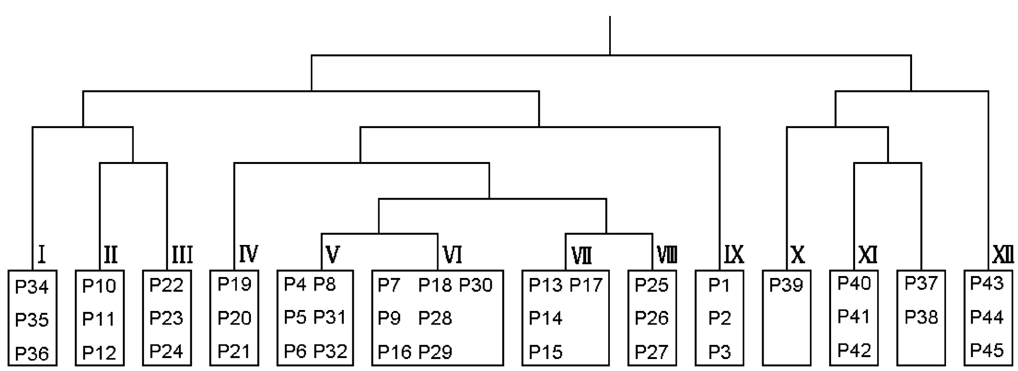

Figure 1 *Dendrogram of TWINSPAN classification .*

Conclusions The TWINSPAN results showed that distribution pattern of associations were mainly affected by the leading ecology factor of humidity and the gradient in degeneration of subalpine grassland . Community composition diverged distinct different groups between non-degraded and severely degraded subalpine grassland . While moderately degraded shade slope and lightly degraded sunny slope , or lightly degraded flat , shade slope and moderately degraded sunny slope had the similar composition characteristics of community .

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Effect of nitrogen application on forage yield in alpine rangeland

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Key words : alpine rangeland , N application amount , forage yield increase

Introduction Large areas of grassland have been deteriorating due to dry climate , simple vegetation structure , poor quality of forage , overgrazing and damage from pests and rodents . Meanwhile , nutrients for plant growth in alpine rangeland depend on biological and chemical mineralization in soil which has been decreasing in fertility because of consumption by plant growth . Research has indicated that N application improved forage yield and crude protein content , which is an important way to solve the problem of protein shortage in alpine pasture which generally has limited legume content . The objective of this study was to determine the appropriate fertilizer application rate for forage yield and protein content .

Materials and method Experiment site was on a fenced winter-spring pasture without grazing at Qinghai San Jiao Cheng Sheep Breeding Farm . The site is 3200-3600m altitude with 321 .7mm annual precipitation ,-0 .2℃ average annual temperature with mountain dry grassland type and dark chestnut-Calcium soil . The vegetation in the grassland mainly consists of *Stipa aliena keng* , *Stipa purpurea Griseb* , *Poa pratensis* L , *Elymus nutans* , *Achnatherum Kansuensis Maxim* , *Potentilla multifida* L and *Bupeurum smithii wol et al* . Urea with 46% pure N was applied in June 2003 with different N application amount N_0 , N_{60} , N_{80} , N_{100} , N_{120} kg/hm^2 to determine the optimum amount by measuring above ground biomass , plant height , vegetation coverage , density and frequency of plants in 1m^2 sized plots replicated three times .

Results Forage yields of plots in different N rates were all improved compared to the control plots in the 1st year , the 2nd year . The increment and increasing ratio were increased by degrees according the N application amount (Figure 1) . It is indicated that N application in alpine grassland improves grass yield effectively . N application affected vegetation measurements significantly , and grass density , coverage and frequency were improved (Table 1) . In the current experiment , input/output was optimal while 120kg/hm^2 N was applied . Crude protein content in hay was improved along with the increase of N application and obtained the greatest increase with 60-80kg/hm^2 N application .

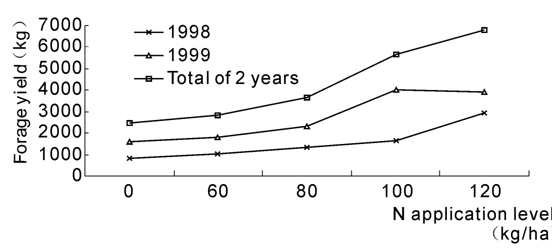

Figure 1 *Forage yield at different N application .*

Conclusions The results were same to the experiment carried out at Tongde Batan region on *Puccinellia tenuiflora* , but the optimum N application for the highest yield in this study was lower than the N requirement for the potential highest yield of tall grass (D .R .Che , 1995) , which was 225kg/hm^2 . The grass yield was still increasing while N application amount reached the highest 120kg/hm^2 , which means the optimal N application amount in alpine area has to be decided in future research .

Table 1 *Effect of different N level on rangeland community .*

plant composition	community Plant	CK	N_{60}	N_{80}	N_{100}	N_{120}
Grasses	Height(cm)	8 .3	11 .2	15 .2	10 .8	12 .9
	Coverage(%)	37 .7	41 .7	48 .3	48 .0	49 .0
	Density	109 .0	183 .0	149 .0	161 .0	156 .0
	Frequency(%)	30 .0	57 .7	35 .7	61 .7	85 .7
Legume	Height(cm)	2 .6	3 .0	4 .5	3 .2	4 .8
	Coverage (%)	2 .3	4 .0	3 .0	6 .3	4 .0
	Density	14 .0	55 .	40 .0	38 .0	36 .0
	Frequency(%)	36 .0	51 .0	40 .7	82 .3	38 .3
Karex	Height(cm)	4 .3	5 .0	4 .8	6 .6	6 .9
	Coverage	18 .0	21 .0	24 .6	29 .0	34 .0
	Density	123 .0	193 .0	191 .0	327 .0	413 .0
	frequency(%)	77 .7	89 .3	98 .3	100	88 .3
others	Height(cm)	5 .8	6 .8	6 .5	8 .4	8 .9
	Coverage (%)	16 .7	19 .3	18 .7	23 .7	41 .0
	Density	117	121	125	119	206
	Frequency(%)	25 .7	33 .3	36 .7	37	40

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Stability of alpine meadow ecosystem on the Qinghai-Tibetan Plateau

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Key words : alpine meadow , stability , coefficient of variance , ecosystem diversity , net primary production , precipitation , temperature

Introduction The stability of grassland ecosystem is one of the most important topics in modern ecology (Bai et al . 2004 ; Tilman & Downing 1994) . However , little relevant information is available for the alpine meadow on the Qinghai-Tibetan Plateau (Zhao & Zhou , 1999) . In this paper , we examined the ecosystem stability and its sensitivity to environmental variations in an alpine meadow using the quantitative methods .

Material and methods In this study , air temperature and precipitation were measured by regular meteorological methods . The above-ground net primary production was measured by the harvest method . The annual variations of precipitation and mean air temperature from 1957 to 2000 , and the above-ground net primary production of the *K . humilis* meadow from 1980 to 2000 were collected .
In this paper ,

$$E = \left| \left(\frac{\Delta y}{\Delta x}\right) / \left(\frac{\bar{y}}{x}\right) \right| = \left| b / \left(\frac{\bar{y}}{x}\right) \right|$$

which can measure the stability of grassland ecosystem . When E does not change with x or time (t) in a given period , the E is constant . The constant E means the measurement of system stability of abiotic factor . Furthermore , it is easy to compare each other because the parameters are dimensionless .

Results and discussion Comparison of alpine meadow ecosystem stability with other five natural grassland ecosystems in Israel and southern Africa indicates that the alpine meadow ecosystem on the Qinghai-Tibetan Plateau is the most stable ecosystem . The alpine meadow ecosystem with relatively simple structure has higher stability , which indicates that community stability is not only correlated with biodiversity and community complicity but also with environmental stability . The high stability of the alpine meadow ecosystem may be resulted also from the adaptation of the ecosystem to the alpine environment .

Conclusions In this study , we use the coefficients of variation (CV) and stability (E) obtained from the Haibei Alpine Meadow Ecosystem Research Station to characterize the ecosystem stability . The results suggest that the net primary production of the alpine meadow ecosystem was more stable (CV = 13.18%) than annual precipitation (CV = 16.55%) and annual mean air-temperature (CV = 28.82%) . The net primary production was insensitive either to the precipitation (E = 0.0782) or to air temperature (E = 0.1113) . In summary , the alpine meadow ecosystem on the Qinghai-Tibetan Plateau is much stable .

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Preliminary experiment on photoregulation of turfgrass

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Key words : photoperiod , light quality , environmental light signals , physiology , photoreceptor

With many experiments in plants under different lighting environment , people have realized that a whole refined and complicated system of light receptor and conductor exist in plants . There are many related research reports . In this , we make a review of turfgrass physiology under photoregulation and relationship with light photoreception .

Regulation of photoperiods Shape and growth of turfgrass could appear plastic variety with environment light periodic change . Periodic light treatment on turfgrass shows that : 14h treatment increased significantly in weight , root shoot ratio , density , coverage , height , plants fiber content improved 3% ～9% ,PEPC enzymatic activity increase 64% ～88% , and soluble sugar content increase 12% ～23% . Turfgrass is sensitive to day length and it affects its geographic distribution and flowering time . For example , Zoysia sinica which flowers in November in the north would not flowering until February and flowering time is less than a month . Periodical prolong environmental day length could change dormancy mechanism of turfgrass in winter . Research shows that , in natural winter , turfgrass turned yellow , grew slower , and ABA content increased ; with artificial treatment of periodical prolong environmental day length , ABA content is decreased , growth is improved and turfgrass maintained green a whole winter .

Light quality Selective absorption is a characteristic of plant response to light . Different light quality can improve photosynthetic rate and regulate photomorphogenesis of plant . While the PAR spectrum of photosynthesis is from 400nm to 700nm , blue light (400nm～500nm) and red light (600nm～700nm) play key roles in photosynthesis ,photomorphogenesis and chlorophyll synthesis . The far-red light spectrum effects photomorphogenesis . The chlorophyll content of rice leaf under blue light were 10% higher than under mixed light , especially chlorophyll a . Toward turfgrass , blue light can limit the growth of turfgrass . The leaf width and leaf color of Z . japonica cv . Lanyin No . Ⅲ under blue light were higher and more dark than red light .

Phytochrome and photoreceptors In addition to the chlorophyll complex of photosynthesis , turfgrass contains a large variety of light signaling receptors feeling and monitoring" in which the light signaling changes in the environment . Plant has been found that at least three types of light receptors : red and far-red photoreceptors phytochrome category , blue light photoreceptors UV2A and UV-light photoreceptors UV2B . Photoreceptors , which are called the entrance , can reset the time of plant's day and night bio-clock , so hundreds of genes' expression could be regulated .

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Study on photoperiod sensitivity and hereditary potentiality maize inbred lines

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Key words : maize ,SSR , heterosis ,photoperiod sensitivity , diallel cross

Introduction In our country , forage breeding has been severely restricted because of significant shortage of special forage maize varieties suitable to plant in different latitudes(Mugo-S ., Zhang-Fenglu ,2001) . It is significant to select high quality and yield forage maize breeds which were suitable to the maize-farm-belt of China . The study compared the photoperiod sensitivity(PS)of different latitudes maize inbred lines(MIL) and clustered heterosis populations of the MIL hereditary potentiality ,finally was forward to providing theory for forage maize breeding .

Materials and methods The material included 17 tropical and subtropical MIL(provided by the Academy of Agriculture Science of China) and 20 temperate-zone MIL (provided by HeNan Agriculture University) ,adopting clustering analysis of MIL agonomic traits(UPGMA) , SSR analysis and diallel cross of MIL(Goodman MM ., Murphy JP ., Senior ML .et al .,1998) . The MIL and their hybrid progenies were planted in spring and winter in 2006 . The trial was planted with three treatments (two with artifical light 16h or 10h , respectively ; another with nature light) . Each treatment was replicated three times .

Results and discussion The sensitivity to light of MIL was variable , with the PS of most of the tropical and subtropical MIL more sensitive than the temperate-zone ; 31SSR primers detected MIL , total 135 polymorphism . For the direct yield traits : fresh weight of plant and dry weight of bract , the variability of the addition , domination and them respectively interacting with environment were remarkable , especial the domination×environment was terribly remarkable to 80% .

The clustering results of some MIL were variant from the maize family tree , maybe because of the abundance heredity diversity of the maize . The study showed that using the combining of heterosis and moderate PS would come into being high quality and yield forage maize breed .

Conclusions 1 .The 37MIL had been assorted to 11 populations by the resemble rate 0 .77 ,the clustering results also basically matched with the relatives of the MIL and the hybrid yield . 2 . From results ,the potential of using the combining of heterosis and environment (PS) was strong .

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Vegetation succession characters of desertification grassland in Hulunbeier steppe

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Key words: desertification, vegetation

Introduction Resent years, because of the influences of nature factors and human activities (Mukaiyama S, 1998), the eco-environment of the Hulunbeier steppe was gradually worsen. Grassland degradation seriously threaded to the local ecological environment, which restricted the development of husbandry. For rational utilization and grassland protection, Understanding the mechanisms and characters of vegetation successions may be important to restoration and reconstruction of Grassland ecosystem.

Materials and methods We sampled four field sites along a gradient of sand desertification in the Hulunbeir steppe from July to August in 2006, to represent the four stages of desert development: potential, slight, moderate and severe. Five 1m×1m plots were randomly established in study sites of four different desertification levels respectively. The height, coverage, biomass and species richness was recorded, and species important values were calculated. Species diversity and Evenness index were calculated using the Simpson index and Pielou index. And index of grassland quality was evaluated according to palatability and coverage of grasses.

Conclusions Result showed that vegetation altered be regard as species composition, species diversity, coverage and structure Consequently (Table 1). Vegetation degradation of grassland was a process of decrease of species quantity, simplification of community structure, the height of plants, coverage, above-ground biomass were all correspondingly showed to decrease. Diversity index of communities was increased significantly in the stages of slight and moderate desertification. With the desert development, the index of grassland quality was significantly decreased, especially in the severe desertification stage, floristic composition transformation has occurred as unpalatable species encroached the area. With desert development, herbaceous species, especially grasses, were lost from the community composition and replaced by xerophytic grasses, for example *Compositae* species. Finally, psammophytic annual plants such as *Chenopodiaceae species* dominated vegetation composition, while Perennial plant maintained a low coverage. (Table 2).

Table 1 *Characteristics of community construction in different stages of desertification.*

Desertification level	Potential	slight	moderate	severe
Above-ground biomass (g/m^2)	113.95±5.22a	99.46±20.49a	83.09±12.27a	105.75±31.63a
Coverage (%)	71.67±2.89c	41.67±2.89b	16.67±2.89a	23.33±7.64a
Height (cm)	35.00±5.00b	28.33±2.89b	16.00±3.61a	26.67±5.77b
Rich index	10.33±0.58ab	12.00±3.46b	9.33±2.08ab	6.67±0.58a
Diversity index	1.55±0.12a	1.88±0.11b	2.00±0.12b	1.64±0.10a
Evenness index	0.66±0.04a	0.77±0.06b	0.90±0.06c	0.86±0.01c
Index of grassland quality	1.18±0.07d	0.92±0.07c	0.34±0.07b	0.11±0.03a

Note: Date with the same letter in one row are not significantly different ($P>0.05$).

Table 2 *Species importance values in different stages of desertification.*

Family	*Gramineae*	*Compositae*	*Rosaceae*	*Leguminosae*	*Chenopodiaceae*	*others*
Potential	0.71	0.04	0.01	0.02	0.04	0.18
slight	0.64	0.04	0.01	0.01	0.15	0.15
moderate	0.51	0.30	0	0.02	0.10	0.08
heavy	0.29	0.16	0	0.06	0.49	0

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Population structure on tubers of *Scirpus planiculmis* in alkali-lake habitat in the Songnen Plains of China

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Key words :Scirpus planiculmis ,tubers Groups ,size distribution

Introduction *Scirpus planiculmis* ,a hydrophytic clonal plant , usually forms single dominant communlty in alkali-lake in the Songnen Plains . *Scirpus planiculmis is* ths main weed in China paddy field(Labrada ,1996) , which has strong ability to asexual reproduction by tuber rhizomes .This study sampled and analyzed the tuber population , mainly including the type ,quantity , biomass ,and size class of tubers .

Materials and Methods The tubers of single dominant *Scirpus planiculmis* community were sampled during anthesis in June and seeds maturation in July .The samples were 50cm length , 50cm breadth , and 30cm depth , repeated five times (Note : backfill the soil after getting the samples) .The tuber of *Scirpus planiculmis* is olivary ellipsoid .Three groups were sorted .Group Ⅰ is made up of new tubers .Group Ⅱ is made up of the old tubers which are linke with Group Ⅰ by a tuber .Group Ⅲ is made up of dead tuber which are linked with anoher Group by dead rhizome (Figure 1) .

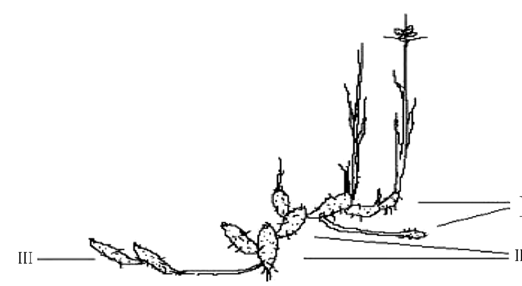

Figure 1 *Rhizome types of* Scirpus planiculmis

Results The volume and weight of tuber shows right thin-tailed distibution(Figure 2) in July .This is under the significant level than classical distribution .The total number and weight of the tubers in July is decreased than that in June(Figure 3) ,among them Group Ⅰ and GrouP Ⅱ is decreased ,while GrouP Ⅲ is stable in number decreased in weight comparatively .The weight loss of the tuber of Group Ⅰ and Group Ⅱ is attributed to the substance transfer to ground individual plants .However , the weight loss of the tuber of Group Ⅲ is the natural loss for consenescence .

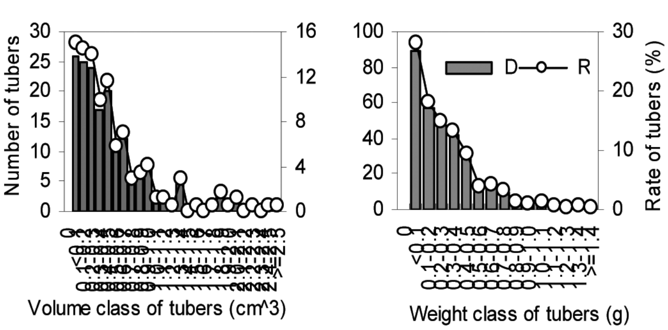

Figure 2 *Distribution and ratio in size and weight of tubers on* Scirpus planiculmis *population in July .*

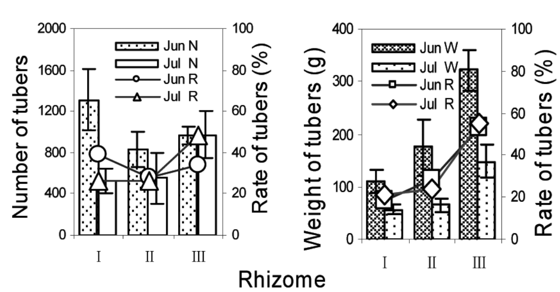

Figure 3 *The number ,weight and rate of tubers at different groups on* Scivpus planiculmis *population .*

Note :D—Distribution , R—Ratio .N—number , w—weight .

Conclusions The tuber of *Scirpus planiculmis* is asexual reproduction organ .That the distribution of its volume and weight has a long right tail indicates maybe there are bigger tuber individuals .However , the sharp shrinkage of the left tail means the smaller ones do not have biological significance .The tuber of Group Ⅰ ,determines new individual plants and new tuber .For clonal popuation ,this is helpful for updating . The tuber of Group Ⅱ ,functions as sustainment and nutrition ,carry foraging behavior by tuber clusters . After multiple observations , there was neither bud with viability nor evidence for potential reproducing ability in the tuber of Group Ⅲ .It is likely to be lost its viability completely .

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Compound system and benefit analysis about Legumes forage intercrop with prickly ash in linxia

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Key words: tree-grass complex, soil water, forage

Introduction We investigated the benefit of tree-grass complex in linxia gansu province, China. This area is arid and sem-iarid, and the soil is proven and less than what their need, ecological forestry and economic forestry play an impotent role in local. So finding new models to develop forest is meaningful.

Material and methods Tish research is located in linxia gansu province, baded on 9 years Chinese prickly ash intercropping with alfalfa, white clover and bird's foot trefoil. We studied the ecological and economic efficiency using econology principle and method. We test the soil moisture of different distance between trees use TSCⅡ intelligence soil moisture fast tester.

Conclusions We test 6-20cm soil moisture, the results show that (Figure 1): Tree-grass complex enhance the soil moisture content in the forest land which interplanting forage, plays the role of water resource conservation. Because the water resource conservation effect on three kind of leguminous forages, so the alfalfa is stronger than white clover and lotus corniculatus, Moreover, along with depth increase, its difference is smaller. About the water use efficiency that white clover is higher than the other.

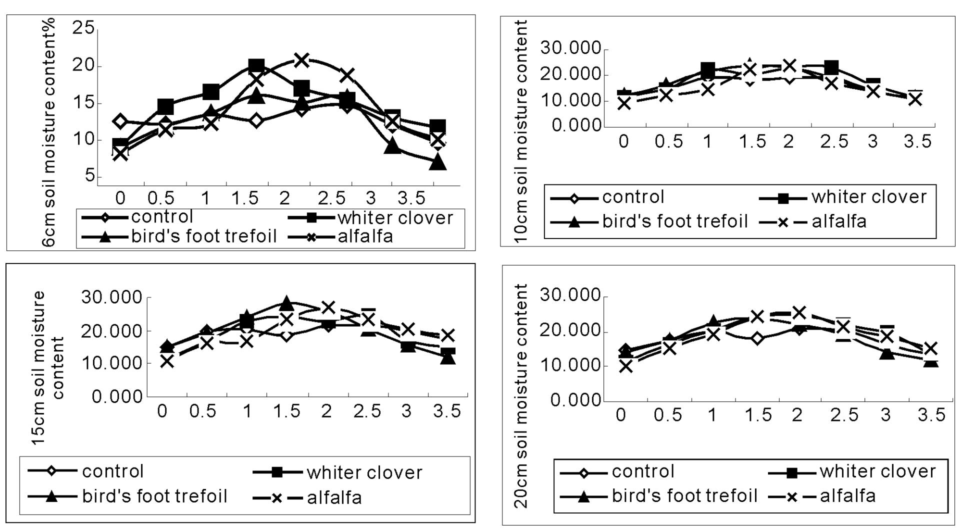

Figure 1 *The change of soil water of whiter clouer, bird's foot trefoil, dfalfa ard ck in different.*

Table 1 *The situation of each intercropping forest land soil fertileity unit(mg/kg).*

	N	P	K	pH
Alfalfa (mg/kg)	54.05	42.29	113.92	8.70
Bird's foot trefoil (mg/kg)	55.36	27.55	273.12	8.82
Whiter clover (mg/kg)	46.11	20.29	133.26	8.78
Control (mg/kg)	39.6	25.36	188.45	8.82

Table 1 indicates that Because of the leguminous forages has the strong own nitrogen-fixing capacity, after intercropping leguminous forage, obviously enhances the soil fertility, particularly soil nitrogen. In Linxia Gansu province, the three kind of leguminous forages in do not Rhizobium, lotus corniculatus's own nitrogen-fixing capacity stronger than alfalfa and white clover.

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Spatial-temporal landscape dynamics in the Hulunbeir forest-steppe ecotone

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Key words : forest-steppe ecotone , landscape pattern , landscape heterogeneity

Introduction The forest-steppe ecotone with alkalized grassland is in Hulunbeir , which borders the Great Xing'an forest region , is one of the most significant ecological barriers in North China . In the last decades , due to the changes of global climate and the general impacts from human activities , timberline in the transition region moved up , grassland changed into desert and the water and soil lost drastically . All these factors , in combination , severely hamper the sustainable development of local resource , environment , economy and society . Nowadays , researches on dynamic changes of landscape structure and function characteristics are still few .

Material and methods By integrating Remote Sensing and Geographic Information System , the spatial information of landscape pattern of ecotone between forest and grass in Hulunbeier during three periods of 1995 , 2000 and 2005 was explained and extracted . This paper explores how and why the landscape pattern changed , based on the basic theory and method of landscape ecology , taking number of patches , fragmentation and division as indexes to analyze the spatial-temporal dynamic changes of the landscape pattern .

Conclusions It is remarkable to interchange between different landscapes , especially among forest land , grassland , cropland and unused land . The area of forest land has decreased sharply by 7858 km^2 , while the unused land increased 4087 km^2 . The indices of landscape characteristics have changed significantly from 1995 to 2005 , with the landscape diversity index and fragmentation index increasing and the landscape dominance index decreasing . Main landscape types including forest , grassland , and cropland , unused land show that their patches quantity increased and patch shape changed more and more complexly (Table 1) . This study revealed the intensities , directions , and rates of landscape pattern changes , and the relationships among landscape pattern , ecological processes , and human activities .

Table 1 *Analysis of landscape index in main landscape pattern from 1995 to 2005* .

	Forest			Grassland			Cropland			Unused land		
Year	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
NP	1392	1359	1008	3817	4007	4666	3817	4007	4666	3817	4007	4666
F	0 .024	0 .0233	0 .0166	0 .0812	0 .089	0 .1165	0 .2699	0 .2288	0 .2211	0 .1459	0 .1569	0 .1647
D	0 .869	0 .8744	0 .8655	0 .9039	0 .9184	0 .987	0 .9488	0 .9742	0 .9921	0 .9584	0 .9677	0 .9994

NP : Number of Patches ,F : Fragmentation index , D : Division index

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Rangeland availability , use of the flora and land ownership in el Toro Gorge (Rosario de Lerma Department , Salta Province , Argentina)

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Key words : Argentina , overgrazing , poverty , Andean communities

Introduction The River Bull Gorge is located in the Eastern Cordillera of the Salta Province , in a NW-SE direction , at an altitude of 1700 m . It is located between Campo Quijano (24°55′S ,65°37′W) , 1520 m .a .s .l . and Las Cuevas (24°21′4 .9″S , 66°1′27 .9″W) , 3250 m .a .s .l . The vegetation (Western Monte and Puna) is correlated with the rainfall , which is concentrated between December and March , diminishing quickly within a few kilometers to the North West because of the topography . In Campo Quijano the annual average rainfall is 1052 mm , Ing . Maury 98 mm , Gobernador Sol 68 mm and Puerta de Tastil 67 mm (Bianchi and Yañez , 1992 ; Morello , 1958 ; Ruthsatz , 1977) . Cattle are grazed on the highland rangelands in summer and the lowlands in winter . The research objectives were : 1 .To determine the condition and value of the rangeland in the study area . 2 .To register the uses of the flora by the local people . 3 .To analyze the cause of the decrease of livestock and its relation to the incentives given by the government for raising cattle and land ownership .

Materials and methods At 9 locations the gorge 124 plant species were collected and their use was determined through information gathering and workshops with local cattlemen .

Results and discussion Fiftheen species are good for grazing , 65 are emergency forage and 36 are not valuable for cattle , the other identified plants have different uses . Comparing national cattle censues , in Rosario de Lerma the highest receptivity was in 1930 , but according to the figures of the last census in 2002 , the number of cows decreased 66 % , sheep 80 % and goats 70 % . Cattle censuses were compared with censuses of humans and a severe decrease in the number of cattle per person was found , and the poverty of local people increased causing immigration away from the study area . The cattlemen perceived that cattle deaths , occurred due to alternate dry and wet years , and not because of overgrazing . The lack of availability of rangeland , rangeland mismanagement , health problems in cattle , attacks by predators , and lack of cattlemen groups and cooperative efforts explain the stock reduction , but define overgrazing as the key problem of the ecosystem .

Conclusions The different plant communities in the gorge belong to the arid ecosystem and they cannot sustain continuous grazing . The primitive way of raising cattle shows the need for rural extension programs and methods for developing irrigated pastures , in order to have reserve forage available in the dry season and to reduce the human immigration from the study area . On the other hand , the efforts of the native people to obtain the ownership of the land are in different stages of progress . Nevertheless ownership of the land doesn't solve the poverty problem . Land ownership should be supported with sound advisory projects , with funds and technical assistance to aid managing and improving the natural resources .

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Observation on the pollen morphology of 5 species of *Caragana* Fabr . plants in the alashan desert

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Key words : Pollen grain , Pollen morphology , *Caragana* Fabr . , Alashan desert

Introduction The Alashan desert is located in the Alashan highland of Inner Mongolia plateau . Many *Caragana* Fabr . species distributed in the desert and arid grasslands of the Alashan highland . They are very important for protection of the environment of the Alashan desert . Observation of the *Caragana* Fabr . pollen morphology from the plants in the Alashan desert can provide valuable information for some researches of how to use the desert plants .

Materials and methods The materials for the study were sampled in 2004～2005 . *Caragana* Fabr . Plants , integrated plants and pollen sample were uniformly gathered . Pollen sample was scattered on double sided pastern paper on carry matter desk equably and plating film by IB-5 hydronium spatter instrument . Sample are sended into S-530 scan electron microscope , choose different magnify multiple and observe angle to go along observe and photograph for pollen sample . All datas of microspore surface characters are root in the average of 20 microspore(Wang Kaifa ,1983 ; Wan Tao ,1999) .

Results and analysis The abnormal pollen morphology of 5 species of Caragana Fabr . is (24 .34～32 .11) μm × (11 .31～20 .27) μm which is belong to minitype . Others are middle pollen types(Caragana tibetica Kom . 32 .11 μm × 20 .27 μm) which equator surface is long or exceed long sphericity , P/E = 1 .59 ～ 2 .06 . The polar surface is 3-split or 3-crack rotundity . Bourgeon apparatus belong to 3 aperture channels type and the channel is thin and length to the two poles , channel edge is tidiness ; Inside aperture sink or not evidence ; Microspore surface is reticulation or aperture ornamentation , mesh or aperture is quite fleet and some assume perforation shape at polar section or channel edge . These are related with collectivity characters of Leguminosae Papilionatae Caragana Fabr . (Table 1) .

Table 1 *Character of pollen morphology of Alashan desert Caragana Fabr .*

Species name	PA(μm)	EA(μm)	P/E	Shape	Germinators		Ornamentation
					Type	Trait	
Caragana tibetica	32 .11 28 .32～33 .56	20 .27 18 .42～22 .12	1 .59	long sphericity	3aperture channels	Slightness and length to the two poles .	reticulation , mesh is fleet
Caragana brachypoda	28 .45 27 .18～31 .05	13 .67 12 .94～14 .91	2 .06	exceed-long sphericity	3aperture channels	slightness and length to the two poles .	apertur , fleet , have perforation
Caragana intermedia	27 .1 25 .23～28 .72	16 .1 14 .88～18 .98	1 .68	long sphericity	3aperture channels	slightness and length to the two poles .	apertur , fleet , symmetry
Caragana stenophylla	25 .41 22 .72～26 .90	14 .78 11 .89～16 .19	1 .72	long sphericity	3aperture channels	Slightness and have film	apertur , fleet , asymmetry
Caragana leucophloea	24 .34 21 .55～26 .32	11 .31 9 .56～13 .66	2 .15	exceed-long sphericity	3aperture channels	Narrow and inside aperture sink	apertur , small and fleet , no perforation

Conclusions *Caragana* Fabr . is belong to evolutional species comparatively but not the furthest(not 3 aperture type) . Pollen morphology is outbalance part in collectivity character of plant , all characters of microspore accord with the genetic stability and diversity .

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Changes of residue function and signaling regrowth after forage cutting

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Key words: mowing, photosynthesis, root uptake and absorption, signal transduction during regrowth

Introduction The world is facing big challenges that farming field keeps reducing; water resource becomes shorter and limited resource degrades continuously. Grassland stockbreeding is more efficient than simple cultivation, so it has been considered an effective solution in agriculture. Cutting (or mowing, foliating and even grazing) is one of the most constant methods to utilize grassland, especially artificial grassland. The regrowth after cutting is essential to the utilization of forage and grassland. The changes in residue function and the signal transduction during regrowth is still not fully understood and is attracting more and more attentions.

Changes of residue function After forage is cut, the compounds stored in residues will be activated and reallocated among remained parts of the plant. The reallocation will help residue regrow as soon as possible. Most importantly, the reallocation will stimulate the remained residues, altering their functions. And in response to the actual stimulus, cutting, the residue also has to change its original function to adapt new situation. Photosynthesis is essential for residue living. With this process, substance and energy can be produced and the residue can regrow smoothly. Photosynthetic rate of the aboveground parts will increase, resulting in more production and accumulation of carbohydrates. Meanwhile, the residue will keep higher rate of photosynthesis for a longer period after cutting. Intriguingly, new tillers and shoots also have greater rate than the control. Compounds reallocation and photosynthesis enhancement lead to smooth regrowing of the aboveground part, but restrict the growth of roots. However, this restriction happens without weakening its function. After cutting root absorption and uptake can be enhanced (Osmond et al., 1997). In addition, the transmission distance is shortened after cutting, so it is understandable that translating ability is to be enhanced.

Signaling regrowth after forage cutting Many evidences have been shown that signals will appear when plant encounters environmental stimuli, including biotic and abiotic stimuli. These signals conclude phytohormones, ions, and secondary metabolites. Cutting (and grazing) is also one kind of abiotic stimulus. So, some of the signals functioning in plant response to known stimuli will be reasonably effective in the signal transduction of regrowth after forage cutting. It is understandable that phytohormones, such as ABA, IAA, GA_3 and CKs, play important roles in the regrowth after cutting. And also cytosolic Ca^{2+} is expected a fundamental signal in this signaling. In addition, some secondary metabolites, such as amino acid, protein, simple carbohydrate, may also act as signals to elicit the regrowing response. The hypothesized signal transduction in forage regrowth should include all these elements. Phytohormones, such as IAA and GA_3, will affect the reallocation of reserves and the translocation of newly synthesized carbohydrates. ABA and Ca^{2+} concentration will be involved in the regulation of stomatal movement (Yang et al., 2004), leading to change in photosynthesis. The pH variation in xylem sap leads to changes in transmission of xylem. However, most of the aforementioned signals and signaling are just supposed to work in the regrowing process. Further investigation needs to be done.

Concluding remarks What signal does connect cutting stimulus with residue regrowth? Further work has to be done to investigate which the right one is and how it does. From the viewpoint of methodology, analytic chemistry and biophysics should be integrated to investigate the substances working beneath the regrowth. And, stomatal regulation and photosynthesis variation can be put more attentions. In addition, change in root function is also worth of further exploration.

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The monitoring of ecological effect of implement of sand control project in sand source area round Beijing and Tianjing

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Key word : Rangeland , Desertification , Dynamic monitoring , Remote sensing , sand control project , area around Beijing and Tianjing

Introduction Rangeland desertification is a serious ecological problem in north dry and semi-dry region in China . Since 2000 , the sand control project has been carried out in sand source area Beijing and Tianjing . The monitoring result exhibits that the implementation of sand control project has lead to positive effect on rangeland vegetation

Method Dynamic monitoring of rangeland desertification depends on remote sensing technology and field investigation . The vary of vegetation cover and overground biomass inversed NDVI (normal different vegetation index) from MODIS data were used to explain the rangeland quantity change from 2000 to 2006/2007 , the comparison of vegetation component get by field investigation between out and inner enclosure to illustrate the rangeland quality change , and sand area in different period obtained by Landsat TM data through supervised classification method to quantify the dynamics of rangeland desertification .

Result From 2000 to 2006/2007 , the average vegetation cover in Nemenggu , Hebei and Shanxi provinces increases 6 percentage points , the grass output increases 12 .0% averagely (Tab .1) , and the serious deserted rangeland at HunShanDaKe sandlot decrease 24 .8% averagely (Tab .2) . The proportion of eximious timothy at inner enclosure is higher than the out .

Table 1 *Change of vegetation cover and grass output from 2000 to 2007 .*

province	Vegetation cover (%)			Grass output(kg/ha)		
	2000	2007	variation (percentage point)	2000y	2007y	variation (%)
Neimenggu	26 .0	32 .3	6 .3	1021 .7	1150 .3	12 .6
Shanxi	37 .7	43 .3	5 .6	1410 .0	1564 .7	11 .0
Hebei	45 .0	51 .0	6 .0	2121 .7	2387 .7	12 .5

Table 2 *Change of serious deserted rangeland from 2000 to 2006/2007 .*

county	decrease(%)
abaga	18 .8
Sunitezu	21 .5
xilinhaote	24 .2
xianghu	25 .3
zhengxiangbai	31 .0
zhenglan	27 .8
average	24 .8

Conclusion Based on the monitoring result by remote sensing and field investigation ways , It is can be concluded that the implementation of sand control project has led to good ecological effectiveness .

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Investigation the improvement operations affections on ecological indexes of rangeland health in rangelands of Golestan province ,Iran

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Introduction Changes in rangeland vegetation ,soil and water resources create by some natural distributions or management (Miller 2004) .Changes are determining variety of plant community (Bestelmeyer 2006) .Potential vegetation classifications such as ecological sites ,ecological types (USDA ,NRCS 1997) and range sites are commonly used by land management agencies as a framework for organizing natural resource information ,and also as a tool for communicating natural" baseline conditions for ecosystem health assessments ,predictions of vegetation response to management ,and resource value potentials .Now rangeland health is base on the concepts of succession espoused by Clements (1916) .Rangeland mangers must have knowledge about ecological factors that determine the rangeland health .

Material and methods In this study used Landscape Function Analysis method for inventory's rangeland health in six landscapes . Landscape Function Analysis (LFA) is a monitoring procedure that uses quickly determined field indicators to assess the functional status of rangelands (Tongway and Hindley 2004) .The 11 soil parameters were measured on the three transects of 50 meters length and compared three functional properties stability infiltration and nutrient cycle

Result Resulted shows numbers of patches in closed area landscapes were very more than beside of them .The index of landscape stability was higher on the closed area than the next to for patches ,and the index of nutrient cycling was higher in closed area than at the side of for patches and the index of landscape infiltration was higher on the closed area than the beside for patches . These indexes were higher in patches than inter patches .

Table 1 *Value of Stability ,Infiltration and Nutrition recycle for closed area landscapes and the near of closed area landscapes in patches and inter patches .*

Landscapes	Patch	Stability	Standard error	Infiltration	Standard error	Nutrition recycle	Standard error
Closed area	Patch	86/4	0/5	58/8	0/8	66/4	0/7
landscapes	Inter Patch	47/4	0/3	48/9	0/7	45/7	0/88
The near of closed	Patch	63/0	0/3	58/5	0/9	49/7	0/5
area landscapes	Inter Patch	13/7	0/9	26/7	0/5	34/4	0/5

Conclusion According above results we can analysis the management of rangelands by LFA model .Improvement operations changed indicators of rangeland health in this area .Closed area landscapes because of light grazing had best condition than the near of closed area landscapes and for any three index variations is significant

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The results of analysis of *Allium* genus of Mongolia

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Key words: Chromosome, karyotype, population, polyploidy

Introduction There are a lot of factors influencing the evolution and heredity of live organisms. One of its branches is the field of karyology that studies the specifics of chromosome structure composition and form, is considered to be material basis for organism heredity and modification. Over thirty species of wild *Allium* that grows on the territory of Mongolia. In addition in fact that these are the constant members of the dry steppe plant community, they grow in high mountains, forest steppe zone, desert and deserted-steppe and Mongolian plateau. *Allium mongolicum* and *Allium polyrrhizum* that grow in Mongolian Gobi-desert zone are, of a high nutritional quality and is considered to be one of the main plants of Mongolian grass lands.

Materials and results We studied Khubsugul, Bulgan and Biger populations. In Khubsugul and Bulgan population satellite chromosome is located at 6^{th}st chromosome' s short arm. SM chromosome is located at the third pair of chromosomes. But there is difference in the Gobi-Altai of Biger population karyotype.

We are the first to discovered B chromosome in *A. altaicum* in Mongolia. As a result of this, we see that there is a numeric change of SM chromosome, which in can that there is a polymorphism in the Biger population. But all three populations have a lot of similarities as well. All of them are of 2A karyotype, relative length of chromosome are close, and have very clear satellite chromosome. Morphologically there are very similar, although the Biger population *A. altaicum* bulb is bigger than the other population. This is due to polymorphism in the Biger population.

Our comparison of karyotypes *A. altaicum* and *A. fistulosum* has revealed a high degree of similarity, indicating a close relationship. Therefore we can conclude that the cultivated species *A. fistulosum* originated from the natural species *A. altaicum*.

Conclusion We can conclude the following from our study:
Basic number of chromosomes increase: its diploids, tetraploids, pentaploids and hexaploids. There is a karyotype differentiation *A. bidentatum*, *A. amphibolum* and *A. mongolicum*. They all belong to 2B karyotype. We have studies several populations of *A. altaicum*. Namely, it is remarkable that in this country under the extremely diversified environmental conditions, specific karyotype patterns may appear in the more or less isolated populations of often low individual number, as a result of natural selection, genetic drift, geographical of ecological isolation. Factors causing and maintaining such karyotype variations or even polymorphism maybe in Mongolia the following physico-geo graphic conditions: The average 1580 m high above see level; the cold continental climate; the highly diversified topographs forms and because of this very great microclimate differences within small distances; the ecological isolation in the great closed basins on the mowing or semi-fixed sand-dunes, on the ridges and plateaux of inselbergs; the overlapping and mosaic pattern of vegetation zones; on the southern slopes the absence of vegetation characteristic of certain altitudes; in general, the increased fragility of the arid ecosystems.

How do grazing and stochastic rainfall affect vegetation ?— Insights from a simulation approach

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Key words : Simulation model ,stochastic precipitation ,interaction analysis ,understanding degradation ,grazing impact

Semi-arid and arid regions are endangered by desertification and degradation on a global scale .Most of the drylands are characterized by unpredictable and stochastic rainfall ,so the effects of overgrazing may be masked by rainfall .Due to the stochastic rainfall ,the strong dependence of vegetation on rainfall and the lack of empirical long-term studies on vegetation dynamics it is difficult to separate the effects of grazing and climate without using a modelling approach .

We therefore use a simulation model to investigate how an interaction between and grazing and stochastic rainfall affects vegetation dynamics .To separate the natural and anthropogenic effects from each other we built a grid-based and individual-based simulation model which describes the dynamics of the dominant tussock grass species of a temperate semi-arid steppe , *Festuca pallescens* ,under grazing in Northwest Patagonia (Argentine) .The model operates at the scale where the grazing decisions take place and includes a biologically plausible grazing model .Further ,it describes the impact of stochastic rainfall and grazing on the essential biological processes seedling establishment ,growth ,and mortality .

We use a pattern-oriented approach to indirectly determine unknown model parameters and to calibrate the model to show the observed dynamics .In a second step we simulate the dynamics of the *Festuca* steppe under different stocking rates .An analysis of the simulation experiments reveals how stochastic precipitation affects demographic processes of the perennial tussock grass F *pallescens* ,how grazing triggers the demographic processes ,and how grazing and stochastic rainfall interact .

The separation of the natural and the anthropogenic effects on vegetation greatly advances our quantitative understanding of the grazing impact in semi-arid and arid regions and provides robust arguments for the discussion of sustainable management of rangelands .

Grasslands/Rangelands Resources and Ecology

——Soil Quality and Plant Nutrition

Shifting rangeland mineral resource limitations : ecological responses to atmospheric Nitrogen deposition

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Key points : Deposition ofm fixed nitrogen (N) from the atmosphere into natural and managed systems is increasing worldwide , primarily as a result of fossil fuel combustion and agricultural fertilization practices . While historically most rangelands have been subjected to relatively low N deposition rates , N deposition is projected to increase in rangelands . This unintentional wide-scale fertilization has the potential to dramatically shift mineral resource limitations in rangeland ecosystems . In contrast to forested ecosystem response to N deposition , one of the most evident rangeland responses to N deposition is a shift in community composition , with declines in biodiversity and potentially shifts in the dominant functional groups . Evidence to date suggests that many other ecological processes , such as interactions with insect herbivores and carbon (C) and N cycling may in turn be affected by this shift in species composition . Increasing predictive capability of rangeland responses to N deposition is crucial for developing appropriate management strategies .

Key words : nitrogen deposition , biodiversity , nutrient limitations , global change

Introduction

Deposition of anthropogenically-fixed nitrogen from the atmosphere onto plant and soil surfaces is profoundly changing N availability and ecological stoichiometry in ecosystems worldwide . Since N is typically a major limiting resource in temperate terrestrial systems , this change in nutrient availability may have major consequences for plants and soils in both natural and managed rangelands . Historically N deposition research has focused on forests and , to a lesser extent , mesic grasslands in Europe and North America due to the high rates and long-term , chronic deposition in these areas . However , rates of deposition are currently increasing and the areas of impact expanding , with estimates of large increases in deposition over the next 100 years in rangeland areas including Asia , Africa , and South America(Lamarque et al ., 2005) . Understanding , and potentially mitigating , N deposition influences on rangelands requires development of predictive models of N enrichment on rangeland plant , community , and ecosystem properties and processes .

Anthropogenic activities have more than doubled the annual inputs of fixed N into the biosphere , and these inputs are expected to continue to increase in the coming decades (Vitousek et al ., 1997 ; Lamarque et al ., 2005) . Some of this fixed N becomes volatilized from agricultural activities (primarily as NH_x) or emitted as a result of fossil fuel combustion (primarily as NO_y) , and is later deposited from the atmosphere onto terrestrial systems (Lovett , 1994) . Deposited N can then become incorporated into the biota through root or microbial uptake of N deposited into the soil surface and via foliar uptake of gaseous and particulate N compounds (Lovett , 1994) . This deposited N may affect ecosystem properties , including fundamentally shifting the absolute and relative availability of nutrients (Vitousek et al ., 1997) .

Aber et al .(1998) developed a conceptual model overviewing the major influences of N deposition temperate forests . In this model , ecosystems at stage 0 are N limited , but chronic N deposition shifts systems to become progressively less N limited . By stage 3 systems are N saturated . Following N saturation , net primary production (NPP) and N mineralization decline , and N leaching losses are high . Aber et al . (1998) further suggest that land use history determines the initial degree of N limitation at the site , and that the forest stand type (deciduous or evergreen) dictates the rate at which sites progress through the stages and become N saturated . Predicting , and potentially mitigating , rangeland responses to N deposition requires a conceptual model similar to that developed by Aber et al . for forested systems . Considerable uncertainty remains in how rangeland response to N deposition will differ from the forest ecosystem responses described by the Aber et al . model . Here I present an overview on some of the potential effects of N deposition on rangeland plants , communities , and ecosystems , with particular emphasis on key ways in which rangeland responses may differ from forested ecosystems .

Plant mineral nutrition

At the individual level , Aber et al .(1998) suggest that N deposition leads to increases in foliar N concentration ; subsequent increases in processes such as photosynthetic rates and growth are expected until negative effects of declining Ca :Al and Mg :N ratios dominate . Studies mesic rangeland plant responses to simulated and natural N deposition typically indicate strong responses to N for the first stages of N deposition , with generally positive responses to N additions in terms of leaf or shoot N , photosynthesis , and growth (e .g ., Power et al ., 1995 ; Kirkham , 2001 ; Throop , 2005) .However , with the exception of the extremely long-running Park Grass experiment (Crawley et al ., 2005) , the short-term nature of most rangeland N fertilization studies makes results relevant only to the early stages of the Aber et al . model , while systems are still N limited . Long-term , chronic N addition experiments are needed to understand shifts in plant mineral nutritional trajectories following system N saturation .

How might these patterns differ for drier rangelands in which water, rather than N, limits plant growth? Studies to date suggest that dry rangeland plant responses to N are highly species-specific, with some species showing positive or neutral response to N additions, and others showing co-limitation by water and N (e.g., Lajtha and Whitford, 1989; Drenovsky and Richards, 2004; James et al., 2005). Across a precipitation gradient, there was conflicting evidence for shifts from N to water limitation with decreasing precipitation, with responses dependent upon the indices considered (Hooper and Johnson, 1999). The authors conclude that co-limitation affects plants at ecophysiological, community, and ecosystem levels, and that these influences are in turn affected by biogeochemical feedbacks in resource availability. Thus, a mechanistic understanding of individual plant-level responses to N deposition across varying precipitation regimes may require broader scale assessments of how N deposition-induced changes in larger scale (e.g. community and ecosystem) processes in turn affect mineral resource availability.

Community composition

In contrast to the ecosystem-focused Aber et al. model, some of the strongest impacts of N deposition in rangelands appear to be shifts in the composition of plant communities and interactions among organisms. Nitrogen deposition has been identified as the third main threat to biodiversity worldwide (behind changes in land use and climate); and grasslands, savannas, and Mediterranean systems may be among the most susceptible to N deposition as these systems are often limited, at least in part, by N (Sala et al., 2000). An analysis of functional group responses to N deposition across biomes suggests that rare species, perennials, N fixers, and native species may be most susceptible to local extinction following N enrichment (Suding et al., 2005). In rangelands, empirical evidence for decreased plant diversity in response to N deposition is particularly clear for European mesic grasslands and heathlands. A strong negative correlation between deposition load and species richness and cover has been documented in Great Britain (Stevens et al., 2006), and it has been estimated that a cumulative load of 714 kg N ha^{-1} would cause species richness to decline by 25% (Stevens et al., 2004). Substantial declines in diversity may occur quite rapidly (within three years) with high rates of N additions, but would likely occur only after 10 or more years of chronic, low-level additions characteristic of N deposition (Dise and Stevens, 2005). Proposed driving mechanisms for species losses include shifts in plant competitive abilities with altered resource availability, with N deposition in California grasslands causing competitive exclusion of native forbs by invasive non-native grasses (Weiss, 1999) and losses of forb diversity (Zavaleta et al., 2003). In contrast, coastal sage scrub subject to N deposition transitions from dominance of shrubs to dominance of grasses (Egerton-Warburton et al., 2001; Wood et al., 2006). In Minnesota, species richness declined rapidly with N fertilization, and led to a shift from C_4 warm-season grasses (with typically high N use efficiencies) to C_3 cool-season grasses (with typically low N use efficiencies) (Wedin and Tilman, 1996). Though there are many system-specific differences in particular groups that are lost, there is a clear common pattern of declining rangeland diversity with N inputs. This is in strong contrast to forested ecosystem responses where shifts in dominant canopy species are not commonly reported. However, given the lifespan of trees, changes in community composition of forested ecosystems would be expected to occur over much longer temporal periods. Given strong controls of community composition on many ecological processes, deposition-induced changes in plant community diversity will likely be a key variable for understanding and predicting rangeland responses to N deposition.

In contrast to mesic systems, N deposition into dry rangelands may have fewer consequences for community composition if plants are limited by soil moisture rather than N. However, relatively little is known about mineral nutrient-induced shifts in species composition in arid and semi-arid rangelands. In the northern Chihuahuan Desert, fertilization studies suggest that N deposition may cause increased grass cover and decreased legume abundance, as well as lead to a shift in the dominant grass species(Baez et al., 2007). In the same desert, N treatments shifted species composition, leading to a loss of C_4 summer annuals (Gutierrez and Whitford, 1987). Species diversity in dry rangelands may be maintained in part by resource pulses (Chesson et al., 2004), suggesting that temporal relationships between precipitation and N deposition patterns could also affect community patterns. Additional N fertilization studies in dry rangeland systems are needed to develop an understanding and generalize about how, if at all, N deposition and precipitation patterns interact to affect plant communities.

In addition to driving changes in plant community composition due to alteration of mineral resource availability, evidence to date suggests that N deposition may affect relationships between plants and secondary stresses such as insect herbivory. These shifts may in turn influence community and ecosystem processes (Throop and Lerdau, 2004). In mesic grasslands, simulated N deposition affects the survival or performance of insect herbivores (e.g., Power et al., 1998; Throop, 2005); these changes may affect herbivore populations (e.g., Haddad et al., 2000) and may ultimately affect plant community composition (Power et al., 1998; Carroll et al., 2003). In the case of the dominant heathland shrub *Calluna vulgaris* in Britain, N deposition-induced increases in susceptibility to secondary stresses such as insect herbivory and winter frost injury appears to be a factor in community change from shrubland to grassland(Power et al., 1998; Carroll et al., 2003). Similarly, simulated N deposition increased the fungal pathogen load for C_4 grasses in a Minnesota grassland, apparently as a result of increased foliar N concentration (Mitchell et al., 2003). Conversely, N deposition-induced shifts in plant communities may also affect herbivore and pathogen diversity. In Sweden, declines in butterfly species richness appear to be due, at least in part, to changes in plant community composition driven by N deposition. Butterfly species most likely to be lost are those reliant on nutrient-poor conditions, with greatest local extinctions occurring for those species in areas with greatest encroachment of woody plants into grasslands (Ockinger et al., 2006). Similarly, checkerspot butterfly populations in California have declined in areas where N deposition facilitates invasion by non-native grasses and competitive exclusion of butterfly host plants. This cascade of events is prevented with moderate grazing as cattle graze preferentially on grasses (Weiss, 1999).

Ecosystem processes

Aber et al. (1998) focus their model on the ecosystem level, positing that net primary production (NPP) increases with initial N deposition, but begins to decline as the system becomes N saturated (stage 2). Simulated N deposition typically increases NPP in mesic rangelands (Dukes et al., 2005; Bassin et al., 2007; Chung et al., 2007), but it is unclear whether sustained N deposition will eventually cause declines in NPP similar to those exhibited by forests. These declines occur as a result of deposition-induced losses of base cations, mobilization of aluminum, and subsequent nutrient imbalances and aluminum toxicity (Aber et al., 1998). Initial increases in NPP in response to N deposition may not occur in drier rangelands where water and N co-limit production, although eventual declines in NPP could still occur if nutrient imbalances or aluminum toxicity occur. However, the response of NPP to N deposition in rangelands may be much more complex than in forested systems if deposition-induced shifts in community composition substantially affect NPP. Studies with manipulated plant community diversity patterns have found that simulated N deposition leads to greater stimulation of NPP in high diversity communities than low diversity communities (Reich et al., 2001; Chung et al., 2007). Thus, there may be complex interactions between diversity and NPP whereby N deposition initially causes increases in NPP, but that these increases are offset by declines in plant diversity and by a subsequent dampening of the positive influence of N on NPP.

Mounting concerns over rising concentrations of atmospheric carbon dioxide, along with the possibility of economic incentives for carbon (C) sequestration, underscore the importance of understanding the extent to which N deposition influences system C sequestration capacity. If N deposition affects NPP, these changes could translate into altered C storage, although N deposition has less potential to strongly affect C sequestration in rangelands than forested systems because of minimal capacity in rangelands for C storage in woody tissue (Townsend et al., 1996). Once again, empirical evidence suggests that N deposition-induced changes in community composition may be an important driver of rangeland C sequestration response to N deposition. Soil organic C storage increased in a Minnesota grassland under simulated N deposition, but only under diversity treatments where the plant species present exhibited elevated foliar lignin concentration in response to N deposition (Dijkstra et al., 2004). Nitrogen deposition could potentially lead to large changes in rangeland C sequestration if deposition leads to increased woody plant biomass. However, although positive correlations between N deposition rates and woody plant expansion have been reported (Kochy and Wilson, 2001, 2005), conclusive drivers of woody plant expansion in rangelands remain elusive (Archer et al., 1995).

Ecosystem processes mediated by microbial activity may be strongly affected by N deposition, with Aber et al. (1998) proposing that N mineralization mirrors NPP with declines following N saturation, while nitrification and N leaching increase following N saturation. Indeed, simulated N deposition can increase N mineralization rates in rangelands (Morecroft et al., 1994; West et al., 2006). However, as with foliar N and NPP, it is not clear whether chronic N deposition-induced shifts in mineral resource availability will cause eventual declines in N mineralization in rangelands. Also in congruence with the Aber et al. model, simulated N deposition caused increased nitrification and leaching in a dry coastal dune grassland (ten Harkel et al., 1998) and increased nitrification in a Mediterranean grassland (Barnard et al., 2006). These patterns may be the result of altered resource availability to microbes driving changes in metabolic activities and biomass, although evidence to date suggests that simulated N deposition in rangelands can also strongly affect microbial community composition and function (Bradley et al., 2006; Chung et al., 2007). However, changes in these microbially-mediated processes may also be indirectly affected by changes in plant species richness, with the positive response of microbial biomass to N additions positively related to species richness in a Minnesota grassland (Chung et al., 2007). Leaching of N from a Minnesota grassland was also enhanced with N additions, but once again these were affected by plant species richness, with greater losses from monoculture plots as compared to high diversity plots (Dijkstra et al., 2007). Predicting rangeland ecosystem responses to N deposition will thus require understanding not only how N enrichment directly affects microbially-mediated processes, but also the nature of N deposition impacts on plant community composition, and how these changes in turn indirectly mediated ecosystem-level processes.

Conclusions

Projected increases in the deposition of anthropogenically-fixed N into rangelands will drastically shift mineral resource availability in these systems. The majority of N deposition research to date on the impacts of atmospheric N deposition has taken place in forested ecosystems. As such, much uncertainty remains regarding rangeland response to chronic, low-level N additions. This is particularly true in drier rangelands where water is typically a major limiting or co-limiting resource. Developing predictive models for rangeland response to N deposition will require long-term experimental work spanning from the physiological to the ecosystem level. One clearly apparent contrast from the conceptual model developed by Aber et al. (1998) for N deposition influences in forested ecosystems is that decreases in plant community diversity are a major consequence of N deposition in rangelands. Thus, N deposition in rangelands may have both direct consequences from altered mineral resource availability, as well as indirect consequences mediated by shifts in plant community composition. The sustainability, forage quality and quantity, and aesthetic value of rangelands may all be affected by N deposition. Indeed, a recent economic analysis suggested that the net financial benefits for decreasing N deposition loads may be particularly high in grassland ecosystems (Wamelink et al., 2007). These benefits can only be clearly calculated, however, with a comprehensive understanding of rangeland responses to N deposition. Rangeland researchers must face the challenge of developing predictive models of N deposition impacts on rangeland plant, community, and ecosystem properties and processes. Characterizing these responses and making generalizations across sites that differ in dominant vegetation and precipitation regime is crucial for understanding, and potentially mitigating, the negative consequences of N deposition on rangelands.

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Nitrogen cycling in intensively grazed pastures and practices to reduce whole-farm nitrogen losses

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Key points

1. A large proportion of the N (>70%) consumed by grazing animals is excreted and this excreta is the main source of N losses from grazed pastures by ammonia (NH_3) volatilisation, nitrous oxide (N_2O) emission and nitrate (NO_3^-) leaching.
2. Management strategies and practices that can reduce N losses in grazing systems include optimising N inputs, manipulating soil N cycling processes, selecting for plants and animals that maximise N utilisation and altering grazing and feeding management.
3. Using stand-off/feed pads or housing systems for removing grazing animals off pasture during greatest risk periods of N loss can reduce excreta deposition to soil at these times, thereby reducing N leaching and N_2O emissions. However, NH_3 losses as a result of N pollution swapping" need to be controlled.
4. Mitigation strategies and practices always need to be evaluated in a whole farm system context to ensure overall efficiency gains through decreasing N losses per unit of animal production and to achieve a tighter N cycle.

Key words: Nitrogen, grazed pasture, leaching, nitrous oxide, ammonia, nitrogen loss, mitigation strategy

Introduction

Grasslands cover between 20 and 40% of the earth's land surface (Reynolds et al. 2005). Some of the land occurs naturally in the semi-arid climate with no external inputs. These extensive low input systems may be legume-based, but production is often limited by N availability. In the more humid regions including Australia, New Zealand (NZ) and parts of North and South America and Europe, most pastoral land is managed. The managed pastures are generally more productive with higher per-hectare animal productivity as an important goal for the pastoral farmers. Input of resources including N fertiliser to the managed pastures can be substantial, resulting in a large N surplus (i.e. N inputs-N outputs in products). For example, N surpluses of 150 to 250 kg N ha^{-1} yr^{-1} occur in highly productive dairy farm systems in the Netherlands and northern Germany (Rotz et al. 2005).

In grazed pastures, the conversion of consumed N into product is low and a substantial amount of N (>70%) is recycled through the direct deposition of animal excreta. Such a low utilization of pasture N reflects a simple feature of the pasture-animal relationship; in most situations, pasture plants require significantly higher concentrations of N to grow at optimal rates than is needed by the grazing ruminant for amino acid and protein synthesis (Haynes and Williams 1993). The proportion of N in the urine increases with increasing N content of the diet. In most intensive high-producing pasture systems, where animal intake of N is high, more than half the N is excreted as urine.

The large N surplus and low N utilisation in intensively grazed pasture systems increases the risk of N losses to waterways and the atmosphere. There have been increasing concerns about the environmental impacts of the N losses, and accordingly, research has been focusing on developing strategies and practices to reduce the losses. This paper first outlines major N transformations and losses in managed grazed pastures and then presents a range of options that can be used to reduce N losses from intensively grazing systems.

Nitrogen transformation processes leading to N losses in grazed pastures

The transformations and losses of N in managed grazed pastures have been previously reviewed (e.g. Haynes and Williams 1993). The N in excreta following deposition undergoes microbial mineralisation before it is released as ammonium ion forms (NH_4^+) and NH_3. This mineralisation of N is much faster from urine than from dung. N can be lost to the atmosphere by NH_3 volatilisation, or converted to nitrate (NO_3^-) through nitrification process by nitrifying bacteria in soil. NO_3^- is then prone to leaching losses and denitrification. Denitrification is the conversion of NO_3^- to gaseous N products (N_2O and N_2). The primary transformations leading to N losses are ammonia volatilisation, nitrification and denitrification. The magnitude of N input to grazed systems is generally the main factor determining the N surplus and therefore the potential for N losses. For example, Ledgard et al. (1999) found that a three-fold increase in total N inputs to intensively-grazed dairy pastures in NZ resulted in a four-fold increase in N surplus, a four-to five-fold increase in gaseous and leaching losses, and a halving of the N use efficiency (Table 1). A summary of dairy farm systems across western Europe showed an even wider range in amount and form of N inputs, N outputs, and N surplus, with denitrification being generally higher overall and N leaching lower (Bossuet et al. 2006).

Table 1 *N inputs and outputs from intensive dairy farm systems in NZ receiving N fertiliser at nil or 410 kg N ha^{-1} yr^{-1} (Ledgard et al. 1999 and unpublished data). Bracketed values are range in N flows measured over 5 years. Data are compared with that from a range of farm systems in western Europe (Bossuet et al. 2006).*

	0 N (NZ)	410 N (NZ)	EU farms
N Inputs (kg N ha^{-1} yr^{-1}):			
Clover N_2 fixation + atm. dep.	170 (90-220)	50 (25-135)	6-133
Fertiliser N	0	410	0-262
Manure N (imported)	0	0	0-22
Purchased feed	0	41	6-489
N Outputs (kg N ha^{-1} yr^{-1}):			
Milk + meat	78 (68-83)	114 (90-135)	20-127
Transfer of excreta to lanes/sheds	53 (41-63)	77 (72-91)	
Denitrification	5 (3-7)	25 (13-34)	10-41
Ammonia volatilisation	15 (15-17)	68 (47-78)	18-81
Leaching	30 (12-74)	130 (109-147)	16-63
Immobilisation of fertiliser N		70 (60-84)	
N balance (kg N ha^{-1} yr^{-1}):	-11 (-74 to +47)	7 (-11 to +24)	
Farm N surplus (kg N ha^{-1} yr^{-1}):	92	387	70-463
N use efficiency (product-N/input-N)	46%	23%	22-36%

Ammonia volatilisation In grazed pastures, biological degradation of animal excreta and hydrolysis of fertilisers containing urea and ammonium ions leads to the continuous formation of NH_3 in the soil, which can volatilise to the atmosphere. Jarvis et al. (1989) found that NH_3 loss from urine patches increased under high N fertilisation because more N was excreted in urine. Less NH_3 is lost from grazing systems than from animal housing systems, where the combined loss from the animal houses, manure storage and field application can be large. Jarvis and Ledgard (2002) made a critical comparative analysis of NH_3 losses from two contrasting model dairy systems in the United Kingdom (UK) and NZ. The desk study has demonstrated distinct differences between the two farming systems in terms of total N input, N off-take, N surplus and per hectare NH_3 loss. These values were 1.7, 1.2, 1.8 and 2.4 times higher in UK than in NZ, respectively. The greater per hectare loss of NH_3 in the UK farm was attributed mainly to the higher fertiliser N input, and to the housing of animals and the subsequent spreading of the manure to the farm. However, when NH_3 loss was expressed in relation to the farm N surplus, there was little difference between the two farms with NH_3 loss being approximately 20% of the N surplus in each case.

Nitrogen leaching Review of research on grazed systems suggests that NO_3^- leaching increases exponentially with increased N inputs (Figure 1). Studies have also shown the greater importance of urine N compared to fertiliser N in contributing to NO_3^- leaching, and urine typically contributes 70%-90% of total N leaching loss (reviewed by Monaghan et al. 2007). Fertiliser N is generally used efficiently by pastures but it enhances pasture N uptake and pasture N concentrations, thereby exaggerating N excretion in urine and increasing risk of loss. NO_3^- leaching losses are much higher during winter as a result of high rainfall and low evapotranspiration. Winter leaching of N can be further exacerbated by dry summer/autumn conditions and an associated slowing down of plant growth, which results in a build-up of NO_3^- levels in soil by autumn (Scholefield et al. 1993). Estimates of N leached from managed pastures vary widely, ranging from 6 to 162 kg N ha^{-1} yr^{-1} and this is due to differences in N input, pasture N uptake, soil drainage and animal type (e.g. Stout et al. 2000). Leaching of Ca^{2+} and other base cations is associated with leaching of NO_3^-, which can potentially decrease soil pH (Haynes and Williams 1993). Leaching of N forms other than NO_3^- is generally low and not measured. However, ammonium leaching can occur on some soils and may be enhanced where

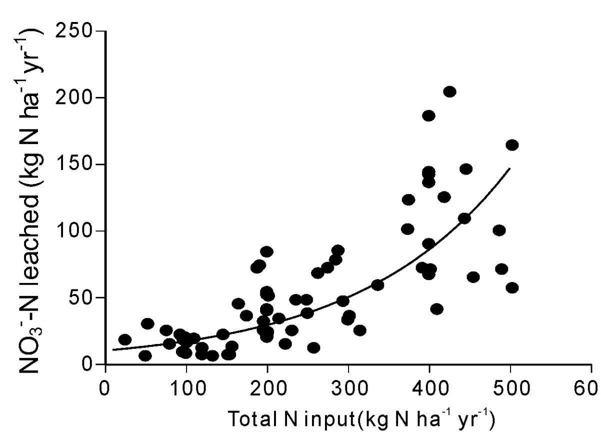

Figure 1 *Nitrate leaching from grazed pasture systems as affected by total N input. Data are a summary of studies in NZ, France and UK. The line of best fit is an exponential function obtained by fitting the data on the log scale.*

mitigation practices target reduced nitrification . Recent research also indicates that in some situations , dissolved organic N can be a significant source of N leached (Jones et al . 2004) .

Nitrous oxide emission High N_2O emission rates in grazed pastures have been observed (e .g . Hyde et al . 2006) and these high rates are associated with N and C from the deposition of animal excreta to the soil and anaerobic conditions as a consequence of soil compaction caused by animal treading . Wet soil conditions soon after N fertilisation or grazing resulted in high N_2O emissions from pastures . N_2O emissions from dairy pasture soils in New Zealand and Australia ranged from 6 to 11 kg N_2O-N ha^{-1} yr^{-1} (Dalal et al . 2003 ; Luo et al . 2008a) , where losses of up to 29 kg N_2O-N ha^{-1} yr^{-1} have been recorded from an Ireland grassland with N application rate of 390 kg N ha^{-1} yr^{-1} (Hyde et al . 2006) . There has been limited research on practices to increase the ratio of N_2 :N_2O emitted and more applied research is needed to identify options to increase loss of the benign N_2 relative to the potent greenhouse gas N_2O .

Management practices to reduce N losses

Strategies to reduce N losses from grazed pastures need to focus on reducing the N surplus in the system and on increasing N use efficiency through converting more N to animal products such as milk , meat and wool . As outlined in Figure 2 , there is a range of possible management strategies and practices that can be used to reduce N losses from grazed pastures . Some are in use , whilst others need further research and development before adoption . Larger reduction of N losses may be achievable through the use of multiple strategies . However , the individual effects of each strategy may not necessarily be cumulative .

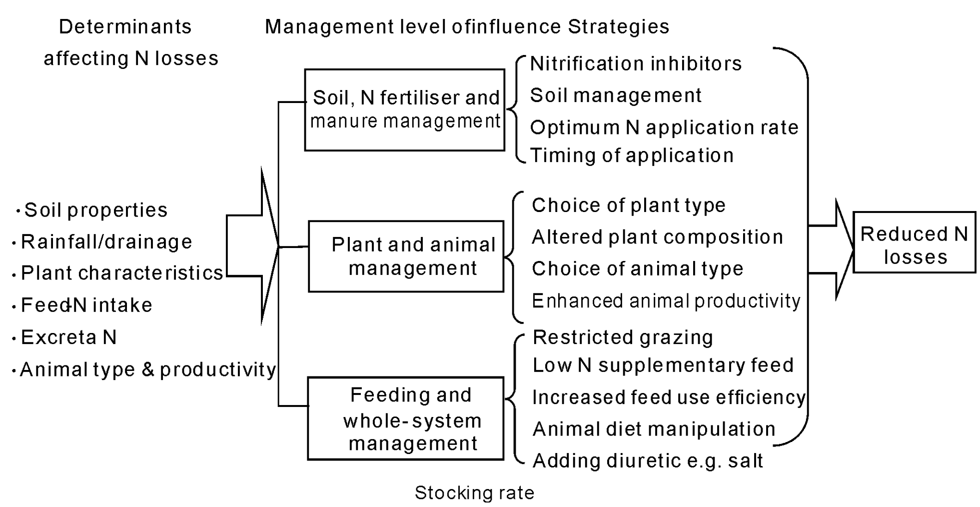

Figure 2 *On-farm management strategies for reducing N losses .*

Soil , N fertiliser and farm manure management

Soil management Soils differ in their risk of N losses . For example , poorer-draining clay-textured soils generally have higher denitrification and N_2O losses and lower N leaching . Reduction in N_2O losses could be achieved by altering soil conditions e .g . liming , improving drainage and avoiding soil compaction , although the general applicability of these methods is limited . However , this can result in the dichotomy of N pollution swapping , such as improved drainage reducing N_2O emissions but increasing N leaching . Farmers can also alter efficiency of N cycling in soil by strategic immobilisation of excess N prior to high N loss periods such as by carbon addition or by controlling N transformation processes in soil (e .g . inhibiting nitrification by use of inhibitors) .

N fertiliser or manure management Appropriate fertiliser or manure N management decisions should be made to optimise application rates and timing to ensure efficient use of the applied N . Limiting the amount of N fertiliser or manure applied under wet conditions in autumn and winter , when pasture growth is slow and soil is wet , can decrease direct leaching of fertiliser or manure N and N_2O emissions (van der Meer 2008) . Techniques , such as incorporation and injection of effluent and animal manure into the soil , are available that reduce the amount of NH_3 volatilisation during and after field application (Sommer et al . 2003) , but these techniques increase CO_2 emissions because more fuel is required (Hansen et al . 2003) . These NH_3 reduction techniques may also lead to N pollution swapping with associated increased N_2O emissions and leaching from the soil (Brink et al . 2001) .

N process inhibitors Technologies employing urease and nitrification inhibitors (NI) can be used as effective mitigation alternatives to control N losses from urine and N fertiliser by acting on the N processes of urea hydrolysis and nitrification respectively. For example, studies have shown that both NO_3^- leaching and N_2O emissions from urine patches can be potentially reduced by up to 70% with land application of NI onto pastures (reviewed by Monaghan et al. 2007). Alternatively, this reduction could be achieved by strategically targeting the urine patches. A detailed animal metabolism study has shown that NI can be delivered to animals (e.g. using a slow-release bolus) and excreted intact in the urine resulting in inhibition of nitrification of urine-N on deposition to soil (Ledgard et al. 2008). A recent field grazing study using this novel approach showed a 30% reduction in both NO_3^- leaching and N_2O emissions (Ledgard and Luo, unpublished). However, accumulation of NH_3 and NH_4^+ due to the use of NI may increase potential of NH_3 volatilisation and NH_4^+ leaching.

Plant and animal selection

Some strains of ryegrass have been shown to have increased rooting depth (Crush et al. 2007) which increases their ability to remove N from a greater depth of soil, thereby potentially reducing the risk of N losses. In plants with high tannin levels which are consumed by grazing animals, less N is excreted in urine relative to dung (e.g. Misselbrook et al. 2005). Studies by Merry et al. (2003) have shown that feeding beef cattle with grass silage containing elevated concentrations of water soluble carbohydrates increased the N use efficiency for microbial growth in the rumen from 46% to 68%. Similarly, Miller et al. (2001) found that dairy cows on a high sugar" variety of perennial ryegrass excreted 18% less N in total and 29% less urine N. Thus, manipulation of plant composition offers potential to reduce N excretion in the urine, thereby reducing the risk of subsequent N losses from this highly concentrated N source. Plants also have the potential to alter soil N cycling via the quality of their residues. We have measured a 10-fold difference in gross N immobilisation rate between non-N-fertilised grassland dominated by *Agrostis* and *Holcus* spp. compared to ryegrass with a regular N fertiliser history. Such differences in immobilisation potential may be important controllers of N losses from N sources such as animal urine.

Animal type influences the efficiency of N cycling. Our field research showed less NO_3^- leaching from sheep or deer than from beef cows for the same level of pasture N intake, associated with greater spread of urine-N and increased efficiency of N cycling (Hoogendoorn et al. unpublished data). Breeding and selection of grazing animals for increasing productivity is also an attractive option to reduce N losses. For example, increasing milk production efficiency in dairy cattle will partition more N to milk formation relative to maintenance and reduce the amount of N that ends up in excreta. Similarly, growing meat-producing animals to their finishing weight more quickly reduces the associated maintenance requirements, thereby reducing total intake and N excretion. This also reduces methane and N_2O emissions thereby reducing their greenhouse gas footprint.

Feeding and whole-system management

Low N feed supplement Pasture typically contain an excess of protein relative to animal requirements and supplements with low protein feed (e.g. maize silage) can increase efficiency of N utilisation (e.g. Kebreab et al. 2001). Potentially, diets can be managed to meet animal requirements such as by supplementing with low protein feed at high levels in non-lactating animals with lesser protein demand than for periods of high milk production. However, such strategies need to account for the whole system, as discussed later.

Diet additives or manipulation Animal supplementation studies have shown that salt addition to feed can also increase urine volume, decrease urine-N concentrations (Ledgard et al. unpublished data) and increase spread of urine, thereby possibly increasing N efficiency and decreasing N losses. Kool et al. (2006) showed that increasing the hippuric acid concentration in urine reduced N_2O emission by up to 50% in a laboratory study, and suggested that manipulating the diet of animals to increase the hippuric acid content of the urine could be potential N_2O mitigation strategy. Further research on this is required.

Nil or restricted grazing systems In temperate environments with winter grazing, practices involving the use of stand-off/feed pads or housing systems can reduce N_2O emissions and NO_3^- leaching. With this practice, animals are kept off grazing paddocks, so excreta deposition is reduced at a time when it leads to greatest N losses (e.g. late-autumn/winter). This practice provides opportunity for controlling N losses, as the animal excreta is collected and can be applied evenly to the pasture at targeted rates and optimum time when the risk for N losses is minimal (Luo et al. 2008b; van der Meer 2008). In these systems, collection and application of large quantities of manure become critical for N use efficiency, as there are many opportunities and places for N compounds to escape from animal manure management systems. Management techniques are increasingly important with these practices to avoid N pollution swapping (e.g. reducing N leaching from paddocks but increasing NH_3 loss from animal houses). However, studies (e.g. van der Meer 2008) suggest that N losses could be much higher for animals grazing on pastures than for housed animals with optimised effluent treatment using anaerobic lagoons. Anaerobic digestion of the animal manure during storage has an additional potential advantage of producing methane as biofuel.

Whole system efficiency Management of all factors involved in the N cycle to reduce N losses in animal grazing systems is complex, and requires a whole farm systems approach. If management practices are used to reduce N loss in one part of the system, the preserved N is prone to loss elsewhere if all parts are not equally well managed. The measure of the N efficiency needs to take account of N losses per unit of production as well as per unit of land. Management practices and technologies that increase the N efficiency within the soil/plant/animal system are likely to increase pasture and animal productivity , which in turn , is likely to increase methane emissions (e .g . increased stocking rates) . Preferably , increased N efficiency would be met by reducing N inputs and operating a tighter N cycle . Additionally , a whole-system approach needs to consider the whole food chain and to account for multiple environmental emissions and efficiency of use of resources such as energy , through the use of tools such as Life Cycle Assessment (LCA) . LCA use is relatively new to agriculture and studies have shown that the majority of environmental emissions are associated with the on-farm stages . A recent dairy farm system study used LCA to examine the effects of some intensification and N mitigation options (Basset-Mens et al . 2008 ; Figure 3) . Intensification using N fertiliser increased milk production per dairy-farm hectare by 23% and increased profitability , but led to a large reduction in energy efficiency and an increase in emissions of N sources and greenhouse gases per kg milk . In contrast , further intensification with maize silage (+78% milk production per dairy-farm hectare) resulted in little change in environmental efficiency (increased efficiency on the dairy farm but significant losses from the crop area) but increased energy use and decreased profitability . Integration of a winter stand-off or feed pad decreased N leaching , N_2O and total greenhouse gas emissions , but reduced profitability .

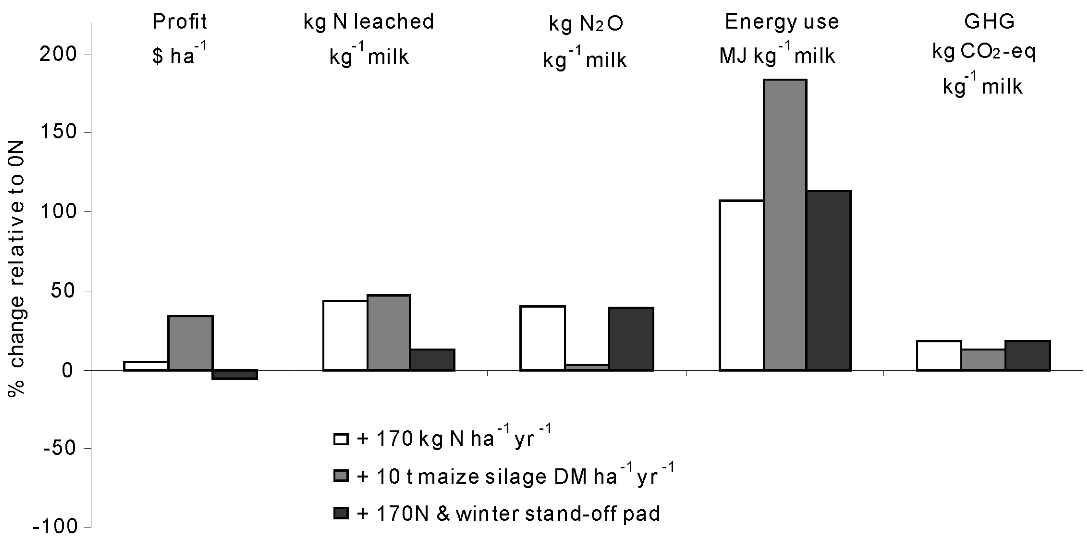

Figure 3 *Effects of intensification on profit ha^{-1} (bsaed on Economic Farm surplus) ,energy use efficiency and environmental efficiency indices estimated using Life Cycle Assessment for NZ dairy farmlet systems relative to a non-N fertiliser clover-based farmlet(from Basset-Mens et al .2008 Jensen et al .2005).*

The actual farmer practices and likelihood of adoption of environmental mitigation technologies are dependent on many factors . For example , a farmer group study using a Multiple Criteria Decision Making tool to examine a range of potential systems involving N mitigations ranked a system using a winter stand-off or feed pad poorly because of criteria such as capital requirements , risk , stress , extra skills and labour needs (Dooley et al . 2005) . These studies highlight that environmental efficiency can vary markedly with different farm systems and practices , but that achieving adoption of environmentally efficient practices by farmers requires consideration of economic and social factors as well as production and environmental factors .

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Salt driven interactions between *Salsola inermis* and *Pistacia lent*

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Key words : salinity, *Pistacia*, *Salsola*

Introduction In the live germplasm collection of Pistacia spp. (Anacardiaceae), at the Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel, Salsola inermis (Chenopodiaceae) grows around trees of Pistacia spp. (60～100 cm from the trunk), but its growth in the vicinity of P. lentiscus was inhibited. P. lentiscus is an evergreen aromatic big Mediterranean shrub, rich in resin and essential oil, composed mainly of the monoterpenes α-pinene, limonene, sabinene, and the sesquiterpene germacrene D (Barazani et al. 2003). Monoterpenes and sesquiterpenes such as α and β pinene, camphene, limonene, α-phellandrene, pulegone and camphor are known to possess phytotoxic effect. Moreover, the allelopathic effect of some plants was reported to be associated with the release of essential oil to the soil.

S. inermis is an annual which germinates in the beginning of winter, develops during summer, flowers and produces seeds in autumn. It grows in big patches, and its distribution is limited to saline and disturbed habitats in arid regions. It was assumed that allelopathy is involved in growth inhibition of *S. inermis* around *P. lentiscus*. In this study, we aimed to test the nature of these interactions.

Materials and methods The *Pistacia* spp. germplasm collection field is located in the Negev desert highland of Israel. The average yearly rainfall is 90 mm, concentrated in the winter months (November to March). Summer and winter maximum and minimum temperature averages are 35 and 20 °C and 15 and 0 °C, respectively. Plants of *Pistacia* were planted during autumn of 1996 and are growing in loess soil, under the same environmental conditions for the last 10 years (Golan-Goldhirsh and Kostiukovsky, 1998). During the dry season (April-November), plants are irrigated by drip irrigation (Netafim, Israel) twice weekly, and as necessary during winter. Germination of *Salsola inermis* occurs during winter. Then, wide patches of seedlings are observed in the field. All analyzes reported were conducted during the growing season of *S. inermis* in summer of 2002.

Results and discussion The growth of *Salosla inermis* plants is inhibited in the vicinity of the evergreen *Pistacia lentiscus*, but not around deciduous *P. atlantica* and *P. chinensis*. The study of this observation at the *Pistacia* spp. germplasm collection at the Jacob Blaustein Institute for Desert Research, Israel, is reported in this paper. *In vitro* bioassays did not reveal allelopathic effect. Moreover, germination of *S. inermis* seeds on filter paper moistened with *P. lentiscus*-soil filtrate was twice as high as that in deciduous trees-soil filtrates. Nevertheless, fresh and dry weights of mature *S. inermis* growing next to *P. atlantica* and *P. chinensis* was 2.9 to 4.8 times higher than that of plants growing in the vicinity of *P. lentiscus*. Conductivity measurements in summer, during the growth season of *S. inermis*, indicated that soil salinity beneath deciduous *Pistacia* trees was 16.5～17.5 mS and below *P. lentiscus* was 2.5 mS. It is therefore proposed that salt depletion in the vicinity of *P. lentiscus* inhibits its growth, pointing to the halophylic nature of *S. inermis*.

In an hydroponic experiment, young seedlings of *P. lentiscus* grew for a month in a medium containing NaCl at 50 and 100 mM, not showing stress symptoms. In addition, no significant differences ($p > 0.05$) were found in stomatal conductance between plants growing in control and in salt treatments, although a trend of decline was obtained at 100 mM. The results indicated that *P. lentiscus* is able to tolerate and accumulate salt, which contributes to its wide distribution along the Mediterranean coast.

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Effect of tillage and slurry application on soil quality and CO_2 emissions

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Key words : cow slurry , tillage , microbial activity , CO_2 emissions

Introduction Agricultural ecosystems generally contain less soil organic carbon (SOC) pool than their potential capacity because of the low return and high rate of mineralization of biosolids , and severe losses due to accelerated erosion and leaching . The depletion of SOC pool leads to decline in soil biological quality and resilience with attendant reduction in biomass productivity , decreased capacity to degrade and filter pollutants , increased risks of soil degradation by erosion and other processes , and increase in emission of greenhouse gases (GHGs) . Some farming practices , such as organic fertilization , no-tillage and legume-based rotations can mitigate these problems . The main objective of the current work was to study the effects of the utilization of cow slurry and no-tillage on soil quality and CO_2 emission . We also intend to study the potential of soil microbial activity to assess the effect of these agricultural practices .

Materials and methods In Spring 2005 , a 2-year field assay was established in Basque Country (northern Spain) , in an acid (pH = 5 .1) silty clay loam soil . The field assay consisted of an intensive crop rotation (cereal-legume mixture in winter /forage corn in summer) . The following treatments were applied in a randomized complete block design with 3 replicates : (i) convencional tillage + mineral fertilization , (ii) convencional tillage + cow slurry , (iii) no-tillage + mineral fertilization , and (iv) no-tillage + cow slurry . An absolute control (v) , consisting of a contiguous native meadow , was also studied . Mineral fertilization consisted of 150 kg N ha^{-1} , 100 kg P ha^{-1} , and 150 kg K^{+} ha^{-1} and similar doses were used for the organic fertilization treatment with fresh cow slurry . For the conventional tillage , soil was ploughed to 25 cm with a mouldboard plough and then rotavated . Direct sowing for the no-tillage treatment was carried out with a Semeato machine . Soil OM content (MAPA , 1994) , dehydrogenase activity (Dick *et al* ., 1996) and CO_2 emission (PP-Systems EGM-4/SRC-1) were measured . Data were analysed using ANOVA and Fisher test .

Results and discussion The highest value of soil OM content was found in no-tilled and organically (cow slurry) fertilized plots , although the differences were statistically significant only when compared to those conventionally tilled plots treated with mineral fertilizer . Soil dehydrogenase activity , which apparently plays a role in oxidation of organic matter , also showed the highest value in no-tilled and organically fertilized plots , but in this case it was significantly higher than all the rest of the treatments . Dehydrogenase activity can be more sensitive to treatments most likely due to its being associated with viable microbial populations (Dick *et al* ., 1996) . Within each tillage system , plots amended with cow slurry showed higher values of dehydrogenase activity . Regarding CO_2 emission , conventional tillage seemed to increase CO_2 flux to atmosphere .

Table 1 *Effect of treatments in summer 2007 . Different letters within each line indicate significant differences (p < 0 .1).*

	Till+Mineral	Till+Slurry	No-till+Mineral	No-till+slurry
OM content (%)	2.71 ± 0.05^a	2.92 ± 0.07^{ab}	2.88 ± 0.09^{ab}	2.99 ± 0.09^b
Dehydrogenase (mg INTF kg^{-1} dry soil h^{-1})	0.33 ± 0.09^a	1.23 ± 0.18^a	0.37 ± 0.13^a	3.77 ± 1.35^b
CO_2 emission (g CO_2 m^{-2} h^{-1})	0.46 ± 0.16^a	0.50 ± 0.02^a	0.23 ± 0.03^a	0.39 ± 0.02^a

Conclusions Cow slurry application increases soil OM content and dehydrogenase activity , particularly when is combined with no-tillage . Dehydrogenase activity has a great value as early and sensitive indicator of changes in soil properties induced by different systems of tillage and fertilization . No-tillage can contribute to reduce CO_2 emission form soil .

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Resources use efficiency in tall fescue and annual ryegrass pastures with different nitrogen nutrition (Humid Pampa, Argentina)

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Key words: resource use efficiency, nitrogen, seasonal growth, tall fescue, annual ryegrass

Introduction The Humid Pampa pastures frequently grow under suboptimal N nutrition. The series of experiments presented here were designed to better understand the agronomical impact and the efficiency of N fertilization practices that are expected to have an increasing demand because of the eminent agriculture area expansion in the region. Results on radiation and N use efficiency for two conspicuous temperate forage grasses-*Festuca arundinacea* Schreb. (FA) or *Lolium multiflorum* Lam. (LM) -under different N fertilization levels applied in late autumn (AUT) or in early spring (SPR) are reported.

Materials and methods Experiments were conducted in the EEA INTA Balcarce (37°45′ S lat. 58°18′ W long.) on Typic Argiudol soils in 1994, 1995, 1997, 2003 and 2005 (LM) and in 1996 and 2006 (FA). Data on nine experiments with N application in AUT (four) or in SPR (five) were used. N treatments covered the range 0-250 kg N ha^{-1} (applied as urea under non limiting P). Independent plots (5.5 m^2) were used. For each regrowth period forage accumulation (kg DM. ha^{-1}), photosynthetically active radiation intercepted (PARint, Mj m^{-2} s^{-1}), radiation use efficiency (RUE, origin = 0), N absorption efficiency (NAE, kg N uptake/kg N applied) and N use efficiency (NUE, kg DM ha^{-1}/kg N uptake) were measured. Plant N concentrations (%) were determined, except in 2005 and 2006. Briefly, nitrogen nutrition index (NNI) were calculated as proposed by the reference N dilution curve (Nref) (Gastal and Lemaire, 1997) and critical N dilution curve (Ncr) (Justes *et al.*, 1994). Data were analyzed using ANOVA ($P = 5\%$) and regressions were fitted.

Results Forage accumulations were significantly incremented by N. Responses varied between seasons and species (Figure 1a). N uptake increased linearly in relation to increments in N applied (Figure 1b), however, NAE was higher in SPR than in AUT (on average 63% and 25%, respectively). NUE was higher for LM than for FA (on average 49 and 34 kg DM ha^{-1}/kg N uptake), no differences being detected between seasons. On other hand, N application increased PARint and RUE but, while higher PARint were observed for LM than for FA, principally in AUT (on average 280 and 166 Mj m^2, respectively), the estimated RUE for SPR doubled those estimated for AUT, independently of the species (Figure 1c). Finally, for both seasons and species, N rates compatible with optimum N nutrition (NNI=1) were approximately 135 (Ncr) or 195 (Nref) kg applied N ha^{-1}, and 106 (Ncr) or 147 (Nref) kg N uptake ha^{-1}.

Conclusion A higher use efficiency of resources was mainly associated to season (spring greater than autumn) and, to a lesser extent, to genotype (annual ryegrass greater than tall fescue).

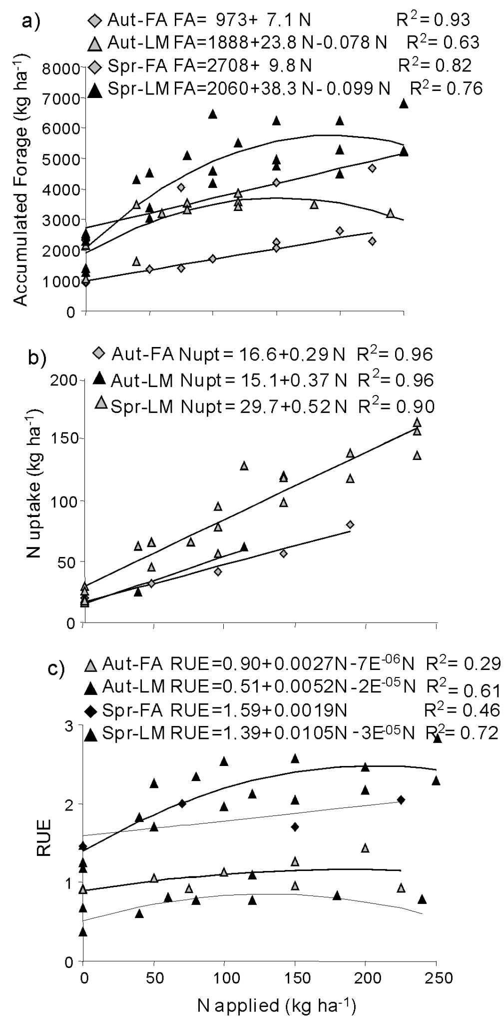

Figure 1 *Forage accumulation (a), N uptake (b) and radiation use efficiency (RUE) with applied N applied in late autumn (AUT) or in early spring (SPR). LM, annual ryegrass. FA, tall fescue.*

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Root phenotypic plasticity in response to P deficiency in two tall fescue cultivars

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Key words: tall fescue, phosphorus, Mediterranean, root: shoot ratio, P utilization efficiency

Introduction Low soil P availability has been recognized as a key factor limiting pasture production in many soils. Changes in the partitioning of C between shoot and root (Mollier & Pellerin, 1999) or root length per unit of root biomass are particularly important to provide a greater root-soil contact to improve uptake of P (Gahoonia & Nielsen, 2004). The objective of this work was to analyze the genotypic variability of two tall fescue cultivars of different origin in response to P deficiency.

Materials and methods Two cultivars of tall fescue (*Festuca arundinacea* Schreb.), El Palenque Plus (EP, temperate) and Fraydo (F, Mediterranean), were cultivated under three P levels (0, 10 and 100 mg P added per kg mixture 1:1 w/w of soil (4.5 ppm P and 4.9% OM) and river sand, P1, P2 and P3, respectively) during 63 days in 12 PVC containers per cultivar per P level, arranged in three blocks in a glasshouse. Four harvests were performed (33, 42, 54 and 63 days after seeding). Shoot and root dry matter, shoot and root P content and total root length were measured. Statistical analyses were carried out using SAS (SAS Inst., Cary, NC, USA). Means were separated using LSD ($P<5\%$) and slopes compared using dummy variables.

Results and discussion EP produced more root in relation to shoot (significantly steeper slope) than F under all of P treatments (Figure 1). Conversely to F, EP was capable of producing longer roots per unit of root biomass in response to P deficiency (Figure 2). However, specific root length was not significantly different between cultivars for P1 and P2. Phosphorus utilization efficiency (total plant biomass at the last harvest divided by tissue P concentration) was higher in P2 than in the other treatments and was similar between cultivars (Data not shown).

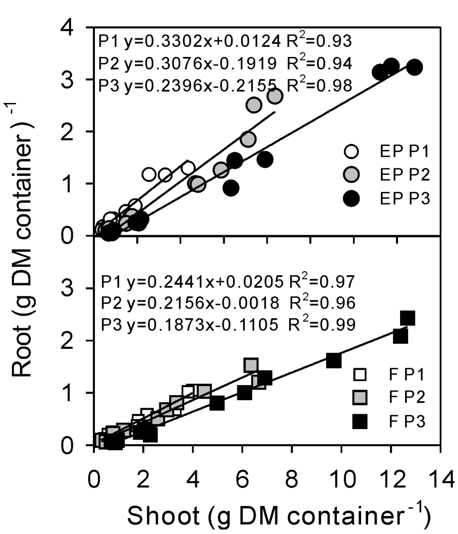

Figure 1 *Root DM vs. shoot DM in two tall fescue cultivars subjected to three P treatments.*

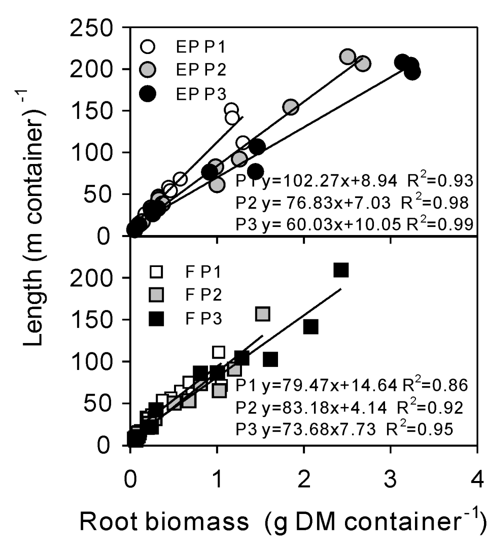

Figure 2 *Root length vs. root biomass in two tall fescue cultivars subjected to three P treatments.*

Conclusions EP tended to show a higher phenotypic plasticity in response to P deficiency: a higher biomass allocation to root system and an increased proportion of fine roots. However, no significant differences were found under the most limiting P availability between cultivars. Phosphorus utilization efficiency was increased under moderate P deficiency (P2) only.

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Pyrrolizidine alkaloid accumulation in tall fescue during plant growth and development

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Key words: lolines

Introduction Tall fescue, *Lolium arundinaceum* (Schreb.) Darbyshire, infected with the endophytic fungus, *Neotyphodium coenophialum* (Morgan-Jones and Gams) Glenn, Bacon, and Hanlin, accumulates peramine, ergot and loline alkaloids. The loline alkaloids are present in much greater amounts than the other alkaloids. In the common endophyte strain the predominant pyrrolizidine alkaloids are N-formylloline (NFL) and N-acetylloline (NAL). Accumulation of these alkaloids is a significant determinant for ecological fitness. The objectives of this study were to determine development of *N. coenophialum* in tall fescue and the accumulation of NAL and NFL in different plant tissues and clippings.

Materials and methods Flowering plants were collected from field grown plants at Lexington, KY in 1982 and 1983 (Burhan, 1984). Plants were grown in pots in the glasshouse with 4 replications in a split-plot design with time and frequency of harvest as sub-plots. Harvests were made weekly from pots that had not been previously harvested and regrowth tissue was harvested at 3 week intervals. NFL and NAL was measured by gc/FID. Endophyte was measured by ELISA of Johnson et al. (1982).

Results and discussion In flowering plants greatest loline abundance was found in the spikelet and much lesser amounts in descending order in rachis, stem, leaf sheath and leaf blade. Endophyte concentration was greatest in the rachis. Leaf blades contained the lowest concentration of NFL, NAL and endophyte in these flowering plants. Samples were taken at anthesis and most likely levels of alkaloids and endophyte would have increased as the spikelet matured. In flowering plants the amount of NAL + NFL in the stem, rachis and leaf blade had a positive and significant linear correlation with the amount of endophyte in the respective tissue. Small amounts of NFL and NAL were measured in roots from plants grown in soil or sand culture but not in roots grown in solution culture. Presence of these alkaloids in all tissues examined, strongly suggests translocation within the plant. Koulman et al. (2007) measured NFL in sap from cut leaves and guttation water of tall fescue. The observation that the lolines are in the guttation water and thus found on the surface of the leaves may be significant for insect deterrence.

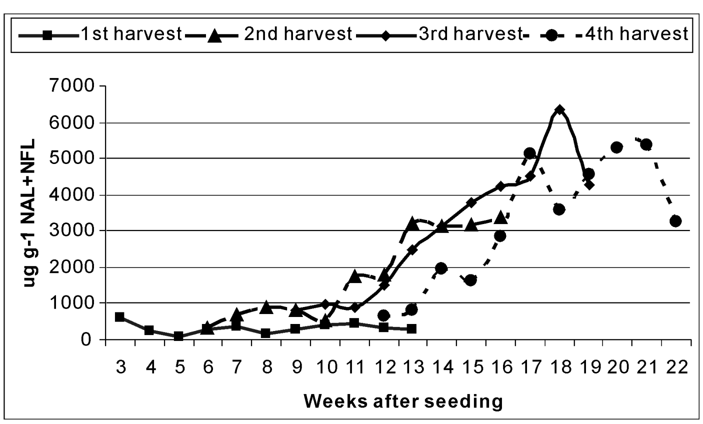

Figure 1 *Harvest frequency effect on alkaloid accumulation.*

In vegetative plants the greatest amount of lolines are found in the pseudostem with lesser amounts in the leaf blade. Pseudostem tissue also contained as much as two orders of magnitude more endophyte than the blade (~1000 vs 10 g g^{-1}). However, there was no significant correlation between endophyte and NAL and NFL concentration. This result is probably because of translocation of the alkaloids and the dynamic of endophyte growth and accumulation of alkaloids. NFL + NAL concentrations were very similar in initial harvest from 3 to 13 weeks after seeding (Figure 1). However, with additional harvests at 3 week intervals the alkaloid content was much higher. Plant maturity alone was not sufficient to cause an increased alkaloid concentration as indicated by similar alkaloid accumulation at the initial harvest time with 10 weeks difference in age. The increase in alkaloids with clipping may be result of mobilization of plant reserves for regrowth and thus also available for endophyte biosynthesis of the alkaloid.

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Phosphate uptake by white clover (*Trifolium repens* L.) genotypes with contrasting nodal root morphology

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Key words: phosphate efficiency, root morphology, *Trifolium repens*

Introduction Phosphate (P) fertiliser is a major cost in New Zealand farm budgets. Movement of P to the root surface is the rate limiting step in P acquisition by plants. Plants with finely divided roots that colonise a large volume of soil are more efficient in obtaining P than plants with coarse, unbranched roots (Hill et al., 2006). In this study we analysed P uptake and the growth response of two white clover genotypes, previously selected for either relatively long fine roots (LFR), or relatively short thick roots (STR).

Materials and methods P response curves were determined for the two genotypes in a glasshouse experiment. $CaHPO_4$ was mixed with an allophane ash soil at 0, 50, 100, 200, 400, 600, 800, 1000, and 1200 mg P kg^{-1} dry soil. Basal potassium and magnesium fertilisers were also added. There were 5 replicates of each genotype x P level combination in a row-column design. After 40 days growth in pots, the plants were washed free of soil and shoot dry weight (DW) measured. Root length, surface area, and diameter were measured using WinRhizo5.0™ image analysis software. After the image analysis the roots were oven dried and weighed. Shoot and root systems were analysed for total P.

Results The clovers had identical root DW but the LFR genotype had thinner, longer roots with more root tips mg^{-1} DW (Table 1). The LFR genotype had higher P uptake per unit root DW in all P treatments. Shoot P content (mg P per plant) was higher in the LFR genotype and shoot DW of the LFR genotype was heavier than for the STR genotype in P treatments >600 mg P kg^{-1} (Table 1).

Table 1 *Average root DW, diameter, length, number of root tips mg^{-1} root DW, P uptake and shoot DW for white clover genotypes with contrasting root morphology, and grown over nine soil P levels.*

Genotype	Root DW	Diameter	Length	Tips	P uptake	Shoot DW
	mg	mm	m	tips mg^{-1} root DW	μgP mg^{-1} root DW	mg
LFR	133	0.376	24.33	12.6	20.9	618
STR	128	0.420	16.74	8.49	17.4	519
	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$

Discussion The thin, frequently branching roots of the LFR genotype acquired P more effectively than the relatively short, thick roots of the STR genotype, as was expected from the literature (e.g. Hill et al. 2006). The additional root length of the LFR genotypes was achieved at the same root DW as the STR genotype, so the LFR genotype made more effective use of carbon invested in the root system. Reducing fertiliser P inputs into New Zealand pastures while maintaining productivity would have major economic and environmental benefits. Clover breeders should select for high fine root length frequencies and increased branching to optimise P acquisition. Indirect selection through exploitation of linked root traits in white clover will be useful (Jahufer et al., 2007).

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Effects of grazing and rainfall variation on root and shoot decomposition in steppe ecosystem

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Key words: Nitrogen and carbon cycling, litter bag, semi-arid grassland, Inner Mongolia

Introduction Overgrazing affects large areas of Inner Mongolia semi-arid grassland. Grazing effects on above-and belowground decomposition as a key process of ecosystem carbon and nitrogen cycling are still unclear.

Materials and methods We studied the effects of grazing on shoot and root decomposition using the litter bag method in a long-term grazing exclosure, a moderately winter grazed site and a long-term heavily grazed site at Xilingole steppe (43°38′N, 116°42′E). Decomposition of control and site-specific root and shoot biomass were analysed to distinguish effects of local environmental factors and litter quality as altered by grazing. Growing seasons of average (2004) and very low precipitation (2005) allowed to study effects of inter-annual rainfall variation on decay dynamics.

Results Grazing impact on local environment (Figure 1) and litter quality parameters had no effect on decay rates of shoot and root dry mass. In contrast to expected grazing effects, we found pronounced impact of rainfall variability on decay rates (Table 1). In the year of average precipitation (2004) root decomposition was faster than shoot decay, while under dry conditions (2005) the opposite was observed. Not shown: fitting a simple exponential decay function, we found soil moisture storage the best parameter explaining root decomposition dynamics. Contrarily, shoot decay rates were almost constant and unaffected by annual rainfall variance. Initial N content had no effect on N release dynamics and net N immobilization was not observed during decay process of shoot and root (see Parton et al. 2007).

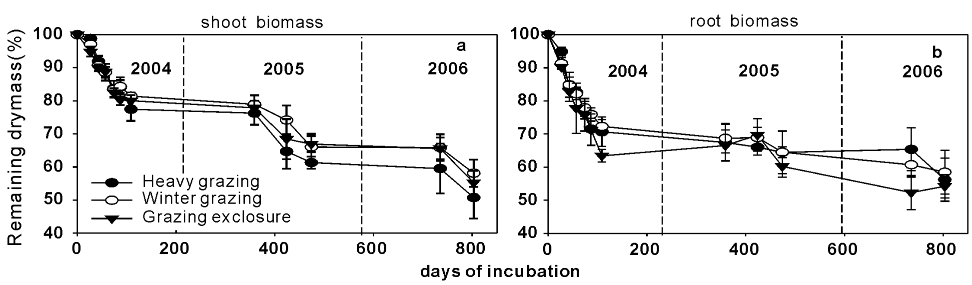

Figure 1 *Test for local environment effects on decay dynamics of shoot and root biomass among three grazing intensities from 2004-2006.*

Table 1 *K-values of shoot and root biomass incubated in 2004 (325 mm rain) and 2005 (166 mm rain) at different grazing intensities. K-values calculated as-LN $(X/X_0) = kt$ (Olson 1963).*

	k-value shoot	*k*-value root		
Site	2004	2005	2004	2005
Heavy grazing	0.28	0.36	0.40	0.20
Winter grazing	0.24	0.26	0.38	0.23
Grazing exclosure	0.26	0.29	0.41	0.17

Discussion When root decay is limited in dry periods, shoot decomposition becomes relatively more important for plant nutrient supply. Photodegradation (UV-B radiation) might explain balanced aboveground decay dynamics (Austin et al. 2006). Consequently, separate analysis of shoot and root decomposition is crucial to describe carbon and nitrogen cycling in semi-arid environments. Under average rainfall conditions grazing effects on nutrient supply through decomposition are less pronounced because of more active belowground processes. The grazing impact on C and N fluxes through decomposition of plant biomass, thus, likely exhibits a strong interaction with seasonal rainfall patterns.

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Selection of forage pigeon-pea (*Cajanus cajan* (L .) Millsp) lines for soil decompaction

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Key words : *Cajanus cajan* , soil compactation , decompactation

Introduction According to Camargo & Alleoni (1997) , pigeon-pea plays an important role among species fit to promote soil decompaction , due to the capacity of its roots to penetrate highly compacted soil layers . Since differences not only among species but also within species have been observed for this character , selection within a species like *Cajanus cajan* seems to be an excellent aid to help solving the problem of soil compaction . This work had the purpose of selecting , among forty pigeon pea pure lines , the most efficient genotypes to promote soil decompaction .

Materials and methods In a series of five experiments , seeds of forty pure forage pigeon-pea lines were planted in PVC tubes containing an upper 30 mm layer of vermiculite , compacted clayey soil (to a density of 1 .6 g/cm^3) and a lower vermiculite layer , in a randomized block design with four replications , in a greenhouse . Nine pre germinated seeds were planted in each 143 mm diameter tube . Around two weeks after planting , the plants were harvested and dry mass of their parts was determined . In all experiments , the cultivar Fava Larga served as the control and the main measured characteristic was the amount of roots produced in the compacted soil layer . Three lines were selected and went though a series of three experiments where , besides pigeon-pea root and shoot dry mass , root development of Tanz nia grass plants (*Panicum maximum* Jacq .) seeded after pigeon-pea harvest was evaluated . The experiments had ten blocks , half of which had the pigeon-pea plants completely harvested after approximately two weeks . In the other half , the aerial part of the pigeon-pea plants was removed ; Tanz nia seeds were planted and after about two weeks the plants were harvested and the same type of data were collected . Sample compacted blocks went through computerized tomography to check their soil bulk density uniformity .

Results In the series of five experiments , three lines were selected since they yielded significantly more roots in the compacted soil blocks : g5～94 , g8～95 and g124～95 , although high variation coefficients were found . These lines went trough new experiments : in the first one , sand was used in the place of the upper vermiculite and that caused , due to water infiltration , soil penetration resistance to fall from 3 .8 MPa to 1 .6 MPa , in two weeks . For that reason , the second part was not performed and Tanzânia grass seeds were not planted . Also in this case , g5～94 had significantly higher amount of roots in the compacted layer than the control . A second experiment was performed , using again vermiculite in the upper layer . When the pigeon-pea plants were harvested , average penetration resistance of the soil blocks was 14 .6 MPa and the tubes that had received the Fava Larga plants had significantly (Duncan $p<0.05$) higher resistance than those that received the g8～95 plants . Dunnett test ($p<0.05$) revealed superiority of g5～94 and g8～95 over the control , in quantity of roots in the compact layer , but no difference was found among the Tanzânia plants , when the variation coefficient went up to 49% . In the third experiment , the same scheme was performed but only the g5～94 and g8～95 lines were used . When the pigeon-pea plants were harvested the average penetration resistance was 12 .6 MPa and the variation coefficient , 20 .7 % . When the Tanzânia plants were harvested , penetration resistance ranged from 1 .7 to 24 .8 MPa and the variation coefficient was 68 .5% , demonstrating that the longer staying of the plants in the greenhouse tends to cause problems in the soil properties , confirming observations by De Maria (1999) about problems to evaluate roots under these conditions . Root dry mass of the two lines were significantly higher than that of the control (Dunnett $p<0.05$) . Roots of the Tanzânia grass grown where those lines had been grown were only numerically higher than those of the control , probably due to the high variation coefficients . Tomographical images revealed that the blocks were uniformly compacted and horizontallly the soil bulk densities ranged from 1 .41 to 1 .52 g/cm^3 .

Conclusions There is genetic variability in the *Cajanus cajan* species to penetrate compacted soil layers and two genotypes , g5～94 and g8～95 were the most efficient . The artificially compacted soil blocks used were adequate for the purpose of these experiments , since tomographical images revealed their soil bulk density uniformity .

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Root development of three commercial forage pigeon-pea cultivars in artificially compacted soil

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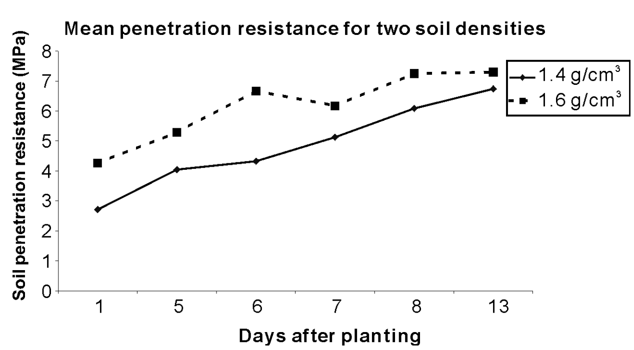
Key words: *Cajanus cajan*, soil compactation, decompactation

Introduction Soil compaction is an increasing problem in Brazil and the use of appropriate species for soil decompaction is the most practical and economical way to face this problem. Among these species, pigeon-pea plays an important role due to the capacity of its roots to penetrate highly compacted soil layers (Camargo & Alleoni, 1997). Observations in a pigeon-pea line collection showed that there are differences among them in that capacity. To test pigeon-pea lines to this characteristic, it is necessary to select a control, among the available commercial cultivars. The purpose of this work was to select the most efficient commercial forage pigeon-pea cultivar to penetrate compacted soil layers, to serve as a control in the process of selecting pure lines.

Materials and methods Seeds of three commercial forage pigeon-pea cultivars, Anão, Caqui and Fava Larga, were planted in PVC tubes containing 30 mm layers of vermiculite, compacted clay and vermiculite, in two randomized block design with four replications experiments in a greenhouse. Nine pre germinated seeds were planted in each 143 mm diameter tube. The soil was compacted to three calculated density levels: 1.0, 1.4 and 1.5 g/dm^3 in the first experiment and in the second experiment, to two levels, 1.4 and 1.5 g/cm^3. Plants were irrigated according to the average water loss. After three weeks in the first experiment and two in the second, it was determined the dry mass of the aerial parts of the plans, of the roots in the upper vermiculite layer, in the compacted soil layer and in the lower vermiculite layer. Sample tubes without plants were prepared and had their weight periodically determined to estimate the water loss. Soil resistance to penetration in the compacted layer was also determined, in the second experiment, using a digital laboratory penetrometer.

Results Root dry mass in the compacted soil layer was the main used criteria. In the first experiment, no significant interaction was found between cultivars and soil density. The average root dry mass found was 72.5 mg, 73.8 mg and 69.7 mg for cultivars Anão, Caqui and Fava Larga, respectively, without any statistically significant difference. A root mass significant reduction (Duncan, $p<0.05$) was found for the 1.5 g/cm^3 density (52.0 mg) against the 1.0 g/cm^3 density (88.8 mg) and the 1.4 g/cm^3 density (75.3 mg).

In the second experiment, monitoring soil penetration resistance showed an increasing tendency for both soil densities (Figure 1), indicating that probably the soil water content was reducing. No statistical difference was found for the soil densities or for the root dry mass in the compacted layer. However, in this case, the Fava Larga cultivar (30.4 mg) yielded 19% more than Caqui (25.5 mg) and 27% more than Anão (20.0 mg).



Conclusions The three forage commercial pigeon-pea cultivars had potential for soil decompaction, since all of them were able to produce roots in the compacted soil layer. Cultivar Fava Larga was selected for its performance in the second experiment and for the fact that presently is the most used pigeon-pea cultivar.

Reference

Camargo, OC., ALLEONI, LRF (1997) Compactação do solo e o desenvolvimento das plantas. Piracicaba. 132 p.

Correction of sulphur deficiency on naturalized pastures of Western Patagonia (Chile)

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Key words : Sulphur, pasture, Patagonia

Introduction Sulphur has been recognized as a main deficiency in soils in different parts of the world. Its importance is highlighted in legume-dominant pastures and has been extensively used for decades in New Zealand (e.g. Cornforth, 1998). Soils in western Patagonia are mainly of volcanic ash origin and show widespread sulphur deficiency, as a result of recent colonization during the XX Century (Hepp, 1996). This paper reports experimental evidence on S use in W. Patagonia.

Materials and methods Results shown correspond to: (a) a survey and analysis of agricultural soils; (b) Two experiments with randomized block design (RBD) and four replicates, plot area of 12 m^{-2}, located in the Coyhaique area (45°32′28″S; 72°5′51″W), with five levels of P (as triple superphosphate) and five levels of S (as elemental S) in a four-year evaluation period. All plots were managed with 2～3 cuts per season, weighed, dried, and subsampled for botanical composition. Naturalized pastures were initially dominated by *Poa pratensis*, with *Dactylis glomerata*, *Trifolium repens*, *Taraxacum officinale*, *Cerastium spp*, *Acaena pinnatifida* and other minor species. Soils were of volcanic ash origin, with pH of 6.5; 15 and 5.1 mg kg^{-1} of available P and S, respectively.

Results and discussion Data from the survey indicated that ash soils of the Intermediate Zone of Western Patagonia (rainfall 700～1,500 mm) had average pH levels of 5.8～6.5, high cation exchange capacity, negligible aluminium saturation, low-medium levels of available P, high K levels, and extremely low available S levels (normally under 2～3 mg/kg). P and S responses are likely under these conditions.

Table 1 shows that there are significant effects on pasture production when P is applied in combination with S. These effects are apparent from the second year on. If S is not applied, even with very high P fertilization, pasture production does not respond (S-0 level). Levels of S as low as 15 kg ha^{-1} induce 4-7-fold DM production increments.

Table 1 *Effects of repeated P and S fertilization (four years) on naturalized pastures of the Intermediate Zone of western Patagonia. Pasture dry matter production (DM: t/ha) and white clover abundance (% in DM).*

kg P ha⁻¹	*Year1*		*Year2*		*Year3*		*Year4*		*kg S ha⁻¹*	*Year1*		*Year2*		*Year3*		*Year4*	
*	DM	%	DM	%	DM	%	DM	%	**	DM	%	DM	%	DM	%	DM	%
0	0.53 a	4.2	1.56 e	8.0	2.82 d	48.9	3.16 d	45.8	*0*	0.51 a	8.0	1.15 c	14.9	0.62 c	31.8	0.48 d	5.8
8.7	0.49 a	6.1	3.19 d	26.0	4.43 c	60.4	4.31 c	44.6	*15*	0.58 a	6.0	4.09 b	47.1	4.25 b	76.0	3.30 c	47.9
17.5	0.55 a	0.0	4.02 c	22.0	4.65 bc	68.9	4.64 b	51.6	*30*	0.49 a	4.1	4.83 a	38.0	5.84 a	77.0	5.84 b	60.9
34.9	0.51 a	7.0	5.45 b	59.8	5.01 b	74.4	4.45 b	51.9	*45*	0.52 a	5.4	5.11 a	21.8	5.66 a	62.1	6.56 a	49.4
69.9	0.51 a	4.1	6.27 a	38.0	5.81 a	71.6	5.66 a	60.9	*60*	0.50 a	7.4	5.30 a	46.5	6.08 a	71.6	6.05 ab	44.2

Significant differences between means within columns ($p<0.05$). Base fertilization: * 60 kg S ha^{-1}; ** 70 kg P ha^{-1}.

From the second season on, a change in botanical composition was observed, with a strong white clover increase in the sward, boosted by P in the presence of S fertilization.

Degraded naturalized pastures of this area may therefore be recovered with soil P-S correction. Moderate levels of fertilization produce very significant increments in DM production (from 500 to over 5,000 kg DM ha^{-1}). There is also a pasture composition/quality change, with a strong legume increase, which is likely to have positive effects on animal production responses. However, after four years, there was a decline in pH levels (5.9) in soils of high P-S treatments.

Conclusions In western Patagonia, sulphur is a main primary component in soil fertilization programmes. There is a P-S interaction, indicating that P response is subjected to sufficient available S levels in soils. White clover abundance seems to be directly correlated with the correction of S levels in these soils. Effects on soil acidification have to be monitored.

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Yield trends and soil mineral changes in three summer winter forage cropping systems for 5 consecutive years in southern Kyushu , Japan

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Key words : cropping system , forage crops , mineral balance , yield

Introduction Mineral balance between plants and soil to which fertilizer is applied is important in a sustainable agriculture (Haynes and Naidu , 1998) , especially on unfavorable soil conditions . Cropping systems are chosen based on considerations of crop yield , soil physical and chemical properties and climatic conditions . Summer crops of maize (*Zea mays* L . : M) and sorghum (*Sorghum bicolor* Moench : S) and a winter crop of Italian ryegrass (*Lolium multiflorum* Lam . : IR) are major forage crops in southern Kyushu of Japan . This study tested three cropping systems typical to the region (double cropping of M and IR (M-IR) , double cropping of S and IR (S-IR) , and double cropping of maize (M-M) for 5 consecutive years for their performance in yield and mineral balance on the non-fertile , poorly permeable heavy soil .

Materials and methods Field experiments were conducted based on the standard regional cultivation under the heavy soil and three different summer-winter forage cropping systems were examined for 5 years (May 2001-April 2006) . Samples of all plants , divided into each plant organ , were oven-dried to determine dry matter yield . Total nitrogen (TN) of plant and soil was analyzed by Indophenol method . The TN balance was calculated as input in fertilizer minus output in harvested crop .

Results and discussion Annual dry matter yield of three cropping systems on the heavy soil is shown in Table 1 . The annual variation of herbage yields of summer crops (52 .8% and 54 .4% in M and S , respectively) was greater than that of winter crop , IR (23 .1%) . Low yields of summer crops were associated with frequent typhoons and heavy rainfalls . Consequently , in M-IR and S-IR , incorporation of IR into the cropping system decreased the year-to-year variability in herbage yield (31 .2 and 48 .3% , respectively) . In TN balance , the input in fertilizer was larger than the outputs in herbage for all cropping systems (Figure 1) . Thus , TN content of soil increased in the fifth year , except for M-M . The TN balance of summer crops (M and S) decreased from the first year to the fifth year due to the increase in yield and TN content of crops .

Table 1 *Annual dry matter yield (kg/m²) of 3 cropping systems on the heavy soil .*

Year	M—IR	S—IR	M—M
2001—2002	2 .13	2 .06	1 .90
2002—2003	1 .56	—	2 .43*
2003—2004	1 .60	1 .81	1 .50
2004—2005	0 .90	—	0 .77
2005—2006	2 .49	2 .12	1 .36
Mean	1 .74	1 .56	(1 .59)**
SD	0 .54	0 .76	(0 .55)**
CV (%)***	31 .2	48 .3	(34 .8)**

* M-IR , ** Excluding data in 2002-2003 , *** Coefficient of variation .

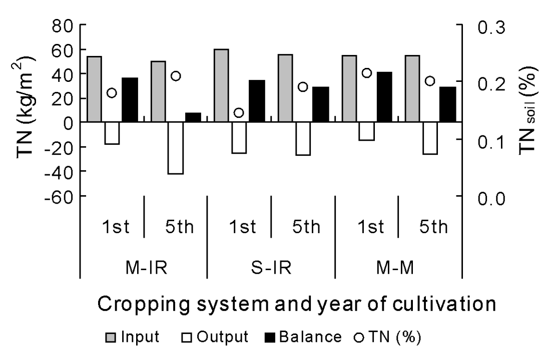

Figure 1 *TN balance and TN contents of soil (TN_{soil}) in 3 cropping systems on the heavy soil .*

Conclusions The results confirm the relatively low productivity on the heavy soil and show the advantage of combining a winter crop with a summer crop for stabilizing annual herbage production on the heavy soil in southern Kyushu . Even in the heavy soil , consecutive cropping might contribute to increase the soil fertility and yield of summer crops , and to reduce the mineral balance remained in the soil environment .

Reference

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Effects of cultivation of *Puccinellia tenuiflora* on the chemical and physical characteristics of alkalinized soil in western areas of Jilin

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Key words: alkalinized soil, alkali-grass, *Puccinellia tenuiflora*, chemical and physical characteristics of soil

Introduction Alkalinized soils are expanding over the western area in Jilin province of China and have been partially used as grasslands. Alkali-grass (*Puccinellia tenuiflora*), a perennial plant in the *Poaceae family*, grows well in those areas, unlike most grasses which do not grow in soils with very high levels of pH. It has been observed that some grasses become established after several years of cultivation of the alkali grass in these soils. Thus, it is expected that the grass could be used to improve alkalinized soil. Changes in soil characteristics from alkali-grass cultivation, however, were not determined in detail in previous studies. The present study, therefore, was conducted to clarify the effects of alkali-grass cultivation on the chemical components and physical characteristics of alkali soil in Jilin.

Materials and methods Soil samples were collected from the alkalinized region around Da-an city of Jilin province. Samples were collected from different depths (0 to 2, 2 to 10, 10 to 20, 20 to 30, 30 to 40 and 40 to 50 cm) from five points in each three types of the alkali areas where alkali-grass had cultivated for three years (Third year) and ten years (Tenth year) or never cultivated (Control), respectively. Electrical conductance (EC mS/cm), pH, minerals (Na, Ca, Mg, K, P, Fe and Cl mg/kg), CO_3^{2-} (g/Kg) and HCO_3^- (g/Kg) of the samples were analyzed after soils were dried and passed through a screen mesh

Results and discussion Mean values of EC, pH (Table 1) and Na contents of shallow layers of soil of Third and Tenth years were lower than those of Control respectively, although those values of middle layer of soil of Third year were higher than those of Tenth year. On the other hand, mean values of EC and Na contents of deep layer of soil of Third year were higher than those of Control. There is significant positive correlation ($r^2=0.772$) between CO_2^{2-} content and pH of alkalinized soils. These data suggest that anions in the soils would be neutralized by unknown factor(s) such as organic acids released from roots of alkali-grass and, as a result, sodium concentration of the soils could decrease via transportation of ions.

Table 1 *Characteristics of pH of soils collected from different depth in the alkalinized lands which are cultivated alkali-grass.*

	Depth of soil (cm)					
Soil type	0-2	2-10	10-20	20-30	30-40	40-50
Control	11.1	11.4	11.3	11.2	11.3	11.2
Third year	9.9	11.3	11.3	11.3	11.3	11.3
Tenth year	9.9	9.4	9.1	10.1	10.4	10.5

Conclusion Based on the results obtained in the present study, it is likely that alkali-grass could improve the alkalinized soil via process of neutralization by unknown factor(s) released from the roots.

Caucasian clover (*Trifolium ambiguum*) is persistent in New Zealand montane , improved rangeland but requires regular sulphur application for productivity

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Key words : Caucasian clover , Kura clover , *Trifolium ambiguum* , persistence , sulphur

Introduction Caucasian clover (Cc) became dominant after 10 years in a 25 species , grazed pasture under higher rates of phosphorus (P) and sulphur (S) . At low P and S inputs , Cc persisted but was unproductive on the low fertility tussock grassland site (Scott , 1998) . This paper records the outstanding persistence and productivity of Cc when S and P were applied regularly to two rangeland sites in the upper Rangitata valley(Lat 43°S , Long 171°E) .

Methods Jarvis *et al* . (1998) reported responses of hexaploid Monaro Cc to S fertiliser for an experiment which was established (500m asl , 940 mm rainfall) in spring 1992 . P at 5 rates and S at 4 rates were applied in 1998 and again in 2001 . Plots were cut in December each year to obtain spring/early summer herbage accumulation and botanical composition . A similar experiment was established on a higher terrace (700m asl , 1000mm rainfall) in 1975 (Lucas *et al* . ,1981) .This site has been top-dressed at 2-3 year intervals at 200kg/ha sulphur superphosphate (8% P , 20% S) for the last 20 years .

Results and discussion Figure 1 shows the large DM response of Cc to S and P in 2002 after treatments were reapplied in 2001 . Three years later the responses to P were less marked especially at low S (Figure 2) . The mean 2005 yields were less that half those of 2002 . Craighead and Metherell (2006) also indicated that S applications are required more regularly than P . In the 1975 experiment , Cc has persisted in the sward for more than 32 years and is still a significant contributor to the pasture under intensive continuous grazing by red deer . The grass component was dominated by *Agrostis capillaris* and *Anthoxanthum odoratum* at both sites . The 15% cover of the prostrate invasive *Hieracium pilosella* present at the start of each experiment was suppressed after 3 years by the application of P and S fertiliser and Cc seed .

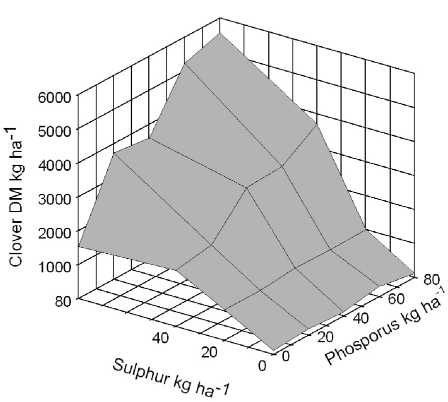

Figure 1 *Cc DM (kg/ha)* 2002 .

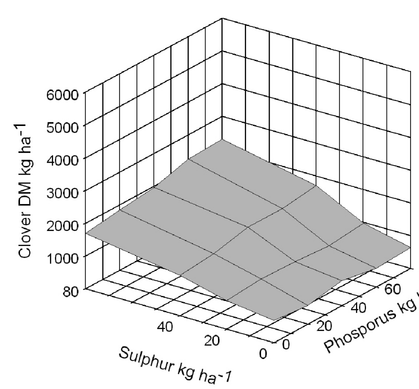

Figure 2 *Cc DM (kg/ha)* 2005 .

Conclusions Caucasian clover is well adapted to the montane rangeland regions of New Zealand . Persistence is currently demonstrated at sites at 700 and 550m a .s .l . where Cc was sown in spring 1975 and 1992 .Sulphur applications are required every 2-3 years to maintain productivity at these inland sites

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Effects of phosphate fertilizer on regrowth of *Medicago sativa* after defoliation

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Key words : phosphorus , buds , regrowth ,alfalfa , starch

Introduction Regrowth after defoliation was related to carbohydrate reverses in resident tissue . Phosphorus advanced regrowth speed and forage yield of alfalfa . A field experiment was conducted to study the effects of phosphate fertilizer on the relationship between regrowth speed and carbohydrate reserves of alfalfa (*Medicago sativa*) .

Materials and methods he trial was designed randomly with 4 treatments (0 , 90 , 180 , 270 Kg P_2O_5 /ha) and 3 replicates . The area of plot was 4 m×2 m . Each plot was seeded with 18g alfalfa (var . Sanditi) seeds in 30 cm row space on September 23 , 2006 . Alfalfa was cut with 5cm stubbles on May 3 , 2007 . Ten plants from each plot were dug on 0 , 2 , 5 , 9 , 13 d after defoliation . The number and dry weight of new buds and shoots , starch content in resident tissue were investigated .

Results and discussion

Regrowth performance

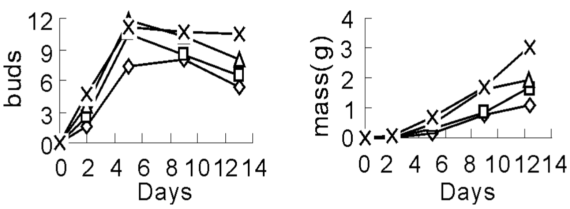

Figure 1 *Effects of phosphorus on regrowth .*

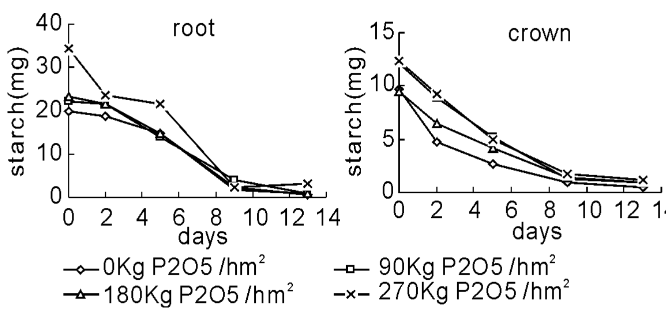

Figure 2 *Starch reserves as influenced by phosphorus .*

Buds per plant reached the peak on 5 days after defoliation in all treatments , and mass per plant rapidly increased after 5 days (Figure 1) . Both of buds and mass per plant were increased as P application rate increased . The correlation of buds per plant on 5 days and mass per plant on 13 days after defoliation was significant (R^2=0 .36) . It suggested that buds in dormancy were promoted by the application of phosphorus , and then regrowth of alfalfa increased .

Starch reserves during regrowth Rapid decrease of starch reserves in root and crown occurred from 0 to 9 days after defoliation (Figure 2) . Decreasing rate of starch was higher than that of water soluble carbohydrate . It showed that starch reserves in main root and crown of alfalfa played an important role during early term of regrowth . Starch loss in root during the first 5 days in plot applied phosphate fertilizer rate at 0 , 90 , 180 , 270 Kg P_2O_5 /ha was 5 .1 , 8 .2 , 8 .4 , 12 .9mg/plant , respectively , and the regrowth weight /root starch loss was 33 .7% , 36 .5% , 55 .8% , 52 .6% , respectively . The results showed that more starch reserves were utilized and used more efficiently as phosphate application increased .

Conclusions Utilization of starch reserves in root and crown of alfalfa during early regrowth period was increased as P application rate increased . Phosphorus could promote the regrowth speed of alfalfa by enhancing the efficiency of root starch reserves for emergence of buds in dormancy after defoliation .

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Impacts of long-term enclosure on soil microbes in mountain-pasture in Bayinbuluke

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Key words : Bayinbuluke , enclosure , soil microbes , subalpine grassland , subalpine meadow steppe , subalpine steppe meadow

Introduction Biomass of microbes functions to store and regulate release of plant nutrients and is an important component of soil fertility . Presently , research on soil microbes focuses mostly on morphology , physiology , conversion of substances , and the impact of root system on development and activity of microbes etc . but little about research has been conducted on grasslands .

Xinjiang is an important province of animal husbandry and Bayinbuluke is the secondary biggest pasture area in China . The unbalance between grass availability and animal requirements leads to the increasing degradation of grassland and endangers animal husbandry . Enclosure favors the restoration of grassland vegetation , promotes soil microbes , and increases soil fertility and protects against desertification .

Materials and methods Subalpine grassland , subalpine meadow steppe and subalpine steppe meadow of 25-year enclosure life in Bayinbuluke were selected . Sampling points were selected at random inside and outside each sample area with a sampling depth of 60cm and an interlayer-space of 5cm . The soil microbes were analyzed with the dilution plate method .

Results and analysis

Impact of enclosure on soil microbe population Bacteria in soil microbe samples inside and outside enclosures in those three grassland types exceeds 50% of gross .Bacteria , ctinomyces and fungi in soil microbe inside enclosures in subalpine grassland and subalpine meadow steppe exceeds that outside due to higher moisture and nutrient contents than that outside ; but it is opposite in subalpine steppe meadow due to higher moisture and nutrient contents outside than that inside . Bacteria , ctinomyces and fungi in those three grassland types are of obvious surface accumulation .

Impact of enclosure on total soil microbes With little interference from the outside in the long-term enclosure , neither eating nor trampling , the total microbe count inside enclosures of subalpine grassland and subalpine meadow steppe is statistically higher than outside . The enclosures of 1～5 years are not significantly different between inside and outside , which was reported by Li Hui et al ., and demonstrates that the enclosure time decides the difference in soil microbe count inside and outside the enclosure .

Conclusions For vertical distribution of soil microbes , the three grassland types studied have most soil microbes in the top soil layer , showing a surface accumulation feature ; soil microbes between 0～60cm decreases with depth ;
For the impact of enclosure on total soil microbes , microbe counts inside the enclosure of subalpine grassland and subalpine meadow steppe is much higher than outside ; but total soil microbe inside of enclosure of subalpine steppe meadow is lower than outside .

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P and K effects on N partitioning during regrowth of Italian ryegrass

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Key words: N partitioning, P deficiency, K deficiency, ^{15}N pulse-chase

Introduction Phosphorus and potassium are essential elements for normal growth and development of plants. Phosphorus deficiency is revealed as leaf shape distortion and also leads to a reduction in the number of leaves (Rao *et al*. 2006). P deficiency also decreased N uptake and translocation of NO_3^- from roots, due to decreases in primary root elongation and shoot regrowth (Kim *et al*. 2003). Potassium deficiency induces reduced growth and development, shortening of internodes followed by bushy appearance, cholorosis and necrosis, affecting reproductive growth and sugar translocation. The objective of this study was to investigate the effects of P and K deprivation on N partitioning during regrowth of Italian ryegrass.

Materials and methods Italian ryegrass (*Lolium multiflorum* L.) was grown hydroponically in controlled environment and fed with complete nutrient solution. When plants reached full-vegetative stage, the plants in 20 pots were fed with 3 mM KH_2PO_4 (P and K-sufficient, +P/+K), while other plants in 20 pots received a P and K-free nutrient solution (P and K-deprived, -P/-K) for 7 days before defoliation. The treatments with and without P and K were grown for 24 days after the P and K treatments were imposed. To label the N reserves uniformly, the plants for both P and K treatments were fed with 4.0 mM $Na^{15}NO_3$ for 7 days before defoliation. The plants were then defoliated 6 cm above root base (day 0) and allowed to regrow on either under + P/+K or P/-K medium containing 4.0 mM $Na^{14}NO_3$. Harvested plants were separated into regrowing shoot, stubble, and roots. ^{15}N in the nitrate, amino acids and proteins contents were analyzed at 0, 6, 12, and 24 days after the final treatment of ^{15}N labeling.

Results The changes in ^{15}N excess content of nitrogenous fractions in the remaining organs (stubble and roots) during 24 days of regrowth after defoliation are shown in Figure 1. The amount of ^{15}N-nitrate in stubble largely decreased during regrowth on the +P/+K medium, but no significant changes were measured on the -P/-K medium (Figure 1A). The ^{15}N-nitrate in roots was largely decreased during regrowth (Figure B). A distinctly higher decrease of ^{15}N-amino acids in stubble (Figure 1C) of the P and K-sufficient plants was observed for the first 6 days of regrowth, while remained at same level in-P/-K plants. Higher decrease of ^{15}N-proteins in all treatments was observed for the first 6 days of regrowth (Figure 1E and 1F). The changes in ^{15}N excess content in nitrogenous fractions in regrowing leaves are shown in Figure 2. The amount of ^{15}N-nitrate and ^{15}N-protein continued to increase linearly in all treatments (Figure 2A and 2C). The amount of ^{15}N-amino acids was significantly higher under +P/+K stress condition for the first 12 days of regrowth. After 24 days of regrowth, the amount of ^{15}N amino acids in -P/-K plants exceeded that of +P/+K plants.

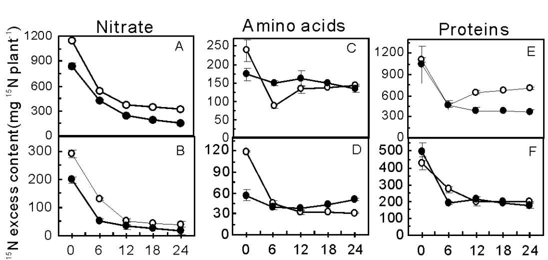

Figure 1 *changes in amounts of ^{15}N excess of nitrate (A, B), amino acids (C, D), and protein (E, F) fraction of stubble (A, C, E) and roots (B, D, F) of + P/+ K* (○) or-P/-K (●) *plants during 24 days of regrowth. Each value is given as the mean ± S.E. for n=5.*

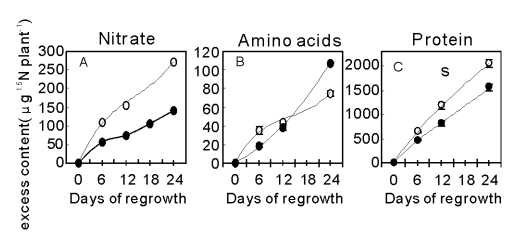

Figure 2 *changes in amounts of ^{15}N excess of nitrate (A), amino acids (B), and protein (C) fraction of leaves of + P/+ K* (○) or-P/-K (●) *plants during 24 days of regrowth. Each value is given as the mean ± S.E. for n=5.*

Conclusions During regrowth of Italian ryegrass ^{15}N tracing demonstrated that N reserves labeled continuously decreased in stubble and roots, whereas ^{15}N-labeled nitrogenous compound in the regrowing leaves increased throughout the experiment of period, clearly indicating a remobilization of N reserves into regrowing leaves. After regrowth of Italian ryegrass, total ^{15}N content in regrowing leaves on the -P/-K medium was lower than that on the +P/+K medium. This clearly indicated that the pool size of N reserve compounds in remaining organs plays an important role in -P/-K plants to initiate the regrowth.

Effects of grazing on AM colonization and spore density in arid grasslands of Loess Plateau

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Key words: arbuscular mycorrhizal fungi, herbivores, Loess Plateau

Introduction Arbuscular mycorrhizal fungi (AMF) form symbioses with the roots of the majority of terrestrial plant species. These associations are generally considered mutualistic to both plants and fungi. However, few studies foucsed on the relationships among AMF, plants, and herbivores. The objective of this study was to investigate the effects of grazing on AM in arid grasslands of the Loess Plateau.

Materials and methods This study was conducted in Huanxian Ecological Research Area of Lanzhou University (N37°12′, E106°82′), located in Loess Plateau, Gansu Province, China. Four grazing intensity plots (0, 2.7, 5.3 and 8.0 sheep hm^2) were designed in 2002. Every plot area is 5000 m^2 with 3 replicates. *Stipa bungeana* and *Artemisia capillaries* are the two dominant species in the grassland. The roots and rhizosphere soil from *S. bungeana* and *A. capillaries* with 20 replicates were randomly collected in every plot for determining AM colonization rates and spore densities in 2006. Data were analysed using One-way ANOVA with SPSS (v13.0).

Results Our results showed that there were no significant difference ($P > 0.05$) in AM colonization rates of *S bungeana* and *A capillaries* for four grazing intensities (Figure 1). AM colonization rates in the roots of *S bungeana* are higher in 5.3 and 8.0 sheep hm^2 treatments than CK. However, the rates of AM colonization of *A. capillaries* decreased while the grazing intensity increased. AMF spore densities in rhizosphere soil of *S. bungeana* and *A. capillaries* under four grazing intensities significantly decreased ($P < 0.05$) as grazing intensity increased (Figure 2).

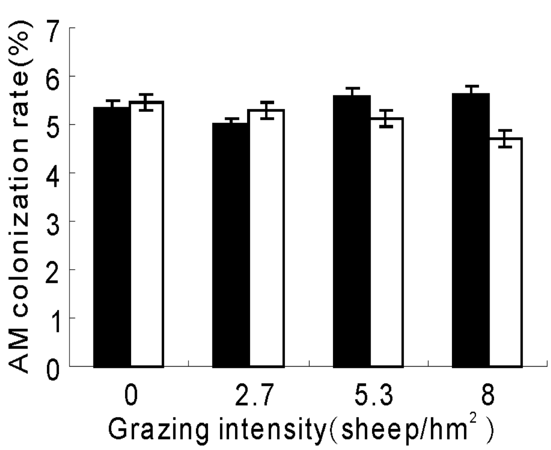

Figure 1 *AMF spore density in the rhizosphere soil of S. bungeana and A. capillaries under four grazing.*

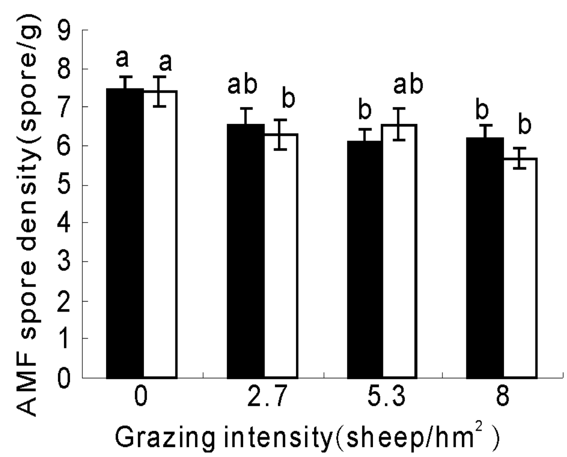

Figure 2 *AMF colonization rate in roots of S. bungeana and A. capillaries under four grazing.*

Note: The black bar shows the results of *S. bungeana* and the white bar shows the results of *A. capillaries* in Figure 1 and Figure 2.

Discussion Our results showed that herbivores can regulate AMF colonization rates in various plants with different strategies. Aboveground consumers may reduce photosynthate translocated to the root system and available to mycorrhizal fungi, resulting in a reduction in AMF spore density in rhizosphere soil. In general, the grazing can result in a negative relationship with AMF sporeproduction.

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Nutrient dynamics in a semi-arid grazing land of southern India

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Key words: annual uptake, grazed, live shoots, nutrient dynamics, semi-arid

Introduction Cycling and distribution of minerals in various compartments of the ecosystem is most important aspects ecosystem study. The semi-arid grazing land ecosystem at Madurai developed under short evolutionary grazing histories and low moisture regimes, in which grazing pressure has dramatic effects on plant community and biomass (Karunaichamy, 1992). The objective of this experiment was to study the distribution of N, P and K in the vegetation components and to estimate the annual nutrient budget in grazed and ungrazed lands dominated *by Chrysopogon fulvus* (Spreng) Chiov.

Materials and methods The study area is located in the southern part of Tamil Nadu (9°58′N; 78°10′E) at an altitude of 100m above mean sea level. Average monthly temperature ranges between 35.3℃ and 25.3℃. The mean annual rainfall was 571 mm during the two-year study. Twenty quadrants of 50×50 cm were sampled randomly in grazed and ungrazed areas at monthly intervals. Litter was collected carefully from each plot. The root phytomass was evaluated by excavating soil cores of 25×25×30 cm. Soil samples (30 cm depth) were also taken at the same harvested plot for determination of soil nutrients. Total N and P in plant components and soil were digested and analyzed colorimetrically by an autoanalyzer. Potassium was estimated using an atomic absorption spectrophotometer. The transfer of nutrients between various compartments and the release of nutrients through root and litter disappearance were calculated following balance sheet approach (Singh and Yadava, 1974).

Results The live shoot component showed higher content of N, P and K in the grazed plot (Table 1). Live shoots contains higher nutrient content than other components. The trends of soil nutrient concentrations were in the following order K>N>P in both grazed and ungrazed areas. The maximum storage of nutrients was in lives shoots and root components. Content of N and K (mg/m^2) in live shoots showed a significant positive relationship with a linear combination of rainfall, air temperature and soil moisture in both grazed and ungrazed plot.

Table 1 *Nutrient (%) in the vegetation components (±S.E; n=5). Values in the parenthesis are ungrazed plot.*

Components	N	P	K
Live shoots	1.85±0.04(1.67±0.04)	0.08±0.01(0.05±0.00)	0.75±0.06(0.94±0.09)
Dead shoots	1.60±0.07(1.49±0.06)	0.07±0.01(0.04±0.01)	0.49±0.04(0.59±0.09)
Litter	1.57±0.08(1.52±0.08)	0.03±0.00(0.04±0.01)	0.50±0.09(0.48±0.08)
Roots	1.64±0.07(1.36±0.08)	0.05±0.01(0.04±0.00)	0.59±0.05(0.59±0.07)

Total uptake of nutrients in plant components was higher in the ungrazed plot than grazed plot (Table 2). In the grazed plot, of the total ecosystem nutrients, less than 4% of N and 1% of P & K were channeled through biological cycling. About 95% of the nutrients remain in the root debris, organic matter and soil fractions. In the grazed plot, annual release of nutrients in litter and roots to soil was lower than the ungrazed plot.

Table 2 *Net uptake, release and retention of nutrient (kg/ha/year) Values in the parenthesis are ungrazed plots.*

Nutrients	Soil	Uptake	Retention	Release
N	5149(5286)	185(256)	91.3(71.7)	93.7(184.3)
P	905(991)	7.2(7.6)	4.3(2.6)	2.9(5.0)
K	5828(7566)	70.9(124.3)	37.5(48.3)	33.4(76.0)

Conclusions Cycling of mineral elements in a semi-arid grazing land was regulated by both live shoot and root compartments and faster recycling through root decomposition. Heavy grazing affects productivity and gives way to unpalatable species for invasion (*Barleria buxifolia* Linn.). The present study clearly indicates that heavy grazing not only degrades the nutrient economy of the system but also slows nutrient cycling within the plant biomass.

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Characteristics of the chemical composition and carbohydrate/protein fractions along with the growth of alkali-grass (*Puccinellia tenuiflora*) as feed for ruminants

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Key words: alkali-grass, protein/carbohydrate fractionation, alkalinized lands, ruminant, feedstuff

Introduction Alkali-grass (*Puccinellia tenuiflora*), a perennial plant in the *Poaceae family*, grows well in heavily alkalinized, high pH soils presumably due to its neutralizing effect on alkali soil. Alkali-grass can be fed to ruminants, but the optimum combinations with other feedstuffs are unclear because the chemical composition of alkali-grass has not been evaluated in detail. Therefore, the present study was conducted to clarify the characteristics of carbohydrate/protein fractions along with the growth of the plants.

Materials and methods Alkali-grasses cultivated for three years in the alkalinized region in Jilin Province of China were harvested at four stages: vegetative, reproductive (flowering and post-flowering) and post-reproductive growth phases. The carbohydrates and proteins of the growing alkali-grasses and control samples (*Aueurolepidium chinense*, alfalfa and timothy hey) were fractionated according to the methods of a net carbohydrate and protein system (Hall *et al*., 1988; Licitra *et al*., 1996).

Results and discussion Analysis of the chemical composition of alkali-grass showed that the crude protein contents of the plant were relatively high and decreased from the vegetative to reproductive stages (from 17.5 to 13.2% DM), but it was very low after post-reproductive stage (7.1%). It was also demonstrated that alkali-grasses of the vegetative and reproductive stages had very high levels of protein A fraction which mainly consists of NPN (non protein nitrogen; about 50% of CP) and very low levels of carbohydrate A and B_1 fractions, which mainly consist of saccharides, organic acids, starches and pectin. On the other hand, alfalfa hay had higher levels of protein B_1 and carbohydrate A and B_1 fractions than those of the growing alkali-grasses, *Aueurolepidium chinense* and timothy hay.

Conclusions It was demonstrated in the present study that the growing alkali-grass contains relatively high levels of CP, very high level of NPN and very low levels of soluble carbohydrates, showing that combination of alkali-grass and alfalfa hay as feed for ruminants would be best for compensate of nutrient balance among the feedstuffs used in the present study.

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Response of natural and cultivated hay meadows to fertilizer applied by small scale livestock farmers in the mountainous Sandzak region of Serbia

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Key words: fertilizer, nitrogen, pasture, mountains

Introduction Farmers rely on hay as winter feed from 1st October to 1st May. They will graze their cows part time if grass is available. It may be possible to extend the grazing season, with increased milk yields and lower production costs, by early fertilization with N applied at T_{sum200} to jump-start growth of natural pastures (NP) and artificial pastures (AP).

Materials and methods Farmers from 9 forage machinery and forage groups took part from three municipalities, and provided areas of NP and AP normally used as hay meadows, at altitudes from 500~1300 m.a.s.l. On each pasture 3 plots 10×10 m were set out. A 12:6:6 N:P_2O_5:K_2O compound fertilizer was used for basal dressing. Extra N was from calcium ammonium nitrate (KAN) at 27% N. Treatments for NP (9 sites) were Control: no fertilizer (0:0:0), Basal: 200 kg/ha compound (24:12:12), and Basal + N: 200 kg/ha compound + 200 kg/ha KAN (78:12:12); and for AP (7 sites) were Control: no fertilizer (0:0:0), Basal: 300 kg/ha compound (36:18:18), and Basal + N: 300 kg/ha compound + 200 kg/ha KAN (90:18:18), applied 28 March-10 April 2004. Plots were sampled 1 week before hay stage, after 66-87 days' growth.

Results and discussion Variation in DM yield was high among both NP and AP sites (Figure 1). Yields without fertilizer were 57% greater for AP than for NP. Response to spring fertilization was 40.6 and 54.5 kg DM/kg N for NP and AP respectively. Response tended to be curvilinear for NP, but was linear for AP up 90 kg N/ha. Altitude accounted for 23 and 35% of the variation in response to the high level of N in NP and AP (Figure 2). At 2005 prices for hay and fertilizers returns over the cost of fertilizer for Basal and Basal + N were 243 and 224% for NP and 312 and 371% for AP respectively.

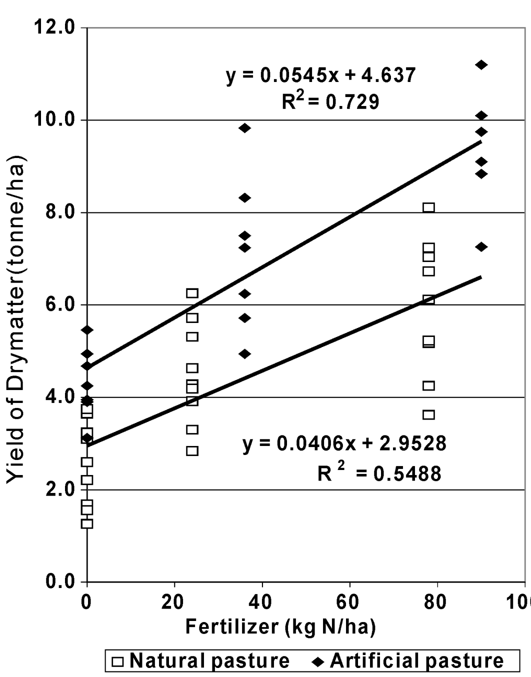

Figure 1 *Response of pastures to early N fertilization.*

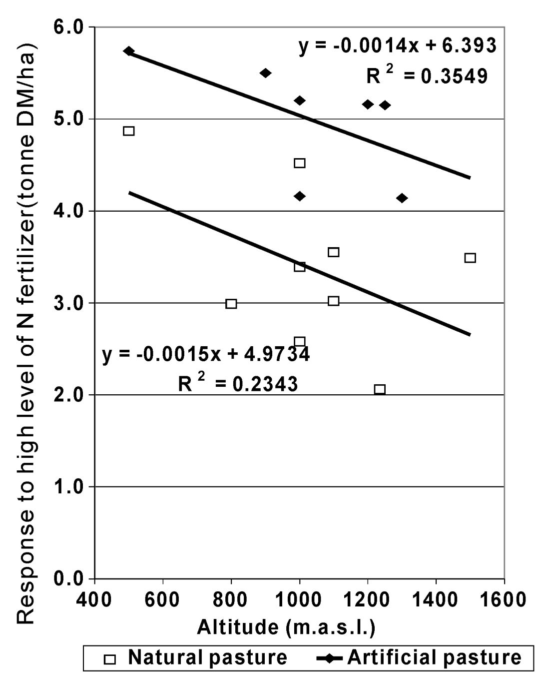

Figure 2 *Effect of altitude on response of pastures to N.*

Conclusions DM yields of both natural and artificial pastures were doubled by early application of 1 kg N/ha/day of growth. This response was reduced by altitude, but was highly economic at 2005 prices for fodder and fertilizer.

Effects of liming and nitrogen application on the Cu, Mn, and Zn concentrations in herbage from extensively managed pastures

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Key words: trace elements, soil/plant interactions, animal nutrition, liming, nitrogen level, pastures

Introduction In less intensively managed grassland in Central Europe, the micronutrient concentrations in herbage are apparently more likely to be in levels between barely sufficient and deficient than to be excessively high. Insufficient amounts of selenium, copper, manganese, and zinc cause physiological disorders in ruminants.

Materials and methods Three identical experiments on low-input pastures in different locations in low-mountain areas of Central Germany were set up in a Latin Rectangle design with three replicates. The locations were chosen based on a screening of more than 100 locations in which soil pH and carbon content were the most important criteria (Table 1). At each site treatment plots were laid out to include the effects of liming (= 0 or 4 t CaO ha^{-1}), and N application (= 0 or 80 kg N ha^{-1}, applied as calcium ammonium nitrate). Se, Cu, Mn, and Zn were determined by AAS.

Results The three locations show significant differences in Zn, Mn and Cu concentrations in herbage (Figure 1). Location is the most important factor of variation for all elements. Se was insufficient to meet animal requirements (< 50 μg kg^{-1} DM) for all locations and treatments. The increasing pH value caused by liming results in a significant decrease in Mn concentrations in several growths. This effect is very important at location A, which has the lowest soil pH (pH 4.8), but also for the secondary growth at location C (pH 4.9). The effect of liming is less clear for Zn and not significant for Cu, although the effect on soil pH was very clear (Table 1). Application of nitrogen shows no constant effect on the concentrations of Se, Zn, Mn and Cu. Although N fertilization increases DM yield, no dilution effect is evident.

Conclusions Considering the nutrition of beef cattle, the animal requirements for the essential selenium are not met in any location or treatment. The amounts of zinc and copper are close to the recommended levels (Anonymus 1996) but sometimes even slightly below. The manganese supply is mostly safe but the amounts are very variable (between < 25 and > 175 mg Mn kg^{-1} DM). The effect of soil pH is of limited importance for the Cu and Zn concentrations, considering values between pH 4.8 and 6.6.

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Table 1 *Chemical characteristics of the soils in different experimental locations.*

Location	A	B	C
g C in kg soil DM	40.1	20.9	20.6
g N in kg soil DM	3.0	3.0	3.0
mg Se in kg soil DM	0.45	0.31	0.36
mg Cu in kg soil DM	1.3	3.0	3.0
mg Mn in kg soil DM	156.5	105.6	159.0
mg Zn in kg soil DM	3.4	3.2	3.9
pH (before liming)	4.8	5.6	4.9
pH (limed plots)	5.9	6.6	6.1

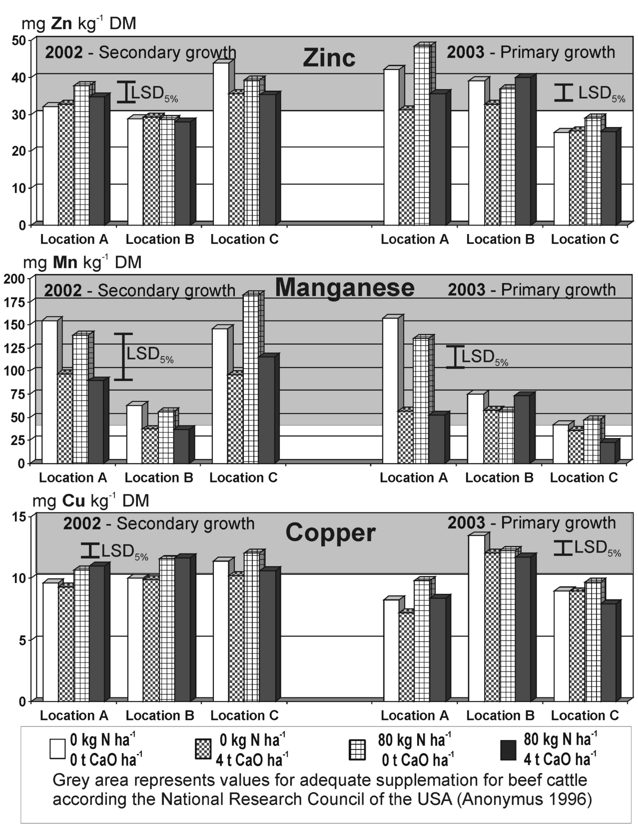

Figure 1 *Effect of liming and nitrogen fertilization on zinc, manganese and copper concentrations in two growths from different locations.*

Comparison of aggregates content and carbon proportion of top soil in perennial forage

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Key words : total carbon (TC) , total organic carbon (TOC) , water-stable aggregates

Introduction Carbon storage in cropland soil , a potentially huge carbon pool , accounts for approximately 10% of global terrestrial carbon storage . In croplands , tillage is one of the key drivers behind the degradation of soil stability and leads to the accelerate decomposition of soil organic carbon . Perennial forages are widely accepted as being beneficial to the storage of soil organic matter and the formation of the soil aggregates , which can effectively improve and enhance soil fertility . In this study the carbon sequestration rate was estimated to be on average 0.332Mg . ha^{-1} .a^{-1} after cropland was converted to forage land , this outcome has positive effects in terms of improving sustainable agriculture , including a reduction in CO_2 emissions . The purpose of this study was to compare the carbon fixation rates of various perennial forage at different topsoil depths .

Materials and methods This study was carried out in the western Loess plateau (35°40′N , 107°51′E) , which has an annual rainfall of 562 mm . In 2002 , seven different species of forage were sown . In august of 2007 , soil samples from 0-5cm and 5-10cm depths were collected , with six subsamples collected using a cutting ring (volume of 200 g cm^{-3}) to determine bulk density . The proportion of water-stable aggregation (>0 .25mm) was measured by wet sieving . Total organic carbon (TOC) , total carbon (TC) were determined through a combustion method using liquiTOC (elementar , Germany) .

Results For the 0-5cm layer , water-stable aggregates (>0 .25mm) was the highest under bromegrass . The TC ranged between 19 .687-25 .75 g/kg , with the highest under clover . Every index measured was significant lower in the 5-10cm layer compared to 0-5cm layer , with water-stable aggregates reduced by 50% , and TOC and TC declining by approximately 20% (see table) . A significant positive correlation was found between water-stable aggregates (>0 .25mm) and TOC/TC ($R=0.340^{*}$ and 0.448^{**} , respectively) .

Table 1 *Water-stable aggregates(>0 .25mm) ,carbon content and bulk density of 7 different perennial forages .*

Sample	Layer	Water-stabe aggregate (>0 .25mm)%	Bulk density (g/cm^3)	TC (g/kg)	TOC (g/kg)	TOC/TC
AM sweet pea	0-5 cm	16 .873 a	1 .066 ab	19 .687 a	10 .163 a	0 .514 a
Bromegrass		33 .988 b	0 .986 a	22 .623 b	13 .259 bcd	0 .585 b
Clover		17 .536 a	0 .983 a	25 .750 c	15 .062 d	0 .584 b
Crowtoe		21 .447 a	1 .152 b	20 .438 ab	10 .354 a	0 .506 a
Lucerne cv . longdong		19 .526 a	1 .155 b	21 .036 ab	11 .421 abc	0 .541 a
Lucerne cv . saditi		18 .038 a	1 .119 ab	19 .774 a	10 .893 ab	0 .547 ab
Sainfoin		17 .376 a	1 .149 b	23 .125 bc	13 .778 cd	0 .585 b
AM sweet pea	5-10 cm	10 .599 a	1 .139 a	17 .460 bc	7 .931 ab	0 .454 bc
Bromegrass		15 .046 b	1 .191 ab	17 .664 bc	8 .213 bc	0 .465 bc
Clover		8 .282 a	1 .272 bc	18 .518 d	8 .304 bc	0 .448 d
Crowtoe		10 .272 a	1 .247 bc	17 .754 bc	7 .578 a	0 .427 bc
Lucerne cv . longdong		8 .894 b	1 .197 ab	18 .084 cd	8 .573 c	0 .474 cd
Lucerne cv . saditi		8 .147 a	1 .250 bc	16 .347 a	7 .491 a	0 .458 a
Sainfoin		10 .89 a	1 .325 c	17 .339 b	8 .232 bc	0 .475 b

Conclusions In this study the organic carbon of perennial forage in the topsoil accounted for over 50% of the total carbon , with water-stable aggregates and TOC showing significant differences between 0-5cm and 5-10cm layer . This finding indicates that tillage disturbs the soil causing the spatial distribution of organic matter to become more homogenous . Further , tillage has no beneficial effect in terms of both carbon fixation and maintaining soil health . Lastly this study indicated that different perennial forages result in significant differences in organic carbon fixation .

NO_3^- uptake and its partitioning in drought stressed perennial ryegrass (*Lolium perenne* L.)

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Key words: drought stress, ^{15}N-uptake, perennial ryegrass

Introduction Drought is the major limitation to crop productivity (Boyer, 1982), and affects up to 45% of the world agricultural lands (Bot *et al*. 2000). The availability of water seems to be the most important factor limiting plant growth and productively in dry areas. It is well documented that nutrient uptake is inhibited in dry soil. Soil drought decreased mineralization of organically bound nutrients (Bloehm *et al*. 1992; Walworth, 1992), and nutrient transport in soil by mass flow and diffusion (Seiffert *et al*. 1995), and thus may diminish nutrient availability at the root surface, which may lead to foliar nitrate depletion (Foyer *et al*. 1998). Perennial ryegrass (*Lolium perenne* L.) is one of the most important plant species in forage ecosystems and used all over the world as a valuable species for turf. The objective of this work is to investigate the kinetics of N uptake and distribution in response to the change of water deficit stress using ^{15}N-tracing in perennial ryegrass.

Materials and methods The $^{15}NO_3^-$ feeding was carried out every day throughout the entire 10 days of sampling period. For ^{15}N feeding for the well-watered (control) treatment, 25 mL of ^{15}N solution (1 mM $K^{15}NO_3$ with 8.34 ^{15}N atom % excess) was administered evenly through three porous plastic tubes buried vertically to a depth of 5 cm in each pot at 10:00 h and 16:00 h, respectively. Using the same protocol of administration, plants submitted to water-deficit received 2.5 mL of ^{15}N solution, containing the same ^{15}N atom % and the same amount of N as applied to the control pot (i.e 0.7 mg N pot^{-1} d^{-1}). The sample was harvested at 0, 2, 4, 6, 8, and 10 days after treatment. Freeze-dried power samples (1-5 mg) were weighed into tin capsule for total N determination. N content and ^{15}N atom % of total N was determined using N single mode analysis on an ANCA-SL isotopic ratio mass spectrometer (PDZ-Europa, Crewe, UK).

Results Leaf water potential reached a minimum value of 2.5 MPa after 10 days of drought stress treatment. This showed that drought stress occurred during the experiment. ^{15}N-uptake, expressed by the amount of newly absorbed N in the total N fraction in shoot plus roots, was significantly decreased to 58% in drought-stressed plants compared to control after 10 days of treatment. The amount of ^{15}N distributed to shoots of drought-stressed plants was 35% lower than in the control plants 10 days after treatment (Figure 1). In roots, ^{15}N amount in drought stress treatment is decreased to 44% at day 6 and then rapidly decreased to 30.9% at day 10 compared with control (Figure 2).

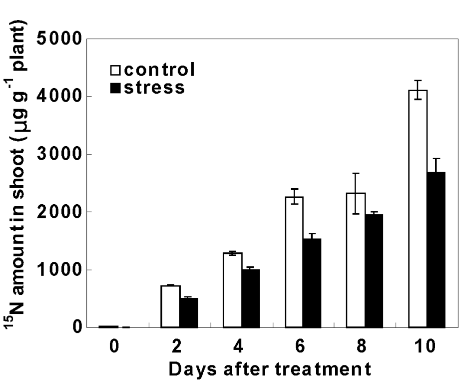

Figure 1

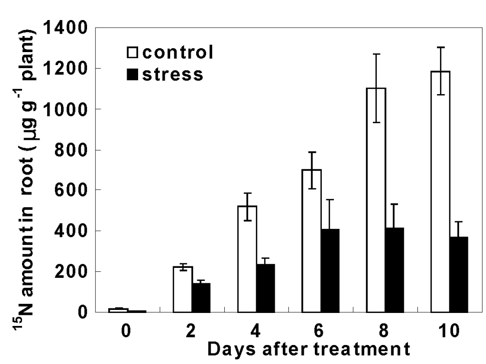

Figure 2

Conclusions In the present study, ^{15}N-uptake was significantly decreased with prolonged periods of drought while the rate of decrease in ^{15}N amount by water deficit was higher in the roots than in the shoots of perennial ryegrass. These results usually were explained by a reduction in N availability and the limitation of N acquisition under drought stress.

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Effect of Molybdenum and Boron on increasing alfalfa seed yield

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Key words : alfalfa , microelement , borax , ammonium molybdate , seed yield

Introduction Although the content of microelements is low in plants , they play a role in translocation and energy exchange in metabolism , and have an important influence on crop yield (Guoxiao ,etc . ,2006 ;Chang Yao-hong ,2007 ; Hu Ai-tang ,2003) . Different concentrations of borax and ammonium molybdate were sprayed at early florescence ,squaring , and florescence of alfalfa in this study , and the effect of boron and molybdenum on yield of alfalfa seed was measured .

Experimental area survey The experimental area is located in the grassland research station ,Hutubi ,Xinjiang .E :86°7′ , N :44°8′ , H :0 .446km . Annual precipitation is 161 .3 mm , annual evaporation is 2312 .7mm ,average humidity is 54% during growing season , the annual accumulated temperature over or equal to 10℃ is 3561 .3 , the frost-free period is 173 days . The total salt content of the research area in 0～20cm is more than 1 .5% ,and pH is more than 8 .5 .

Materials and methods Test materials are Xinmu No .1 Variegated Alfalfa , borax (the boron content is 11%) , ammonium molybdate(the molybdenum content is 5 4%) .

The treatments were foliar sprays of borax at 0 .4% , 0 .6% and 0 .8% , ammonium molybdate at 0 .05% , 0 .07% and 0 .09% , and normal water . There were sprayed during early florescence , squaring period and florescence , respectively . The size of plots were $10m^2$. Each treatment was repeated three times in a randomized block design .

The following was measured on 10 plants : plant height , growth rate , branch numbers , the number of racemes , the pod numbers per inflorescence , the seed setting number in each pod after regrowth , and seed yield , 1000-grain weight , germination rate after harvest seed .

Table 1 *The effects of boron and molybdenum on alfalfa seed yield and yield components .*

treatment	1000-grain weight (g)	the number of branches (m^2)	pod / inflorescence(a)	inflorescence / branches (a)	seeds / pods(a)	seed yield (kg/hm^2)
Ammonium Molybdate0 .05%	1 .900±0 .0262	421 .66±30 .1	15 .53±0 .68	15 .13±1 .5	5 .97±0 .20	592 .31±65 .2
Ammonium Molybdate 0 .07%	2 .052±0 .0258	392 .33±25 .6	14 .23±0 .70	14 .36±1 .6	5 .00±0 .23	513 .3±70 .8
Ammonium Molybdate 0 .09%	1 .899±0 .0203	388 .67±23 .6	11 .66±0 .42	13 .36±2 .0	5 .20±0 .27	408 .00±42 .9
borax 0 .4%	1 .872±0 .0199	472 .67±45 .1	15 .26±1 .1	11 .26±1 .2	5 .77±0 .21	471 .00 ±68 .5
borax0 .6%	1 .900±0 .0234	484 .00±33 .5	13 .8±0 .90	12 .1 ± 1 .2	5 .37±0 .22	492 .00±73 .2
borax 0 .8%	1 .900±0 .0123	492 .00±50 .1	16 .3±1 .3	13 .46±1 .3	5 .73±0 .26	507 .00±68 .6
ck	1 .944±0 .0244	380 .00±32 .6	10 .06±0 .51	16 .66±2 .2	4 .40±0 .19	438 .75 ±61 .4

Results and discussion The results showed that alfalfa seed yield ,branch numbers , the pod numbers per inflorescence and the seed setting number in each pod were higher than in the control after spraying boron and molybdenum . When 0 .05% ammonium molybdate was sprayed , the yield increased 35% compared to the control . Branch numbers , the pod numbers per inflorescence and the seed setting number in each pod increased 10 .96 % , 54 .37% , 35 .68% ($p<0.05$) , respectively . When 0 .8% borax was sprayed , the yield increased 15 .56% relative to the control .Branch numbers , the pod numbers per inflorescence and the seed setting number in each pod also increased($p<0.05$) . When 0 .07% ammonium molybdate was sprayed , thousand-grain weight increased 5 .6% compared to the control . After the different concentrations of borax and ammonium molybdate were sprayed , the numbers of racemes per reproductive branch were lower than that in the control .

The effect of boron and molybdenum on increasing yield of alfalfa seed is evident from this study . With increasing concentrations of Ammonium Molybdate , the seed production decreased gradually , and seed production increased with increasing concentrations of borax . Various factors related to the formation of seed production were affected , especially inflorescences per pod and per pod seed of alfalfa .

Effects of different land use on soil organic carbon and microbial biomass C in the Longzhong part of Loess plateau

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Key words : Loess plateau , Different land use , Soil organic carbon , Soil microbial biomass C

Introduction The soil organic carbon (SOC) and microbial biomass C (MB-C) play key roles in soil conservation , agriculture production , and global environmental changes . Land use and management practices have great influence on SOC and MB-C . Pool size and activity changes in components of soil organic can be influenced by many factors , including climate and land use . The objective of this study was to investigate changes in SOC and MB-C after conversion to different land use .

Materials and methods The study was conducted at Semi-Arid Climate and Environment Observatory of Lanzhou University (35°57′ N , 104°09′ E) . Soil type is Sierozem , elevation is 1966 m , mean air temperature is 6 .7℃ , mean annual rainfall is about 382 mm . Four sites [fenced grassland (FG) ,grazing grassland (GG) , millet field (MF) and fallow cropland (FC)] , each 1 hm2 and adjacent to each other , were selected for the study . FG and GG : dominant grass was Stipa . Bungeana , fenced in Oct . 2005 . MF : planted S . italica (L .) Beauv . FC : fallowed in 2006 and 2007 . Both organic manure and chemical fertilizer were applied to croplands except in the fallowing year . Three sample plots (50×50 m^2) were randomly located within each site . In May 2007 , ten soil samples at five soil depths (0-60cm) were taken in each plot using soil cores and each five soil samples from same depth were mixed together . Soil samples were analyzed organic carbon and microbial biomass C . Data were analyzed using General ANOVA .

Results The data was shown in Table 1 , SOC and MB-C in the 0-10 cm layer decreased in the order : FG>GG>MF>FC . But in the 10-20 cm and 20-30 cm layers , SOC in FG and GG were almost at the same level . In MF and FC soil , the maximum SOC was in the 20-30 cm . SOC and MB-C of FG and GG were decreased with increased soil depth . MB-C of FC in the 20-30 cm layer was higher by 51% than those in the 10-20 cm . MB-C of MF in 10-30 cm layers was higher than in FG , GG and FC (Table1) .

Table 1 *Change of SOC and MB-C under different land use regimes*
The data in the table are means (SE) , different capital letters in the same row mean significant difference at $P < 0.05$;the different lower cases in the same column mean significant difference at $P < 0.05$.

Soil depth	SOC (g/kg)			
	FG	GG	MF	FC
0—10 cm	9 .1(0 .5)aA	8 .9(0 .6)aA	7 .5(0 .1)bB	7 .2(0 .2)bB
10—20 cm	6 .7(0 .3)bAB	6 .4(0 .2)bB	7 .9(0 .3)abA	7 .4(0 .3)bA
20—30 cm	5 .9(0 .6)bB	5 .6(0 .6)bB	8 .2(0 .4)aA	9 .3(0 .5)aA
	MB-C (mg/kg)			
	FG	GG	MF	FC
0—10 cm	141 .4(4 .7)Aa	107 .6(8 .1)Ba	105 .7(2 .8)Ba	40 .0(1 .6)Ca
10—20 cm	27 .35(2 .9)Cb	46 .15(6 .0)Bb	99 .60(2 .1)Aa	16 .9(0 .9)Cc
20—30 cm	26 .63(3 .1)Bb	25 .50(0 .5)Bc	80 .99(1 .3)Ab	25 .7(0 .8)Bb

Conclusions The SOC and MB-C in 0-10 cm layer decreased in the order : fenced grassland>grazing grassland>millet field>fallow cropland . The SOC in the 10-20cm soil layers were shown millet field>fallow cropland>fenced grassland>grazing grassland . Fertilization and human activities were found to have major impacts on SOC . The MB-C of MF was higher in the 10-20 cm and 20-30 cm than FG , GG and FC . After land use change , soil microbial biomass was affected , fallowed cropland is more sensitve than others , two grasslands also have small change . Different land use has been shown to have profound influence on MB-C and SOC .

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Nitrous oxide emission and methane oxidation potential in the pastoral soil under intensive dairy farm management

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Key words: N_2O, CH_4, nitrogen, carbon, excreta

Introduction Anthropogenic nitrous oxide (N_2O) emissions from agricultural soils are estimated to contribute ~14% of New Zealand's greenhouse gas (GHG) inventory (New Zealand Climate Change Office 2007). The global annual soil sink for methane (CH_4) was estimated to be 3-9% of the atmosphere's removal rate (Smith et al., 2000). We report N_2O emission and CH_4 oxidation rates in freely and poorly drained soils on an intensively managed dairy farm following a cattle urine application.

Materials and methods The two soils examined were located beneath pasture grazed by dairy cattle in Waikato region of New Zealand (37.8°S, 175.3°E) with average annual rainfall of 1240 mm and air temperature of 14℃. Cow urine was applied to create experimental urine patches in the soils at 10 L/m2 (650 kg N/ha). Fluxes of N_2O and CH_4 were measured using static chambers (diameter 250 mm, height 130 mm), with 3 replicates for urine patches and controls, over 100 days in autumn and winter seasons. Gas samples were analysed by gas chromatograph with a 63Ni-electron capture detector (ECD) for N_2O and a flame ionization detector (FID) for CH_4. Soil and relevant environment parameters were measured/monitored over the trail period.

Results There were eight occasions for both soils when N_2O fluxes in the urine patches exceeded the 100-day average. For the freely drained soil, seven of these days occurred during the first 3 weeks after urine application and accounted for 61% of total emissions. Higher than average daily emissions occurred throughout the 100 days of measurement for the poorly drained soil, and 4 of these days during the first 3 weeks after urine application accounted for 41% of total emissions. For both soils, N_2O emissions of the urine-amended plots always exceeded the controls. Nitrous oxide emission factors (EF3) were 1.3 and 0.4% for the poorly and freely drained soils respectively.

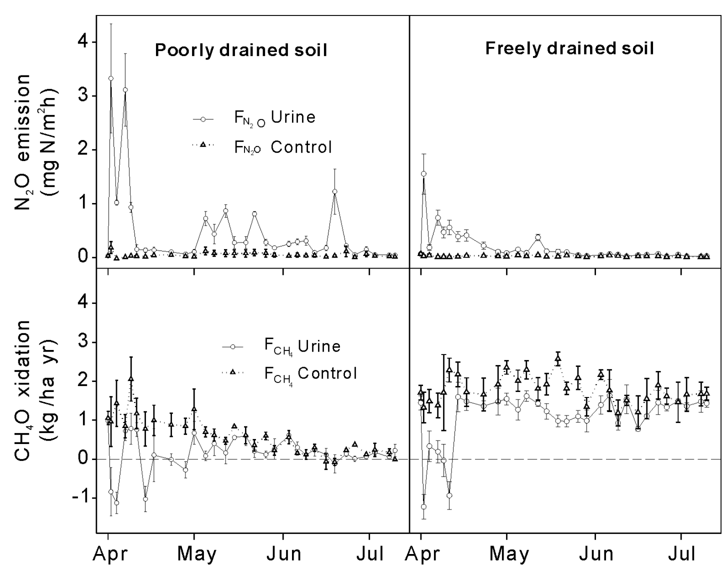

Figure 1 *Nitrous oxide emission and CH_4 oxidation rates measured over 100 day trial period (n=3).*

Following urine application, the poorly drained soil was a net source of CH_4 on Days 2, 3, 13, 22, 27 and 79. On the day of urine application and 7 and 9 days later, the freely drained soil was also a net source of CH_4. Over 100 days, for the poorly drained soils, the integrated CH_4 oxidation rates were 0.6 ±0.1 and 0.2±0.1 kg C/ha yr for the Controls and Urine plots, respectively. For the freely drained soil, the corresponding rates were 1.8±0.2 and 1.1±0.2 kg C/ha yr.

Conclusions Applying urine markedly increased soil's N_2O emissions. The integrated N_2O emitted from poorly drained soil was 3 times than that from freely drained soil. Cattle urine application reduced the CH_4 oxidation rates of freely and poorly drained soils for up to two months and by 0.7±0.2 and 0.4±0.1 kg C/ha yr. Overall, the two soils' responses were not significantly different.

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Production, botanical composition and nutrient status of an originally *Lolium perenne*—dominant sward receiving long-term manure applications

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Key words: slurry, nitrogen, phosphorus, *Lolium perenne*, *Agrostis stolonifera*

Introduction Long-term slurry applications may alter the botanical composition of herbage (Christie, 1987). Perennial ryegrass (*Lolium perenne* L.) is the most important plant species in intensively managed grassland in the UK. The aim of this study was to investigate the effect of long-term slurry application on production and botanical content of a *Lolium perenne*-dominant sward and to determine the possible role of macronutrients in determining botanical composition.

Materials and methods The experiment was established on a sown sward of *Lolium perenne* L. at Hillsborough, Northern Ireland and has been managed as a three-cut silage system since 1970. Eight treatments have been applied to plots of net area 18.75 m^2 in three randomized blocks (each containing two replicates of each treatment) i.e. unfertilized control (UF), fertilized control (FE; 200 kg N, 32 kg P, and 160 kg K ha^{-1} y^{-1}), pig slurry at 50, 100 and 200 m^3 ha^{-1} y^{-1} (Pig50, Pig100 and Pig200), and cow slurry at the same three rates (Cow50, Cow100, Cow200). In 2006 the proportions of dominant species in each plot at each harvest and at the first two harvests the concentrations of N and P in *Lolium perenne* (L.p.) and in two other major ingressing species (*Agrostis stolonifera*, A.s.) and *Poa* spp. were determined (except in treatment UF).

Results Total annual DM yield varied from 3.1 t ha^{-1} (UF) to 18.2 t ha^{-1} (Cow200). Perennial ryegrass content declined and Agrostis content increased with increasing slurry application rate (Table 1). Nitrogen concentration in either species was only markedly increased by Cow200. Only in perennial ryegrass did P concentration increase with slurry rate. Therefore increasing deficiency in N and P does not explain severe decline in perennial ryegrass at high slurry rates. However, perennial ryegrass was less able to take advantage of the higher availability of N (Figure 1) and P (similar pattern to N) at high rates of slurry application. Among the other macronutrient concentrations determined in perennial ryegrass, Ca suffered the steepest decline with increasing slurry rate, suggesting a possible limitation to perennial ryegrass contribution, although physical factors such as smothering' of the herbage by high application rates of slurry may have also been involved.

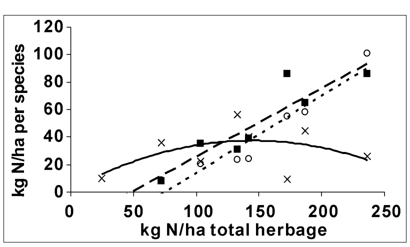

Figure 1 *Relationship between N offtake by L.p. (x, solid line), A.s. (■, broken line) and Poa (○, dotted line) and total offtake (r^2 = 0.27, 0.83 and 0.92), respectively.*

Table 1 *Proportion in dry matter (3 cuts) and N and P content (mg g^{-1}) of Lolium perenne (L.p.) and Agrostis stolonifera (A.s.) (2 cuts).*

	L.p. Prop.	A.s. Prop.	L.p. N	A.s. N	L.p. P	A.s. P
UF	0.31	0	11.9	0	1.81	0
FE	0.23	0.29	14.1	20.2	2.31	2.74
PIG50	0.37	0.18	12.5	17.5	2.36	2.58
PIG100	0.20	0.48	11.5	17.7	2.39	2.82
PIG200	0.03	0.61	12.1	18.4	2.61	2.86
COW50	0.39	0.26	12.3	17.7	2.19	2.68
COW100	0.21	0.47	12.8	19.1	2.27	2.68
COW200	0.09	0.47	19.1	22.3	2.93	2.96
s.e.m.	0.04^{***}	0.049^{***}	0.73^{***}	0.44^{***}	0.09^{***}	0.08ns

Conclusions The inability of perennial ryegrass to withstand long-term application of high rates of slurry application cannot be explained by deficiency in N and P induced by competition but limitation in other nutrients may be responsible, perhaps together with physical effects of high slurry application rates on plant growth.

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Effect of soil temperature and soil moisture on soil respiration of ungrazed grassland in Loess Plateau, Gansu

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Key words: soil respiration, soil temperature, soil moisture, grassland, Loess Plateau

Introduction Soil respiration (SR) is a major component of greenhouse gas emission and is a crucial pathway of the C cycle. The potential increase of SR caused by global warming may present a positive feedback effect on atmospheric CO_2 and climate change (Kirschbaum, 1995). However, the factors that control the exchange of CO_2 between soil and atmosphere in Loess Plateau, Gansu are not well understood. The results in this paper represent a preliminary exercise in studying SR variations and its correlation with soil temperature (Ts) and soil moisture (Ms).

Materials and methods Monthly measurements of SR were made from August 2006 to July 2007 in a fenced *Stipa. bungeana* grassland (free from grazing since Oct. 2005) which located in the Semi-Arid Climate and Environment Observatory Station of Lanzhou University (35°57′N, 104°09′E). The measurements of SR were made by using a LICOR 6400 portable photosynthesis system fitted with a soil respiration chamber (LICOR, Inc., Lincoln NE). SR was measured between 8:00～10:00. 12 PVC collars that held the SR chamber were set 24 hours before SR measuring. Ts at 2, 5cm depths and Ms down to 10cm were measured simultaneously.

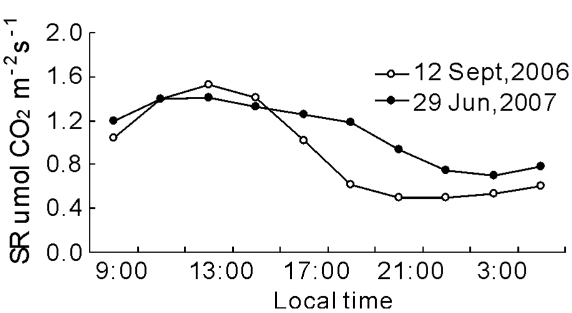

Figure 1 *Diurnal variations of SR.*

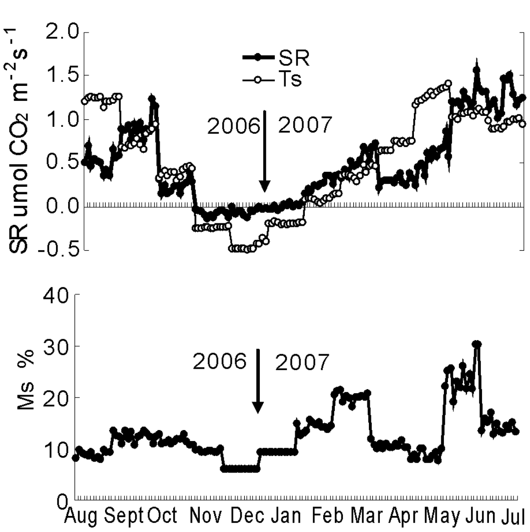

Figure 2 *Seasonal variations of SR, Ts and Ms.*

Results Diurnal variations of SR could be expressed as one-humped curves, reaching to the maximum around 13:00 and falling to the minimum between 0:00～3:00 in different growing periods. Ts at 5cm depth was the dominant factor controlling SR ($P<0.001$). Ms had relatively little effect on diurnal SR variation as it changed little within one day. Seasonal SR variation was dominated by Ts-Ms interaction and root biomass. The maximum of SR was observed in Jun, 2007, while the minimum in Nov, 2006. Negative CO_2 efflux was observed from Nov, 2006 to Jan, 2007. The correlation between Ts at 2cm, 5cm depths and SR were much remarkable($R^2=0.54$ and $R^2=0.56$, $P<0.001$). Ms was secondary factor controlling SR variation at seasonal scale. The single Ms effect on SR was examined by normalizing SR at a reference value of 20℃, and the correlation was significant ($R^2=0.39$, $P<0.001$). When both Ts and Ms effects on SR were considered, SR could be given better simulations:

$SR=0.024T+0.039Ms-0.26$ ($R^2=0.73$, $P<0.001$).

Conclusions Ts was dominant factor controlling diurnal SR variation when Ms was relatively stable. Both Ts and Ms effects on SR could better reveal SR variation at seasonal scale, thus the predictive capacity of the model about SR variation has been improved.

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Improvement of production and nutrient uptake of *Pueraria phaseoloides* by rock phosphate fertilization in Kombucha suspension and *Glomus manihotis* fungi inoculation

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Key words: *Glomus manihotis*, Kombucha, *Pueraria phaseoloides*, rock phosphate

Introduction Rock phosphate (RP) is often considered as an alternative to the use of more expensive soluble P fertilizers (SP). Symbiotic association between AM fungi and legume plants has been reported to be more responsive and efficient with RP than the other type of P fertilizers. Kombucha is a sweetened tea beverage that contains various organic acids such as citric and malic acid (Bartholomew and Bartholomew, 2001). Ishikawa *et al*. (2002) reported that citric and malic acid were capable of mobilizing P from the soil. The objective of the research is to investigate the influence of RP fertilization in Kombucha suspension and *Glomus manihotis* fungi inoculation on the dry matter (DM) production, and nutrient uptake of puero (*Pueraria phaseoloides*).

Materials and methods The experiment was conducted in a greenhouse on the acid latosolic soil. A completely randomized design with 5 treatments, and 5 replicates was used. The treatments were control (T0), RP (T1), RP + *G. manihotis* (T2), RP + Kombucha (T3), and RP + Kombucha + *G. manihotis* (T4). Standard fertilization as urea (46% N) and KCl (60% K_2O) at 50 kg N ha^{-1} and 83 kg K ha^{-1}, respectively, were added to each pot. RP (27% P_2O_5) fertilization as the treatment was used at 87 kg P ha^{-1} (2.22 g RP pot^{-1}). We prepared 10 glasses and poured 100 ml of Kombucha suspension, added 2.22 g of RP into each glass and stirred the suspension for T3 and T4. Each pot received 6 kg of dry soil and contained two seedlings of puero, inoculated with 50 g crude inoculum of *G. manihotis*, according to the assigned treatment at the time of planting. After 8 weeks of growth, plants were cut and oven-dried at 70^{0}C for 48 hours. These samples were analyzed for measurement of DM production, nitrogen (N) and phosphorus (P) uptake. Data were analysed using GLM procedure of SAS. Significant differences among the treatments were tested using Duncan's Multiple Range Test (Steel and Torrie, 1980).

Results and discussion There were no significant differences in DM production, N and P uptake between T0, T1, T2, and T3. However, T4 increased DM production, and N and P uptake compared to T0, T1, T2 and T3 (Table 1). Kombucha produced citric and malic acid (Bartholomew and Bartholomew, 2001), and was capable of solubilizing RP (Ishikawa *et al*., 2002). Puero has magnolioid roots, which are highly responsive to AM fungi inoculation. Therefore, their association with AM fungi combined with RP fertilization in Kombucha suspension will improved the growth and development of puero.

Table 1 *Dry matter production, nitrogen and phosphorus uptake of Pueraria phaseoloides by rock phosphate fertilization in Kombucha suspension and Glomus manihotis fungi inculation.*

Treatment	DM Production (g $plant^{-1}$)	N Uptake (mg $plant^{-1}$)	P Uptake (mg $plant^{-1}$)
T0 (control)	0.71 b	21.73 b	1.91 b*
T1 (rock phosphate)	0.98 b	28.08 b	2.72 b
T2 (RP+G. manihotis)	1.35 b	34.50 b	3.43 b
T3 (RP+Kombucha)	0.48 b	15.31 b	1.20 b
T4 (RP+Kombucha+G. manihotis)	3.06 a	81.25 a	7.20 a

* Significantly different at DMRT 5%

Conclusion Rock phosphate fertilization in Kombucha suspension combined with *Glomus manihotis* fungi inoculation increased DM production, N and P uptake of *Pueraria phaseoloides* in the acid latosolic soil. No differences in DM production, N and P uptake were found between other treatments.

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Nitrous oxide emissions from dairy pasture systems in New Zealand

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Key words: dairy farm, nitrous oxide, grazed pasture, maize supplement, New Zealand

Introduction Animal excreta deposited during grazing are the single largest source of nitrous oxide (N_2O) from agriculture in New Zealand. N_2O gas is formed in soils during nitrification and denitrification processes and these processes are affected by many soil and climatic factors (e.g., soil water-filled pore space (WFPS) and nitrate concentrations). There are a number of possible management options that can reduce N_2O emission from dairy farms (Clark *et al*. 2005). These options include using restricted grazing regimes to reduce excreta-N deposited onto wet soil and using low-N feed supplements (e.g. maize) as an alternative to using N-rich pasture. A dairy farm system study was carried out to evaluate effects of these options on N_2O emissions. In this paper we summarise N_2O emission data and environmental efficiencies in terms of N_2O emissions per unit of milk production obtained from this study.

Materials and methods The study site contained white clover-based pasture (perennial ryegrass, *Lolium perenne*; white clover, *Trifolium repens*) on a poorly drained loam soil. Farm systems included: 1) Control: a normal rotational pasture grazing regime with a stocking rate of 3.0 cows ha^{-1}; 2) Maize supplement: a rotational grazing regime with a stocking rate of 3.8 cows ha^{-1}. About 5 tonnes DM ha^{-1} of maize silage were brought in annually; 3) Stand-off: Same grazing regime and stocking rate as the control, but cows were kept on stand-off pads for 18 hours each day with grazing for 6 hours on pasture during the winter period. Measurements of N_2O were made for two years on the grazed pastures, maize growing land and stand-off pad (Luo *et al*. 2008a,b). The New Zealand IPCC inventory methodology was used to calculate indirect N_2O emissions from leached and volatilised N.

Results Nitrous oxide emission rates exhibited marked seasonal variation, largely explained by changes in soil WFPS (Figure 1). Annual N_2O emissions from the grazed dairy pastures were 4.7, 4.0 and 3.4 kg N_2O-N ha^{-1} for the control, maize supplement and stand-off treatments, respectively. The N_2O emission rate from the maize growing land was 2.1 kg N_2O-N ha^{-1}, and this was equivalent to emission of 0.1 kg N_2O-N per tonne of maize silage. Emissions of N_2O also occurred from the stand-off pad. Total annual N_2O emissions (including both the field measured and calculated direct and indirect emissions from all components of the farm systems) were 7.7, 8.0 and 7.0 kg N_2O-N per hectare of dairy farm on the control, maize supplement and stand-off farm systems (Table 1). Total N_2O emissions per kg of milk production from the maize supplement and stand-off farm systems were 22% and 9% lower than that from the control system, respectively.

Table 1 *N_2O emissions and environmental efficiency indicators (Luo et al. 2008a,b).*

	Control	Maize supplement	Stand-off
N_2O emissions ($kg\ N_2O\text{-}N\ ha^{-1} yr^{-1}$)	7.7	8.0	7.0
Change in N_2O emission compared to control (%)		4	-9
Milk solids ($kg\ ha^{-1}\ yr^{-1}$)	13.437	17.925	13.437
Efficiency indices ($kg\ N_2O\text{-}N\ tonne^{-1}$ milk)	0.57	0.45	0.52
Gain in efficiency (%)		22	9

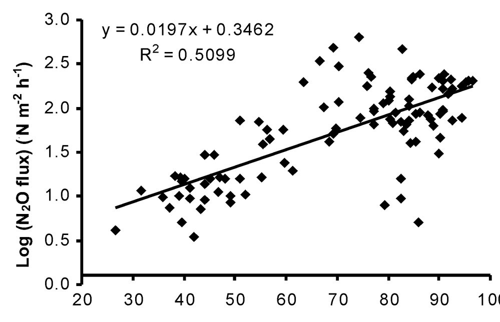

Figure 1 *N_2O emissions as affected by soil WFPS.*

Conclusions The results confirm that the use of low-N feed supplements or restricted grazing regimes during wet winter are effective at reducing N_2O emissions from dairy farms in terms of N_2O emissions per unit of milk production.

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Seasonal changes of mineral elements in yak blood , herbage and soil around Qinghai lake

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Key words : yak , winter and spring grassland , summer grassland , mineral element , dynamic change

Introduction Little information is available on the mineral nutrition of yaks(Bos Grunniens) .Five mineral elements in herbage and soil were studied in the Qinghai lake area (Zhang et al ,1997) . The results showed that Copper and Zinc content in herbage was lower than standard , Manganese content was lower than standard in both herbage and soil , while Molybdenum content exceeded standard in herbage This study aimed to understand the present status of mineral elements in the main yak raising area around Qinghai lake , to provide some scientific basis for supplementation of mineral elements to yaks .

Materials and methods Whole blood samples from yaks aged from 2 to 8 years old were collected from Haiyan Tongbao Farm , at an altitude of 2 ,900 meters above sea level , Samples were collected in March while yak were on spring pasture , grazing natural grassland and supplemented with hay at night with a poor body condition score . More blood samples were collected on the same farm in July while yak were grazing summer grassland without any supplement . At the same times , samples of pasture herbage and soil (15cm depth) were also collected . Zinc , Calcium , Copper , Iron , Potassium and Sodium levels were measured by atomic absorption spectrometry , Sulphur by LY/T 1255-99 , Phosphorus by GB12393-90 , Chloride by ion chromatography , Fluorine by ion selective electrodes , Iodine by GB/T 13882-92 and Selenium by GB/T 12399-1996 (codes refer to national standard methods of P .R .China) . Blood results were statistically analysed with SPSS for differences between ages and sex within one age group . Herbage and soil results were analaysed .

Results The results showed that the contents of Sulphur and Selenium in whole blood were greater in summer compared with spring , while other minerals were lower ($P \leqq 0.05$). The content of Calcium , Phosphorus , Potassium , Sodium , Iron , Selenium and Copper in summer soil in around Qinghai lake area were 0.7120 mg/g , 0.2390 mg/g , 2.1840 mg/g , 1.0430 mg/g , 47 .78 mg/g , 197μg/kg and 0 .0540 mg/g respectively ., There were no differences between seasons for the Calcium , Sodium , Iron or Copper content of soils . In summer the content of Phosphorus decreased by 10 times , Potassium decreased by 8 times and Selenium increased by 4 times compared to winter . For the content of mineral elements in herbage , there were no differences in the Calcium , Phosphorus ,Potassium , Sodium , Iron or Copper content between the two seasons , while the Selenium content decreased by 5 times from Spring to Summer .

Conclusions The results showed that the deficiency of mineral elements for yak in summer grassland were even worse than those in winter and spring grassland ., We should give supplementary feeding for mineral elements in summer time for increasing yak productivity and performance further .

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Effects of water and nutrient treatment on gas exchange and water relations of two *Casuarina equisetifolia* clones

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Key words: *Casuarina equisetifolia*, nutrient treatment, water relations, gas exchange

Introduction The relative success of a plant, both in an evolutionary sense and in terms of biomass productivity, depends on its ability to sequester and efficiently utilize soil resources that often are scarce. Nitrogen (N) and water are considered to be the resources most often limiting survival, reproduction, or growth, although macro-or micro-nutrients, oxygen, physical space, or other soil factors also may be important in some circumstances. The ecophysiological responses of plants to fluctuations in available water and N, therefore, have been and will continue to be important subjects of research (Evans, 1989).

Methods Two *Casuarina equisetifolia* clones (CH and TCR) were grown in the pots and the pots received two different nitrogen treatments and water treatments starting from July to December 2000. Photosynthesis and WUE of the clones were measured seasonally and diurnally to determine different response of the clones.

Results and discussion Photosynthesis and stomatal conductance were well correlated in our study in both clones (Figure 1); r-values were in excess of 0.5. The slopes and intercepts of the two linear regressions were nearly identical. However, the data set for TCR contained more values in the upper range of photosynthesis (A) and stomatal conductance (g). The results showed that physiological processes in foliage of the Casuarina clones respond differently to water stress. Genotypic and population level difference in photosynthetic rate and water relations have been reported within hardwood genera or species (Abrams and Knapp 1986; Furukawa et al., 1990). Based on the earlier reports and from the present study, it can be concluded that high intrinsic rates of photosynthetic rate, light control of stomatal water loss, high WUE, and osmotic adjustment to cellular desiccation are all very desirable for the growth of the tree species. The physiology of CH appears to be more susceptible to extreme drought than does that of TCR. These results could lead to the conclusion that TCR would be a better choice for high biomass production under non irrigated in grassland ecosystem condition than CH.

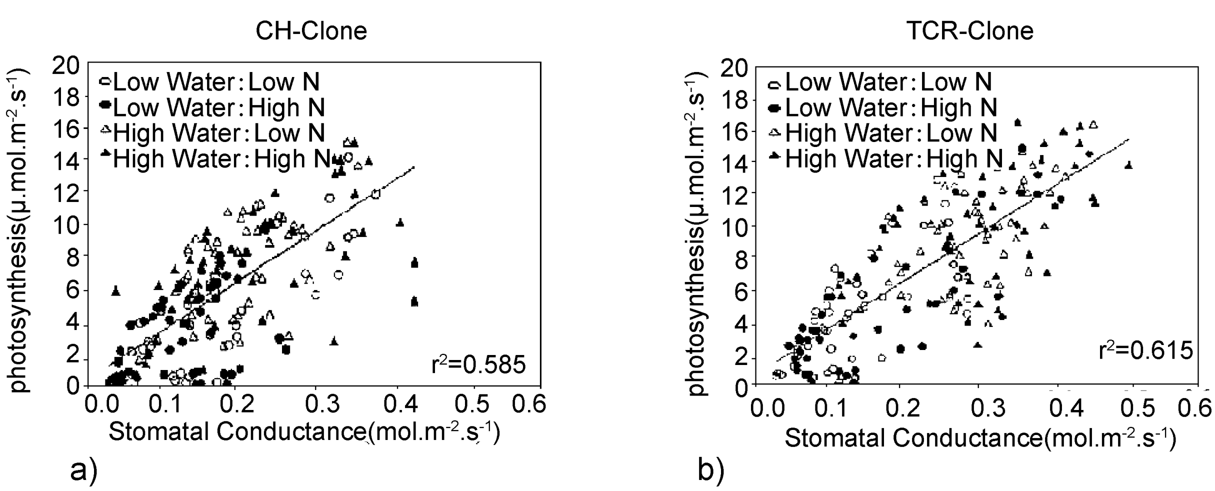

Figure 1 *Linear regression of photosynthesis (A) vs. stomatal conductance (g) for a) CH and b) TCR clones of* Casuarina equisetifolia. *Data from all treatment combination and from seasonal and diurnal measurements.*

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Preliminary investigations on Columbus grass (*Sorghum almum* Parodi) for fodder in semi-arid Nigeria : effects of nitrogen fertilizer on growth components and herbage yield

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Key words : Columbus grass , semi-arid environment , sowing methods

Introduction In Nigeria , Columbus grass is a recently introduced forage crop grown mostly in research settings . Most of the ruminant population in Nigeria is located in the semi arid zones , characterized by a long dry season of 6-7 months , during which there is a serious lack of forage both in quantity and quality . This research was therefore conducted to investigate the effect of different levels of nitrogen fertilizer on the growth characteristics and herbage yield of Columbus grass in semi-arid Nigeria as fodder during this period .

Materials and methods The experiment was conducted in the rainy season of 2005/2006 at the Usmanu Danfodiyo University Teaching and Research Farm (13°1′N , 5°15′E) using a Randomized Complete Block Design (RCBD) with three replications . Land was prepared manually using a hoe . The plots were marked out into parallel rows , separated by 0 .5m footpath . The plots were rectangular , slightly sunken basins of $3m^2 \times 4m^2$ ($12m^2$) . Seeds of Columbus grass (*Sorghum almum* Parodi) were manually broadcasted on the plots at the rate of 19 .8kg ha^{-1} . Nitrogen fertilizer (NPK 15 :15 :15) was applied at the rate of 0 , 40 and 80 kg ha^{-1} . Plant height , leaf length , leaf width , number of leaves and number of plants per plot were measured in each plot at 2 , 4 , 6 , 8 and 10 weeks after planting (WAP) Herbage yield was estimated once at 10 WAP . Data were subjected to analysis of variance , and LSD was used to compare means (SAS 1988) .

Results and discussion Plant height , leaf length and leaf width of Columbus grass under different nitrogen applications at different time intervals are presented by weeks post planting in Figure 1 . Nitrogen application affected ($P<0.05$) plant height at 10 WAP and leaf width at 2 and 10 WAP respectively . Similarly , stand count was affected ($P<0.05$) at 4 to 10 WAP (Figure 2) . Mean number of leaves did not differ significantly ($P>0.05$) between the treatments . 80 kg ha^{-1} produced the highest ($P>0.05$) mean DM yield of 7100 kg ha^{-1} . This was slightly lower than the value of 8180 kg ha^{-1} reported by Muhammad (2004) in the same ecological zone .

Conclusion It can be concluded from the results of this study that 80 kg ha^{-1} produced the best results in the area of study .

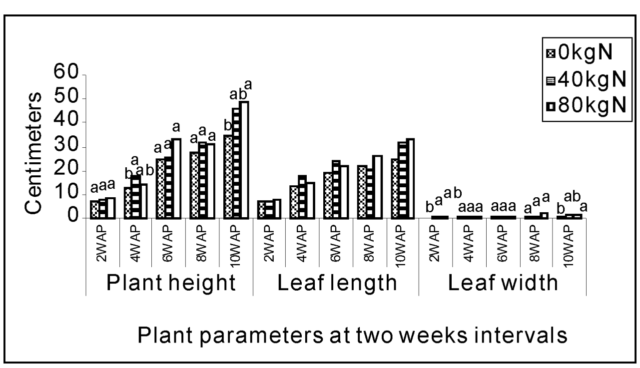

Figure 1 *Plant height , Leaf length and Leaf width of Columbus grass with different sowing methods at different time intervals .*

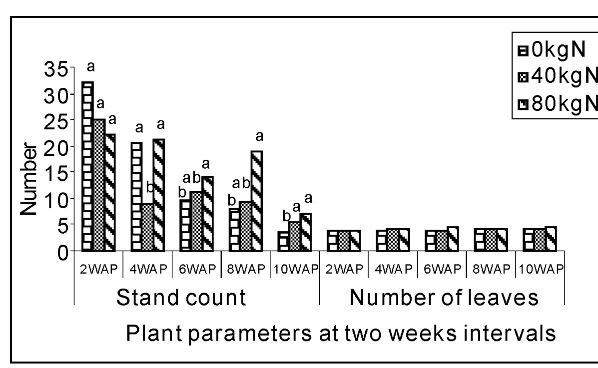

Figure 2 *Stand count and number of leaves of Columbus grass with different sowing methods at different time intervals .*

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Biomass production and soil carbon in the grazing lands of Eastern Ghats , Tamil Nadu

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Introduction The productivity of grazing land is an important factor to maintain soil organic carbon . Soil carbon is an important determinant of site fertility due to its role in maintaining soil physical and chemical properties (Reves , 1997) . Biomass production indicates land productivity and declining soil organic carbon indicates land degradation (Ramachandran *et al* ., 2007) . Land use and soil management practice can influence soil organic carbon dynamics . Thus , the present investigation is focused on soil organic carbon , rainfall and productivity of grazing lands in the Eastern Ghats of Tamil Nadu(TN) .

Materials and methods The present study was carried out at Yercaud , Sirumalai , Hogenakal and Thoppur . Biomass and productivity studies followed the methods of Singh and Yadava , (1974) . Organic carbon was estimated by the method of Walkley-Black (1934) .

Result and discussion Maximum productivity was observed at Yercaud (1890) and minimum at Thoppur (1348) . This may be due to the vegetation and rainfall condition of that area , similar observations were reported by Singh and Yadava (1974) . Organic carbon was higher at the 0-10 cm soil depth in all study areas similar to the findings of Ramachandran *et al* ., (2007) at Kolli Hills . Organic carbon variation at different location may be due to the variation in productivity of these study areas (Table1) . The content of organic carbon was higher during winter due to high litter fall in that season . Present investigation reveals that higher rainfall increases the biomass productivity and soil organic carbon in the Eastern Ghats of Tamil Nadu .

Table 1 *Grazing land biomass productivity and soil organic carbon in the Eastern Ghats of TN .*

Location Dominant grassland species(rain fall)	Biomass Productivity g/m^2/yr	Organic carbon (%)					
		Soil Depth (cm)			Seasons		
		0—10	10—20	20—30	Winter	Summer	Monsoon
Yercaud *Themeda triandra* Forsk . (1958mm)	1890	4 .08	3 .42	2 .85	4 .31	3 .40	3 .04
Hogenakal *Heteropogon contortus* Linn . (710mm)	1680	1 .55	1 .18	0 .99	1 .52	1 .42	1 .25
Sirumalai *Themeda triandra* Forsk (780mm)	1751	1 .73	1 .39	1 .20	2 .82	1 .50	1 .29
Thoppur *Heteropogon contortus* Linn . (754mm)	1348	1 .33	1 .20	1 .03	1 .36	1 .15	1 .06

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Interactive effects of pelletised lime and fertiliser N on sward productivity

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Key words: lime, N fertilization, sward productivity

Introduction Maintaining an optimum soil pH through liming is critical for soil health and grass growth. Pelletised lime is finely ground limestone, pelletised into fertiliser-sized granules that can be conveniently spread using a conventional fertiliser spreader, making it easier to apply than regular liming materials and eliminating the dust problem associated with them. Pelletised lime has been shown to produce yield responses in crops such as alfalfa, soybean and wheat but the effects on grass yield have yet to be evaluated. The fine particle size of pelletised lime may result in a quicker reaction in the soil and a smaller quantity may be required compared to bulk spread aglime, which often has some larger nonreactive particles as part of its composition. Some studies however, have reported a slower rate of reaction, possibly due to the lignosulfonate binding agent and/or the distribution pattern (Murdock, 1997). This study is aimed at evaluating some of the potential benefits of using pelletised lime on grassland, in a three-year fully replicated plot experiment and through a concurrently running on-farm trial at four farms across Northern Ireland. The first year results of the experiment are presented here.

Materials and methods A grassland plot experiment investigated the following rates of pelletised lime (0, 175, 350 and 525 kg lime/ha/yr) and dolomitic ground limestone (0, 175, 350 and 525 kg lime/ha/yr) applied annually in spring. Nitrogen fertiliser (as CAN) was applied equally over three applications, at the following rates, 0, 75, 150, 225 and 300 kg N/ha/yr. There were three replicates of each treatment, laid out in a randomised block design, along with controls, giving a total of 117 plots. Each plot (2m x 8m) was cut using a Haldrup harvester, under a three cut silage system (cuts at ~ 6 week intervals) with 2 slurry applications per year after harvest. In the on-farm trial, silage fields were marked on into 24 m wide strips. Pelletised lime was applied to alternate strips. Two cuts of silage took place per farm, with strip-cuts made using an Agria mower. Grass dry matter (DM) yield was measured at each cut, along with N Offtake, and the nutrient composition of the grass was analysed. Grass Quality was measured by the digestibility of the grass, the crude protein content and dry matter content at each cut. Soil pH and soil chemical composition were analysed at the start of the experiment and will be evaluated after three years of the study to assess the effects of pelletised lime on soil pH and other chemical properties, along with grass yield and grass quality. The pH at the start on the study was 5.78, which is below the UK guidelines for the optimum soil pH for continuous grass swards on mineral soils

Results Within the plot trial there was no significant effect of lime at Cut 1 or Cut 3 or on the total DM yield for the year. There was a slightly significant (*) difference in DM yield at Cut 2 for plots that had received lime compared to those that had not. Plots which had received pelletised lime had a small significantly lower DM yield at zero N and at the highest N application rate (300 kgN/ha/yr). However, the effect was only slightly significant and applied to Cut 2 only. There were no overall statistically significant effects of pelletised lime on grass DM yield, grass quality, N offtake or nutrient composition of the herbage in year 1. In the on-farm trial there were significant differences in grass yield and nutrient composition of the herbage between different farms, but there was no significant lime effect on DM yield of chemical composition of the herbage at any cut.

Conclusions Pelletised lime had no overall significant effect on herbage DM response curves to nitrogen in both plot and on-farm trials in the first year of use. There were no overall statistically significant effects of pelletised lime on grass quality, nitrogen offtake or in the nutrient composition of the herbage. No overall positive benefits or conclusive interactive effects of pelletised lime and fertiliser N on sward productivity were apparent in year 1. Two further years of experimental data will enable more conclusive benefits of using pelletised lime on grassland to be scientifically evaluated.

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Productivity potential and seasonality of five grass species under varying Nitrogen levels at three latitudes in Ireland

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Key words: grasses, production, latitude, management

Introduction This multi-site project was initiated in Ireland to address the expected implications of the recent European Union CAP reform (26 June 2003), which established management directives that curtail soil fertility and animal stocking rates to threshold levels on farms. As this is expected to increase extensification of grassland use, the existing ryegrass based high fertility production systems (DAF 2007, Gilliland, 2007) need to be re-evaluated for their ability to meet grazing animal needs in comparison with alternative minor grass species. Comparative studies of grass species have been conducted in the past (Frame, 1989 and 1991) but varietal improvements have since been achieved in most species. Furthermore, the interactions between climate, fertility levels and stock grazing strategies for seasonal production have not been adequately determined. Therefore, the primary objectives for the current study were to assess the relative productivity potential of a range of grass species under different fertility and defoliation regimes at widely different climatic locations.

Materials and methods The study was conducted at three locations, Crossnacreevy (54°32′N, 05°52′W), Backweston (53°22′N, 06°30′ W) and Moorepark (52°09′ N, 08° 16′W), which equate to a maximum range of difference in day length of 60 minutes on 16 June (derived from Meeus, 1991) and a wide range in mean daily temperatures, rainfall and photosynthetically active radiation levels. Single (?) varieties of five grasses (*Lolium perenne*, *Phelum pratense*, *Festuca pratensis*, *Festuca arundinacea* and *Dactylis glomerata*) were sown with companion white clover (*Trifolium repens*) in a three replicate field plot experiment at each site in 2006. Three nitrogen (N) levels: High, 420 kgN ha^{-1}, Medium, 210 kgH ha^{-1} and Low, 105 kgN ha^{-1} were applied. Sward height assessment by rising plate metre was performed fortnightly, January-November 2007. For the High N and Medium N treatments, coincident, approximately monthly, defoliations were imposed, whereas at the Low N treatment, defoliation frequency was timed independently at each site, occurring when the average sward height of the third tallest species achieved 6 cm above the base defoliation height.

Results and discussion There were significant effects of site, species and nitrogen level on yield and seasonality of production. The differences in seasonality of growth were evident between the sites from early in spring, with first Moorepark (20 March) and then Backweston (27 March) and finally Crossnacreevy (12 April) reaching the initial target defoliation height at the Low N treatment. Total annual production ranged by 2.1 t/ha between the sites (8.1 t/ha Crossnacreevy to 10.2 t/ha Backweston), by 1.5 t/ha between species (*D. glomerata* cv, Donata 8.4 t/ha to *P. pratense* cv, Dolina 9.9 t/ha) and by 4.0 t/ha between nitrogen treatments (High N, 11.2 tDM ha^{-1} to 7.3 tDM ha^{-1} for the Low N), which also significantly affected companion clover content in all species and sites. Nitrogen use efficiencies and herbage supply profiles were calculated for all species by site combinations and evaluated with reference to the white clover content for each of the three nitrogen treatments.

Conclusions The generally accepted hierarchal ranking of these grass species, which have been long established under temperate maritime growing conditions, was not accurately reproduced. Imposing the fertility and location variables affected the species differentials and it was also concluded that advances in plant breeding had further acted to significantly distort the established production superiority of *L. perenne* over these other minor' grass species.

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Physical soil quality in the main areas of pastures in dairy production in Uruguay

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Key words: soil physical, pasture, dairy

Introduction During the last decades dairy production in Uruguay has become more intensive. A better knowledge of soil quality in dairy production is needed to improve and develop sustainable soil use and management practices under this scenario. As part of a larger research project some results related to soil physical properties in these systems are presented.

Materials and methods This study was conducted during 2005 and 2006 on eighty six dairy farms located in the Departments of Colonia, San Jos and Florida (Mor n et al, 2006). Soils from the selected farms vary from Argiudolls to Hapludolls. For each farm, two sampling sites representing two different phases of the pasture rotation were selected. Sampling sites compared a perennial pasture in it's third-year (P) with an annual winter pasture (V). Additionally, undisturbed sites usually located under an old fence, were also selected as a reference for both phases of the pasture rotation. Hence, there was one reference for the perennial pasture (RP) and one for the annual winter pasture (RV). For each site and its correspondent reference six soil samples were taken at the 0-10 cm depth with PVC cylinders of 167 cm^3. Soil samples were saturated in the laboratory, placed in a tension table under a suction of 60 cm until equilibrium was established. Soil macroporosity was then calculated. Soil samples were dried and bulk density was determined. Total porosity was estimated from the bulk density data for each sample and assuming a particle density of 2.65 g/cm^3. Treatments were analysed as a randomized split-plot design.

Results and discussion Table 1 depicts a summary of results obtained in all three departments. For the soil physical quality indicators evaluated, no significant differences were observed between the two phases of the pasture rotation (P vs V). Thus, the mean value is presented for P and V as well as for RP and RV. There was a significant effect ($P<0.0001$) for the contrast between disturbed (P, V) and undisturbed sites (RP, RV) in each of the departments where the study took place. This indicates a degradation of soil physical properties. Soil bulk density for P, V was significantly different between

Table 1 *Averages of soil physical indicators in the three more important departments in milk production of Uruguay.*

	Bulk Density g/cm^3	Macroporosity (cm^3/cm^3 total)100	Total porosity (cm^3/cm^3 total)100
Colonia P, V	1.51	4.17	43.12
Colonia RP, RV	1.30	5.64	50.92
San José P, V	1.41	5.21	46.66
San José RP, RV	1.27	6.52	52.11
Florida P, V	1.37	4.49	47.28
Florida RP, RV	1.26	5.45	52.38

P=perennial pasture, V=annual winter pasture, RP=reference P, RV=reference V

Colonia > San José ≈ Florida. Total porosity for P, V also presented significant differences: Florida ≈ San José > Colonia. Soil macroporosity for P, V was: San José > Colonia ($P<0.05$) but Colonia ≈ Florida and Florida ≈ San José. The observed differences are not totally related to the impact of dairy production, since much of the sampling sites have a previous history of conventional agriculture. This can reasonably explain the higher degradation observed in Colonia compared with the other Departments.

Conclusion There is a consistent soil physical degradation in soils under dairy production in all three Departments. However, this impact is more important in the Department of Colonia.

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Nitrogen fixation in irrigated lucerne (*Medicago sativa*) systems assessed using ^{15}N natural abundance

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Key words : nitrate reductase , soil nitrate

Introduction While lucerne is grown on some 270 ,000 ha in the SE of South Australia its capacity to fix N_2 has not been assessed , although in eastern Australia an irrigated lucerne stand was found to fix ca 85% of its N in its fifth year , and 45% in its sixth year (90 kg N/ha/yr) (Brockwell et al ., 1995) . The present study examines possible N_2-fixation by irrigated lucerne in farmers fields in the principal lucerne seed producing region of Australia .

Materials and methods The study was conducted in the area around Keith in south-eastern South Australia in December of 2006 . Five properties growing lucerne were visited and four lucerne fields under irrigation sampled on each property . Soils at the sites were mostly shallow , neutral to alkaline sododols over limestone , with a few leached mildly acid sands . Most lucerne stands had been grazed earlier in the year and each lucerne stand had already been cut once in the months preceding our visit but was currently locked up for a second hay cut . Dry matter cuts of 0 .47m^2 were taken for estimation of dry matter production at five separate locations . Dependence of lucerne on N_2-fixation was assessed using the ^{15}N natural abundance (^{15}N) technique .

Results and discussion Variation in dry matter production between sites (4 .6-9 .9 t/ha) probably reflected time since last cutting and irrigation applied . Amounts of N_2 fixed in the standing dry matter at the time of harvest ranged from 72-243 kg N/ha , with an average of 148 kg N/ha . This does not represent seasonal or annual totals , but only that in standing dry matter at the time of our sampling after the first seasonal hay cut , and it is likely that total annual N_2-fixation could be 2-3 times this . Taking a conservative approach (2x) we estimate that N_2-fixation in irrigated lucerne in this region must average $>$300 kg N/ha . This does not include possible contributions in lucerne root N .Kelner et al ., (1997) multiplied shoot N fixed by 1 .59 to acount for N in roots , which for the sites in our study would equate to 477 kg N fixed/ha/yr . Further work would be required to validate these extrapolations . Nevertheless these productive pure lucerne hay/seed systems fix substantial quantities of N .

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Sources of nitrogen in a Napier grass/legume mixture on smallholder dairy farms in central Kenya

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Key words: nitrogen, *Pennisetum purpureum*, *Desmodium*, *Macrotyloma*, *Noenotonia*

Introduction In Kenya, dairy production is a major source of smallholder farm income, especially in recent years after the collapse of coffee prices. The smallholder dairy systems are characterised by low weight gains in young stock and low milk production (5-6 kg cow^{-1} day^{-1}). The low yields are attributed to inadequate year-round feed supply, protein and energy intake. The main source of forage is Napier grass (*Pennisetum purpureum*) grown in monoculture. A Napier grass/forage legume mixture can address the constraints to forage yield as the legumes have the ability to fix atmospheric nitrogen (N) through their symbiotic association with rhizobia (Giller, 2001).

Materials and methods The site was in central Kenya (36.3°E, 0.30°S). The soils are humic Nitosols with relatively high inherent fertility. The area receives 1,000 mm of rainfall in 2 seasons. The experiment was laid out in a randomised complete block design replicated 5 times with plots measuring 8 x 8 m. Napier grass (*Pennisetum purpureum*) cv. Bana was intercropped with one of the following legumes: *Desmodium intortum* cv. Greenleaf (ILRI 104), *Macrotyloma axillare* cv. Axillare (ILRI 6756) and *Neonotonia wightii* cv. Tinaroo (ILRI 9794). All the legumes were inoculated with appropriate *Bradyrhiziobium* spp. After the first three months establishment period the forage was harvested every 8 weeks and the yield separated into grass and legume components. Biological nitrogen fixation (BNF) was determined using the ^{15}N natural abundance method.

Results The Napier grass/*Desmodium* mixture had the highest legume and total dry matter (DM) yield ($P>0.05$) in the three years of the trial, although the grass component yield was slightly lower than that from the mixture with *Macrotyloma*. The mixture with *Neonotonia* had the lowest legume and total DM yield in the same period. Over a period of three years the Napier/*Desmodium* mixture had the highest total nitrogen yield followed by the mixture with *Macrotyloma* (Table 1). The mixture with *Desmodium* derived the highest amount from biological nitrogen fixation (BNF) while the Napier/*Neonotonia* mixture had the least N from BNF (Table 1). The proportion of nitrogen derived from BNF was relatively low, the highest being 22%. Even with *Desmodium* which had the highest proportion of N from BNF the mixture still extracted 412 Kg/N ha from the soil (Table 1).

Table 1 *Nitrogen yield and sources in a Napier grass legume mixture in central Kenya.*

Mixture of Napier grass with:	Grass N yield (Kg/ha)	Total N yield (grass+legume) (Kg/ha)	N from BNF (Kg/ha)	Proportion of N from BNF (%)	N from soil (Kg/ha)
Desmodium	265	530	118	22	412
Macrotyloma	353	487	66	14	421
Neonotonia	267	326	32	10	294

Conclusions The low proportion of N derived from BNF could be attributed to the high inherent soil fertility at the site. The legume mixtures still extracted a large amount of N from the soil which would have to be replenished but still contributed a large amount of N from BNF.

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Impacts of strategic grazing on herbage accumulation and nutritive value of naturalised hill pasture

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Key words : Deferred grazing , herbage mass , digestibility , protein , neutral detergent fibre

Introduction Steep hill country is an important part of the landscape in southern Australia . Despite lower productivity , this land plays a critical role in controlling recharge , water and nutrient runoff and soil erosion . A major problem in steep hill country is overgrazing on hilltops , which leads to poor groundcover by perennial pasture species and dominance of annuals in winter and spring . Restoration of perennial pastures including perennial native grasses that are well adapted to Australian environment is the key to improve the sustainability and profitability of the farming systems . Previously Nie *et al* . (2005) revealed that a series of strategic grazing strategies can increase perennial grass population by 30% ～47% , and groundcover up to 90% in summer/autumn . This paper reports the effects of strategic grazing on pasture production and nutritive value .

Materials and methods This study was conducted on a commercial farm (143°08′E , 37°25′S) near Ararat , Victoria , Australia from 2002 to 2006 . The soil was a sedimentary clay loam with low fertility (e .g . Olsen P=4 mg/kg soil) and low pH (pH_{H_2O} =5 .2) . The average annual rainfall during the experimental period was 450 mm . Four treatments were imposed in a randomised complete block design with 3 replicates . They were : 1) a short-term deferred grazing treatment (SD) (pastures not defoliated between October and January each year) ; 2) long-term deferred grazing (LD) (from October to May) ; 3) late-start deferred grazing (LSD) (the starting time varied according to stem elongation of annual grasses each year to remove the growing points of these species ; generally from October/November to May) ; and 4) set-stocking (ST) . The pasture was initially dominated by exotic unimproved annual species and perennial species were mostly Australian native grasses . Herbage accumulation (HA) was estimated by measuring pre-and post-grazing herbage mass (deferred grazing treatments) , or herbage mass in 3 randomly located pasture cages per plot (ST) from July 2005 to July 2006 . Samples from 30 toe cuts per plot were collected on a seasonal basis for nutritive value analysis . The samples were oven dried at 60℃ for 24 hours for lab test and mean nutritive values calculated over 4 seasons .

Results and discussion There were significant ($P<0.05$) differences in HA between treatments (Table 1) . Compared with ST , LSD increased HA by 67% , LD by 56% , and SD by 31% . There were also significant ($P<0.01$ or $P<0.05$) differences in nutritive characteristics (Table 1) . Overall , with few exceptions , deferred grazing treatments increased dry matter digestibility (DMD) and crude protein content (CP) , but reduced neutral detergent fibre (NDF) , in comparison with ST . The increases range from 2% ～13% for DMD and 10% ～30% for CP . SD and LD reduced NDF by 7% and 3% , respectively , but LSD did not , compared with ST . Major reasons for improved yield and nutritive value under deferred grazing were probably attributed to longer growing season , higher yield and better nutritive value of the perennial native species than the exotic annuals , which were observed and reported by Nie & Mitchell (2006) .

Table 1 *Herbage accumulation (HA , kg DM/ha) from July 2005-July 2006 and nutritive value : DMD-dry matter digestibility (%) ; CP-crude protein (%) ; and NDF-neutral detergent fibre (%) under various grazing regimes .*

Treatment	HA	DMD	CP	NDF
SD	3500	59 .1	12 .7	62 .0
LD	4141	56 .0	11 .1	64 .5
LSD	4433	53 .4	10 .8	66 .8
ST	2662	52 .2	9 .8	66 .5
s .e .m .	284 .5*	0 .95**	0 .30**	0 .89*

* $P<0.05$; ** $P<0.01$

Conclusions While various deferred grazing treatments improve the plant population density and groundcover by perennial pasture species (mostly Australian native species) in this marginal land class , they also have a positive impact on pasture yield and nutritive value . Deferred grazing could achieve both environmental and economical benefits for difficult landscapes such as steep hills .

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Growth and development in cultivars of *Phleum pratense* and *Lolium perenne* during winter

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Key words : timothy , perennial ryegrass , growth , biomass , carbohydrates

Introduction More variable winter climate with frequent fluctuations between frost and mild weather are expected in Norway (RegClim 2005) . The aim of the study was to provide a detailed picture of growth and development of contrasting cultivars (cvs .) of timothy (*Phleum pratense* L .) and perennial ryegrass (*Lolium perenne* L .) during winter as part of a climate change study .

Materials and methods Cultivars of timothy (Engmo , Grindstad , Jauniai , S48) and perennial ryegrass (Riikka , Gunne , Veja , S23) , all of North European origin , were established on a coastal location (Fureneset , 61°N , 5 .04°E , 30 m a s l) in Norway . Plants were established in May 2005 in 101 black polyethylene bags filled with a fertilized sand-peat mixture , 10 seedlings per bag and placed in the field , and 20 bags per m^2 . Destructive sampling was performed on five occasions from 20 October 2005 to 21 April 2006 for determination of above ground biomass , tiller density and leaf area , all dried at 60℃ for 48 h (dw) . Total carbohydrate content was analyzed according to Ashwell (1957) and LT50 values were calculated from freezing tests (H glind et al . , 2006) .

Results Distinct differences between ryegrass and timothy during winter were observed (Figure 1) . Lowest LT50 values were found in January for ryegrass (-8 .6℃) and in March for timothy (-14 .2℃) . In April the observed LT50 values were-6 .5℃ and-8 .6℃ for ryegrass and timothy , respectively . The autumn was very wet , with frequent rain , giving the plants poor hardening conditions . Mid-winter was mild prior to a cold period in late winter and spring (Table 1) .

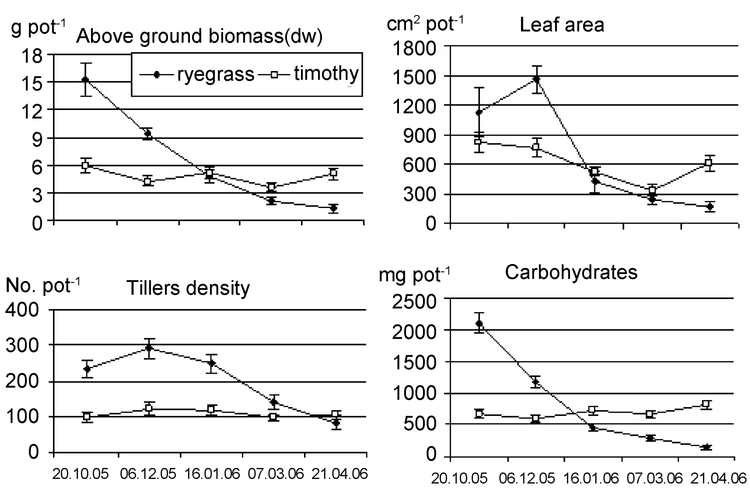

Figure 1 *Above ground biomass , tiller density , leaf area and carbohydrates during the period 20 Oct . 2005 to 21 April 2006 .*

Table 1 *Mean monthly temperatures (℃) and precipitation (mm) from on-location weather station .*

Month (2005-06)	Air temp .	Precip .
May	8 .3	154
June	11 .3	158p
July	15 .3	101
August	13 .3	218
Sept .	12 .0	411
Oct .	10 .3	210
Nov .	5 .8	418
Dec .	3 .0	187
January	2 .9	201
February	2 .8	129
March	-0 .1	57
April	5 .2	169

Conclusions A high above ground biomass and tiller production in ryegrass compared to timothy during the autumn levelled out towards the spring due to a rapid loss of ryegrass tillers during winter . The reduction also caused a considerable reduction in carbohydrates per unit area in ryegrass . Timothy kept most of its above ground biomass with slightly increased carbohydrate content , and achieved a higher level of frost tolerance .

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Use of biofertilizer in the formation of joined pastures with *Brachiaria decumbens* and *Stylosanthes sp*[1]

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Key words: joined pastures, heifers, organic fertilization

Introduction The competitive advantage of beef cattle on pasture is mainly the low cost and low risks of diseases associated with animal nutrition. When initializing the growing phase, calves are affected by the weaning stress. If it was associated with forage production seasonality, the growth will be affected and the production cycle increase. The system becomes then less efficient and the production cost increases. Biofertilizers produced in the farm represents an opportunity to improve animal performance, without large increase in the production cost. Besides, biofertilizer uses also has environmental advantages, as it reduces chemical fertilizer consumption, as well as the release of residues into the environment. The objective of this study was to evaluate the productive capacity of the pastures that receive or not receive biofertilizer in their formation.

Materials and methods This study was developed in tropical conditions in the region of Aquidauana, MS, Brazil, from August 2004 to August 2005, using twenty-four pastures with *B. decumbens* stapf and *Stylosanthes sp*. Twelve pickets received and twelve not receive organic fertilization with biofertilizer at pasture formation. The biofertilizer was made with fresh manure, biofertilizer residue, milk, molasses, ash, manganese sulfate, zinc sulfate, bone meal, Arad phosphate, magnesium sulfate, monoammonium-phosphate, boric acid, ammonium molybdate and water. The mixture was diluted at 25% v/v and 300 L of the product was applied per picket. Forty heifers with seven month age and 200 kg of live weight were distributed into four groups. Each group was kept in a group of six pickets and managed in rotational grazing system. At every 15 days, pasture samples were collected from the pickets to evaluate the pasture availability. The animals were weighted every 28 days. Data of monthly availability of pasture dry matter and daily mean gain during all the experimental period were examined by analysis of variance, and, if fertilization significant effect was detect, the means were compared by the t-test, at 5% significance level.

Results and discussion There was no significant difference for pasture dry matter availability (DM) in any month between the fertilized or not fertilized pastures, during all the experimental period (Figure 1). Despite this, it should be emphasized that DM in pastures that received biofertilizer was always higher than in pastures which did not receive the fertilizer. The non-significance for the differences in DM can be explained by the observed large standard errors. The largest weight gain observed in heifers kept on pastures receiving biofertilizer (Table 1) corroborates the larger productive capacity of these pastures. The superiority of pastures receiving the biofertilizer may be related to the high nitrogen content in this fertilizer. Fagundes et al (2005) reported that this is the main limiting factor to plant development under the pasture conditions here assessed.

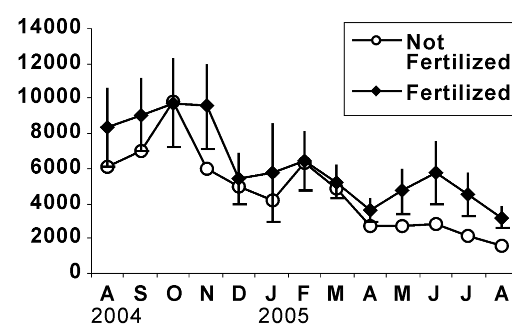

Figure 1 *Monthly dry matter availability of the pastures during all the experimental period. There were no significant differences in any of the evaluated months ($p > 0.05$). (Vertical bars = s.e.)*

Table 1 *Daily mean weight gain (DWG) of Nellore heifers grazing on pastures receiving or not biofertilizer.*

	Fertilized Pastures	Non-fertilized Pastures	CV (%)
DWG (Kg/d)	0.336a	0.243b	46.24

Means followed by different letters, are significantly different by the *t*-test at 5% of significance.

Conclusion The use of biofertilizer at pasture formation led to an increase in the productive capacity of the pastures.

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Seasonal nutrition content changes of stockpiled and standing Leymus cinereus forage

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Key words: seasonal nutrition content, stockpiled forage, standing forage, Leymus cinereus

Introduction Great Basin wildrye (Leymus cinereus Scribn. & Merr.), an indigenous, tall and robust grass species of the Intermountain Region of North America, has the potential to produce large amounts of forage, however, due to elevated meristematic growing points and a tendency to become coarse and unpalatable at maturity, it is often avoided or devalued as a forage resource. Stockpiled forages often retain higher nutritional quality than post-senescent forage of the same species (Buckmaster 1992; Strohbehn et al. 2004). Great Basin wildrye frequently occurs naturally in meadows, essentially as a monoculture, permitting the use of equipment for cutting and windrowing. This project evaluated the nutritional quality of Great Basin wildrye as both a stockpiled and a standing forage.

Materials and methods In a meadow located at the University of Nevada-Gund Ranch, Great Basin wildrye was sampled for nutritional analysis on June 1. A portion of the meadow was then windrowed with the cutter bar raised above the growing points (46 cm). On the first of each succeeding month, July-October, both standing and windrowed wildrye were sampled for nutritional analysis. Data were organized into paired t-tests that compared windrow and standing forage values by month.

Results Dry matter, as expected, was much higher in the windrow than standing forage ($P<0.0001$) until October when they were equal. Acid detergent fiber (ADF) content was consistently lower in the windrow ($P<0.0001$, Figure 1). In the standing crop, ADF increased from July to October, indicative of declining energy values. Crude protein was higher in the windrow throughout the test period ($P<0.0001$). Crude protein decreased steadily from 12% in June to 4.6% in October in standing forage (Figure 2). Phosphorus was lower in the windrow than standing forage in July, however, it maintained that level, while phosphorus in the standing forage decreased from July to October, eventually containing less than windrow forage. Both hemicellulose and the neutral detergent fiber ratio (NDF/ADF) remained higher in the windrow (at a consistent level) than in the standing forage which decreased over time. There were no differences for NDF, nitrate-nitrogen, manganese, and sodium between windrow and standing forages. Potassium, sulfur, zinc, iron and copper contents were generally higher in the windrow forage.

Conclusions Cutting and windrowing Great Basin wildrye can be an affective management tool for improving the nutritional quality of a grass species that is often underappreciated as a forage source. Cutting the wildrye above the meristematic growing points avoids problems often associated with spring and summer grazing, while preserving forage quality for several months. At the end of the assessment period, the stockpiled forage was equal to that of standing forage in energy content (ADF) and higher in crude protein. Following this procedure will allow livestock producers to feed June quality forage during fall and early winter, long after the standing forage quality declines.

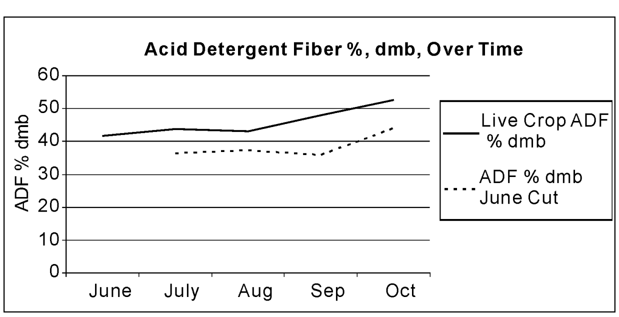

Figure 1 *Change in ADF content over time.*

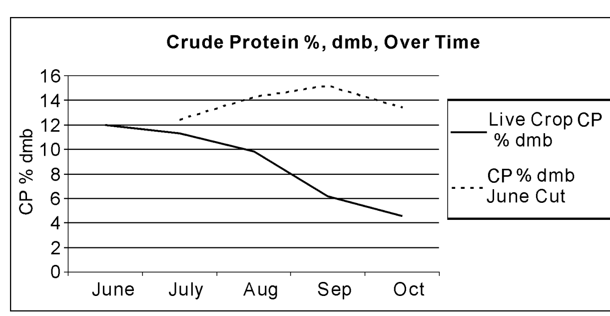

Figure 2 *Change in crude protein content over time.*

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Fertilisation strategies for sown organic pasture in the Mediterranean mountains of north-east Portugal

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Key words : fertilisation , manure , organic farming , pasture .

Introduction The leptosols are dominant soils in the North-east of Portugal , and are occupied mainly with forest , shrubs , cereal and fallow . The restricted and dispersed areas of pasture and fodder crops limit the sustainability of bovine and ovine meat production in organic farming . To achieve this goal in future , the conversion of some of these areas to long-term legume-rich pastures is essential . This experiment was developed to study the viability of these kinds of crops in organic farming systems on these soils .

Materials and methods The experiment has been carried out since autumn 2003 near Bragan a (NE Portugal-41°50′ N , 6°35′W and 860 m asl) in a leptosol with 24 g kg^{-1} organic matter (OM) content , 4 .5 pH(H_2O) , 42 mg kg^{-1} P_2O_5 and 81 mg kg^{-1} K_2O . It comprised the comparison of six fertiliser treatments (F) within two types of pasture (PA) , spontaneous vegetation (SV) and sown pasture (SP) . The fertiliser treatments included different combinations of bovine farmyard manure [(M)-30 t ha^{-1}] , lime [(Ca) 1 .5 t ha^{-1} of lime] , phosphorous [(P) 100 kg ha^{-1} of P_2O_5] , boron [(B) 1 kg ha^{-1}] and the control with no fertiliser (C) . The treatments were : (i) C ; (ii) Ca ; (iii) M ; (iv) Ca+P ; (v) Ca+P+Bo ; (vi) M+Ca+P+Bo . The SP seed rate was 18 kg ha^{-1} in the following proportion of functional groups : 9 annual legumes (50 %) ; 2 perennial legumes (5 %) ; 4 grasses (41 %) ; and chicory (4 %) . It was conducted as a two factor nested design , fertilisation treatments within pasture type , with three random replicates (exclosure cages of 1 m^2) per subplot . The vegetation was subjected to the usual grazing in the farm , and the dry matter (DM) yield samples were obtained each year at the end of spring and autumn , inside the exclosure cages on a 0 .5×0 .5 m quadrat . The data for DM yield excluded a reseeding fallow period from autumn 2005 to spring 2006 and seasonal yields (SY) were analysed as repeated measures .

Results and discussion There were significant effects for the F(PA) x SY interaction ($p<0.0001$) on DM yields , for the effect of F(PA) on DM yields , on spring and autumn DM yield differences and on individual DM yields ($p < 0.01$) . Treatment means for each season and year (Fig 1) showed the following results : a) treatments with manure were always the highest yielding group ; b) the SV control treatment yielded significantly less than the four manure treatments in spring 2004 and 2007 , less than the SP M+Ca+P+Bo treatment in spring 2005 , less than the SP M and SV M in autumn 2004 and less than the SP M+Ca+P+Bo and SV M+Ca+P+Bo treatments in autumn 2006 ; and c) only the SP Ca and SP Ca+P treatments had similar yields to the manure treatments in spring 2007 . The high values of legume proportion in these last two treatments in spring 2007 (54 and 61 % DM respectively) may explain the importance of natural reseeding of annual legumes in these treatments . Rinehart (2006) advises manure use in pasture establishment and Jagtap and Abamu (2003) also verified yield improvement of maize under cattle manure application in the absence of N fertiliser .

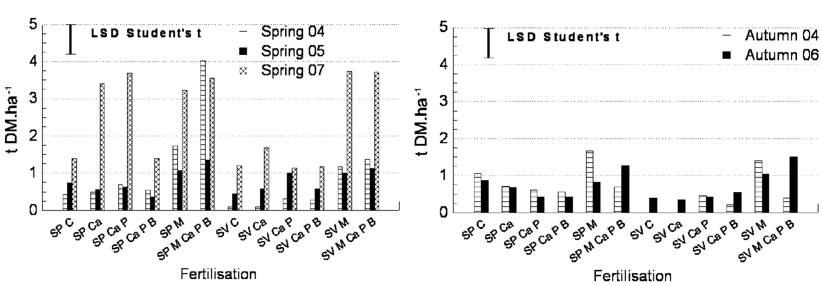

Figure 1 *Dry matter yields in spring and autumn for the 12 fertiliser and pasture type treatments .*

Conclusions Manure demonstrated itself to be the most valuable fertilisation strategy for pasture yield in these low fertility soils and climate conditions , Liming may boost the reseeding of annual legumes and have also a significant effect on dry matter production ? in the medium term .

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Establishment and growth of legumes in acid soils in the Falkland Islands

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Key words: Calcified seaweed, clover, lotus, nitrogen fixation.

Introduction The main problems with sheep production in the Falkland Islands (FI) are mainly a function of the low quality of native pasture and are; (a) low ewe live weights reduce ovulation rate and subsequent ewe and lamb survival, (b) lifetime performance of lambs (low lambing percentage-60%, high percentage mortality-10-20% and low lamb birth weights x kg-), (c) significant ewe live weight loss through winter and early spring, (d) Hogget live weight loss during winter and early spring increases death rates and productivity of those that survive. Forage crops can help improve this situation as they have better quality and, in some cases, quantity of production than native grasslands. Legumes are a good source of feed as they have high protein content, better yield in mixtures and fix Nitrogen. Also FI soils have a low pH, low Ca & P, synthetic fertilizer is expensive and is not compatible with organic production systems. One alternative is to use locally-found Calcified Seaweed (CS-an acceptable organic material to raise the pH, Ca & other minerals). The overall aim of this work is to investigate the effect of acid soils on legume establishment, growth and nitrogen fixation in the FI.

Materials and methods Two groups of experiments were conducted,
1. In a controlled environment at Queen's University Belfast, **a.** In an experiment in pots, the effect of different doses of Calcified Seaweed (CS) on growth of legumes (*Trifolium repens* var. Gwenda, *Lotus Corniculatus* var. Leo and *Lotus Uliginosus* var. Maku) was investigated, **b.** In soil incubations with different doses of CS and different particle size distribution (< 0.25 mm and > 2.4 mm) at two different temperatures (11℃×75 days and 60℃×4 days) and lime as a control.
2. Field experiments in the FI, at Bold Cove, Hope Cottage, Saladero and Shallow Harbour. At each farm grazing exclusion cages were used in established reseeds to measure the yield, chemical composition and nitrogen fixation of the legumes during the growing season (October-February). Data collected was used to measure how much nitrogen is being fixed using ^{15}Nitrogen-isotopic techniques. The soil ^{15}N-enrichment to measure N_2 fixation, have been extensively reviewed (Ledgard and Peoples, 1988; Witty et al., 1988).

Results and discussion *Trifolium repens*-based swards fixed 60; 63; 65; and 67 kg N/ha, with a range between 31-95 kg N/ha depending on the site during season 1. At the three lowest doses of CS, Al and pHw were unaffected by particle size, however at the two higher doses of CS Al was reduced, at the higher dose only pHw increased with increasing particle size in an incubation experiment (60℃). For pH in water the difference between doses of 0 g/kg and 6.4 g/kg is 0.47 points (< 0.25 mm) and 0.11 points (> 2.4 mm) in comparison to a control value of 0.67. From these results, it would be best to mill the CS to improve the pHw and decrease the exchangeable Aluminium (Al).

Table 1 *Statistic differences between treatments to Ca (meq/100g), Al (meq/100g) exchangeable and pH in water.*

Doses of CS g/kg (tonnes/ha)	Control			Particle size distribution					
	Lime			< 0.25 mm			> 2.4 mm		
	Ca	Al	pHwater	Ca	Al	pHwater	Ca	Al	pHwater
0 (0)	1.02d	8.01a	4.41d	1.02e	8.01a	4.41c	1.02d	8.01a	4.41b
0.8 (0.63)	1.42dc	7.34b	4.48d	1.57d	7.69ab	4.43c	1.63c	7.61ab	4.45ab
1.6 (1.26)	1.89c	6.62cB	4.61cB	2.16c	6.87bA	4.53bAB	1.92c	7.24bA	4.48abA
3.2 (2.52)	2.73bA	5.16dC	4.77bB	3.50bB	5.95cB	4.62bAB	2.68bA	6.73bA	4.53aA
6.4 (5.00)	4.65aA	2.77eC	5.08aC	6.21aB	3.94dB	4.88aB	6.04aB	6.26bA	4.52aA

Values with different lower cases in the column are statistically different for doses. Different upper cases in the row are statistically different for particle sizes.

Conclusion It can be concluded from the first years' data that doses of calcified seaweed and particle sizes significantly affected the release of nutrients from incubated soils. Finer CS material had a better reaction with the soil and released nutrients faster than coarse CS. Nitrogen fixation rates in the Falkland Islands range from 31-95 kg N/ha.

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Soil quality assessment in rangelands using a minimum data set

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Key words: soil quality index, minimum data set, soil properties, extensive grazing, rangelands

Introduction Soil quality is assessed in terms of the ability of soil to perform those soil functions that are necessary to meet the goals of the particular land use (Karlen et al., 2001). For rangelands, these goals include plant growth and community composition to support grazing animals. Our main objectives for this research were: 1) Demonstrating a technique for scoring predictive indicators of soil quality proposed by Rezaei (2003) for two data sets (Table1); and 2) Designing predictive models for the relationships between soil properties and plant growth characteristics. With regard to key indicators, total nitrogen, exchangeable potassium, and nutrient cycling index imply nutrient availability for plant growth; topsoil and effective soil depth denote both water availability and nutrient resources; water retention capacity indicates available water, grade of structure, and the slake test (aggregate stability) shows soil resistance to erosion.

Methodology Samples were taken from a total of 234 transects within stratified land units in Alborz Mountain, Iran. For soil chemical analyses samples were collected from (0-10cm) and for soil physical characteristics a pit was dug to 150 cm (or less if bedrock was encountered) at the mid point of each transect. We used the current year production of above ground biomass as an indicator of the productivity of the soil-landscape system.

An integrated soil quality assessment procedure was derived from methods developed by Mausbach & Seybold (1998), and Andrews *et al*.,(2002). The method for scoring the components of the data sets and construction of the Soil Quality Index (SQI) for native rangelands aimed to detect the criterions that maximize production and environmental performance. Observed indicator values were transformed to unitless 0 to 1 values, with 1 given for the maximum potential and the optimum performance of the associated soil function(s) for a particular indicator. Principal Components Analysis (PCA) was performed for each data set. The PCA decomposition properties, indicator loading factors and the % of variability explained by each eigenvector (λ), were combined and used as weighting factors for the scored indicators.

Results and discussion The first three principal components (PCs), were retained as having latent roots > 10% for Data Set 1. In order to approximate the proportion of each variable, x_i, the individual percent variance explained by each PC was first divided by the cumulative variance for the first three retained PCs to provide weighing factors for each PC ($\mathbf{f}_i$) for the components of the data sets 1 & 2. Next, the size of the elements (λ_{1i}, λ_{2i}, λ_{3i}, λ_{ii}, ...) was multiplied by the corresponding weighing factor ($\mathbf{f}_i$). Finally, the corresponding products for each variable were added together to produce the additive approximate contribution for each variable (vector of variables). The soil quality index for Land Units was calculated for rangelands using Equation 1: $SQI = \sum \rho_i \times S_i$ (1) Where ρ_i is a weighing factor for each indicator that is derived from a PCA for the ascribed indicators and S_i is the score for each indicator based on bivariate relationships between soil properties and plant growth characteristics.

The percentage of variance explained by the regression of SQIs with plant yield produced R^2 values of 0.75 and 0.77 for total yield (TY) for Data sets 1 & 2, respectively (Figure 1). The results of this research imply that for soil quality assessment and monitoring purposes, the use of inherent properties such as effective profile depth and water retention capacity together with dynamic indicators such as nutrient cycling index and slake test gives a better understanding of the system. The small but consistently higher correlations between yield and SQI using Data set 2 indicators rather than Data set 1, suggests that Data set 2 may be more suitable for rangeland assessment in this semi-arid system. This priority for Data set 2 was driven by the nutrient cycling index.

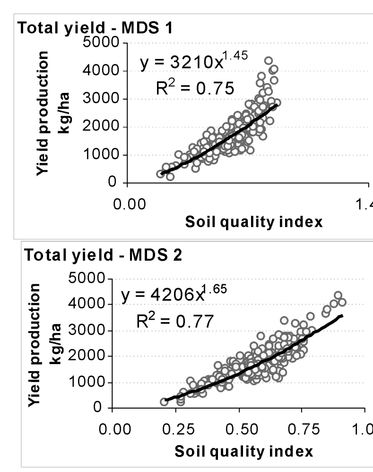

Figure 1 *Relationships between assigned soil quality indices and measured values of total yield for MDSs 1 & 2.*

Table 1 *Proposed minimum data sets for calculating Soil Quality Index (SQI).*

Soil functions	Minimum Data Set 1	Minimum Data Set 2
Fertility	Total nitrogen% (N%)	Exchangeable potassium (K)
		Nutrient cycling index (from LFA)
Water retention	First layer thickness (FLT)	Water retention capacity at wilting point (WP)
capacity	Soil profile effective thickness (PET)	Soil profile effective thickness (PET)
Stability	Grade of pedality (GP)	Slake test (ST)

Response of an improved pasture to different phosphoric fertilisation strategies in basaltic soils

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Key words : pasture , legume , phosphorus , fertiliser

Introduction Phosphoric fertilisation and broadcast seeding of a legume is a valuable technology to improve native pastures . Phosphorus (P) represents the main input cost for these pastures , with a large impact on their productivity . The objective of this trial was to evaluate sources and levels of P fertiliser on such pastures .

Materials and methods The trial was conducted on a medium to deep basaltic soil (Molisol) , at Glencoe Experimental Farm in a temperate to subtropical climate . The main properties of the selected soil , from 0-10 cm depth were : pH (water) : 5 .7 , organic carbon : 45 .3 g/kg and available P (citric acid) : 3 .8 mg/kg . The native canopy was sprayed (glyphosate) , and white clover (*Trifolium repens*) cv . Zapic n was broadcast seeded . A factorial arrangement of 3 P fertilisers (superphosphate , SP , 23% P_2O_5 ; Gafsa phosphate rock , GPR , 28% P_2O_5 ; Hyperfos , a mixture of superphosphate and rock phosphate , Hy , 27% P_2O_5) and 4 initial levels (0 , 40 , 80 , 160 kg P_2O_5/ha) with 4 replications in a split plot design was used . At the beginning of the second year , split plot received 2 levels (0 , 40 kg P_2O_5/ha) of an annual application of each source for every initial dose . The main evaluation consisted of botanical composition (BC) and forage dry matter (DM) measurements from harvests with an experimental rotary mower . The plots were cut every time pasture reached 18-20 cm , leaving a stubble residue of 4-5cm . Analysis of variance was performed on data recorded and adjusted regression equations were developed for legume production to the initial treatments . Relative efficiencies (RE) with reference to superphosphate , were estimated using significant regression equations .

Results and discussion Average cumulative white clover forage yield during the 4 year period , for the 3 P fertilisers , varied between 3617 and 13898 kg DM/ha depending on initial dose , without any annual P application . This represents a legume increase of 58 kg DM/kg P_2O_5 . On average , RE was 134 for GPR and 122 for Hy , relative to SP (100) . In the refertilised situation (initial plus annual applications of 40 kg P_2O_5/ha) , legume forage yields during the 4 year period , for the 3 P fertilisers averaged , varied between 13842 and 24990 kg DM/ha depending on initial dose . This represents a white clover increase of 67 kg DM/kg P_2O_5 . The average RE , was 135 for GPR and 167 for Hy , relative to SP (100) . When only the effect of the annual applications was considered , 87 .3 kg DM/kg P_2O_5 were produced on average . Even though the soil considered does not offer optimal pH conditions for the use of GPR and Hy , it is possible that differences among plants in their ability to utilize P from such sources explain the response , in agreement with Khasawneh and Doll (1978) . White clover would have a higher capacity of rhizosphere acidification and calcium and P absorption . Previous national results show a similar behavior of white clover in other soils , when GPR is utilized (Mor n , 2002 ; Risso y Mor n , 2002) .

Conclusion There was a significant effect of the initial P doses and of the annual refertilisation in the legume yield . GPR and Hy fertilisers were significantly more efficient compared to SP , for both the initial fertilisation and the refertilisations . Such RE , combined with responses higher than 50 kg DM/kg P_2O_5 , present important practical connotations .

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Free amino acids content and nitrogen mobilization in *Panicum maximum*

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Key words: ^{15}N, organic reserves, tropical grass

Introduction ^{15}N-tracer techniques cannot be used accurately in the field to quantify N mobilisation due to problems of equally and uniformly labelling all the different soil N pools with ^{15}N. In remaining tissues of grasses following defoliation, protein is degraded to amino acids through the action of protease enzymes; the amino acids being subsequently transported to leaf meristems to support growth. Potentially therefore, amino acids concentrations could be used as a surrogate for N mobilisation determination in the field. A greenhouse experiment involving ^{15}N techniques was used to test the hypothesis that, following defoliation of *P. maximum*, a correlation exists between the N mobilised from leaves and the amino acids concentration of these tissues.

Material and methods *P. maximum* Tanzania plants were cultivated in pots filled with fine sand. The position of the pots in the greenhouse was randomised in replicate blocks. Plants were cut to 30 cm 33 days after seeding. Three replicate pots were harvested immediately after cutting (day zero) and 1, 2, 3, 5, 7, 14 and 21 days thereafter. Concurrent with the first harvest, all nutrient solution was washed from the remaining pots that were than watered with a nutrient solution enriched with ^{15}N. At harvest, young leaves" (two youngest expanded leaves at the time of the first harvest) were separated and weighted. Total free amino acids content was determined following reaction with ninidrine and OPA derivatives amino acid were detected as described by Jarret et al. (1986). The total N and ^{15}N concentrations were determined using a continuous flow mass spectrometer. The difference between the total and labelled nitrogen content (unlabelled nitrogen) was assumed to be the nitrogen present within the plants at the time of the first harvest.

Results and discussion Unlabelled N content of young leaves decreased from 1.53 ± 0.06 to 0.61 ± 0.01 on the first seven days after defoliation and unlabelled N mobilisation rate was highest just after defoliation (decrease of 0.51 mg/plant of unlabelled N between day zero and day 1). There was also an increase of amino acids concentration in young leaves of Tanzania" just after defoliation, which was higher two days after defoliation (200.8 nmol/mL; Figure 1). The increase of the amino acids content at the same time as unlabelled N mobilisation increases may be related to protein degradation through the action of protease enzymes and subsequent transport of amino acids to meristems to support growth. Aspartic acid, glutamic acid, asparagine, glutamine, glicine, threonine, tyrosine and leucine+isoleucine represented more than 90% of free amino acids in young leaves of Tanzania. Although the most important transportable" amino acids (aspartic acid, glutamic acid, asparagine and glutamine) represented around 50% of free amino acids, its concentration did not follow any pattern throughout harvests.

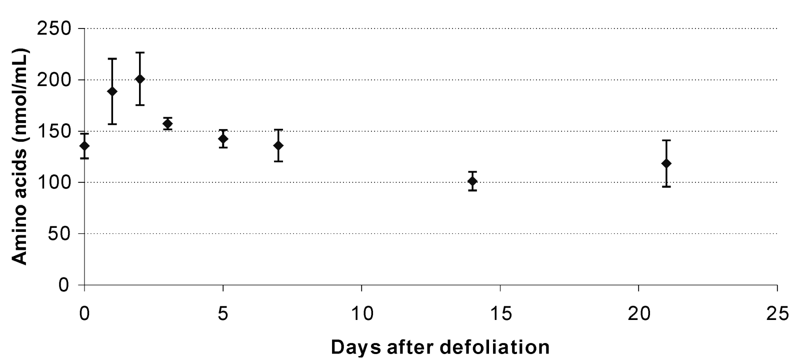

Figure 1 *Free amino acids concentration (nmol/mL) on young leaves of* P. maximum. *Means of three replicates ± s.e.*

Conclusion There is a correlation between free amino acids content and N mobilisation on young leaves" of *P. maximum* after defoliation.

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Does pre-existing vegetation make a difference for re-establishing native shrubs ?

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Key word : native plants , re-establishment , plant/soil interface , microbial populations , PLFA

Introduction There exists within the Canadian prairies large areas seeded to monocultures of introduced grass species. Introduced species cover large areas of land in North America. Smooth brome grass (*Bromus inermis*) is one of the more plentiful. Chosen for agronomic reasons but is also known for its invasive potential for surrounding native grassland. This grass as a monoculture is susceptible to many of the shortcomings found with monocultures such as increased sensitivity to environmental events, low diversity in structure and species (fauna and flora), and lower long term productivity. There exists a need to increase diversity by replacing and/or re-establishing native species to increase biodiversity both from an ecological perspective as well as sustainability perspective. This work has set out to determine the differences which occur between alluvial soils beneath stands dominated by smooth brome, native grass (dominated by *Agropyron* ssp.) and buffalo berry (*Sheperdia argentea*) for establishment of two native shrubs; silver sage (*Artemisia cana*) and buffalo berry.

Materials and methods Topsoil was harvested from under stands of smooth brome (Br), native prairie (N) and buffalo berry (Bb). The soil was air-dried, large root fragments were removed, and then the soil was placed in 1 litre cardboard milk cartons. Seedlings of buffalo berry and silver sage were placed within individual cartons using a 2 by 3 factorial random complete block design with 10 replicates. Growing conditions within the greenhouse were: constant temperature of 21℃ with 12 hr of light. One centimeter of sand was placed on surface of the soils to eliminate the possibility of cross contamination from wind-blown or water-splashed soil among cartons. Water was applied daily. Soil microbial populations were characterized using phospholipid fatty acid analysis (PLFA) before and after plants were grown. Prior to germination seeds were surface sterilized. Plants were grown in cartons for a period of 4 months. Both above-and below-ground biomass data are presented and PLFA results. ANOVA for statistical analysis of biomass and discriminant analysis for PLFA results were done. A correlation matrix was calculated for plant variables and relative PLFA changes.

Results and discussion Buffalo berry seedlings initially showed a response to the Bb soil but final shoot biomass was not different ($P>0.05$) with a mean of 2.9 g for all soil types. Root biomass did differ ($P<0.05$) with Bb soil having a root biomass of 1.1 g while Br and N both had 0.8 g. Under buffalo berry most of the discrimination is explained by PLFA iso c17:0 + c17 and c15:0. Also the changes occurring in c15:0 and c16:0 are important in distinguishing among soils. These phospholipids are abundant in bacteria of the genus *Frankia*, associated with the nitrogen fixing shrub buffalo berry. Sage seedlings differed in shoot biomass in all soil types ($P<0.05$): Bb 1.6g, Br 1.1 g and N 0.8 g. Sage root biomass was greatest ($P<0.05$) in Bb 1.2 g while Br had 0.6 g which did not differ from 0.4 g obtained from N. The correlation matrix among plant variables and relative PLFA changes indicate that c15:0 was the most influential PLFA signature in the soil. Plant biomass was negatively correlated with c15:0 concentration across all soils. Bb soil contained the highest initial concentration of this marker suggesting that sage growth in this soil may have benefited from the presence of the nitrogen fixing bacteria associated with buffalo berry plants. Bb soil resulted in both shrub species having an initially greater ($P<0.05$) growth rate.

Conclusions Our results indicate what covers the soil originally has an effect in growth potential of re-established species. This difference is attributed to differences in soil microbial populations. The symbiotic relationship between *Frankia* and buffalo berry negated any advantage of soil type for this shrub's shoot biomass but a potentially higher initial concentration in Bb would appear to have benefited root growth. Response of species to soil type in this work was species specific.

Effect of Azospirillum on fodder production in the semi-arid region of South India

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Introduction Productivity of the tropical and subtropical grazing lands is generally very low. Chemical fertilizers are expensive and ecologically not desirable. Greater emphasis is now laid on the application of biofertilizers to increase the fodder production. Nitrogen fixing bacteria have the potential to reduce nitrogen fertilizer requirements in many agricultural areas. Yield increase after inoculation with Azospirillum have been recorded in many places throughout the world. *Azospirillum lipoferum* inoculation showed higher green forage yield than *Azospirillum brasilense*. In the present investigation *Azospirillum lipoferum* strain (ICM 1001) was used to increase the productivity of five fodder grasses.

Materials and methods The culture of Azospirillum lipoferum ICM 1001 was obtained from ICRISAT, Hydrabad, India. Root inoculation was done by immersing fodder grass tillers in the bacterial strains of semi liquid inoculums for 12 hours, later the tillers were transplanted to the field. Furrow irrigation was adapted for the application of water at every third day. Plants were harvested after 3 months and samples were dried at 800℃ for 22 hours until constant weight was reached.

Results and discussion Table 1 Shows that Bajra-Napier BN3 attains the greatest maximum plant height peak when inoculated with the strain Azospirillum lipoferum 1001. This increased the tiller number also. Compared with the controls, biomass production was higher in Azospirillum inoculated clones. It effectively increased the above ground biomass production more than the below ground production. Increasing rate of plant growth and forage yield has been obtained in Azospirillum inoculated fodder grasses. Similar findings were also observed by Jawahar and Suresh (2007), and Saikia and Jain (2007). Bajra Napier BN2 variety with Azospirillum lipoferum 1001 inoculation showed higher biomass production. It is a suitable fodder species for the subtropical regions of South India.

Table 1 *Effect of A. lipoferum inoculation on biomass production of fodder grasses.*

		Height cm	No. of tillers	Shoot biomass g/plant	Root biomass g/plant	Total biomass g/plant
Brocharia mutica	Control	120	14	67.2	12.96	80.16
	AL 1001	149	16	71.4	18.52	89.92
Bajara-Napier BN2	Control	209	5	302.06	123.12	425.20
	AL 1001	282	6	459.32	164.76	624.06
Bajara-Napier CO1	Control	153	6	242.56	82.80	325.36
	AL 1001	201	8	336.52	111.96	446.48
Panicum maximum	Control	172	12	120.96	26.92	147.68
(Hamil grass)	AL 1001	222	21	156.80	29.48	186.24
Panicum maximum	Control	152	12	103.20	19.16	122.36
(guinea grass)	AL 1001	206	16	140.31	27.43	167.74

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Patterns in tropical grass silicification : response to substrate fertilization

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Key words : Urea , phosphorous fertilizer , grass silicification , tropical

Introduction Silica is accumulated mostly in grasses . The effect of soil properties has not been much documented . Proportions of silica in plants decreased on raising the soil pH and concentration in soil decrease with higher value of pH (Jones & Handreck 1965) . There is a quantitative relationship between silica concentration in the soil solution and the amount taken up by plants . We explore the hypothesis that soil fertility (N-P-K) influences leaf silicification of tropical fodder grass species . The response of plant silica concentration to substrate fertilization in 5 grass species was examined , as well as silica relationships with leaf structural parameters tightly correlated with leaf functioning .

Materials and methods The experimental garden of the Faculty of Agronomic Sciences of Abomey-Calavi University in Benin belongs to a subequatorial climate with 2 dry seasons : mid-July to mid-September , and mid-November to mid-March . Precipitation averaged 1197 mm in 2002 with 278 mm from January to May , the experimental period . Plots were well watered . Soil is sandy loam , acid , with a fragile structure , poor in exchangeable bases , phosphorus , but with appreciable sodium concentration ; N standard level of the experimental site was 0 .08% N , and C/N mass ratio is 10. 6 . Five tropical fodder grass species were studied : *Andropogon gayanus* var . *Bisquamulatus* (Hochst .) Hack ., *Hyparrhenia smithiana* (Nees ex Steud) Clayton , *Panicum maximum* var . C1 , *Panicum maximum* Jacq and *Pennisetum purpureum* Schumach . Clumps from various climatic areas were established on 25th September 2002 in plots at Abomey-Calavi . Eight tillers per clump were planted in each plot sized 4 m×6 m . Design was 2 treatments×5 species×5 replicates . Nutrients were initiated 30 days after transplantation , on 28th October 2002 . 100 g of $CaH_4(PO4)_2$ 56% P_2O_5 and 100 g of Urea 46% N , were directly applied per m in form of granules around each treated clump and tap watered at 1 L per clump per day . Plants were harvested in April 2003 . Ten standardized leaf blades , bulks of sheaths and blades were sampled . Leaves were washed and stored . Bulk sheaths and blades and 40 samples of 10 blades were harvested . SLA was estimated from leaf fragments . Samples were oven dried at 65℃ for 48 h for dry matter DM was calculated and relative water content (RWC) as % RWC = 100 × (1 DM/FM) . Silica (SiO_2) and soluble ashes (SA) concentrations were analyzed in bulk samples . Silica was analyzed gravimetrically by dry ashing , and weighted and SA calculated as (total ashes silica) . ODM = DM-SiO_2 (1) ; SA = 100 × (TA-SiO_2)/ODM (2) ; % SiO_2 = 100 × SiO_2/ODM (3) ; DM = dry matter , ODM = Organic Dry Matter ; TA = Total Ashes . 80 bulk samples of blades and sheaths were analyzed for silica and soluble ashes concentrations . Statistical analyses were performed using STATISTICA 6 .0 . ANOVA was performed with species and fertilization . Relationships between silica and SA , RWC and SLA were assessed using Pearson correlation coefficients .

Results Dry mass production ranged from 430 to 1200 gm^{-2} , depending on treatments and species . Variations were significant with the highest values in *Andropogon gayanus* var . *Bisquamulatus* (AGB) (> 1200 gm^{-2}) and the lowest in *Pennisetum purpureum* (< 450 gm^{-2}) . The highest production belongs to fertilized treatments . Substrate fertilization was significant on the plant SiO_2 concentration . Values were higher in blades compared to sheaths except for *Hyparrhenia smithiana* were the reverse was true . Mean values ranged from 2 .13% to 4 .83% of DM in blades and 1 .51% to 4 .20% in sheaths , depending on species and treatments . The effect of fertilization varied depending on species ($P < 0.001$) . SiO_2 in blades generally decreased except *Panicum maximum* Jacq (PMJ) . SiO_2 in sheaths consistently decreased . SiO_2 decreased both in blades and sheaths for *P . purpureum* (PP) , *H . smithiana* (HSm) and AGB . Magnitude ranged from 29% to 54% in blades , and from 17% to 59% in sheaths depending of species . The impact of fertilization was not significant for *Panicum* accessions . Comparing 10 observations (i .e . blades + sheaths) , SiO_2 concentration decreased in the fertilized treatments in 9 cases and significantly so in 6 cases . RWC , SA and SLA were significantly affected . This indicates a rather specific pattern of variation of leaf traits in response to fertilization depending on species . The response of other traits was more complex compared to SiO_2 . SiO2 positively correlated with SA in blades , so with RWC in control treatment but negatively in the fertilized . Plant silica generally decreased with substrate fertilization consistently with previous results on *Bouteloua gracilis* (Pieper *et al* . 1974) . This might be a consequence of enhanced biomass production , i .e . dilution effect (Griffin *et al* ., 2002) .

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The impact of different grassland land-uses on earthworm populations in a New Zealand fragipallic soil

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Key words: earthworms, cattle grazing, sheep grazing, mowing, fallow, irrigation, nitrogen, New Zealand

Introduction In the North Otago region of New Zealand's South Island, the first stage of a new irrigation scheme has recently been completed allowing land use to change from dryland sheep farming (10 stock units/ha) to more intensive irrigated dairy farming (>20 s.u./ha). The implications for the pasture and soil resources of this region (pallic soils characterised by weak structure and a compact fragipan subsoil horizon) are largely unknown. Reported here are the impacts of different land-use treatments on earthworm populations.

Methods Factorial combinations of harvest method (cattle grazing, sheep grazing, mowing and pasture fallow), pasture species [perennial ryegrass (R) and tall fescue (F)] and irrigation (with and without) treatments were applied to 24 paddock pairs. Enough nitrogen (N) was applied (in split applications) to one paddock of each pair so that N was not limiting pasture growth (see White & Knight 2007 for details). In winter 2006 and 2007, four to eight 10 cm wide×20 cm deep cores were taken from each paddock and all earthworms were found and counted.

Results Irrigation, harvest method, pasture species and nitrogen all affected earthworm numbers (Figure 1). There were fewer worms under cattle grazing compared to sheep grazing, mowing and fallow in 2006. In 2007, there were fewer worms under cattle grazing and mowing than fallow which had less worms than sheep grazing ($P<0.001$). Overall, there were 80 and 73% more earthworms in irrigated soil compared to dryland soil in 2006 and 2007, respectively ($P<0.001$). However, the increase in worms due to irrigation in 2006 was greater under sheep grazing and fallow than cattle grazing and mowing ($P<0.01$). There were more earthworms in ryegrass compared to fescue paddocks but only when combined with fallow (2006 and 2007) and sheep grazing (2007 only) ($P<0.03$). Adding N had no effect on worm numbers in 2006. In 2007, there were fewer worms overall in plus-N paddocks but this effect was only significant when combined with irrigation and cattle grazing or mowing ($P<0.05$).

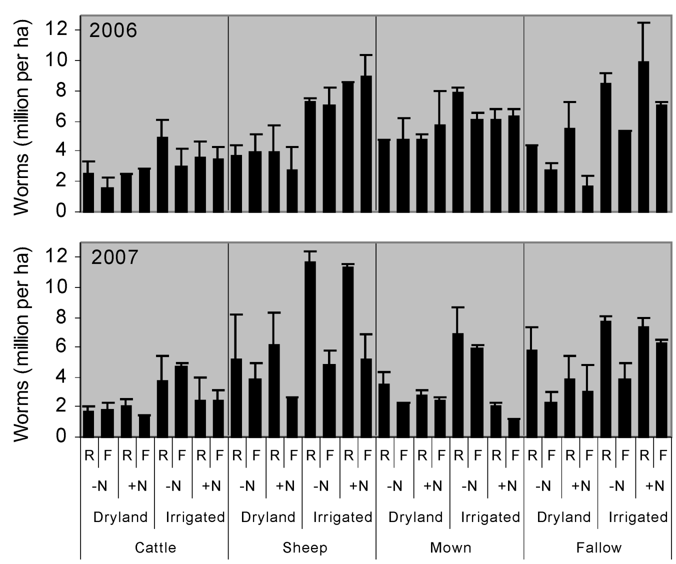

Figure 1 *Total earthworm number (million per ha) under different land-use treatments over two winters.*

Conclusions Irrigation increases whereas cattle grazing generally decreases worm abundance. The greater number of earthworms in irrigated soil agrees with previous research and relates to their need for a moist well-aerated environment (Lee 1985). Pasture grazing/harvesting impacts on earthworm populations have received little research attention. Fewer earthworms under cattle grazing may be related to greater soil bulk density, lower macroporosity and injury from trampling (Bruyn & Kingston 1997). Future research will examine worm biomass and earthworm species abundance to help understand how land use change may affect the potential beneficial processes performed by earthworms in soil.

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Intensive grazing leads to degradation and spatial homogenization of topsoils in two major steppe types in Inner Mongolia , P .R . China

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Key words : semiarid grassland , intensive grazing , heterogeneity , *Leymus* , *Stipa*

Introduction Intensive land use and especially overgrazing in semi-arid grasslands results in degradation of steppe vegetation associated with changes in the amount , composition , and turnover of soil organic matter (SOM) . The concurrent degradation of soil structure and destruction of aggregation leads to enhanced soil erosion . The effect of intensive grazing on the amount and composition of SOM was assessed by comparison of grazed and ungrazed plots in *Leymus chinensis* and *Stipa grandis* dominated steppe types in Inner Mongolia , China .

Materials and methods The research was conducted at the Inner Mongolia Grassland Ecosystem Research Station (IMGERS , Chinese Academy of Sciences) in the Xilin River Basin (Inner Mongolia) at an altitude of 1270 m above sea level . The semiarid shortgrass steppe ecosystem is composed of *Leymus chinensis* and *Stipa grandis* dominated steppe types . Climate is characterised by a mean annual temperature of 0 .7℃ and precipitation of 343 mm with the highest values from June to August . Soils are classified as Calcic Chernozems derived from Aeolian sediments above acid volcanic rocks (WRB , 2006) . Both *Leymus* and *Stipa* dominated sites were sampled at continuously grazed plots (CG) and ungrazed plots (UG79) , which were fenced in 1979 . At all sites regular , orthogonal grids with spacings of 15 m and 5 m were sampled at 0-4 cm to elucidate the spatial structure of topsoil parameters . Each sample was analysed for bulk density , texture , soil organic carbon (SOC) content , total N and S content , inorganic C , C/N , pH , and δ^{13}C .

Results Intensive grazing in both *Leymus* and *Stipa* dominated grasslands results in changes in the amount , composition , and turnover of SOM . All CG plots have significantly increased bulk densities and decreased SOC contents , total N and S contents . The *Stipa* dominated site tends to show higher bulk densities and lower SOC , total N and S contents at CG than the *Leymus* dominated site . Elemental stocks for SOC , total N and S are also lower on *Stipa* dominated sites . No significant differences were detected for pH values , C/N and δ^{13}C between CG and UG from *Leymus* and *Stipa* dominated sites . The spatial distribution of the investigated topsoil parameters changes under intensive grazing at both major steppe types . Generally , heterogeneity of bulk density , SOC content , total N and S concentrations and Ah thickness decreases under continuously grazing from a pure nugget or patchy to a homogenous distribution .

Conclusions The observed changes in the amount and composition of SOM under continuously grazed plots of both *Leymus* and *Stipa* dominated sites can be attributed to the combined effect of animal trampling , reduced above-and belowground organic matter input , and erosion in consequence of grazing . These effects could lead to degradation of soil aggregation and release of aggregate-protected soil organic matter , associated with enhanced susceptibility to soil erosion . The results of Steffens et al . (2007) confirm the assumption of declined soil aggregation , as they reported reduced microaggregation and reduced free and occluded particulate organic matter contents at the same sites , which are the most sensititve indicators for topsoil organic matter effects due to intensive grazing . The higher sensitivity of *Stipa* dominated sites to intensive grazing compared to *Leymus* dominated sites can explained by drier soil conditions associated with a lower degree of stabilisation of soil organic matter in microaggregates and organo-mineral associations . Moreover , a reduced input of organic matter and a lower stage of regeneration at *Stipa* dominated sites lead to lower elemental stocks and higher bulk densities . The increased heterogeneity at sites with grazing exclusion can be ascribed to vegetation recovery due to formation of islands of fertility" , and deposition of windblown material in ungrazed plots (Steffens et al ., accepted) .

Our results show a significant deterioration of topsoils at both major steppe types in consequence of intensive grazing and the benefit of excluded grazing in securing the status quo of affected soil parameters .

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How do native and improved" grasses affect above-ground production and soil organic C?

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Key words: *Agropyron cristatum*, *Psathyrostachys juncea*, *Stipa viridula*, *Pascopyrum smithii*, *Bouteloua gracilis*

Introduction Crested wheatgrass [*Agropyron cristatum* (L.) Gaertn.] and Russian wildrye [*Psathyrostachys juncea* (Fisch.) Nevski] are commonly used for reseeding in the more xeric Mixed Prairie because they are perceived to be more productive than native species. However, crested wheatgrass has been implicated in soil deterioration (Dormaar et al., 1995) while native grasses are being examined with increasing interest in Canada for their potential use in reclamation and forage production (Kerr et al., 1993). The objectives of our study were to compare the above-ground net primary production (ANPP) and soil organic C among communities of selected native and introduced grasses and wheat, and to assess the benefits of simple mixtures.

Materials and methods A 10-year study was initiated on Dark Brown Chernozemic (Typic Haploboroll) soil near Lethbridge, Alberta. Eleven treatments consisting of monocultures of introduced [*Agropyron cristatum* (L.) Gaertn, *Psathyrostachys juncea* (Fisch.) Nevski] and selected native species [*Bouteloua gracilis* (H.B.K.) Lag. Ex Steud., *Pascopyrum smithii* (Rydb.) A. Löve, *Stipa viridula* Trin.] mixtures of native species, and wheat (*Triticum aestivum* L.) were established in a randomized complete block design with four replications. ANPP was estimated over eight years, and soils were sampled in the final year of the study. The vegetation was analyzed for N and the soils were analyzed for organic C. Light fraction was determined by grinding soil (2 mm sieve) and using NaI floatation.

Table 1 *Annual net primary production (ANPP) over 8 years (1997 to 2005) and soil organic C characteristics of native and introduced species to 60 cm depth 10 years after establishment.*

		ANPP		Nitrogen		Organic C		
Treatment	Origin	Total	Harvested	Conc.	Harvested	Stable fraction	Root (>2 mm dia)	Light fraction
		(kg ha^{-1})		(mg g^{-1})	(kg ha^{-1})	(Mg ha^{-1})		
P. *smithii* (1)	Native	322	178	20	5.2	88	0.44	7.8
S. *viridula* (2)	Native	376	272	20	7.1	84	0.49	6.9
B. *gracilis* (3)	Native	313	177	20	4.6	87	0.66	7.8
1+2 (4)	Native	362	240	21	7.5	84	0.60	9.0
1+3 (5)	Native	320	183	22	6.3	85	0.58	8.0
2+3 (6)	Native	368	257	19	6.8	81	0.64	9.0
1+2+3 (7)	Native	359	223	21	6.9	88	0.73	9.8
P. *junceus* (8)	Introd.	342	238	18	5.2	79	1.51	10.1
A. *cristatum* (9)	Introd.	363	257	15	6.1	83	0.97	9.9
T. *aestivum* (10)	Introd.	287	244	21	6.5	84	0.04	3.8
P:		0.01	0.06	0.01	<0.01	0.15	<0.01	<0.01
Contrasts								
1−3 vs 7		0.57	0.72	0.61	0.04	0.58	0.07	<0.01
1−3 vs 8,9		0.62	0.22	<0.01	0.99	0.02	<0.01	<0.01
1−9 vs 10		0.28	0.41	0.27	0.37	0.96	<0.01	<0.01

Results and discussion Introduced grass species were not more productive than native species ($P > 0.05$), and both had similar ($P > 0.05$) effects on soil organic C (Table 1). However, the introduced perennial grasses yielded greater organic C in light fraction than monocultures of native species. *T. aestivum* had the least root or light fraction organic C, which contributed to marginally less soil organic C (Table 1). The light fraction is a highly labile component of soil organic matter and is derived from the fine roots (< 2 mm) and partly decomposed large roots.

Conclusion There does not appear to be any distinction between native and introduced perennial species in their benefits to ANPP. However, soil organic C (less light fraction) seemed to be benefited by native species.

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Na compound fertilizer promotes growth and enhances drought resistance of desert plants

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Key words : Na compound fertilizer , desert plant , *Zygophyllum xanthoxylum* , growth , drought resistance

Introduction Wang et al . (2004) identified that Na plays an important role in drought adaptation of desert plants in northwestern China . Further studies in the laboratory also proved that suitable concentrations of sodium can not only promote the growth of desert plant *Zygophyllum xanthoxylum* , but also improve its stress resistance . Based on above , we have successfully developed a Na compound fertilizer through a series of experiments and the results from these tests indicated that this Na fertilizer is able to promote the growth of desert species *Zygophyllum xanthoxylum* , *Haloxylon ammodendron* , *Nitraria tangutorum* and *Reaumuria soongorica* and enhance their drought resistance .

Materials and methods Germinated seeds were transplanted in pot filled with mixture of different amount fertilizers and soil . *Z . xanthoxylum* grown under well watered conditions for 28d and 60d for shoot and root experiments , respectively , and thenirrigation was stopped . After 14d and 15d for shoot and root experiments , respectively , some relevant indexes were measured .

Results Compared with CK , *Z . xanthoxylum* leaf fresh weight , dry weight , water content , area and relative organic dry weight , and plant height of CF treatment significantly increased by 30% , 241% , 57% , 350% , 96% and 8 .4% respectively in the sodium fertilizer treatment (Table 1) ; in addition , the root fresh weight , main root diameter , root volume , root length , root activity and activity absorbing area significantly increased by 229% , 25% , 107% , 164% , 99% and 338% respectively (Table 2) . There were similar trends for *H . ammodendron* , *N . tangutorum* and *R . soongorica* : Na compound fertilizer also significantly promoted the growth and enhanced drought resistance of these desert plants (data not show) .

Table 1 *Effects of Na compound fertilizer on shoot of Z . xanthoxylum . CK (no fertilizer + drought stress) , CF (common fertilizer + drought stress) , NaF (Na compound fertilizer + drought stress) . Z . xanthoxylum seedlings normally grown for 28 d and then were stopped irrigating for 14d .*

	Fresh weight (g/plant)	Dry weight (g/plant)	Water content (g/g DW)	Leaf area (cm^2)	Relative organic dry weight(%)	Plant height (cm)
CK	0 .37±0 .03c	0 .07±0 .002c	3 .0±0 .2c	11 .1±1 .3c	58 .5±0 .5c	7 .0±0 .2c
CF	0 .75±0 .08 b	0 .08±0 .001b	8 .7±0 .2 b	15 .5±0 .6 b	60 .5±0 .9b	8 .1±0 .3b
NaF	1 .26±0 .05a	0 .11±0 .007a	13 .5±0 .3a	21 .8±1 .9a	63 .4±0 .3a	9 .1±0 .2a

Table 2 *Effects of Na compound fertilizer on root of Z . xanthoxylum . CK , CF and NaF are the same as in Table 1 . Z . xanthoxylum seedlings normally grown for 60d and then irrigation was stopped for 15d .*

	Fresh weight (g/plant)	Diameter (mm/plant)	Volume (cm^3/plant)	Length (cm/plant)	Activity (ng/g FW/h)	Activity absorbing area (m^2/plant)
CK	0 .80±0 .14c	1 .26±0 .14c	1 .04±0 .17c	5 .56±0 .29c	48 .22±4 .70c	0 .37±0 .05c
CF	1 .98±0 .10b	1 .39±0 .11b	1 .47±0 .12b	8 .42±0 .78b	79 .90±4 .06b	0 .60±0 .11b
NaF	2 .63±0 .04a	1 .58±0 .02a	2 .15±0 .20 a	14 .66±0 .59a	95 .72±6 .98a	1 .62±0 .12a

Conclusions Under slow drought stress , Na compound fertilizer is able to promote the growth of desert species *Z . xanthoxylum* , *H . ammodendron* , *N . tangutorum* and *R . soongorica* and enhance their drought resistance . Consequently , this fertilizer can assist in the alleviation of desertification .

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Sward height effect on emission of NH_3 from broiler manure applied to *Dactylis glomerata* L.

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Key words: orchardgrass, forage, poultry, litter, land application

Introduction Ammonia volatilization is a major N loss pathway from land applied manure. Strategies for reduction generally involve injection, incorporation or rapid infiltration of the manure. These techniques are often not available for application on perennial forages. Previous work has shown lower emission when liquid pig manure was applied in bands under a growing crop of winter wheat (Sommer et al. 1997). This potential abatement method has not been examined for solid manures which cannot be injected into grass. The objective of this study was to examine the effect of grass height on NH_3 emission from applied broiler litter.

Materials and methods This field study (4 replicates) was conducted on established orchardgrass (*Dactylis glomerata* L.). Sward canopies were trimmed to 25, 75, 175 or 275mm height above the ground just before manure application; the grass in all plots grew sightly during the two-week measurement period but height differences were maintained. Broiler litter was broadcast at 470 kg N or 100 kg NH_4-N ha^{-1}. Ammonia measurements were made using 0.5×2 m wind tunnels with continuous air flow averaging 1 m sec^{-1} as measured with turbine anemometers, and measurements of air flow in a cross-sectional grid through the tunnels were taken with a hot wire anemometer. Ammonia in air samples collected from the tunnels were trapped in phosphoric acid and analyzed by flow injection. Sampling frequency, starting with 4 times on day 1, declined over the 14-day measurement period after manure application.

Results and discussion For all grass heights, more than half of the emissions occurred in the first 24 h after manure application. This shows the importance of rapid incorporation of manure, where this can be done. In the first day, there was a negative effect of grass height on NH_3 emission, but the effect was small after day 2 (Figure 1). Loss of ammonia-N during the 14-day measurement period totaled 65.3%, 59.6%, 56.0% and 42.8% of applied ammonia-N for the 25, 100, 175 and 275 mm heights, respectively, or 9.1 to 13.9% of applied total N. Only the tallest grass height had a significant effect on ammonia emissions with a reduction of 34% compared to the short grass. These reductions were lower than those reported by Sommer et al. (1997) for liquid hog manure. The difference could be due to relative density and shape of the canopies, and alternative measurement techniques (wind tunnels vs. micromet-mass balance). Emission reduction appeared to be related to the reduced airflow at height of 50-200 mm above ground and possibly to direct ammonia absorption by crop leaves (Sommer et al. 1997). Applying manure under a crop canopy may have additional benefits of reducing odour and runoff and increasing the rate of nutrient uptake (unpublished data). However, delayed manure application may result in reduced yield. Effect on emissions by other crops, crop canopy structures and manure types, and the influence of precipitation, need to be examined.

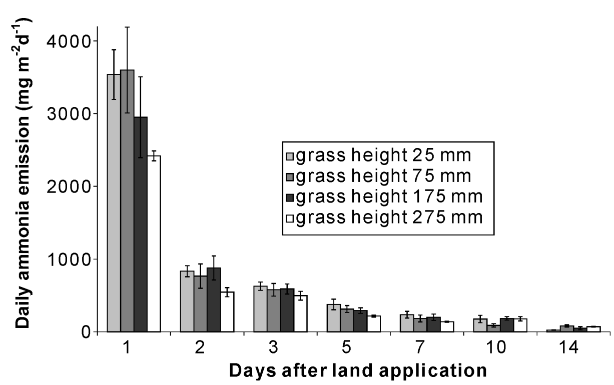

Figure 1 *Daily NH_3 emissions from applied broiler manure as affected by grass height at the time of application.*

Conclusions Grass canopy can be used to reduce ammonia emissions for surface applied broiler manure. While the effect was smaller than reported for swine slurry, there are few methods available for reducing emissions from solid manure applied to grass. Future studies should attempt to optimize the effect.

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Effect of nitrogen fertilisation and cutting frequency on the yield and regrowth of *Panicum maximum* Jacq in West Cameroon

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Key words: *Panicum maximum*, nitrogen fertilisation, cutting frequency, yield, regrowth

Introduction Ruminant production in most tropical countries relies heavily on the availability of grazing land. However, with the high population densities in some of these regions and the emergence of out of season cropping on riparian areas, all arable lands are occupied throughout the year. The alternative left for the animal farmers, is forage cropping and appropriate management techniques. The present work was designed to evaluate the effect of nitrogen fertilisation and the cutting frequency on the yield and regrowth of *Panicum maximum* in West Cameroon.

Materials and methods The study was carried out at the Animal Experimental Farm of Dschang University from March 2006 to January 2007. Rainfall in this zone varies between 1500 and 2000 mm. The soil is classified as ferralitic. A 3×3 factorial design with 3 doses (0, 60, 80 kg/ha) of nitrogen in the form of Ammonium Sulphate at 21% N and 3 cutting frequencies (F1 =30 days, F2=45 days, F3=60 days) at a height of 20 cm in 3 replicates was used. Seventy (70) tillers of *P. maximum* bearing one to two tali were planted on each plot in April 2006 with a spacing of 25 cm by 25 cm. A single dose (100 kg/ha) of simple super phosphate at 21% P was applied in all plots. The ammonium sulphate was fractioned in two parts. The first one-third was applied in equal quantity one month after planting. The remaining two-thirds were divided according to the number of cuts to be done excluding the last one. Two months after planting, the plots were zero timed at 20 cm above the soil and the harvest of regrowths started one month later. 500 g sample were taken after each cutting and oven dried at 60℃ for dry matter (DM) estimate. The average height obtained from 3 measurements was used to evaluate the rhythm of regrowth. Two factors Analysis of variance was carried out on the data and significant differences among treatments were tested with Duncan's multiple range tests.

Results and discussion Independently of nitrogen fertilization cutting frequency had significant effect (P>0.05) on the biomass production with the highest yield (13.77 t DM/ha) obtained at 60 days cutting frequency (Table 1). Increased DM yields with extended cutting intervals are consequences of additional tiller and leaf formation, leaf elongation and stem development. It was observed that nitrogen fertilization did not have a significant effect on the Dry Matter Yield (DMY) of *P. maximum*. This could be due to losses through leaching and volatilisation. Nitrogen fertilization at higher rates may yield lower dry matter (DM) due to nitrogen toxicity or nutrient imbalances (Maurice *et al.*, 1985).

Table 1: *Effect of nitrogen fertilization and cutting frequency on biomass production of* P. maximum.

Cutting frequency (days)	Nitrogen fertilization (kg/ha)			Mean±SD
	0	60	80	
F1:30	12.06a	11.08a	12.63a	11.92±0.78c
F2:45	12.74a	13.44a	12.45a	12.88±0.51b
F3:60	14.68a	14.08a	12.55a	13.77±1.09a
Mean±SD	13.16±1.36a	12.87±1.57a	12.55±0.09a	

a, b, c: Means with same letter in one row are not significantly different (P>0.05)

Table 2: *Effect of nitrogen fertilization and cutting frequency on the RR of* P. maximum.

Cutting frequency (days)	Nitrogen fertilization (kg/ha)		
	0	60	80
F1:30	102.44c	109.93c	111.02c
F2:45	121.53b	134.72b	137.94b
F3:60	145.70a	150.96a	160.04a

a, b, c: Means with the same letters in one row are not significantly different (P>0.05)

Both cutting frequency and level of nitrogen fertilization had significant effect (P<0.05) on RR (Table 2). Nitrogen fertilization effect could be related to the fact that N stimulates meristematic and retards leaf senescence (Andrew and Johansen, 1978). Cutting frequency effect could be related to the fact that infrequent and light defoliation maintains balanced growth of roots and shoots of plants (Chapman and Lemaire, 1993).

Conclusion Nitrogen fertilization had no significant effect on the biomass production of *P. maximum*. Cutting frequency significantly influenced biomass production with the highest forage yield obtained from plots cut at 60 days frequency. Nitrogen fertilization significantly influenced the RR of *P. maximum*. Cutting frequency had significant effect on the RR with the highest RR obtained at 60 days cutting frequency.

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Litterfall deposition along an altitude gradient, Northeast Mexico

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Key words: litterfall, litter constituents, leaves, reproductive structures, branches

Introduction. Litterfall and litter decomposition are key nutrient cycling processes in forest ecosystems (Isaac and Nair, 2006). In addition, throughfall and stemflow help maintain forest floor soil fertility (Silva and González, 2001). Despite the great number of floristic studies carried out in the northeastern region of Mexico, little research has been carried out to address the spatial and temporal patterns of litterfall deposition. Thus, the aim of this study was to assess the spatial litterfall production along an altitude gradient in northeastern Mexico, which covers three main vegetation types.

Materilas and methods. In this study, four experimental plots (50m×50m) were chosen. One plot was located in a pine forest (Bosque Escuela, 1600 masl), the second was located in the ecotone of a *Querqus* forest and the Tamaulipan thornscrub (Ejido Crucitas, 550 masl), and two plots were allocated in the Tamaulipan thornscrub (one located at the Faculty of Forest Sciences (Campus, 350 masl), Autonomous University of Nuevo León, and the other in Ejido Cascajoso, 300 masl). At each plot, 10 litter traps (1.0 m^2 each) were used. Litter constituents (leaves, reproductive structures (flowers, fruits and seeds), twigs or branches, and others (unidentified, fine plant residues) were collected at 15-day intervals between December 21, 2006 and December 20, 2007). Litter deposition data (kg ha^{-1}) was subjected to a one-way analysis of variance design.

Results Total litterfall deposition ranged from 7,266 (Ejido Crucitas) to 4,119 (Bosque Escuela) kg ha^{-1} (Table 1). Leaves represented the main component with a deposition that ranged from 74% (Bosque Escuela) to 86% (Ejido Cascajoso) of total annual litter production. Branches deposition ranged from 4% (Ejido Cascajoso) to 14% (Ejido Crucitas), reproductive structures deposition ranged from 5% (Bosque Escuela) to 10% (Ejido Crucitas), the contribution of others constituents of litterfall ranged from 1% (Campus) to 12% (Bosque Escuela) of total annual litter deposition.

Table 1 *Contribution of litterfall constituents (kg ha^{-1}) at research sites, northeastern Mexico.*

Litter	Research Site			
Constituent	Bosque Escuela	Ejido Crucitas	Campus	Ejido Cascajoso
Leaves	3,052	5,372	4,497	5,483
Reproductive structures	225	751	502	544
Branches	356	1,049	815	245
Others	487	93	51	111
Total	4,119	7,266	5,865	6,383

Conclusions Differences in spatial and temporal litterfall deposition among sites are related to plant phenology, plant tissue life span, community plant structure and environmental variables such as temperature and rainfall.

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Change in soil NH_4^+-N and NO_3^--N under different land use types in the Longzhong part of Loess plateau

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Key words : NH_4^+ —N , NO_3^- —N , different land use types , Loess plateau

Introduction Nitrogen is a limiting element for plant growth in many ecosystems . Inorganic N (NH_4^+-N and NO_3^--N) , in soil is the primary N pool available for plants . The availability of these different N forms can change depending on types of land use (Antonio Gallardo et al , 2005) . The purpose of this study was to research the effect of different land use types on soil N .

Materials and methods This study was conducted at the Semi-Arid Climate and Environment Observatory of Lanzhou University (35°57′N , 104°09′E) . Elevation is 1966 m , which means annual air temperature is 6 .7℃ and means annual precipitation is about 382 mm . Soil type is Sierozem , Four sites [fenced grassland (FG) , grazing grasslands (GG) , millet field (MF) and fallow cropland (FC)] , each 1 hm^2 and adjacent to one another , were selected for the study . Three sample plots (50×50 m^2) were randomly located within each site . In May 2007 , ten soil samples at five soil depths (0—60cm) were taken in each plot using soil cores and each five soil samples from same depth were mixed together . The fresh soil sample passed through 2 mm sieve prior to analysis . Data were analyzed using General ANOVA model .

Results Soil NH_4^+-N content at the same soil layer did not differ significantly between different study sites . Soil NH_4^+-N content within a site did not differ significantly between soil layers in May and July (Figure 1) . The content of NH_4^+-N was significantly higher in May compared to that of July ($p<0.05$) (Figure 1) Soil NO_3^--N content was ranked according to MF > FC > GG ≥ FG ($p<0.05$) , There were some differences between May and July . In May , soil NO_3^--N content of the four study sites were highest in 0-10 cm soil layer and decreased with soil depth . In July , the trend of soil NO_3^--N content of two grassland was same as that of May along the soil profile . While farmland appeared inflexion in the 10-20 cm layer , the trends of them were to reduce then increase . The highest point of MF was in 40-60 cm , and of FC , was in 30-40 cm (Figure 2) .

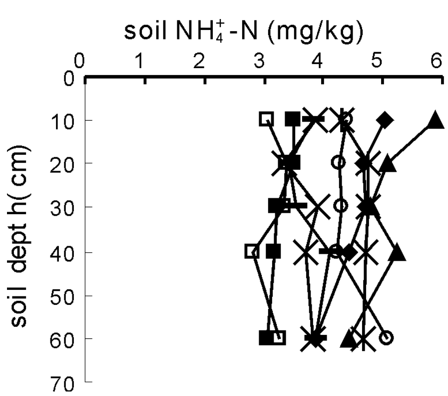

Figure 1 *Soil NH_4^+-N content*

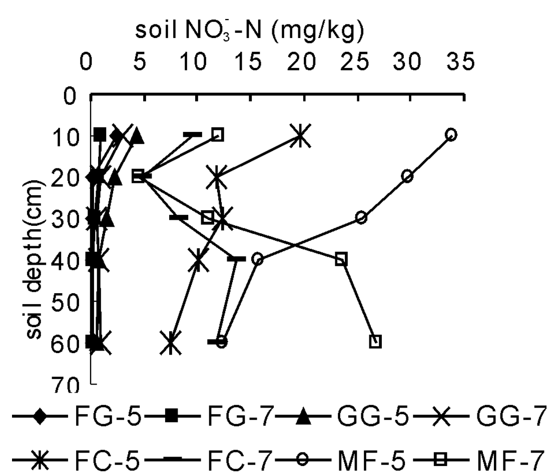

Figure 2 *Soil NO_3^--N content*

Conclusions In the Loess plateau , because of alkaline soil , soil NH_4^+-N content was not significantly differenent . Soil NO_3^--N content was imported for plant growth . Soil NO_3^--N content was different between May and July between farmland plot . Soil NO_3^--N content decreased with soil depth in May , while NO_3^--N content tended to increase in July . Cultivation destroys soil physical structure . In July 2007 , because a great deal of rainfall , soil NO_3^--N content was leached to the deeper soil layers . Compared to farmland , grassland has more cover and root biomass which aides in reducing soil N loss .

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Effects of nitrogen fertilizers on growth and turf quality of Kentucky bluegrass

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Key words: Poa pratensis cv. Huntsville, nitrogen, fertilization, turf

Introduction Interest in turf establishment has boomed in many urban areas of China. Fertilizer application requirements are a key topic in turf management. Various formulations of N-based fertilizers are available for lawn turf. Previous fertilization studies with cool-season turf have used soluble, fast-release N formulations (Moore, R.W., N.E. 1997), or a combination of fast-and slow-release N formulations (Moore, R.W. 1996). Little research has directly compared effects of conventional N fertilizers on introduced Kentucky bluegrass in China.

Materials and methods The experimental design was a factorial treatment arrangement with a control (without fertilization) (marked as H_1, H_2, H_3, H_4 and H_5 (CK) (Table 1) in a randomized complete block (2m×1m, total 15 blocks) on Kentucky bluegrass (Poa pratensis cv. Huntsville). Four conventional nitrogen fertilizers were added (ammonium sulphate, sodium nitrate, ammonium nitrate and urea) under three repetitions. We also fertilizied 80 pots (Φ0.23m×0.20m) with the same treatment regime to determine the biomass yield.

Results and discussion (1) Any kind of N fertilization significantly accelerated the foliation velocity and growth rate but without any significant differences among 4 N sources. In the early period after seeding, no significant effect of N fertilizers could be determined on bifurcating ability, but after growth, N fertilization in autumn could greatly improve bifurcation in next spring. Among 4 N sources, ammonium sulphate was the most effective application. Furthermore, turf-formation velocity could be accelerated. Compared with the control, turf on an N fertilized field could be formed 30 days earlier. Admittedly, N fertilization can effectively improve the turf growth and earlier formation. (2) 4 N fertilizers could significantly ($p=0.01$) deepen the greenness. In spring growing season (see Table 1), 4 N sources made no differences on their effects whereas in autumn growing season (from October to November), Urea application could more significantly increase the leaf chlorophyll content of Kentucky bluegrass. (3) The experiment revealed that 4 N fertilizer applications could significantly increase the biomass of Kentucky bluegrass, but no difference could be testified for effects on aboveground biomass among different fertilizers. (4) Summer withering rate did not reach its peak in the warmest period till late September because of an accumulated high temperature effect. After September 17th, reviving would occur. For different N source applications, any treatment could significantly reduce summer withering rate and ammonium sulphate could be more effective.

Table 1 *Effect of N fertilizers on grwoth of Kentucky bluegrass.*

Treatment	Average foliage		Growth rate (cm/d)		Average bifurcation		leaf chlorophyll content (LCC)				
	Apr 24th	May 14th	Before mowed	After mowed	Sep 14th	Next Apr 14th	May 13th	May 31st	Jun 11th	Oct 1st	Nov 4th
H1	2.87 a	4.43 ab	0.167 a	0.320 a	2.69 a	4.09 a	2.21 A	2.12 A	2.01 A	1.30 AB	1.37 AB
H2	2.80 a	4.02 ab	0.175 a	0.310 a	2.13 a	2.41 bc	2.19 A	2.11 A	1.94 A	1.11 B	1.17 B
H3	2.82 a	4.40 ab	0.180 a	0.360 a	2.50 a	3.77 ab	2.10 A	2.04 A	1.93 A	1.16 AB	1.25 B
H4	2.96 a	4.92 a	0.180 a	0.320 a	2.20 a	3.32 c	2.25 A	2.05 A	1.85 A	1.42 A	1.55 A
CK	2.59 b	3.82 b	0.070 b	0.190 b	2.16 a	1.97 c	1.55 B	1.69 B	1.56 B	0.63 C	0.79 C

Conclusions N fertilizers can be effectively applied in turf establishment of Kentucky bluegrass in the sub-tropic area and can improve the foliation, growth of plants and turf formation and quality, and much better in autumn. Moreover, N sources can have different affects. Ammonium sulphate could be more effective for bifurcation and summer tolerance whereas urea for root growth and greenness.

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Effects of alfalfa stand age on rhizosphere soil phosphorus in saline soil

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Key words : saline-soil alfafa , rhizosphere soil , bulk soil , total P , available P , P fractionation , pH

Introduction Alfalfa is the main perennial legume forage in northwest China . Alfalfa stands can accumulate large amounts of organic matter in the soil and improve physical and chemical characters of soil . Many researches have shown that growing alfalfa can greatly improve soil fertility . This study investigated effects of alfalfa stand age on rhizosphere phosphorus in saline soil .

Materials and methods The work was carried out at the Linze Grassland Faming Experimental Station (Hexi Corridor , western Gansu province) . The elevation was 1390m above sea level . The mean annul air temperature and annual precipitation were 7 .6 ℃ and 121 .5 mm , respectively . Five plots ($55 \times 33m^2$) were planted with alfalfa in 1998 (8 years old) , 2001 (5 years old) , 2002 (4 years old) ,2003 (3 years old) and 2004 (2 years old) . Ten well growing plants were randomly located within each site in full flowering stage . The rhizosphere soil sample was collected by shaking method . Phosphorus contents in all samples were measured colourimetrically using the molybdenum blue method (Murphy and Rilley ,1962) on a UV/VIS Spectrometer . Total P and available P were determined by sodium hydroxide digest method and Olsen method respectively . pH was detected by pH Meter . A modified Hedley's fractionation scheme described by Tiessen (1993) and Sui (1999) was used in P fractionation .

Results There was no significant difference among stands in total P in rhizosphere soil and bulk soil . Available P in rhizosphere soil was higher than in bulk in all stands . Available P content in rhizosphere soil was greater in 5 years old stands than 2 years old stands but available P subsequently declined in 8 years old stands . In bulk soil , there were no significant difference of available P content among 3 ,4 and 5 years old stands , but all of them were higher than in 2 years old stands . and then it decreased remarkably in 8 years old stands . The pH in rhizosphere soil was lower than in bulk soil in all stands . The P fractionation included organic P (Po) fractionation and inorganic P (Pi) fractionation . In Pi portion , the $NaHCO_3$-Pi , NaOH-Pi and hot conc . HCl-Pi (HHCl-Pi) contents in rhizosphere soil were significant higher than in bulk soil in all stands but there were no significant difference in the H_2O-Pi and Ca-Pi contents among stands of different age . With the increase in plant age , all Pi fractions in rhizosphere and bulk soil increased except for the 8 years old stands , however , the NaOH-Pi in rhizosphere and bulk soil decreased from 2 to 8 years old stands . In Po portion , $NaHCO_3$-Po and NaOH-Po in rhizosphere were significant higher than in bulk soil in all stands , but differences among HHCl-Po contents were not significant . $NaHCO_3$-Po in rhizosphere and bulk soil decreased with the increase of plant age . The NaOH-Po increased from 2 to 5 years old stands , but decreased in 8 years old stands . There was no noticeable temporal change of HHCl-Po in rhizosphere and bulk soil . The difference of Residual-P contents between rhizosphere and bulk soil was also not significant . With the increase in stand age , the Residual-P in both rhizosphere and bulk soil decreased .

Conclusion Alfalfa stand age was a major driver of P form and P supply in rhizosphere soil in this saline system . The specific effect on soil P differed depending on stand age and the P fraction examined .

Effect of peat on the soil physical properties

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Key words : peat , sand-peat mixture , chemical properties , soil physical properties

Abstract Peat is a common soil amendment . We investigated differences in chemical properties among peat products and their effects on soil physical properties . The results showed that : (1) There were significant differences on the chemical properties of peats , such as organic matter , humic acid and CEC . (2) The physical properties of sand will be obviously influenced by adding peats . When sand was mixed with peat , the percolation rate , bulk density and air-porosity decreased . On the other hand , the total porosity , capillary porosity and water retention were increased . The more peats and the finer peats are , the more obvious influence on soil physical properties is .

Introduction Peat is a common amendment used on Green construction . The rapid development of China Golf Industry requires a better understanding of the degree to which different peat products alter important soil physical properties . Here we compare chemical properties of six peat products and their effects on soil physical properties with the aim that this information will improve our ability to select the most appropriate materials for rootzone amendment on Greens .

Materials and methods Five peat products were collected in China , signed as local products (LP) , the other one was from Germany (GP) . The particle size distribution of sand met the USGA recommendation . The pH , organic matter (OM) , humic acid (HA) and cation exchangeable capacity (CEC) of peat were measured . The sand-peat mixture was analyzed for physical properties according to ASTM standards .

Results and discussion The properties of six peat products were shown in Table 1 . There was lower pH for GP and LP No .1 , 2 , 3 . Significant differences were observed among peat samples in OM , HA and CEC . For the five LPs , No .1 , 2 , 3 have better quality than No .4 , 5 . The GP and LP No .3 were chosen to be mixed with sand for the testing of physical properties (Table 2) . Compared to sand , there were significant differences in percolation rate and bulk density of two sand-peat mixtures . With the amount of peat increased , percolation rate , bulk density and air-filled porosity significantly decreased , but water retention , total porosity and capillary porosity increased significantly . There was significant different performance between two peats , which was caused by the difference of chemical properties (Table 1) .

Table 1 *The chemical properties of different peats .*

Samples	pH	OM(%)	HA (%)	CEC(cmol/kg)
GP	4 .93c*	96 .0a	58 .3a	125a
LP No .1	5 .20c	73 .5b	44 .9b	73 .2b
LP No .2	5 .10c	61 .0c	40 .2b	64 .4c
LP No .3	4 .58d	45 .5d	30 .9c	53 .6d
LP No .4	6 .81b	37 .7e	15 .0d	25 .9e
LP No .5	7 .60a	18 .1f	19 .2d	31 .8e

* Note : Different letters in the same row indicate significantly difference at $p<0.05$.

The physical properties of sand-peat mixture were influenced by the size of peat (Table 3) . With the particle size of peat became smaller , the percolation rate and air-filled porosity decreased significantly , but water retention and capillary porosity increased obviously .

Table 2 *Effect of different peats on the physical properties of sand-peat mixture .*

Items	Sand	Sand mixed with GP		Sand mixed with LP No .3	
		8 : 2	7 : 3	8 : 2	7 : 3
Percolation Rate (cm/h)	40 .2a*	19 .7c	16 .5c	36 .1a	26 .7b
Bulk Density (g/cm^3)	1 .62a	1 .46b	1 .36d	1 .41c	1 .30e
Water Retention (%)	5 .63e	11 .7d	16 .1b	12 .6c	18 .6a
Total Porosity (%)	40 .6e	45 .0d	48 .5b	47 .0c	51 .1a
Capillary Porosity (%)	9 .13d	17 .1c	22 .0b	17 .8c	24 .2a
Air-filled Porosity (%)	31 .4a	27 .9c	26 .4d	29 .2b	26 .9cd

* Note : Different letters in the same line indicate significantly difference at $p<0.05$.

Table 3 *Effect of different size of LP No .3 on the physical properties of sand-peat mixture .*

Items	Sand	Sand-Peat (4mm) mixture		Sand-Peat (0 .5mm) mixture	
		8 : 2	7 : 3	8 : 2	7 : 3
Percolation Rate (cm/h)	40 .2a*	19 .7b	16 .5b	7 .79c	5 .23c
Bulk Density (g/cm^3)	1 .62a	1 .46c	1 .36e	1 .49b	1 .42d
Water Retention (%)	5 .63d	11 .7c	16 .1b	16 .1b	19 .0a
Total Porosity (%)	40 .6c	45 .0b	48 .4a	44 .4b	45 .3b
Capillary Porosity (%)	9 .13e	17 .1d	22 .0c	24 .0b	26 .9a
Air-filled Porosity (%)	31 .4a	27 .9b	26 .4c	20 .4d	18 .4e

* Note : Different letters in the same line indicate significantly difference at $p<0.05$.

Improving the sustainability and mitigating environmental impacts of grazed grassland

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Key words: grassland, nitrate leaching, nitrous oxide emissions, grazing, nitrification inhibitors

Introduction In New Zealand, the predominant land use is grazed pastures where animals graze outdoor pastures all year. In such systems, a major nitrogen (N) cycling process is the excretion of N in dung and urine by the grazing animal, returning 70%-90% of the N ingested to the soil. The N loading rate under a dairy cow urine patch can be as high as 1000 kg N ha^{-1}. This urine-N is the major source for both nitrate (NO_3^-) leaching and nitrous oxide (N_2O) emissions in grazed pasture systems (Di and Cameron, 2002a, 2002b). Consequently, mitigation technologies have been developed to reduce both NO_3^- leaching and N_2O emissions from grazed pasture systems using nitrification inhibitors.

Materials and methods The effectiveness of a nitrification inhibitor, dicyandiamide (DCD), in reducing NO_3^- leaching and N_2O emissions in grazed pastures was assessed in different soils across New Zealand. Nitrate leaching was measured using undisturbed soil monolith lysimeters (50～80 cm diameter; 70～120 cm deep). Nitrous oxide emissions were determined using closed chamber methods on top of the lysimeters. Pasture yield was measured on the lysimeters by cutting and weighing dry matter yields.

Results and discussion Nitrate leaching was significantly decreased by treating the grazed pasture soils with the DCD nitrification inhibitor (Di and Cameron, 2002b, 2004). For example, NO_3^--N leaching losses from a Templeton soil were reduced from 85 to 20-22 kg N ha^{-1} yr^{-1} (equivalent to 74%-76% reductions) (Di and Cameron, 2004). N_2O emissions from the urine patches were reduced by an average of 70% in four different soils (Di and Cameron, 2006; Di *et al.*, 2007). Pasture yield was also significantly increased by the inhibitor treatment (Di and Cameron, 2002b, 2004, 2005). Therefore, treating grazed pasture soil with the DCD nitrification inhibitor provides both environmental and agronomic benefits by reducing NO_3^- leaching and N_2O emissions, and increase pasture production.

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Biological absorbing capacity of nutrient elements by some temperate tame grasses

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Key words : tame grass , nutrient element , biological absorption coefficient , enriched element , impoverished element

Introduction The biological absorption coefficient (*Ax*) is a useful way to evaluate the ability of a plant to absorb certain elements . The index expresses the flux of the chemical element in the soil-plant system and reflectes the selective absorbing capacity of the plant on for the particular . Biological absorbing capacity of 10 elements in 6 grasses was studied at mountainous region of north subtropical zone of China in this paper . These provided a scientific basis for managing artificial grassland .

Materials and methods The study was conducted at artificial grassland of the Hongchiba area in Chongqin , China (109°04′E , 31°33′N) at an altitude of 1200 m above sea level . Mean annual temperature was is 7℃ ; mean rainfall is 2000 mm $year^{-1}$. The materials used were 3 leguminous grasses , *Trifolium pretense* , *T . repens* and *T . incarnatum* and 3 forage gasses *Dactylis glomerata* , *Lolium perenne* and *Poa pratensis* . Analytical methods for elements was as follows : N was determined by method of $HClO_4$-H_2SO_4 nitrification and P , K , Ca , Mg , Fe , Mn , Cu , Zn and B by ICP-AES . *Ax* of elements was quantified by the element content of plant divided by that of soil in growth location of the plant (Tian et al . 1996) .

Results and discussions The biological absorbing capacity of a grass for a particular elements could be classified into 2 types , enriched element ($Ax>1$) and impoverished element ($Ax<1$) . Table 1 shows that N , P and Ca were enriched elements in aboveground and underground portion of 6 grasses except that P of underground portion in *L . perenne* was an impoverished elements . These results were identical with the reports of Cen (1999) . K , Mg , Fe , Mn , Cu , Zn and B were impoverished elements except that K of aboveground portion of *D . glomerata* is an enriched element . The study results of Tian (et al , 1996) showed similar outcomes . *Ax* of Ca in leguminous grasses was strikingly higher that forage gasses in aboveground portion for 2 type grasses ($P<0.01$) . As regards 10 elements , *Ax* of N was highest ; *Ax* of Fe was lowest in all materials . Compared aboveground portion with underground portion , *Ax* of N , P , K and B of the former were notably larger than those of the latter in 6 grasses ($P<0.05$) . *Ax* of Ca and Zn of the former were markedly larger than those of the latter in 3 leguminous grasses ($P<0.05$) .

Table 1 *Biological absorption coefficient of nutrient elements in 6 grasses .*

	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B
Aboveground portion										
Trifolium pretense	17.69	3.01	0.54	10.77	0.45	0.004	0.070	0.329	0.435	0.302
Trifolium repens	22.89	3.79	0.78	10.97	0.29	0.021	0.080	0.366	0.308	0.351
Trifolium incarnatum	21.62	2.58	0.50	7.17	0.27	0.005	0.041	0.265	0.418	0.233
Dactylis glomerata	15.31	5.52	1.03	2.08	0.23	0.004	0.419	0.411	0.517	0.320
Lolium perenne	16.57	2.46	0.79	2.39	0.14	0.005	0.141	0.235	0.342	0.310
Poa pratensis .	13.76	3.72	0.76	1.97	0.10	0.011	0.097	0.277	0.374	0.335
Underground portion										
Trifolium pretense	11.42	2.07	0.26	2.50	0.51	0.023	0.044	0.386	0.211	0.186
Trifolium repens	16.43	2.07	0.28	3.56	0.35	0.006	0.035	0.456	0.248	0.277
Trifolium incarnatum	18.39	1.38	0.39	2.13	0.16	0.004	0.030	0.355	0.219	0.202
Dactylis glomerata	11.80	1.86	0.17	3.56	0.16	0.087	0.236	0.632	0.565	0.248
Lolium perenne	11.24	0.95	0.19	1.54	0.04	0.019	0.103	0.274	0.452	0.175
Poa pratensis .	8.85	1.67	0.31	1.81	0.06	0.033	0.143	0.340	0.337	0.147

Conclusions N , P and Ca were enriched elements ;K , Mg , Fe , Mn , Cu , Zn and B generally were impoverished elements in 6 grasses . *Ax* of Ca in leguminous grasses was strikingly higher that forage gasses in aboveground portion . *Ax* of N , P , K and B of aboveground portion was notably larger than those of underground portion in 6 grasses . *Ax* of Ca and Zn of aboveground portion were markedly larger than those of underground portion in 3 leguminous grasses .

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Estimation of plant N, P and K contents in the Inner Mongolia steppe using SPAD value

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Key words: N, P. K, steppe of Inner Mongolia, SPAD

Introduction For the last few decades, the Inner Mongolia steppe has been degraded by improper use. As a result, the productivity of grasses and livestock in the steppe has decreased dramatically. Understanding the current state of desertification and the dynamics of degradation of the steppe located at the center of Eurasia is essential for protecting and restructuring this land effectively. A simple and rapid method to evaluate the composition of grasses growing in the steppe is needed. The possibility of estimating N, P and K content of the plants using the SPAD (Soil & Plant Analyzer Development) value was examined in the present study.

Materials and methods The plant samples were collected from 13 quadrates (1 m^2) constructed in the traditional steppe, where *Leymus chinensis* and *Stipa* L. are dominant and *Cleistogenes squarrosa*, *Caragana microphylla* and *Artemisia frigida* are subdominant species, around Xilin hot city in Xilin Gol league of Inner Mongolia in August, 2006. The SPAD readings of 9 points (upper, middle and lower parts of leaves selected from upper, middle and lower part of a plant) of a plant were recorded before sampling by using the chlorophyll meter (SPAD-502: Konica Minolta Sensing. Inc. Co.). Total N, P and K contents of the dried plant samples were measured by Nessler colorimetric and molybdenum-blue colorimetric analysis and flame photometer following the treatment with sulfuric acid and hydrogen peroxide, respectively.

Results and discussion Significant positive correlations between N, P or K and the SPAD value were observed in all cases (Table 1). It was also demonstrated that there were high level coefficients of determination between SPAD readings and K and P contents in plants as well as N, which have a cross correlation with SPAD readings in Chinese grasses (Lei et al., 2001). On the other hand, it was found that the lower leaves tended to have lower SPAD readings were lower in lower leaves.

Table 1 Relationships between N, P or K contents and SPAD value of grasses (n=13) collected in steppe of Inner Mongolia.

	Regression	r	r^2	p
N	$y=0.572x - 7.386^*$	0.981	0.963	<0.001
P	$y=0.072x - 1.109$	0.886	0.785	<0.001
K	$y=0.394x - 12.81$	0.929	0.863	<0.001

*: y = N, P or K; x=SPAD value

Conclusion It was concluded that the SPAD values of plants growing in Inner Mongolia could become good indicators of plant N, P and K contents based on the results obtained in the present study.

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Effect of silicon application on water use efficiency of alfalfa plants

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Key words : silicon application , water use efficiency , alfalfa , soil moisture

Introduction As one of the most important forage crops , alfalfa production is confined by rising irrigation costs and water demand . One tool to imrove sustainability of water use is to increase water use efficiency (WUE) in alfalfa production . Silicon has been found to increase WUE in sunflower by reducing leaf transpiration (Zou et al . 2005) . Silicon also can increase alfalfa shoot and root growth (Guo et al . 2006) . If the WUE of alfalfa could be enhanced by a simple agronomic means such adding silicate to the soil , this measurement could potentially be applied in pasture management .

Materials and methods A pot experiment was conducted in the green house . The equivalent of 23 .8 kg oven-dried sand soil was put into 48 plastic pots with a plastic film on the bottom to prevent drainage loss of water . Four soil moistures were designed : 80% , 65% , 50% , and 35% of field water capacity (FWC) . At each soil moisture condition , three treatments (4 .0 g potassium chloride (-Si) , 8 .0 g Potassium silicate (+Si) , CK) were applied to quantify the effect of silicon application on WUE of alfalfa plants . Alfalfa seedlings were thinned to 10 per pot 10 d after they germinated . During the experiment , sunlight was introduced and soil water was maintained approximately at preset water hold capacity every day by weighing and adding deionized water . Water use efficiency was determined by WUE=Y/I . Y is forage biomass and I irrigation water . The transpiration rate was measured under clear and sunny weather using a portable photosynthesis system (LI-6400 , LI-COR Inc . , Lincoln , NE) .

Results WUE of alfalfa plants was different under the different soil moisture conditions . The addition of silicon significantly increase the WUE of alfalfa plant under the 50% and 65% of FWC conditions (Figure 1) . However , under the 80% and 35% of FWC conditions , addition of silicon had no effect on water use efficiency . This study also showed that WUE of alfalfa plants with +Si treatments under the 50% of FWC condition was significantly higher than that under the 65% of FWC condition . Silicon application significantly reduced the transpiration rate of alfalfa leaves across the four soil moisture conditions (Figure 2) . Compared to the transpiration rate of plants with Si treatments , the transpiration rate of control plant was lower under the 35% of FWC conditions and higher under the 80% of FWC conditions , however , no difference under the 50% and 65% of FWC conditions .

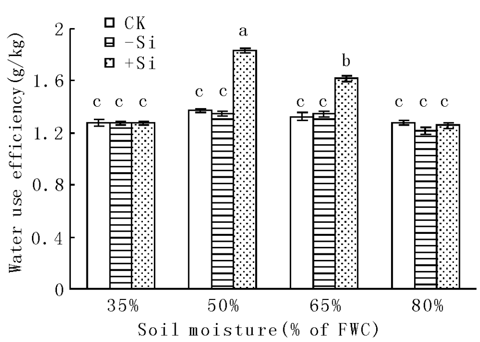

Figure 1 *Effect of silicon on WUE under each soil moisture conditions .*

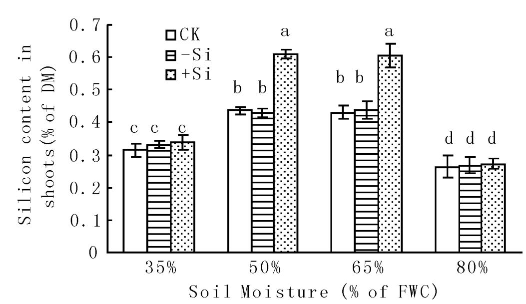

Figure 2 *Effect of silicon on transpiration rate under each soil moisture conditions .*

Conclusions Silicon application significantly increase the water use efficiency under the lightly and moderately water-stress environments (50% and 65% of FWC) by mainly reducing leaf transpiration rate . Silicon , however , had no effect on WUE of alfalfa under the serious water-stress and wet condition . This observation is not in agreement with the results from *Sorghum bicolor* , in which silicon application had no effect on WUE in both wet and dry conditions (Hattoria et al . , 2005) . These results suggest that the response of water use efficiency of crop plants to silicon application is related to soil moisture condition in which plants grow .

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N-P-K balance in a milk production system on a *C. nlemfuensis* grassland and a biomass bank of *P. purpureum* CT-115 clone

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Key words: Milk farming, biomass bank, N, P, K balance

Introduction In very intensive milk production systems in Europe and America with the use of high amounts of chemical fertilizers, the nutrient cycling models consider the losses of N due to leaching and volatilization, as well as the hydro-physical characteristics of the soil affecting the performance of this element (10; 6). However, in more extensive milk production systems, low input agriculture forming the natural cycle occurring within each farm, is of vital importance to potentate nutrient recycling for a stable animal production.

Objective To study the values of N, P and K inputs and outputs in a dairy farm with a sward composed by 60% of *C. nlemfuensis* and 40% of *P. purpureum* CT-115, associated with legumes in 28% of the area.

Materials and methods The grassland covered an area of 53.4 ha, composed by *C. nlemfuensis* (60%), *P. purpureum CT*-115 (40%) and *L. leucocephala* and *C. cajan* legumes intercropped in 28% of the area. The dairy herd consisted of 114 cows, 35 replacement heifers and 24 calves. There was a milk yield of 100,000 litters and the animals consumed 825 t DM from pastures and 75.1 t DM from other supplementary feeds. Nutrients extracted by pastures, nutrients intook by animals from pastures, symbiotically N fixation by legumes and N, P and K determinations outside the system due to animal production were determined (3-11). Volatilized ammonia, nutrient input and litter accumulated in the paddocks were measured once each season.

Results and discussion In the whole system the balance indicates negative values of N, P and K. Out of the total amount of nutrients consumed, animals used only 16 kg N, 5 kg P and 4 kg K for milk production, LW gain and calf production, the remainder returned to the system through excretions. Hence, more than 90% of the N and K, and approximately 81% of the P consumed by the animals were added to the system through excretions. These results agree with those reported by Jarvis (1993) and Cadish (et al., 1994). However, 40% of the excretions occurred in the shade buildings and milking parlours and thus these nutrients did not return to the system. An important internal recycling mechanism, especially for nitrogen and potassium, is their remobilization by the rejected pasture to re-use them for the regrowth activity. This is of particular interest in CT-115 Bank, since stems of CT-115 plants left after grazing remobilize an important amount of these nutrients, guaranteeing a favourable pasture regrowth (Martinez 1996).

Table 1 *N, P and K balance in the system, kg/ha/year.*

Inputs and outputs	N	P	K
External inputs			
Fertilizer	14	-	-
Rainfall	27	-	-
Supplements	16	7	26
Biological N	12	-	-
Internal recycling			
Extracted by pasture	320	57	237
Remobilization	36	5	34
Excreted by the animals	165	33	152
Consumed by the animals from pasture	176	31	130
From litter	11	2	9
Outputs			
Animal products	16	5	4
N volatilized	11	-	-
Losses outside the system	70	13	61
Balance in the system (Inputs-outputs)	-28	-11	-39

Conclusions and perspectives The return of all the excretion to the grassland is recommended as well as increasing the area of legumes to attain a satisfactory balance of N, P and K in the system. Further studies must consider maintenance fertilization, nutrient losses due to leaching and denitrification, as well as variation of the stable OM in the soil and the influence of hydro physical properties in the recycling process.

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Effects of microbiotic crust nutrients on the different Vegetations

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Key word : Microbiotic crust , organic matter , pH , total N , total P ,total K

Introduction In China , more and more people are concerning on prairie desertification . The microbiotic crust consisting of algae , lichen , moss , epiphyte , bacteria and soil particles is an important landscape component in these regions . This research examines effects of microbiotic crust nutrients on vegetation in the transition zone between the Loess Plateau and Mu US sandy land .

Material and methods This research had got the sample in the field and analyzed in the laboratory . The microbiotic crust was sampled in Ordos , Yijinhuoluo banner and this area lies in the transitional area of Loess Plateau and Mu US sandy land . Choose the *Salix psammophila* C .Wang forest , the *Artemisa ordosica* Krasch forest and the *Populus simonii* Carr . forest as 3 sampling area whose growth time were close and take the bare dune as compared area . In the sampling area , chose 2 dunes whose gradient and aspect are similar and sampled 3 repetitions in the middle and the bottom of the tailo . Experimental analysis the sample's nutrient content in the laboratory and the measuring index and its method are as follows : pH measured by pH which type is PHS-3D ; organic-potassium dichromate & concentrated sulfuric acid ; total N-micro Kjeldahl method ; total P-NaOH colorimetry ; total K-NaOH flame photometry . All of the experiment data were analyzed by Excel and SAS .

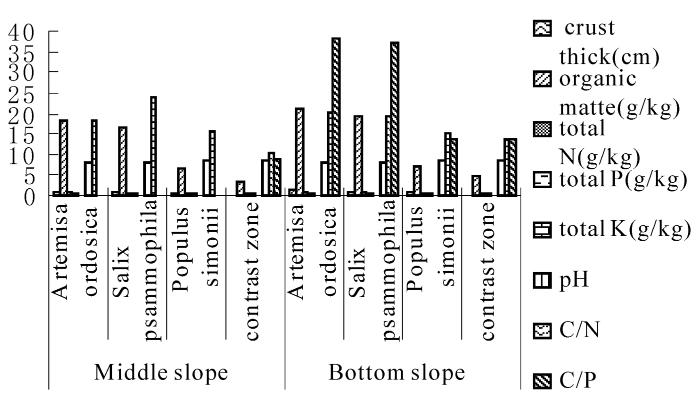

Figure 1 *Nutrient content of the microbiotic crust in 3 sampling area and the contrast zone .*

Results The minimum pH value in the bottom of *Artemisa ordosica* Krasch sampling dune is 7 .95 and the maximum value is 8 . 46 of the middle of bare dune . The pH value of the crust under the *Artemisa ordosica* Krasch and the *Salix psammophila* C . Wang are higher than the *Populus simonii* Carr . forest and the bare dune . That's mainly because the moss has grown in the crust of the 2 former forests and their roots can secrete acidoid during the growth process . In the 3 sampling area , the organic content of the crust is 6 .61-21 .28 g/kg and the total N is 0 .42-1 .06 g/kg , both of them are higher than the compared area . It shows that the microbiotic crust has strong enrichment effect on the nutrient . Both the C/N and the C/P value in the sampling area are higher than the compared area , which shows that the inferior organism of the crust has higher suitability in sandy land with poor nutrient and their existence has important influence on the C circle in this desertificated place .

Conclusions With the increase of crust thickness , the pH value tend to decrease and all the organic matter , total N , total P content are present raising trend . The microbiotic crust has significant enrichment effect of the nutrient . Both the C/N and the C/P in the 3 sampling area are higher than in the bare dune .

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Effects of yearly simulated temperature rise and nitrogen deposition on soil nutrient in the Songnen meadow steppes of northeast China

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Key words: soil nutrient, nitrogen (N), phosphorus (P), soil net N mineralization, global warming, N deposition, the Songnen meadow steppes, NE China

Introduction Soil is the largest carbon store in terrestrial ecosystems. Effects of global environmental change on soil carbon and nutrient cycling are consequently an area of intense research interest (Mosier, 1998). Nutrinet cycling is inherently couples with soil C cycling (Lal, 2004). The objectives of this study were (1) to quantify the effects of soil heating and N deposition on soil total N (TN), soil total P (TP), available N (AN), and available P (AP); (2) to understand how the soil nutrient processes and functions of the Songnen meadow steppes respond to a single year of warming and increased N deposition, and to evaluate the potential consequences of climate change.

Materials and methods The measurements were carried out in the Northern Meadow Plot at the Changling Songnen Meadow Steppes Ecology Research Station (123°45′E, 44°45′N), Jilin, China, beginning from March 2006. The steppes are situated at the east edge of the Eurasian Steppes. Perennial grasses are the community dominants, in which *Leymus chinensis* and *Stipa grandis* indicate local climax communities. Annual averaged temperature is about 4.9℃, and annual rainfall is about 470 mm. Soils are calcareous black soils, sodic saline meadow soils and sandy soils. The experiment was a completely randomized block design with two factors and two levels: atmospheric temperature (heating and ambient); soil N (increased and ambient). Each treatment combination was replicated six times. We exposed plots to warming (160 W m^{-2} of thermal radiation, resulting in a soil-surface warming of 1.7-2℃), and N deposition (increased by 10 g m^{-2} yr^{-1}) in one-to two-way treatment combinations. Warming was applied with infrared lamps suspended 2.5 m high over plot centers. N deposition was administered with crystal $Ca(NO_3)_2$ applications in summer. We began treatments in March 2006 and report responses observed at the end of one year of treatment. Data were analyzed using three-way ANOVA analysis in SAS 9.0.

Results Soil net nitrogen mineralization rate (NMR) responded positively to warming on the steppes but with N deposition or N deposition and warming together. Warming had no statistically significant effect upon either TN or AN, while N deposition and its interaction with warming both had significant effects upon AN but not TN. Warming, N deposition and their interactions overall had no significant effect upon AP. Except that increases in N deposition had a positive effect on TP of about 40%, TP responded with no significance to warming or warming combined to N deposition.

Conclusions In genera, warming and N deposition would both add to future warming and aggravate local non-point source pollutions with respect to the findings from our case study. Since this report is a short-term examination of soil nutrient responses to the single and combined effects of warming and N deposition, the degree to which these findings relate to long-term change is needs to be pursued in subsequent investigations.

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Effect of boron fertilizer on density, growth, seed yield and nutrient concentrations of *Centrosema pubescens* grown in humid subtropical areas of Yunnan in China

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Key words: nutrition requirements, *Centrosema pubescens*, boron, latosol

Introduction Livestock production depends on quality and quantity of forage which can be influenced by fertilizer application (Forth 1984). Pasture improvements techniques in tropical and subtropical areas of Yunnan have largely centered on the use of new species of plants which had been introduced to China from Australia. Less is known about how nutrient limitations may limit forage quality and yield. This study examined the effects of boron (B) on the density, growth, seed yield and nutrient concentrations of *Centrosema pubscens* in terms of nutrient requirements. Yield improvements with B addition could greatly assist animal husbandry in humid subtropical areas of Yunnan.

Material and methods The study was conducted on the southeast of Yunnan (101°17′E, 22°47′N), of latosolic soil type with average annual rainfall of 2220 mm, an elevation of 890 m, a mean temperature of 20.6℃, annual evaporation of 1865 mm. The original vegetation was *Chromolaera odorata*, *Eupatarium coelestinum*, natural grasses and a few *Desmodium* spp. The nutrient contents of 0-20 cm soil were 29.7 $g.kg^{-1}$ organic matter, 1.5 $g.kg^{-1}$ total nitrogen, 14.2 $mg.kg^{-1}$ available phosphorus, 0.5 $mg.kg^{-1}$ available boron, 5.6 pH. The method used was a randomized factorial design of one factor with four levels (viz. nil, 0.55, 1.1 and 1.65 kg B/hm^2) and three replications for *Centrosema pubescens*. The plant spacing was 0.5 m, with sowing rate of 6 kg/hm^2 for each block ($4m \times 4m$). Boron fertilizer was applied at sowing with supplement of P 16 kg/hm^2, Cu 1.2 kg/hm^2, Mn 2.6 kg/hm^2, Co 0.063 kg/hm^2, Zn 1.8 kg/hm^2 and Mo 0.162 kg/hm^2, respectively. Number of seedlings, oven-dry matter and seed yields were recorded for three years. All samples were analysed for N, P, K, Ca, Mg, Zn, Cu and Mn in general method (Bao 2000). Data was analyzed with SPSS 11.0.

Results Seed yield and dry matter yield of *Centrosema pubescens* with B 1.65 kg $/hm^2$ was increased by 163% ($p<0.01$) and 83% ($p>0.05$) to compare with the control treatment in the Table 1. Moreover, with B application, the yields of Ca ($p<0.01$), P, S and Cu ($p<0.05$) increased significantly. Nutrient concentrations of *Centrosema pubescens* fertilized with 1.65 kg B per hectare increased significantly compared with the controlled treatment as illustrated in the Table 2.

Table1 *Effect of B fertilizer application on the number of seedling, seed yield and dry matter yields of* Centrosema pubescens *(Mean SD).*

boron rates kg/hm^2	0	0.55	1.10	1.65
Number of seedlings plants/m^2	4.3±3.1	5.3±0.6	6.3±1.2	4.3±2.1
Seed yields kg/hm^2	27 ± 8.7^b	43.5 ± 12.5^{ab}	58 ± 15.0^a	71 ± 20.1^a
Dry matter yields kg/hm^2	1798±533	1596±229	2640±1311	3294±1232

$^{a\text{-}b}$ Means in a row having a common letter are not different ($P>0.05$)

Table 2 *Effect of various boron rates on the yields of nutrient requirements of* Centrosema pubescens *in VP Boron rates.*

Boron rates kg/hm^2	N kg/hm^2	P kg/hm^2	K kg/hm^2	Ca kg/hm^2	S kg/hm^2	Cu g/hm^2	Zn g/hm^2	Mn g/hm^2
0(CK)	53.9	1.8^b	27.0	8.1^B	3.2^b	12.6^{ab}	44.9	396
0.55	47.9	2.6^b	22.3	7.0^B	2.6^b	9.6^b	33.5	345
1.10	66.0	4.0^{ab}	37.0	14.5^B	3.4^b	15.8^{ab}	52.8	528
1.65	95.5	5.9^a	42.8	36.2^A	6.9^a	23.1^a	49.4	629

$^{a\text{-}b,A\text{-}B}$ Means in a column having a common letter are not different ($P>0.05$)

Conclusion With application of 1.65 kg/hm^2 of boron fertilizer, *Centrosema pubescens* performed not only the best in seed yield but also high yield of quality forage, supplying sufficiently nutrient requirements for livestock.

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Organic fertilization of Sorghum seeds for forage for use by monogastric and ruminant livestock

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Key words: plastic bags, seeds, sorghum, fertilizing organic

Introduction The use of organic wastewater in agriculture to fertilize different crops is one of the more acceptable alternatives to provide an environmentally safe way to dispose of these contamination sources. However is it very important to take into account the optimal wastewater doses according to the international guidelines (Cairncross and Mara, 1990). The measurement of these parameters are done by chemical and microbiological analysis and also by using some indicator plants. In Cuba, technical rules to regulate the use of swine wastewater in agriculture do not exist. The aim of this paper to was define the optimal application rate of swine wastewater as organic fertilizer of a Sorghum bicolour UDG-110 crop by means of a practical and easy method in plastic bags.

Materials and methods The experiment was carried out in polythene plastic bags (2 kg capacity) distributed in three treatments (doses of swine effluent), 10% (T1), 20% (T2) and 30% (T3) with 10 replications each one in a randomized complete block design. A no-water or fertilizer control was included. (C). The organic fertilizer of the swine effluent comes off a fixed dome anaerobic biodigester of 15 m^3. Three seeds of Sorghum were planted in each bag to 5 cm deep. The dry matter (DM), organic matter (OM), N, P, K and pH of soil and effluent were measured at the beginning and also was analyzed the effluent microbiological composition. The heights of the plants were measured every 5 days over a total period of 30 days. The chemical analyses were done following standard procedures of the Association of Official Analytical Chemists procedures and the microbiological analyses. In the statistic study, all microbiological results were transformed to $\log_{10}(x+1)$ and analysis of variance were made according to Steel (et al., 1997).

Results and discussion Treatment 2 (20% of swine wastewater) germinated faster than the rest of the treatments and the control ($P<0.01$). The biomass at 30 days and its chemical composition were higher for the treatment 2, and similar performance was evidenced for the altitude and number of leaves of this crop in this treatment, Table 1 and 2.

Table 1 *Biomass weight to the 30 days. DM (g).*

	Leaves weight	Stems weight	Roots weight	SE±
Control	4.08	3.44	0.63	0.23
10%	3.86	3.21	0.64	0.19
20%	5.99	5.21	0.78	0.21***
30%	3.38	2.72	0.66	0.10

*** $P<0.001$

Table 2 *Chemical composition of the biomass for each treatment.*

Indicators	Control	10%	20%	30%	SE±
DM	15.94	14.96	20.64	15.09	1.01*
CZ	35.05	36.18	35.56	35.01	0.23
pH	7.01	7.06	7.1	7.03	0.58
N	0.700	0.750	2.080	0.450	0.16**
P	0.064	0.070	0.092	0.061	0.28**
K	0.190	0.220	0.290	0.200	0.22*

* $P<0.05$ ** $P<0.01$

Conclusions The 20% of anaerobic effluent as organic fertilizer was the optimal dose to fertilize this cereal. With the application of this method using plastic bags, it is possible to define the reliable limits of the use of residual organic as fertilizers in the agriculture, results obtained for other authors (Chantaprasarn, 2003).

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The study of physico-chemical characteristics of soil-vegetation relationships in saliferous and gypsiferous soils of winter rangelands in Eshtehard (Iran)

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Key words : saliferous and gypsiferous soils , PCA , cover , physico-chemical characteristics , Eshtehard

Introduction In order to integrate management of rangelands ecosystems , it is necessary to be aware of the relationship between environmental factors and plants in these ecosystems . Aridisols occupy vast extension of rangelands in arid and semi-arid regions of Iran . Scattered vegetation cover is representative of special physico-chemical characteristics in these soils . The aim of the present study was to identify gypsophyte and halophyte plants and investigate plant distribution related to physico-chemical characteristics of soils in Eshtehard winter rangelands .

Materials and methods The study area is located in the east of Eshtehard (35° 38′ N , 50°13′ E to 35°34′ N , 50°33′ E) . The mean elevation of the region is 1250 m and the Shour river passes across this plain . Vegetation sampling was conducted in the key area based on a randomized-systematic pattern . Vegetation data included canopy cover and density percentage , estimated quantitatively along transect within each quadrat . The four main plant types were *Halocnemum strobilaceum-Salsola crassa* , *Haplophyllum glaberrimum-Seidlitzia rosmarinus* , *Haplophyllum glaberrimum* , and *Tamarix sp .-Nitraria schober .* , The soil profiles excavated and disturbed soil samples were collected . Based on the standard methods , physico-chemeical characteristics including soil texture , electrical conductivity in saturated extract soil reaction , organic carbon content , gypsum and equivalent calcium carbonate percentage , soluble anions and cations were determined . Multivariate method of principal component analysis (PCA) was used to analyze the collected data .

Results According to Figure 1 , the first two principal components accounted for 85 .83% of the total variance in data set . Therefore , 55 .62% and 30 .21% variance were accounted for by the first and second principal components , respectively . This means that the first principal component is by far the most important for representing the variation of the four vegetation types . Results showed that the vegetation distribution pattern was mainly related to soil characteristics such as salinity , texture , chloride , soil reaction , gypsum and gravel percentage .

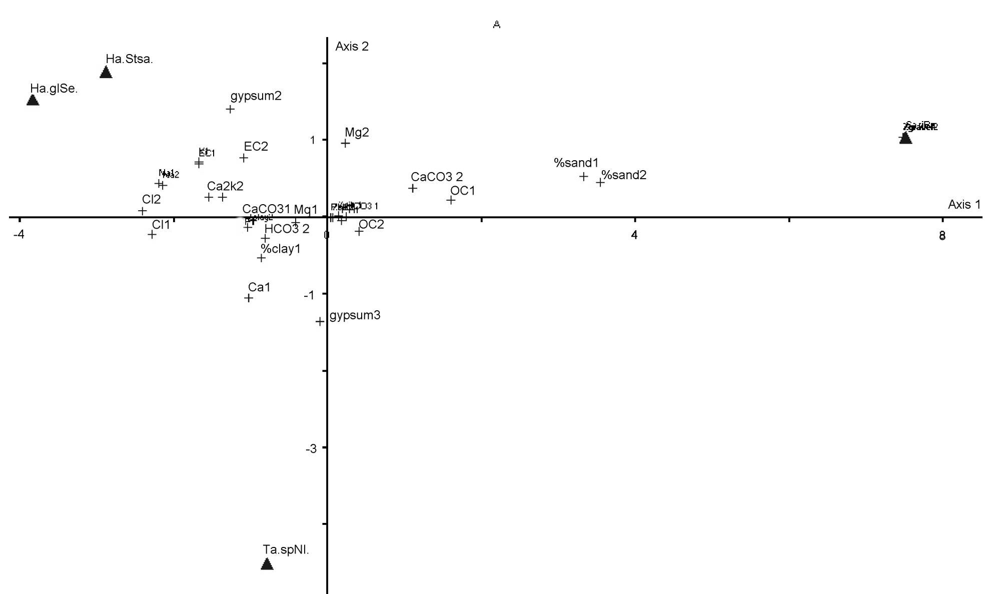

Figure 1 *PCA-ordination diagram of the vegetation types related to the environmental factors in the study area .*

Conclusion Since PCA method show high accuracy and have different abilities , it could be used for habitat analysis and determination of effective ecological factors in winter and desert rangelands .

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Effects of soil pH and Fe^{2+} content on growth and physiology of alfalfa

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Key words: soil pH, iron toxicity, Fe^{2+} content, alfalfa

Introduction Soils in the wet tropics contain high levels of iron that are toxic to alfalfa plants. The soils affected by iron toxicity are characterized by high iron concentration in the soil solution and low pH (Pathirana, 2002). High concentration of water-soluble Fe^{2+} results in growth retardation or even death of alfalfa plants. In addition to high levels of iron, these soils also have a low pH which leads to damages of root growth and rhizobium development, as well as deficiencies of other nutrients such as P and Ca, which results in severe yield losses.

Materials and methods Seeds of WL525 were sown in 40 plastic pots with the size of 20 cm-diameter and 20 cm-height for each pot. The medium for seedling in the pots were the mixture of sand and $FeSO_4$. The contents of $FeSO_4$ in the mediums were five levels, which were 10mg/kg, 50mg/kg, 100mg/kg, 150mg/kg and 200mg/kg. Each $FeSO_4$ level had eight pots. The pH of the mediums were adjusted to two levels of pH4.5 and pH6.0 by the way of placing each pot into plates containing modified 1/4 Hogland nutrient with pH = 4.5 and pH = 6.0 until the Hogland nutrient over 3~5mm of soil surface in each pot. The adjusted pH work did one time every week. Each treatment has four repeats.

Results The rhizobium number, seedling number, shoot weight, root weight and shoot height were higher in pH6.0 than pH4.5 under the treatments of Fe^{2+} contents between 100 mg/kg and 150 mg/kg after 40d growth. But they were lower in pH6.0 than pH4.5 among Fe^{2+} treatments of 10 mg/kg, 50 mg/kg and 200 mg/kg, except for rhizobium number. With the increase of Fe^{2+} content in medium, the rhizobium number, seedling number, and shoot weight significantly decreased ($p < 0.05$) in pH4.5, but the root weight and shoot height increased to highest value at Fe^{2+} content of 100 mg/kg and 50 mg/kg, respectively. There were no significantly difference ($p > 0.05$) about seedling number, shoot weight and shoot height among the Fe^{2+} contents of 10 mg/kg to 100 mg/kg in pH6.0, but were significantly higher ($p > 0.05$) than 150 mg/kg and 200 mg/kg. The rhizobium number significantly decreased ($p > 0.05$) with the increase of Fe^{2+} contents in pH6.0, while shoot weight significantly increased ($p > 0.05$) to highest value until Fe^{2+} content of 100 mg/kg, then significantly decreased ($p > 0.05$).

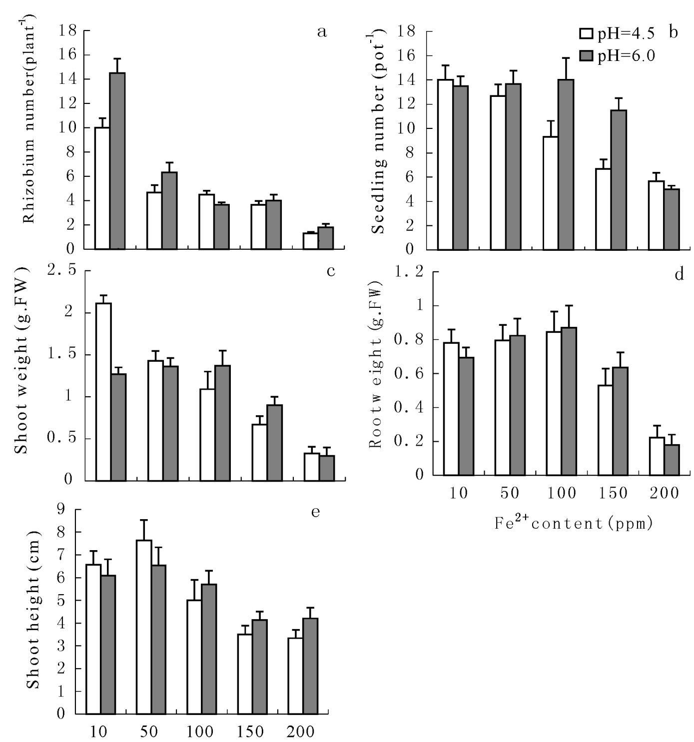

Figure 1 *Changes of rhizobium number, seedling number, shoot weight, root weight and shoot height on different pH and Fe^{2+} contents.*

Conclusions When the Fe^{2+} content of soil were less than 50 mg/kg, the growth of alfalfa did not restricted by Fe^{2+} and lower pH, but the growth of alfalfa were significantly restricted when the Fe^{2+} content was over 100 mg/kg in pH4.5, and over 150 mg/kg in pH6.0. The significantly decreased rhizobium number in pH4.5 may contribute to the yield losses of alfalfa in lower pH of native soil.

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Chemical composition of *Panicum maximum* planted with different manure sources

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Key words: pasture grasses, *Panicum maximum*, chemical composition, nitrogen fertilization

Introduction Factors such as species, season, spacing and fertilization among others have been identified as major factors affecting the nutrient content of forage grasses (Aken'Ova and Chedda, 1985). It is believed that careful manipulation of some of these factors could improve the nutritive quality of the grasses. Guinea grass (*Panicum maximum*) is a major feed resource for the Nomadic Fulani cattle during their migration in search of green feed to the southern part of Nigeria during the dry season. Adegbola (*et al*., 1980) reported that ruminant animals showed good acceptance, high intake and good digestion of the grass.

Materials and methods *Panicum maximum* local (Pm Local) and *P. maximum* Ntchisi (Pm Ntchisi) were established through crown splits at a spacing of 1×0.5 m^2 in June 2002 in a 1.5 ha paddock. The paddock was divided into six (0.25 ha each) plots and each was well fenced with sheep wire at the University of Agriculture, Abeokuta Teaching and Research farm. The six plots were divided into three sub-plots for the two grass species. Two plots for each species were fertilized with urea (150 kg/ha) and caged layer droppings (250 kg/ha) respectively and the third plot left as unfertilized control. Foliages were harvested from each of the six plots at 4 weeks after fertilization separately by cutting them back to 10 cm above ground level. Fresh samples were taken from each plot, weighed and transferred to drying cabinet at 65℃ for drying over 3 days. This was used to calculate the DM content of the samples. The dried samples were milled in hammer mill with 1.0 mm sieve and used for proximate (A. O. A. C., 1995) and fibre (Goering and VanSoest, 1970) analysis.

Results and discussion As shown in Table 1, there were reductions in the DM content of fertilized than unfertilized *P. maximum* stands though, the differences were not significant ($P > 0.05$). However, manure and urea fertilization significantly increased the nitrogen content of the grass over the unfertilized control. There was no significant difference ($P > 0.05$) between the effects of urea and caged layer droppings treatment in EE, Ash and NFE contents. Fiber parameters were significantly reduced ($P < 0.05$) due to manure additions. The values of NDF ranged between 40.60%-43.08% in unfertilized PM to between 36.20%-39.40% in fertilized samples. Also ADF was reduced significantly ($P < 0.05$) from between 34.60%-36.05% to a range of 24.66%-30.40%. ADL content was not affected by manure additions. The crude protein content of *P. maximum* obtained in this study fell within the range of 4%-14% reported by Butterworth (1985) and a range of 14.4%-16.9% reported for NPK fertilized *P. maximum* (Olanite *et al*. 2006). In contrary to most reports, CP content of both local and Ntchisi varieties of PM were similar. With CP content above 8.0%, fertilized PM could supply extra nutrients for optimum performance of ruminant animals. The fiber fractions viz NDF, ADF and lignin as reported in this study were lower than values reported elsewhere (Olanite *et al*., 2006; Butterworth, 1985), this could be due to the age at which the grass was cut.

Table 1 *Proximate and fibre composition of* Panicum maximum *under different manure fertilization*.

Parameter	Unfertilized		Urea fertilized		Caged layer droppings fertilized	
	PM Local	PM Ntchisi	PM Local	PM Ntchisi	PM Local	PM Ntchisi
Dry matter	14.1±0.21	15.8±0.60	12.9±0.11	12.6±0.50	13.5±0.55	13.0±0.60
Crude protein	12.1±0.35b	12.4±1.02b	16.1±0.22a	15.6±1.02a	16.8±0.50a	16.3±1.02a
Ether Extract	2.4±0.18	1.6±0.25	2.8±0.20	3.1±0.60	2.5±0.44	2.8±0.25
Ash	14.6±0.10	13.2±0.30	12.9±1.10	14.2±0.30	12.6±0.87	13.9±0.60
NFE	28.4±0.25	25.9±0.14	27.7±1.20	25.6±0.66	26.5±0.45	26.1±0.64
NDF	43.1±1.62a	40.6±1.05ab	39.4±1.02b	36.2±1.05b	38.9±1.15b	38.4±1.41b
ADF	36.1±0.88a	34.6±1.04a	24.7±1.25c	30.4±0.86b	28.9±0.50b	29.6±1.05b
Lignin	14.8±0.41	14.5±1.25	11.5±0.50	14.1±0.20	14.3±0.55	14.2±0.30

Conclusion With adequate manuring and short cutting intervals of about 4 weeks, optimum nutrient contents with high crude protein and low fibre are expected from both local and Ntchisi varieties of *P. maximum*.

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Critical plant and leaf N concentrations of an ageing timothy sward

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Key words : *Phleum pratense* , nitrogen , N nutrition index , model

Introduction Quantifying the level of N nutrition of grass swards requires the definition of a critical concentration , that is the minimum N concentration required to achieve maximum shoot growth . The critical plant N concentration [N_c ; g kg^{-1} dry matter (DM)] of a tall fescue sward was first defined as a function of shoot biomass (SB ; t DM ha^{-1}) ($N_c = 48.0 \times SB^{-0.32}$) by Lemaire and Salette (1984) ; this was later validated for timothy by B langer and Richards (1997) . The N nutrition index (NNI) is calculated by dividing the observed N concentration by N_c . The NNI was then successfully related to the leaf N concentration of the upper sward layer [Leaf N = 4 .0 + (37 .9 × NNI) ; Gastal et al . , 2001)] , hence making it possible to establish the N nutrition index by simply analyzing leaf N concentration . These models of critical plant and leaf N concentrations were determined on young swards (< 3 years) . Our objective was to determine the critical plant and leaf N concentrations of older timothy (*Phleum pratense* L .) swards .

Materials and methods Timothy (cv . Champ) was sown in 1998 at L vis , QC , Canada (46°47′N , 71°07′W) . The experiment included four rates of N fertilizer (0 , 60 , 120 , and 180 kg N ha^{-1}) applied each year prior to the start of growth in the first week of May from 1999 to 2006 . Timothy was harvested at four developmental stages (stem elongation , early heading , late heading , and early flowering) during spring growth . In the last three years (2004 , 2005 , and 2006) , DM yield was measured and 20 last fully emerged leaf blades were taken in each plot of this replicated experiement . Dried and ground samples of whole plants and leaves were used for the determination of N concentration .

Results Data points for which there was no significant yield increase with a higher rate of N fertilization were below the critical N curve previously validated for young timothy swards (Figure 1) . This critical N curve could not describe non limiting N conditions of this ageing (6-8 years old) timothy sward . A new critical N curve ($N_c = 39.2 \times SB^{-0.36}$) was then developed for older swards (Figure 1) . The N concentration of the last fully emerged leaf blades was strongly related to NNI derived from the new critical N curve [Leaf N = 12 .29 + (21 .12 × NNI) ; Figure 2] . This confirms previously reported results on ryegrass and tall fescue (Gastal et al . , 2001) .

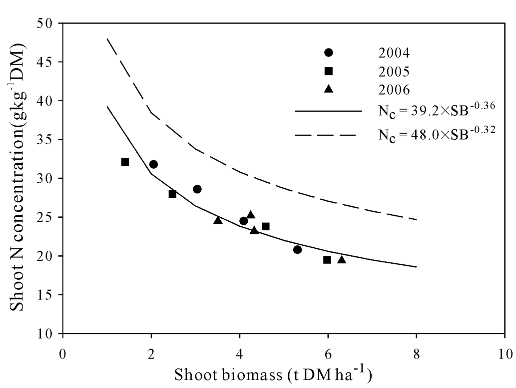

Figure 1 *Shoot N concentration as a function of shoot biomass of a 6-8 years old timothy sward . Dash line represents the critical N curve of Lemaire and Salette(1984) .*

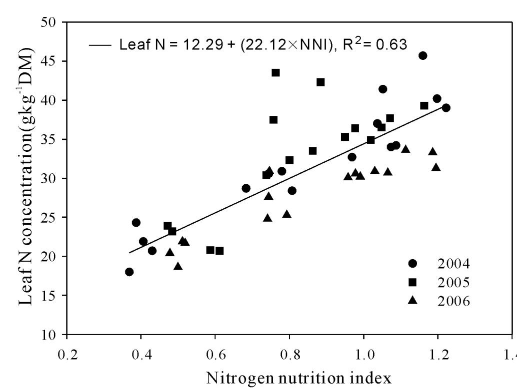

Figure 2 *Nitrogen concentration of the lastly fully emerged leaf blades as a function of the N nutrition index (NNI) of a 6-8 year old timothy sward .*

Conclusions A new critical N curve was developed for older (6-8 years old) timothy swards and the N concentration of the last fully emerged timothy leaf was a good indicator of the level of N nutrition of timothy .

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Effect of nitrogen fertilization and cutting management on the chemical composition of *Panicum maximum* Jacq in West Cameroon

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Key words: *Panicum maximum*, nitrogen fertilisation, cutting management, chemical composition

Introduction Ruminants' feeding in Cameroon is essentially based on the natural pasture. Nutrient content of grazing land forage varies as the growing season progress and can be influenced by soil qualities and the management strategies. In highly populated areas crop expansion reduce the extent of grassland, thereby jeopardizing the potential of ruminant to satisfy their need for maintenance and production (Pamo *et al*., 2006). The only alternative left for livestock producer, is forage cropping and sound management strategies. The main objective of this study was to evaluate the effect of nitrogen fertilisation and the cutting management on the chemical composition of *Panicum maximum* in West Cameroon.

Materials and methods The study was carried out at the Animal Experimental Farm of Dschang University from March 2006 to January 2007. Rainfall in this zone varies between 1500 and 2000 mm. The soil is classified as ferralitic, relatively acidic (pH = 5.7) and rich in organic matter. A 3×3 factorial design with 3 doses (0, 60, 80 kg/ha) of nitrogen in the form of Ammonium Sulphate at 21% N and 3 cutting frequencies (F1=30 days, F2=45 days, F3=60 days) at a height of 20 cm in 3 replicates was used. Seventy (70) tillers of *P. maximum* bearing one to two tali were planted on each plot, on the 7th April 2006 at a depth of about 4 cm, with a spacing of 25 cm by 25 cm. A single dose (100 kg/ha) of simple super phosphate at 21% P was applied in all plots. The ammonium sulphate was fractioned in two parts. The first one-third was applied in equal quantity one month after planting. The remaining two-thirds were divided in function of the number of cuts to be done excluding the last one. Two months after planting, the plots were zero timed at 20 cm above the soil and the harvest of regrowths started one month later and varied according to cutting management. Five hundred grams (500 g) sample were taken and oven dried at 60℃ till a constant weight was obtained and grinded for chemical composition using the A.O.A.C (1990) procedure. Two factors analysis of variance was carried out on the data and significant differences among treatments were tested with Duncan's multiple range tests.

Results and discussion Nitrogen fertilization had no significant effect on CP, CF, Ash and OM content of *Panicum maximum* (Tables 1). Cutting management had significant effect on the chemical composition of *P. maximum*. Taye (*et al*., 2007) obtained similar results, showing that cutting management significantly affects the nutritive value of forages. Nutritive value generally decreases as harvest interval increases (Maass *et al*., 1996). The CP content particularly decreased as cutting management increased. These results tie with those of Crowder and Chheda (1982) which showed that the CP of Panicum decreased with the age of the plant.

Table 1 *Mean CP, CF, Ash and OM content of* Panicum maximum *at different cutting frequencies and levels of N fertilisation.*

N (kg/ha)	Cutting management (days)	Chemical composition (% DM)			
		CP	CF	Ash	OM
0	F1: 30	15.14±2.22[a]	33.25±2.04[a]	13.66±0.98[a]	86.34±0.98[a]
	F2: 45	14.09±1.65[a]	34.41±1.65[a]	14.26±0.80[a]	85.74±0.80[a]
	F3: 60	12.14±2.51[a]	33.91±1.90[a]	15.32±2.03[a]	84.68±2.03[a]
60	F1: 30	15.20±2.58[a]	33.14±1.23[a]	13.81±0.85[a]	86.19±0.85[a]
	F2: 45	13.46±2.90[a]	33.07±0.89[a]	13.88±0.30[a]	86.12±0.30[a]
	F3: 60	11.58±2.09[a]	43.22±14.10[a]	13.21±0.81[a]	86.79±0.81[a]
80	F1: 30	15.53±3.01[a]	32.99±1.32[a]	13.34±0.91[a]	86.66±0.91[a]
	F2: 45	12.57±3.36[a]	32.94±1.62[a]	13.55±0.41[a]	86.45±0.41[a]
	F3: 60	11.80±2.41[a]	34.51±3.15[a]	14.09±1.85[a]	85.91±1.85[a]

Means in the same line with the same letters are not significantly different $p > 0.05$.

Conclusions Nitrogen fertilization had no significant effect on the chemical composition of *P. maximum*. Cutting management significantly affected the chemical composition of *P. maximum*, with the 30 days cutting management giving the best chemical composition.

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Effect of liming and mineral fertilisation on soil properties and long-term sward agrocoenosis productivity

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Key words: permanent meadow, liming, fertilisation

Introduction Long-term mowed sward ecosystems are the least affected anthropogenicaly. Soil under sward ecosystems is not tilled and the influence of agricultural implements is only superficial. Mineral fertilisers not only increase the productivity of sward phytocenosis (Daugeliene, 2002; Butkuviene, Butkute, 2004), but also result in changes of soil chemical properties and biogenic elements migration to deeper soil layers (Daugeliene, 2002; Gutauskas, Slepetiene, 2002). Little information has been available in Lithuania so far on the processes which occur in sward ecosystem soils and influence soil chemical indicators under fertilisation with natural substances. Considerable attention has to be paid to: (1) the amounts of biogenic elements, which influence soil chemical properties; (2) the productivity of sward phytocenosis.

Materials and methods Soil chemical indices were determined on 12-14 years of used sward agroecosystem situated in Western Lithuania. The soil was *Haplic-Luvisol (LVh)*, medium on light loam. Two soil pH_{KCl} levels: 5.1-5.5; 6.6-7.0 and two fertilisation backgrounds: $P_{60}K_{60}$ and $N_{120}P_{60}K_{60}$ were formed by liming and fertilisation. Two different sward types had formed: 1) white clover (*Trifolium repens L.*) + meadow-grass (*Poa pratensis L.*) sward-when fertilising with $P_{60}K_{60}$ and (2) uniform meadow-grass (*Poa pratensis L.*) sward—fertilising with $N_{120}P_{60}K_{60}$. Applied fertilisers: ammonium nitrate, bonemeal and potassium magnesium. Samples for soil chemical characteristics were taken from the upper 0~10 cm depth annually after grasses vegetation has finished. Soil samples were analysed using the following methods: pH_{KCl} ionometrically; N_{total} by Kjeldal method; mobile P_2O_5, K_2O, Ca and Mg by Egner-Riem-Domingo (A-L) method. Permanent grass dry matter (DM) yield of three cuts was determined.

Results and discussion The data from Table 1 shows that amounts of mobile Ca and Mg accumulated in the soil were the highest of all considered biogenic elements. Amounts of Ca in the soil with different pH_{KCl} levels differed by 2.3-3.0, Mg-by 1.6-1.9 times. It was determined by liming. The amounts of all considered elements in 5.1-5.5 pH_{KCl} soil were similar under both fertilisation cases. However, in soil limed to 6.6-7.0 pH_{KCl} lower amounts of mobile P, K and Mg were determined in $N_{120}P_{60}K_{60}$ background. 6.6-7.0 soil pH_{KCl} is more suitable for grasses growth, the availability of nutrients is better; therefore, the observed differences occurred.

However the standpoint to agriculture would change, meadow yields still remain the main farming outcome. Even after 12-14 years, liming affected DM yield, but only on meadow fertilised with $P_{60}K_{60}$ (DM yield higher by 22%). When balanced NPK rates were applied, DM yield was similar (difference only 3%) on both meadows arranged on 5.1-5.5 and 6.6-7.0 pH_{KCl} soil. Meadow was less productive under $P_{60}K_{60}$ fertilisation than under $N_{120}P_{60}K_{60}$. The study showed that N fertilisation still is the key factor providing higher DM yields.

Table 1 *Effect of liming and fertilisation on biogenic element amounts in the soil and grass DM yield, 2003-2006.*

Soil pH_{KCl}	N_{total}, %	P_2O_5, mg kg^{-1}	K_2O, mg kg^{-1}	Ca, mg kg^{-1}	Mg, mg kg^{-1}	DM yield, t ha^{-1}
$P_{60}K_{60}$						
5.1-5.5	0.14±0.01	95±18	142±5	1584±63	184±11	2.64±0.33
6.6-7.0	0.15±0.01	145±14	157±14	4765±145	358±27	3.23±0.46
$N_{120}P_{60}K_{60}$						
5.1-5.5	0.14±0.00	107±26	146±10	2094±125	200±23	4.84±0.61
6.6-7.0	0.15±0.02	129±14	133±10	4760±328	313±33	4.98±0.72

Conclusions Comparing the amounts of biogenic elements the present study showed, that ~30% of legumes in meadow on soil adjusted to 6.6-7.0 pH_{KCl} and fertilised with $P_{60}K_{60}$ can substitute N_{120} rate. However, application of balanced rates of NPK fertilisers provides comparatively higher DM yield. Liming significantly improved soil chemical properties, nutrient availability in all cases and DM yield of meadow fertilised with $P_{60}K_{60}$.

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Effect of sod-production on soil qualities in Beijing areas

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Key words : Sod-production ; Soil quality ; Soil fertility ; Soil structure ; Soil texture

Abstract Two sod-production farms were investigated to make it clear how sod production effects on soil quality . The results showed that the soil chemical property had not been influenced by sod-production . From the observation of soil profile , about 10cm fertile topsoil was taken away by 7 years sod-production on Dongbeiwang Nursery . Compared with the control , the bulk density of topsoil was increased and the porosity was decreased on both nurseries . It means the topsoil in the production of sod became compact , which was mainly caused by rolling . The results of particle size distribution showed that sod-production had no effect on the improvement of soil structure .

Introduction Sod is a common material for turf establishment . The fast development of sod production has been taken place in Beijing Areas since 1990 . There are about 200 sod farms covering about 250 hectares . With the coming of 2008 Olympic Games , about 80% of turf is established by sod in Beijing now . In order to evaluate the effect of sod-production on soil quality , two typical sod farms in Beijing Areas were investigated to compare the soil physical and chemical properties with other farms .

Materials and methods Dongbeiwang Nursery (DN) and Changping Xiaotangshan Nursery (CXN) were investigated . These had been in sod-production for Seven years and two years , respectively . The representative soil samples were collected for analysis of soil chemical and soil physical properties . Soil profiles were evaluated on two nurseries .

Results and discussion The soil pH was 8.38-8.57 . The results of organic matter , soil available nutrients and cation exchangeable capacity (CEC) showed that there was no significant difference between sod plots and tree plots (as Control) on two nurseries . The description of soil profiles on DN was shown in Table 1 . About 10cm fertile topsoil was taken away by 7 years sod-production on DN and no difference was observed on CXN . Compared with control , the bulk density of topsoil was increased and the porosity was decreased on two nurseries (Table 2) . The significant difference was observed on DN . It means the topsoil in the production of sod became compact , which was mainly caused by rolling . The results of particle size distribution showed that sod-production had no effect on the improvement of soil structure . To make comprehend-sive and accurate evaluation , further research should be done , such as the change of soil microbe in sod-production .

Table 1 *Description of soil profiles (0-50cm) on Dongbeiwang Nursery .*

Site	Soil Layer(cm)	Description of soil characteristics
Sod Plot	0—15	Dark Brown , Light Loam , More Roots
(7years)	15—25	Brown , Light Loam , Fewer roots
	25—50	Yellow Brown , Medium Loam , Very Few Roots
Tree Plot	0—35	Brown , Light Loam , More Roots
(Control)	35—50	Yellow , Medium Loam , Fewer Roots

Table 2 *Bulk density and total porosity of topsoil (0-20cm) on two nurseries .*

	Site	Bulk Density (g/cm^3)	Total Porosity(%)
DN	Sod Plot (7years)	1.66±0.09a*	36.9±3.4b
	Tree Plot (Control)	1.42±0.06b	46.0±2.5a
CXN	Sod Plot (2years)	1.60±0.06a	38.4±2.2a
	Tree Plot (Control)	1.52±0.07a	41.7±2.9a

* Note :Different letters in the same row indicate significantly difference at $p<0.05$.

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Response of spatial distribution of phosphorus in soil to wetlands restoration in Yellow River

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Key words : spatial distribution ; phosphorus ; recovery wetlands ; un-recovery wetlands ; YRD

Introduction Phosphorus can notably influence the productivity and reflect the level of nutrition in wetland .The contents of phosphorous were influenced by many factors such as soil depth , submerging conditions , salt contents and other nutrients (Guo , 2000) , and reversely influenced the salinity and the distribution of other nutritive elements . Phosphorous was also concerned as one of the major elements related to degeneration of wetland ecosystems (Kuo , 2005) . In order to clarify the response of spatial distribution of phosphorus to the restoration of wetlands , the different spatial distributions of phosphorus in soil profiles before and after recovery were studied in this paper mainly .

Materials and methods This study was conducted at Yellow River Delta (YRD , 37°35′ to 38°12′N , 118°33′to 119°20′) ,which is located on the west coast of Bohai Sea , Shandong province . In May and June of 2005 , 8 sampling sites were selected both in restored site and the control site . Soil profiles were stratified for sampling at intervals in a total of 70cm depth as follows : 0-10cm , 10-20cm , 20-40cm , 40-70cm . The soil sample were randomly collected from 5 spots according to their depth in each sample plot and mixed well . All soil samples were analyzed by using standard methods .

Results and discussion The contents of phosphorus were comparatively low in both regions (0 .356-0 .691g/kg) . The phosphorus contents in restored iste were higher , while the variation in the control site was larger . The phosphorus contents in surface soil were obviously lower than other layers . Among soil profiles , the significant variation was observed on the middle layer soil , while no significant difference was found on other layer soil g . After restoration , the surface soil was submerged under water , this inundation enhanced the leach of phoshorus . After inundation , the pH values and Fe contents in soil profiles increased . Those increases resulted in the increased fixation of soil , leading to decreased release and validity of phosphorus . This is why the phosphorus contents of in the underground layer soil (10-20cm , 20-40cm) from restored site were slightly higher than the control . The correlation analysis among total P , pH , salt content and soil moisture in both sites showed that the contents of phosphorus had positive correlation with pH and negative correlations with both salt content and soil moisture .

Conclusion The results obtained from this study that contents of phosphorus were higher and more stable in submerging condition confirm that wetlands restoration can enhance the leaching process of rainwater or surface pond water , increase soil fixation , lower the release and depress the validity of phosphorus . Wetlands restoration is the accumulation of phosphorus .

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Biological ways to improve the production of forage pea for use in the animal feed industry

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Key words: forage, pea, bacterial fertilizers, nutrient uptake

Introduction In grassland farming relatively large amounts of chemical fertilizers are applied. It is clear that the situation could be largely improved if the use of chemicals would be replaced by environmentally friendly biologicals together with leguminous plants (Lugtenberg et al., 2004). Legumes such as pea can supply not only a good source of protein for livestock, but can also provide a cheap source of nitrogen to support grass production, and improve soil organic matter through decaying nodules (Lascano, 2001). The objectives of this work was to monitor the effect of inoculation of soybean and peas with *Rhizobium* and nitrogen fixing bacterial strains, so as to find and develop the most effective bacterial fertilizers for growing peas under nutrient deficient salinated soil of Uzbekistan.

Material and methods Experiments were carried out in arable fields of Tashkent province, north-eastern part of Uzbekistan, characterised by a calcareous serozem soil (1% organic matter; 0.6 mg N 100 g^{-1} soil; 3.0 mg P 100 g^{-1}; 12 mg K 100 g^{-1}; 6 mg Mg 100 g^{-1} soil; pH 7.4). Pea (*Pisum sativium*) seeds and bacterial strains *Pseudomonas alcaligenes* 15, and *Rhizobium meliloti* 39 were used for this study. The bacteria were formulated with peat and seeds were inoculated with bacterial inoculants. Plants were grown in open field conditions with a temperature of 36℃ to 38℃ during the day and 20℃ to 24℃ at night. Five weeks after germination, shoots and roots were separated and dried at 105℃ before determining the root and shoot dry weight and N, P, K content of plant. The data were analysed with an ANOVA and Student-Newman-Keuls test for testing the significant differences ($p<0.05$) of main effects.

Results The results showed that bacterial inoculants *Pseudomonas alcaligenes* 15, and *Rhizobium meliloti* 39 increased shoot and root dry matter of pea significantly from 28% to 38% as compared to the control. Shoot growth increased more than root growth. This increase in biomass translated into significantly higher N, P, and K contents (Table 1). They increased N up to K and P uptake significantly. The bacterial strains were capable of fixing atmospheric N, and were able produce auxin.

Table 1 *The influence of effective bacteria strains on root and shoot nutrient uptake of pea on a calcisol (pot experiment, mean and standard deviation of 6 replicas per treatment, control= 0.0268 N mg/shoot, 0.0076 N mg/root; 0.0021 P mg/shoot, 0.0007P mg/root; 0.0194 K mg/shoot, 0.0046 K mg/root (100%)).*

Bacterial Strains	N		P		K	
	Shoot	Root	Shoot	Root	Shoot	Root
Control	100 (0.0082)[1]	100 (0.0067)[1]	100 (0.0019)[1]	100 (0.0283)[1]	100 (0.0225)[1]	100 (0.0311)[1]
P. alcaligenes 5	112	132*	129*	126*	111	118*
Rhizobium meliloti 39	114*	115*	129*	109*	110	110
LSD< 0.05	12	15	14	14	12	14

[1] g/pot
Significantly different from the control for $P<0.05$.

Conclusion The results obtained in our work can have potential applications of bacterial inoculants as bio fertiliser for increasing the productivity of peas as forage crops under N poor soil conditions of Uzbekistan.

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Residue effects of animal manures on forage production and soil fertility after receiving long term of manure application

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Key words: Residue effect, Forage yield, Soil fertility, Manure.

Introduction Application of animal manures in soil is important to improve soil fertility and maintain forage productivity. The objectives of this study were to determine the residue effects of animal manures on forage yield and quality of pangolagrass (*Digitaria decumbens* Stent.) and soil fertility after receiving long term of manure application.

Materials and methods An experimental field of pangolagrass receiving 7 years of cattle and hog manure application was used. Six fertilizer treatments were applied, i.e., no fertilizer, chemical fertilizer applied yearly with $N : P_2O_5 : K_2O = 400 : 144 : 150$ kg/ha, cattle or hog manure equivalent to N 400 kg/ha, and one half of N replaced by cattle or hog manure. The plots were applied with the same amount of chemical fertilizer after receiving 7 years of different fertilizer treatments. Dry matter yields, the chemical contents of plant and soil of pangolagrass were determined.

Results and discussion Dry matter yields, the uptakes of N, Cu, and Zn of pangolagrass were higher in the plots received cattle or hog manure. The plot receiving only hog manure had the highest uptakes of N and Zn. The pH values, the electric conductivity and the contents of organic matter in soil for the plots with manure were higher than those with chemical fertilizer and no fertilizer (Table 1). Hsu et al. (1999) indicated that manure increased in pH values in soil. This study also confirmed that the residue of manure application could prevent acidifying in soil. Hsu et al. (2005) reported that the mineral uptakes of plant increased with applying composts of animal wastes in pangolagrass pasture.

Table 1 *Residue effects of animal manures on forage yield and soil fertility of pangolagrass after receiving long term of manure application.*

Treatment	Dry matteryield	Mineral uptake of plant			Soil fertility		
		N	Cu	Zn	pH	Electric conductivity	Organic matter
	Mg/ha/year	kg/ha	------g/ha------			dS/m	%
No fertilizer (0)	20.7b[*]	49.7c	0.60d	4.02d	4.82cd	0.160b	1.25b
Chemical fertilizer (1)	22.9a	204.1b	0.75d	4.32d	4.75d	0.170b	1.17b
Cattle manure (1)	23.3a	215.5b	1.05c	6.09c	5.74a	0.265a	1.96a
Cattle manure (1/2)+ Chemical fertilizer (1/2)	21.7a	214.9b	1.39ab	5.02cd	5.37b	0.263a	1.79a
Hog manure (1)	23.9a	300.9a	1.21bc	9.66a	5.09bc	0.230ab	1.40b
Hog manure (1/2)+ Chemical fertilizer (1/2)	21.7a	218.8b	1.63a	7.91b	5.03b	0.258a	1.41b

[*] Means with the same letter in the same column are not significantly different at 5% level by MRT.

Conclusions The results showed that the residue effects of long term manure application could improve soil fertility and maintain forage productivity. It was helpful for the management of sustainable agriculture.

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The soil improvement effect of afforestation in grassland
——take Gegentala grassland as example

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Key words : afforestation in grassland , soil fertility , nutrient content , soil improvement effect , preserve

Introduction As an important terrestrial ecosystem , grassland plays an important role in maintaining soil functions , nutrient cycling , and maintaining biological diversity . However , due to over-use and over-grazing , some grasslands have degenerated and become desertified , As a result , the production capability is often reduced year by year , and the development of animal husbandry has been hindered seriously . Afforestation in grassland can improve the ecological environment , mitigate natural disasters and improve yield and quality (Jianquan Yu ,2000) . Therefore , it is necessary to study the effect of afforestation on soil improvement in grasslands to better understand its role on soil and water conservation .

Materials and methods The site was in Gegentala grassland which is in the continental monsoon climate zone , with a zonal chestnut soil , and semi-arid grassland vegetation . The forest species was elm with a row spacing of 1m×2m and stand age was 33 . Samples were collected in the 0-5 cm layer of soil inside the forest , on both the windward and leeside of the forest edge with quadral respectively . The samples were air-dried and sieved (0 .25 mm) , nutrient content was measured using conventional analysis methods , with three replications .

Results Nutrient content is an important feature in representing soil fertility , from Table1 , soil nutrient content internally was significantly higher than outside . With the increase in distance from the forest edge , soil nutrient (except total phosphorus) levels showed a decreasing trend . At the same time , soil pH was lower than in grassland . All this suggests afforestation in grassland can improve soil fertility .

Table 1 *the influence of afforestation in grassland on soil nutrient content .*

position	Soil layer(cm)	total nitrogen (%)	Total phosphorus (%)	organic material (%)	pH
Internal	0-5	0 .41	1 .21	0 .67	7 .92
Windward of (5m)	0-5	0 .33	1 .29	0 .65	8 .58
windward (50m)	0-5	0 .32	1 .27	0 .64	8 .37
windward (100m)	0-5	0 .2	1 .33	0 .51	8 .43
leeside (50m)	0-5	0 .47	1 .71	0 .92	8 .3
leeside (150m)	0-5	0 .26	1 .52	0 .86	8 .6

Conclusions Afforestation in grassland can improve the soil nutrient status , and the effect on the leeside is better than that on the windward side . Reasonable afforestation in grasslands had a positive role in protecting grassland soil .

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Effect of grazing on soil structure and consequences for soil mechanical and hydraulic properties in Inner Mongolia

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Key words: grazing intensity, soil structure, hydraulic and mechanical properties

Introduction Animal trampling can strongly affect soil physical properties. Destruction of soil structure caused by animals leads to increase in soil bulk density followed by an increase in surface runoff. Grazing can cause changes in pore functions which affect the hydraulic properties of the soil. Stresses exerted by trampling can also lead to changes in soil mechanical strength. The soil physical properties can be affected much more when considering arid climate conditions. The objective of this study was to investigate how the animal trampling can affect soil physical (hydraulic and mechanical) properties in an Inner Mongolia grassland ecosystem with different grazing intensity, with different moisture conditions.

Materials and methods The effect of trampling by sheep and goats on physical (hydraulic and mechanical) properties of grassland soils on the steppe in Inner Mongolia, was investigated. The samples were collected from two different steppe ecosystems (*Leymus chinensis steppe and Stipa grandis steppe*). The samples were taken from sites with different grazing intensities: ungrazed since 1979 (UG79), ungrazed since 1999 (UG99), winter grazed (WG) and overgrazed (OG) at the *Leymus chinensis* site and ungrazed since 1979 (SG UG79) and continuously grazed (SG CG) at the *Stipa grandis* site. The studied soils were derived from aeolian sediments above acid volcanic rocks. From each site soil samples, for measurements of soil hydraulic and mechanical properties, were taken.

Results The soil hydraulic functions and soil mechanical properties were affected by grazing. It was found especially for the top soil. The animal trampling caused a decrease in soil total porosity and an increase in soil bulk density. The saturated hydraulic conductivity was lower for the grazed sites compared to ungrazed sites. Grazing caused a reorganization of soil particles which resulted in decreased soil air permeability. Furthermore, animal trampling affected soil sensitivity and intensity of shrinkage. Grazing also affected soil mechanical properties by changing the precompression stress values which were higher for the grazed sites compared to ungrazed.

Conclusions The results show that grazing can strongly affect soil physical (hydraulic and mechanical) properties. Animal trampling causes soil structure deterioration, especially in the top layer of the soil. Changes in soil structure due to grazing affect soil functions as well as plant productivity.

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Clopyralid uptake of contaminated compost-fertilised corn

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Key words: clopyralid, compost, corn, LC/MS/MS analysis

Introduction It has been reported (Sato, 2006) that the cases uncertain cause abnormal growth in horticultural crops (e.g.. tomato eggplant) is generated. In the present investigation, clopyralid (3,6-dichloropyridine-2-carboxylic acid, Figure 1) was detected in cow excrement compost and it's materials feeds. Clopyralid is not registered as an agricultural chemical in Japan. It is uncertain how the chemical was detected in Japan despite not being used. Graminaceous plants have low sensitivity for clopyralid. So, there is the possibility of circulation in the food chain (i.e. imported feed-cattle-fescue-compost-corn). To clarify the likelihood of the circulation, the effect of fertilizing a clopyralid-contaminated compost on the clopyralid uptake of corn was investigated someone two different soil types.

Materials and method The corn seed was sown in the plastic pots (L560 mm, S260 mm, H170 mm) filled with the soil, compost and activated carbon (Wako Pure Chemical Industries, Ltd Osaka, Japan). The details are summarized in Table 1 (one seed per pot, with each treatment being performed in triplicate). The concentration of clopyralid in the compost was 73 μg/kg. Corn was grown in the greenhouse for 65 days, being kept at 20-30℃. Sampling was carried out just before the heading stage at least 5 cm above the soil. Corn samples were cut at 5-10 cm, mixed, and the 30 g of FM were used for the clopyralid quantified analysis by LC/MS/MS.

Table 1 *Experiment treatments for measuring uptake of clopyralid from the soil to the corn.*

No.	soil type	soil amount (kg/pot)	clopyralid-contaminated compost amount (t/10a)	activated carbon amount (t/10a)
1	andosol	20	0	0
2	andosol	20	3	0
3	andosol	20	10	0
4	andosol	20	10	1
5	sandy soil	20	10	0

Results and discussion The results of the uptake experiment are shown in Figure 1. Clopyralid was not detected (< 2 ng/g FM) in the corn grown in soil without clopyralid contaminated compost (T1). This result showed that there was uptake of clopyralid via air. Clopyralid was detected in the corn grown used clopyralid contaminated compost for fertilizer (T2-T5). When compared to T2, the amount of clopyralid in the corn was 2.3 times higher in T3. Since T3 applied 3.3 times as much clopyralid as T2, it would suggest that the amount of clopyralid in the corn is dependant on the amount of clopyralid-contaminated compost, at the concentration level used here. The addition of active carbon (T4) lowered the amount of clopyralid uptake in the corn relative to T3. The amount of clopyralid in the corn grown in the sandy soil (T5) was much higher than that in andosol (3). Two causes of this are conceivable: 1) the difference in the adsorption ability of the soil, and 2) the difference in the activity of microorganisms in soil that break down clopyralid.

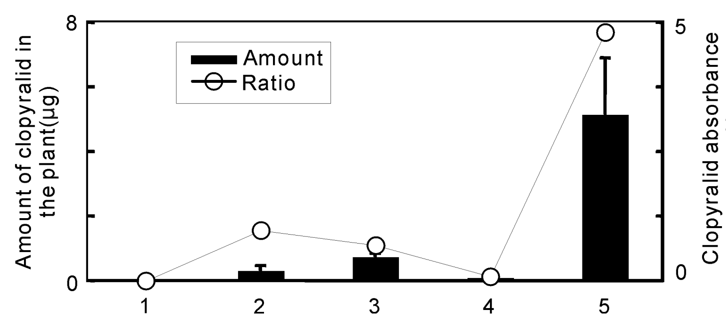

Figure 1 *Amount of clopyralid in the corn (bar; left scale). Ratio of uptaked clopyralid (sequential line; right scale). Errar bars shows standard deviation.*

Conclusion The uptake of clopyralid to corn was dependant on compast fertilization rates and the nature of the soil. Thus, the possibility of the circulation is also varying according to the nature of the soil.

Long-term phosphorus fertilization and perennial legumes addition impacts on a temperate natural grassland : II . Total and particulate soil organic carbon .

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Key words : Natural grassland , improved pastures , P fertilization , legumes , soil organic carbon .

Introduction Soil organic carbon (SOC) is a critical soil quality indicator and its pools have different functional roles in agroecosystems . Natural grassland improved with perennial legumes and P fertilizers is a rare production system in the world . We evaluated long-term P fertilization and perennial legumes inclusion effects on SOC and particulate organic C (C-POM ; 53-2000 μm) in a natural grassland of Uruguay .

Materials and methods We analyzed a 30 ha experiment in a Typic Argiudol of Uruguay (33°14′58″S , 54°29′24″W) . A randomized complete block design with five replications was used . Treatments were : natural grassland (NG) , and natural grassland overseeded with *Trifolium repens* L . and *Lotus corniculatus* L . fertilized with 30 (IP_{30}) , or with 60 kg ha^{-1} yr^{-1} of P_2O_5 (IP_{60}) during 9 yrs . After the 9th year , soil samples were collected to a depth of 0-5 and 5-15-cm , dried , dispersed and passed through sieves of 2000 , 200 and 53 μm (Cambardella and Elliot , 1992) . Soil remaining on the 200 and the 53 m sieves (coarse and fine C-POM , respectively) and the one passing all sieves (mineral-associated organic matter , C-MAOM) was analyzed for total C using the Mebius method (Nelson and Sommers , 1982) . Orthogonal contrasts were used to make comparisons among treatments , NG vs . IP_{30} and IP_{60} average (IP) , and IP_{30} vs . IP_{60} . The level of significance for the statistical test was 0 .1 .

Results and discussions Overall ,there were no treatments effects on SOC at 0-15-cm depth after 9 yrs (mean : 21 .2 g C kg^{-1}) . However , treatments affected SOC by depth and C pools (Table 1) . On average , IP had 8% higher and 11% lower SOC compared to NG at 0-5-cm and 5-15-cm depth , respectively . On the other hand , IP had 40% higher C-POM ($p < 0.01$) and surprisingly 15% lower C-MAOM ($p < 0.01$) than NG at 0-15-cm . As expected , a significant C-POM increase of 40% in the 0-5-cm depth was observed in IP relative to NG . In this layer , C-POM represented 46% of total SOC in IP but only 35% of total SOC in NG . Similarly , C-POM , that represented 21% of the total SOC in IP and only 13% in NG at 5-15-cm , was 40% higher in IP than in NG . Unexpected , IP had 9% and 19% lower C-MAOM than NG at 0-5-cm and 5-15-cm depths , respectively . Finally , no significant differences either on SOC or C pools were found between IP_{30} and IP_{60} at any depth . The SOC stratification , C-POM increase and C-MAOM drop in IP relative to NG , were probably related with the greater biomass production , lower biomass C-N ratio and the changes in the root system distribution observed in IP . These results are in agreement with Palm et al . (2001) and Metherell (2003) that shown that increased availability of nutrients results in increased quality of the litter input and reduces the recalcitrant pool of SOC .

Table 1 Perennial legumes addition and long-term P fertilization (30 and 60 kg P_2O_5 ha^{-1} yr^{-1}) impacts on soil organic carbon (SOC) and particulate organic C fractions (C-POM) in a temperate natural grassland of Uruguay after 9 years .

Soil Depth	(0-5-cm)			(5-15-cm)		
Treatment	SOC	C-POM (2000-200 μm)	C-POM (200-53 μm)	SOC	C-POM (2000-200 μm)	C-POM (200-53 μm)
	g C kg^{-1}					
Natural Grassland	32 .67b[†]	7 .68b	3 .83b	15 .80a	1 .41b	0 .70b
Improved Pasture 30 kg P_2O_5	36 .02a	11 .44a	5 .15a	13 .96b	1 .75a	1 .33a
Improved Pasture 60 kg P_2O_5	34 .73a	10 .81a	4 .87a	14 .11b	1 .73a	1 .12a

[†] Means followed by the same letter within a column are not significantly different at $P \leqslant 0.1$ level .

Conclusion The aggregate of data suggest that for temperate NG on undegraded soils , improved pastures with overseeded legumes and P fertilizers may sustain SOC in the long term . However , excessive SOC stratification , basically due to C-POM rise , and C-MAOM drop on IP are issues that may need further attention in the future .

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Changes in inorganic ion accumulation and growth of *Leymus chinensis* community along the retrogression on the Songnen grassland in northeastern China

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Key words: *L. chinensis*, retrogressive succession, salinity and alkalinity gradients, inorganic ion accumulation, quantitative characteristics

Introduction Songnen grassland is one of the main districts in which Chinese saline-alkali soil concentrates. *L. chinensis* community grassland occupies 65% of total grassland area in the Songnen Plain. The strong rhizomes of *L. chinensis* adapt to saline-alkaline and dune conditions. Through Na^+, K^+, Ca^{2+}, Cl^-, NO_3^-, SO_4^{2-} accumulation and ratio, we tried to find the adaptability of *L. chinensis* growing naturally along the grassland retrogressive process.

Material and methods This research was conducted in the grassland ecosystem experimental station of NENU (44°30′ – 44°45′ N, 123°31′ – 123°56′E). Five plots were selected for sampling, according to the different degree of retrogressive succession. In the middle ten days of July, the full expanded leaves, rhizomes and soil samples of each plot were collected to measure pH, EC, Na^+, K^+, Ca^{2+}, Cl^-, NO_3^- and SO_4^{2-}. Using routine methods, the density, height, and biomass of L. chinensis community were determined (Shi lianxuan, 2006).

Results Along the salinity and alkalinity gradient, the soil pH and EC significantly increased. Plant density, height, dry mass, and underground dry mass of *L. chinensis* community were determined in different retrogressive stages, and they were significant and negatively correlated with the soil pH and EC (Figure 1). Along with the retrogression, Na^+, Cl^- and NO_3^- of leaves were increased; K^+, Ca^{2+} and SO_4^{2-} were decreased. Contrarily, K^+, NO_3^- and SO_4^{2-} of rhizomes were significantly increased (Figure 2). Through analyzed SA and ST, it retained a steady-going level during the plot 2, plot3 and plot 4 (Peng Yanhui, 2004).

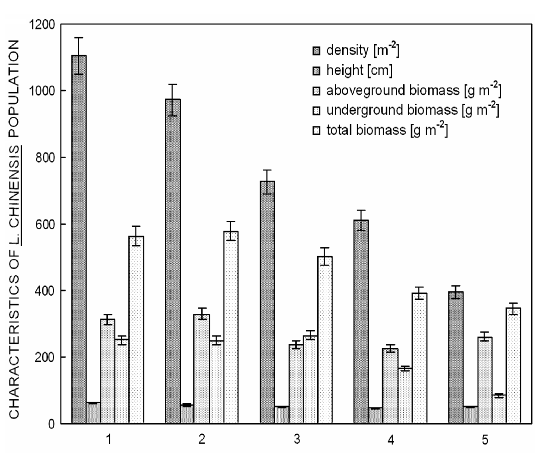

Figure 1 *Changes in quantitative characteristics of* L. Chinensis *community.*

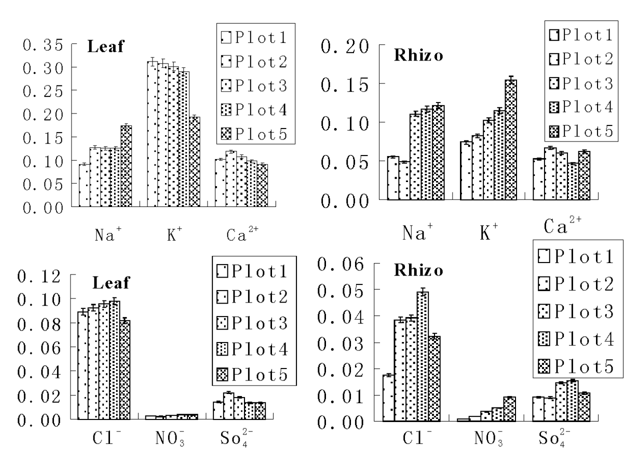

Figure 2 *Changes in inorganic ion accumulation of* L. Chinensis *along retrogression on the Songnen grassland. Unit: (mmol · g⁻¹ DW).*

Conclusions The rhizome of *L. Chinensis* could selectivity absorb K^+, not Na^+ in the certain salinity and alkalinity gradient. In the same way, *L. Chinensis* could specially transport K^+ from the rhizome upto the plant, and restrain Na^+. Furthermore, *L. Chinensis* could accumulate Cl^- and NO_3^- in leaves and rhizomes, so that can resist the stress of Na^+. (Yanhui Peng, 2004)

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Plant species composition and soil microbial community structure in a semi-natural grassland in Japan

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Key words : DGGE , plant functional types , soil chemical properties , soil microbial community

Introduction Plants and soil biota have a strong functional linkage as producers and decomposers of terrestrial ecosystems . However , structural associations between aboveground and belowground communities have not been well clarified . We examined plant species composition , soil properties (N availability , P_2O_5 , pH , water content , total C and N%) and soil bacterial and fungal community composition in a semi-natural grassland in northern part of Japan . The objective of this study is to clarify how microbial community structure is associated with aboveground vegetation structure and local soil environments in semi-natural grassland .

Materials and methods The study was conducted in semi-natural grassland in Shiriyazaki (41°25′N and 141°26′E) located on northern Honshu , Japan (Hossain et al 2007) . Thirty sites were selected at 50m interval along a 1 .5km-long transect line and vegetation height and relative coverage of component species were examined in a 1×1 m plot at each site . Plant species were classified into four functional types : C_4 grasses , C_3 grasses , legumes , and forbs . Soil samples (40×40×60 mm deep) were then collected from the center of each plot , and soil pH , water content , N mineralization rate , soluble P_2O_5 content and total C and N % were measured . Soil bacterial and fungal community compositions were evaluated by denaturing gradient gel electrophoresis (DGGE) of 16S and 18S rDNA fragments and band pattern was analyzed by principal coordinate analysis (PCO) based on Jaccard similarity indices generated from binary data .

Result and discussion Soil pH ranged from 5 .87 to 7 .52 , and soil C/N ratio ranged from 10 .6 to 15 .2 . Plant species richness (m^{-2}) ranged from 6 to 24 and was negatively correlated with soil phosphorus (P) content ($r=-0.409^*$) , which was negatively correlated with the proportion of forb species and positively correlated with the proportion of C4 species . These results show that low soil P content leads to the dominance of forb species and resulting high species richness . Bacterial PCO1 scores , which represents community composition , showed significant correlations with soil pH ($r=0.714^{**}$) and soil C/N ratio ($r=0.606^{**}$) . On the other hand , fungal PCO1 scores showed significant correlations with the proportion of C3 species ($r=-503^*$) and with soil C/N ratio ; fungal PCO_2 scores showed significant correlations with soil total C% ($r=r=0.515^*$) and N% ($r=0.476^*$) . These results suggest that bacterial community structure is largely influenced by soil pH , while fungal community structure is influenced by plant species composition and soil organic matter content .

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Nitrogen losses through denitrification from a grazed pasture as affected by the use of a nitrification inhibitor

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Key words : Denitrification , nitrogen losses , grazed pastures , dicyandiamide (DCD)

Introduction Denitrification is an agriculturally important soil process , since it can decrease the availability of mineral N in soil for plants and can therefore cause N use inefficiency and reduce agricultural production . Additionally , nitrous oxide (N_2O) , one of the gaseous products from denitrification , contributes to global warming . Studies have shown that soil denitrification and N_2O emission rates are highly variable , with high rates being associated with animal grazing and high nitrate concentrations in grazed pastures (Luo *et al* . 2000) . Nitrification inhibitor , dicyandiamide (DCD) , has been used to inhibit the nitrification process and to reduce nitrate concentrations in soil . As a result of reduced nitrate concentrations , denitrification rates could be reduced . However , there is little information available on effects of DCD use on denitrification rates under grazed pastures . The aim of this study was to determine the effects of the use of DCD on denitrification rates under a grazed pasture .

Materials and methods The experiment was conducted at Scott dairy farm near Hamilton in New Zealand from May to September 2007 . The characteristics and details of the soil have been previously given (Luo *et al* . 2008) . The study site was under a ryegrass/white clover pasture and was rotationally grazed by cows . In the first experiment , in May 2007 , the study paddock was grazed by cows at a stocking rate of about 100 cows ha^{-1} for 24 hours . In the second experiment , in July 2007 , the grazing was repeated on an adjacent paddock at a stocking rate of about 200 cows ha^{-1} for 24 hours . Immediately after grazing , DCD was applied at a rate of 12 kg DCD ha^{-1} onto part of the grazed paddock . The rest of the paddock received no DCD and acted as a control . Measurements of denitrification rates from the DCD applied and control areas were continued for two months for each experiment . The denitrification rates were measured using the acetylene inhibition technique , by incubating minimally disturbed soil cores in a closed system under field conditions (Luo *et al* . 2000) . The concentration of N_2O in the gas samples was determined using a Shimadzu GC-17A gas chromatograph .

Results and conclusions The rate of denitrification increased after grazing in May , reaching a maximum at around 10 days , and then declined (Figure 1) . The rates were lower from the DCD treated soil than from the control soil on several sampling occasions . By the end of the 2 month measurement period , the denitrification rates in the control had declined to levels similar to those measured before grazing . However , after this time the denitrification rates from the DCD treatment were still higher than before grazing . Although the patterns of denitrification rate following the grazing in July were similar to those following the grazing in May , the magnitude of the peak rates was much higher due to the higher stocking rate and to the fact that there was more rainfall after July (data not shown) . Spatial variations in denitrification rates were large . Coefficient of variation values for the daily measured rates among the 4 replicates were up to 150% . The large variation is likely to have been caused by unevenly distributed excretal returns from grazing cows in grazed pastures . Over the measurement periods , the total denitrification N losses from the DCD treatment were lower than those from the control (Figure 2) . The lower rates from the DCD treatment were likely to be due to the lower nitrate N concentrations which resulted from the inhibition effect of DCD on nitrification in the soil .

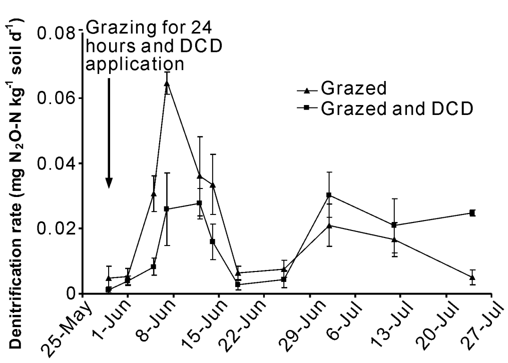

Figure 1 *Denitrification rates following a grazing event in winter 2007 .*

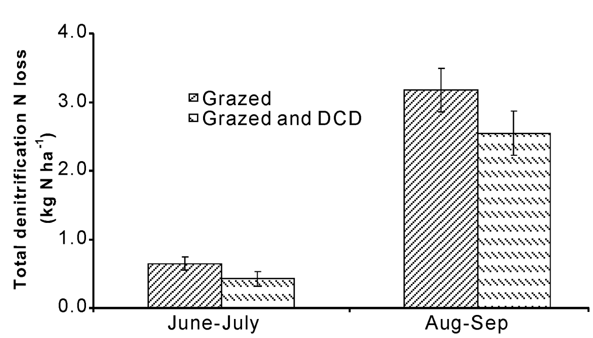

Figure 2 *Total denitrification N losses for 2 months following grazing events in winter 2007 .*

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Nitrogen, phosphorus and potassium utilization and their nutrient cycling in a beef-forage production system

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Key words: Beef production system, Cycling index, Nutrient balance, Nutrient cycling, Utilization efficiency

Introduction Quantification of nutrient flow is the first step for nutrient management in the livestock production system. The objective of this study was to quantify the cycling for nitrogen (N), phosphorus (P) and potassium (K) in a beef-forage production system in Japan.

Materials and methods Survey was conducted in the Experimental Farm of Kyoto University in Kyoto Prefecture, Japan. There were 9.5ha grassland and about 160 head of beef cattle in the farm. The herd consisted of breeding cows, calves, heifers and fattening cows and steers. Forage cultivated on the grassland was ensiled and offered to breeding cows. The whole farm system was divided into three components: animal, manure and soil/crop. The nutrient inflow, outflow and cycling of N, P and K in the soil-plant-animal pathway were quantified from April 2005 to March 2007. Nutrient utilizations in each compartment and the whole farm were evaluated by nutrient balances (nutrient inflow minus nutrient export) and nutrient utilization efficiencies (nutrient export divided by nutrient inflow). Nutrient balance and nutrient utilization efficiency indicate the apparent nutrient losses and the utilization of nutrient in a whole farm or a compartment. Nutrient cycling was represented using Finn's cycling index (Finn, 1980).

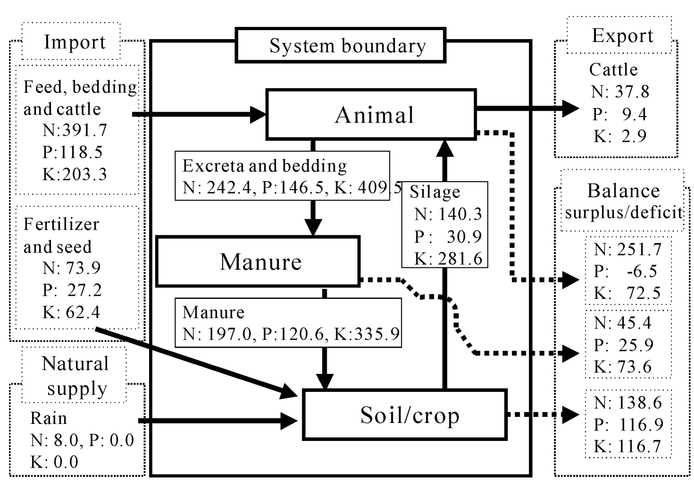

Figure 1. *N, P and K flow in a beef-forage production system (kg year^{-1} ha^{-1}); average 2005-2006, April through March.*

Results The annual average N, P and K flows (kg year^{-1} ha^{-1}) are shown in Figure 1. The major nutrient inflow was imported to animal component from outside the system for all nutrients. The average nutrient balances of N, P and K in the whole farm (kg year^{-1} ha^{-1}) were 435.7, 136.3 and 262.8, and the average nutrient utilization efficiencies were 0.08, 0.06 and 0.01, respectively. The nutrient balances were the largest in animal component for N and in soil/crop component for P and K. The average cycling indices of N, P and K were 0.19, 0.17 and 0.49, indicating that K was the most cycled in the system.

Conclusions The results of each nutrient flow indicated there were differences in the characteristics of nutrients. The quantitative data from this study would give insight to improve nutrient utilization and reduce nutrient losses in the system.

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Carbon and nitrogen characteristic in plants and soils of the degraded alpine *Kobresia pygmaea* meadow in the Tibetan Plateau

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Key words: Alpine *Kobresia pygmaea* meadow; Carbon and nitrogen status; Degradation; Plants and Soil; Tibetan Plateau

Introduction Grassland in the Tibetan Plateau occupies an area of about 1.5 million km^2, or two thirds of the total plateau area (Sun & Zheng 1998). For a long time, grasslands were thought to be inexhaustible, but overgrazing has resulted in serious degradation. Cryoturbation and climate change have also accelerated the deterioration of alpine meadow. Ecosystem alterations cause changes in C and N cycling by altering plant production, rates of soil organic matter accumulation and decomposition, and subsequent C storage in the soils. The objective of the study was to evaluate the influence of land degradation on plant and soil C and N content in degraded alpine meadow.

Materials and methods This work was conducted on alpine meadow in Gande county, Qinghai Province (34°08′N, 100°11′E) located 4060 m asl. Three plots (200m×200m) for each lightly degraded meadow (LD) and severely degraded meadow (SD) were chosen for study. Total vegetation ground cover, and aboveground biomass for grasses, sedges and forbs were evaluated. Total organic carbon and total nitrogen for aboveground plant tissue, the root tissues and soil in the 0～20 cm and 20～40 cm depths were analyzed by dry combustion in a VarioEL® elemental analyzer. Tests for significant differences between treatments were conducted using analysis of variance with least significant difference.

Results The biomasses of grasses, forbs and the root biomasses in the 0～20 cm, 20～40cm and in 0～40m depths in LD were significantly higher than those in SD, respectively, except the biomass of sedges. The total aboveground plant tissue C and root C and N contents were higher for LD than SD, although, there were no significant difference for plant N and soil C and N between LD and SD.

Discussion With grassland degradation, vegetation cover and plant productivity decreased, which resulted in soil degradation, even loss of economical and ecological function. In the degraded succession of alpine meadow, sedges and grasses with dense-short rootstalk were replaced by dicotyledons with taproots, and the belowground biomasses were changed. The change of the community structure and functional groups resulted in the loss of plant tissue and soil C and N (Wang et al 2005). Compared with the lightly degraded meadow, C content is lower in the severely degraded meadow. The decline was primarily attributed to decline in vegetative cover and productivity. In addition, since the carbon dioxide which was removed by photosynthesis from the atmosphere was reduced, there may be a decrease of organic matter input into the soil.

Table 1 *The biomass (±standard error) of plant groups and root in different degraded land.*

	LD	SD
Grasses (g m^{-2})	73.24 (13.32) a	7.91 (3.59) b
Forbs (g m^{-2})	76.03 (10.92) a	137.02 (16.19) b
Sedges (g m^{-2})	18.42 (4.47) b	3.90 (2.09) a
Total	167.69 (24.27) a	148.88 (21.54) a
Root 0-20 cm (g m^{-2})	2266.81 (187.41) a	942.02 (168.70) b
Root 20—40 cm (g m^{-2})	284.89 (116.18) a	28.34 (5.85) b
Root 0—40 cm (g m^{-2})	2551.69 (204.53) a	970.39 (172.35) b

Mean with the same latter are not significantly different at 5% level.

Table 2 *Mean (±standard error) content of C, N for plant, root and soil in 0-40cm in different degraded land.*

	LD	SD
Plant C (g m^{-2})	70.67 (10.23) a	57.79 (8.49) b
Plant N (g m^{-2})	3.30 (0.33) a	2.04 (0.29) a
Root C (g m^{-2})	905.67 (78.14) a	358.10 (62.32) b
Root N	15.33 (2.04) a	6.57 (1.88) b
Soil C	13692.7 (1211.4) a	13131.9 (1032.3) a
Soil N	3633.4 (160.0) a	3772.3 (210.0) a

Mean with the same latter are not significantly different at 5% level.

Isolation and characteristics of Hydrogen-oxidizing bacteria in theleguminous rhizosphere in grassland of Sanjiangyuan region

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Key words : leguminous Rhizosphere , Sanjiangyuan region , hydrogen-oxidizing bacteria , isolation , characteristics

Introduction Dong and collaborators , theorized for the first time that H_2 released from root nodules can promote the growth of microbes around the root , as well as promote the growth of plants , and called this the hydrogen fertilizer theory" (Dong Z *et al* ., 2003) . Isolating hydrogen-oxidizing bacteria in different leguminous soil rhizospheres will significantly aid future studies of populations of this new group .

Material and methods Eight different leguminous rhizosphere soils (W , D , AI , AII , AIII , BI , BII and BIII) from the grassland of Sanjiangyuan Region were enriched for 15d at room temperature at 4.16×10^5 mol/L^{-1} H_2 concentration . Then mineral salt agar medium (MSA) and H_2 treatment system (CHEN X D *et al* ., 2007) were used to isolate and culture the hydrogen-oxidizing bacteria for about 1 week .

Results Sixty three bacterium strains were isolated from 8 different soil samples and the ability to take up hydrogen were measured for these strains . Data showed that 26 bacterium strains had strong ability to take up hydrogen and grow autotrophically (Table 1) . Colony form and physiological biochemistry characteristic were studied . Among these 26 hydrogen-oxidizing bacteria 7 strains were classified to species (Table 2) .

Table 1 *The result of oxidized H_2 .*

Strains	H_2 consumption (10^{-4} mol · L^{-1})	Strains	H_2 consumption (10^{-4} mol · L^{-1})	Strains	H_2 consumption (10^{-4} mol · L^{-1})
W-4	6 .82	BI-8	3 .86	AIII-4	1 .73
W-3	6 .46	AI-9	3 .50	AIII-3	1 .64
BI-9	5 .91	AI-8	3 .36	AIII-9	1 .45
BI-2	5 .90	AI-5	3 .18	W-9	1 .39
AI-4	5 .48	BII-3	2 .89	D-7	0 .94
BIII-2	4 .63	BI-3	2 .38	BIII-4	0 .84
AII-6	4 .52	AI-6	2 .35	W-7	0 .83
AII-1	4 .36	W-1	2 .27	BII-9	0 .81
D-5	3 .87	AI-3	1 .74	blank	0 .06

Conclusions This experiment not only used H_2 treatment system but also improved it . Physiological biochemistry characteristics were studied , and the 26 hydrogen-oxidizing bacteria were classified into the suitable species . .

Table 2 *Classification .*

Strains	*Species*
BIII-2	*Staphylococus*
BIII-4	*Pimelobacter*
A-3	*Aeromicrobium*
W-9	*Xanthobacter*
BII-9	*Xanthobacter*
AIII-9	*Xanthobacter*
AII-6	*Agromonas*

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Unidirectional Na^+ influx under different growth stages of *Puccinellia tenuiflora* and wheat

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Key words: isotope ($^{22}Na^+$) tracing technique, unidirectional Na^+ influx, growth stage, halophyte, glycophyte

Introduction Restricting unidirectional Na^+ influx into root was an important way to reduce the net accumulation of Na^+. However, there was no report regarding whether the unidirectional Na^+ influx was affected by the growth stage. Consequently, it was hard to compare the influxes between/among different growth stages or species. This study was focused on this problem. Thus, Gramineous halophyte *P. tenuiflora* and glycophyte wheat were chosen, for testing the unidirectional Na^+ influxes of seedlings at the 2 leaf, 3 leaf and 4 leaf stages in 25 and 100 mM NaCl treatments.

Materials and methods Seedlings of *P. tenuiflora* and wheat were germinated and then cultured in modified Hoagland's nutrient solution, and subsequently NaCl treated for 7 days after reaching the 2, 3 and 4 leaf stage. Seedlings were harvested and weighed. $^{22}Na^+$ influx was evaluated according to the method described by Essah et al. (2003).

Results With advancing plant growth (Figure 1), unidirectional Na^+ influx was increased significantly in both species, and more obvious in 100 mM NaCl (Figure 2). There was no significant difference between *P. tenuiflora* and wheat in 25 mM NaCl. But in 100 mM NaCl, *P. tenuiflora* had stronger ability than wheat to restrict the increase of unidirectional Na^+ influx in the 4 leaves stage.

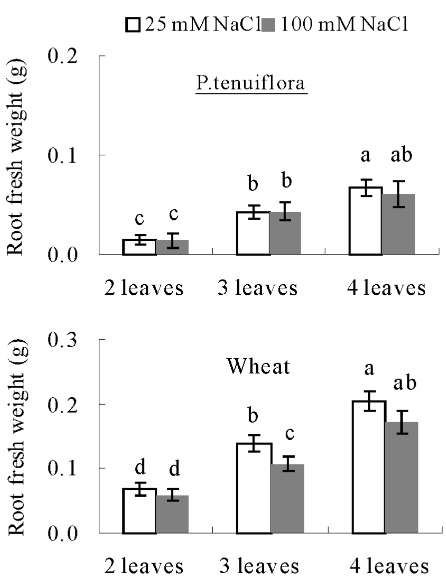

Figure 1 *Root fresh weight of P. tenuiflora and wheat at different growth stages ($P < 0.05$, Duncan test).*

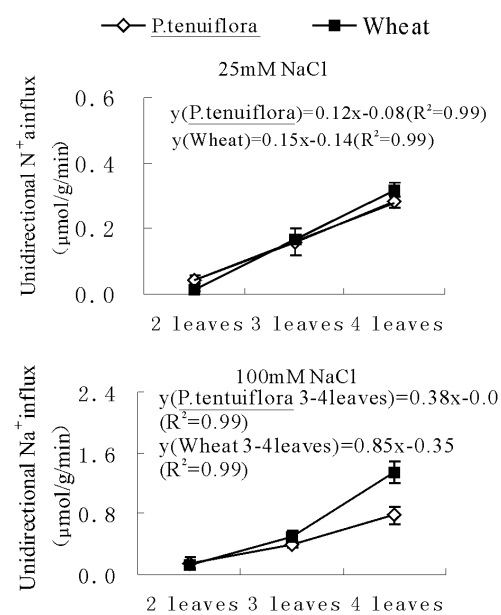

Figure 2 *Unidirectional Na^+ influx of P. tenuiflora and wheat at different growth stages treated with 25 and 100mM NaCl.*

Conclusions Unidirectional Na^+ influx was increased significantly with growth stage in both species, but more obvious in 100 mM NaCl. At the 2-3 leaf stage, the capacities of restricting Na^+ influx in both *P. tenuiflora* and wheat were similar, but significantly enhanced in *P. tenuiflora* after more mature (4 leaves). It was recommended that the growth stages should be taken into account when unidirectional Na^+ influxes were compared between/among different growth stages or species.

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Na^+ uptake pathways in the halophyte *Suaeda maritime*

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Key words: Halophyte, Na^+ net uptake, $^{22}Na^+$ influx, Na^+ uptake pathways

Introduction Reducing Na^+ influx must be the key step for controlling Na^+ accumulation compared with vacuolar Na^+ compartmentalization and Na^+ extrusion (Apse et al., 1999; Ma et al., 2004; Martínez-Atienza et al., 2007), neither of which would be sufficient alone. However, the pathways by which plants take up Na^+ are uncertain since Na^+ uptake by plant roots has largely been explored using species that accumulate little Na^+ into their leaves. By way of contrast, the halophyte *Suaeda maritima* accumulates, without injury, concentrations of the order of 400 mM NaCl in its leaves. Here we use *S. maritima* to examine Na^+ uptake pathways.

Materials and methods Twenty one to 23 day old seedlings were used to evaluate the effects of inhibitors of ion transport on growth and ion accumulation. Na^+ analysis was performed using an atomic absorption spectrophotometer. $^{22}Na^+$ influx was evaluated according to the method described by Essah et al. (2003).

Results TEA^+, Cs^+ and Ba^{2+} significantly reduced the net uptake of Na^+ from 150 mM NaCl over 48 h, by 54%, 24% and 29%, respectively (Tables 1 and 2). TEA^+, Cs^+ and Ba^{2+} also significantly reduced $^{22}Na^+$ influx by 47%, 30% and 31%, respectively (Figure 1). In contrast to the situation in 150 mM NaCl, neither TEA^+ nor Cs^+ significantly reduced net Na^+ uptake or $^{22}Na^+$ influx in 25 mM NaCl (Table 1, Figure 1). Ba^{2+} did significantly decrease net Na^+ uptake (by 47%) and $^{22}Na^+$ influx (by 36% with 1 mM Ba^{2+}) in 25 mM NaCl (Table 2, Figure 1).

Conclusions We propose that two distinct low-affinity Na^+ uptake pathways exist in *S. maritima*: Pathway 1 is insensitive to TEA^+ or Cs^+, but sensitive to Ba^{2+} and mediates Na^+ uptake in low salinities (25 mM NaCl); Pathway 2 is sensitive to TEA^+, Cs^+ and Ba^{2+} and mediates Na^+ uptakein higher external salt concentrations (150mM NaCl).

Table 1 *Effect of TEA^+ and Cs^+ on net Na^+ flux (μmol g^{-1} fresh weight root min^{-1}) of S. maritima.*

NaCl concentration (mM)	Inhition		
	None(control)	TEA^+ (10mM)	Cs^+ (3mM)
150	0.56±0.04a	0.26±0.03c	0.43±0.03b
25	0.20±0.02a	0.15±0.01a	0.18±0.03a

Table 2 *Effect of Ba^{2+} on whole plant Na^+ content (μmol/plant) and root net Na^+ flux (μmol g^{-1} fresh weight root min^{-1}) of S. maritima.*

	BT	25Na	25NaBa	150Na	150NaBa
Na^+ coment	7.0±0.56d	50±5.61b	22±1.4c	100±7.7a	51±4.4b
Na^+ netflux		0.19±0.02c	0.10±0.01d	0.43±0.02a	0.31±0.03b

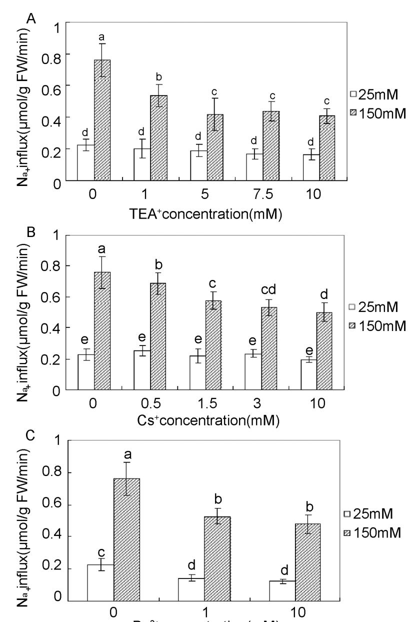

Figure 1 *Root $^{22}Na^+$ influx of S. maritima seedlings treated with different inhibitors.*

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Reference

Essah PA, Davenport R, Tester M (2003) Sodium influx and accumulation in *Arabidopsis*. *Plant Physiology* 133: 307-318.

Tillage systems and biological nitrogen fixation of soybean (*Glycine max*)

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Key words: tillage system, ^{15}N natural abundance technology, Loess Plateau

Introduction Legumes play an important role in rotation systems because of their capability in biological nitrogen fixation (BNF), but it is not known if N_2-fixation by legumes is affected by different tillage systems. This paper examines N_2 fixation by soybean (*Glycine max*) in no till, stubble retained and conventional cultivation systems on the Loess Plateau, China.

Material and methods This work was conducted in 2002-2003 on a Heilu soil at Qingyang experimental station on the Loess Plateau, Gansu, China. Four tillage treatments were imposed in a random block design with 4 replications. Treatments were: conventional tillage with no stubble retained (t), conventional tillage but with straw returned to the soil surface after tillage (ts), no-tillage with no straw (nt), and no-tillage with stubble retention (nts). N_2-fixation was assessed using ^{15}N natural abundance with five Soybean and five Prostrate spurge (*Euphorbia humifusa*) (reference plant) samples/plot. The ^{15}N natural abundance were analysed by isotope ratio mass spectrometry and the percent of plant N derived from air (% Ndfa) calculated as:

$$\%\,\text{Ndfa} = 100 \times (\delta^{15}N_{ref.plant} - \delta^{15}N_{lucerne}) / (\delta^{15}N_{ref.plant} - B)$$

Results In 2002 the nitrogen uptake by soybean were all higher than in 2003 under each treatment, but the significant difference neither in annual variation, nor between treatments. There was no evident difference in % Ndfa between any treatments in 2003 (43.8% ~ 62.4%), but it was much higher than in 2002, and the % Ndfa of soybean was evidently higher in tilled, stubble returned plots (ts) than other treatments. In 2002 the amount of N fixed accounted for 17% ~34.4% of the totle N uptake by soybean, while in 2003 the quantity of N fixed accounted for 43.3% ~66.3% of the N uptake. And the trend of soil NO_3-N (0 ~30cm) at sowing was contrary to the % Ndfa and N fixed in 2002 and 2003 (Table 1).

Table 1 *Dry matter, dry matter N and N fixed by soybean under different tillage system in 2002 and 2003.*

Year	Treatment	Dry matter (kg/ha)	Soil NO_3-N (0~30cm) at sowing (kg/ha)	soybean N uptake (kg/ha)	% Ndfa	N fixed by soybean (kg/ha)
2002	t	1299.0	44.1	38.8	17.6	6.6
	ts	1172.3	39.9	33.7	34.3	11.6
	nt	1129.6	45.7	29.1	22.3	6.5
	nts	1179.8	40.2	31.6	19.2	6.1
	$LSD_{0.05}$	315.2	14.3	11.4	6.0	3.0
2003	t	908.2	21.4	24.7	58.5	14.9
	ts	1024.1	25.3	26.4	62.4	17.5
	nt	825.5	23.8	22.8	54.9	12.9
	nts	936.7	24.7	24.7	43.8	10.7
	$LSD_{0.05}$	325.7	5.8	9.6	31.0	11.3

Conclusions In the Loess Plateau area, % Ndfa of soybean was increased with a combination of tillage plus straw cover (ts) in 2002 and 2003. There was a significant negative relationship between the quantity of N fixed by soybean and the amount of NO_3-N in the 0~30cm soil profiles. This research suggests that the soil NO_3-N content of 40kg/ha is the critical value above which plant BNF ability is weakened.

Effects of molybdenum on enzyme activity and blade cell submicro-structure of *Chamaecrista rotundifolia*

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Key words: molybdenum (Mo), *Chamaecrista rotundifolia*, nitrate reductase; nitrogenase, submicro-structure

Introduction *Chamaecrista rotundifolia* was recently introduced from the Australian Centre for International Agricultural Research (ACIAR) and is suitable for growing in mountainous red soil (Ying et al, 2000). This paper mostly reports the effect of Mo on plant growth and related aspects, to provide a theoretical basis for applying Mo fertilizer to *Chamaecrista rotundifolia*.

Materials and methods Experimental materials were seeds of *Chamaecrista rotundifolia* CPI 34721 strains and the red soil. Pot experiments were conducted comparing five treatments.

Results Leaf nitrate reductase activity was highest with application of 1.0 mg Mo/kg soil and it was 113.1% higher than in the control plot. (Figure 1). The response of nitrogenase activity with the increase of Mo fertilizer was similar to nitrate reductase (Figure 2). In addition, applying Mo could promote granum formation, enhance stability of cell wall and cell membrane and reduce deposits of polymers like bags formed by primary wall and cell membrane (Figure 3).

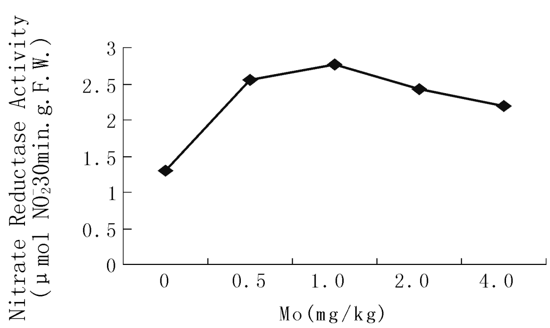

Figure 1 *Effects of applying Mo on the leaves' nitrate reductase activity of Chamaecrista rotundifolia.*

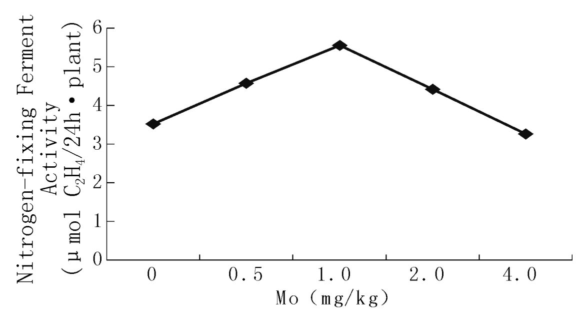

Figure 2 *Effects of applying Mo on nodule nitrogenase activity of Chamaecrista rotundifolia.*

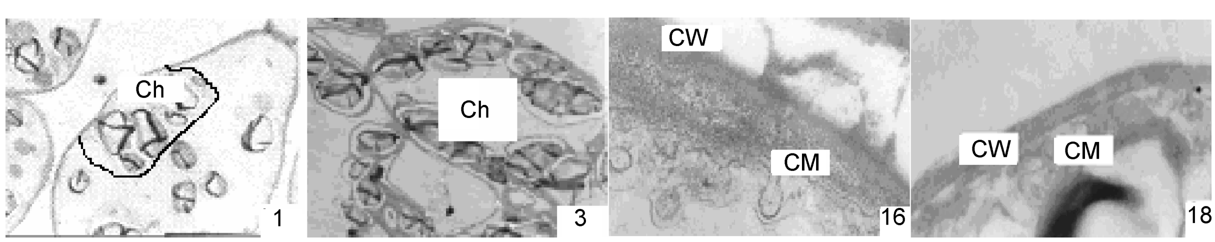

Figure 3 *Effects of applying Mo on the blade cell submicro-structure of Chamaecrista rotundifolia (Photo 1 and 16 are the control. Photo 3 and 18 are the treatment of 1.0 mg Mo/kg).*

Conclusion The proper amount of Mo fertilizer could promote the nitrogen metabolism and enhance the N-fixing ability. In addition, it could promote granum formation and enhance stability of cell membrane to enhance photosynthesis. In this experiment, 1.0mg Mo/kg soil was the most effective and suitable application amount.

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Using ^{15}N isotopic dilution method to quantify the associative nitrogen fixing bacteria from grassland in eastern qilian mountains

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Key words: associative nitrogen-fixing bacteria, phosphate-solubilizing, auxins

Introduction N_2-fixation carried out by associative and free-living microorganisms in the rhizosphere of oat has been recognized as an important factor in nitrogen nutrition of the plant. NFB can produce plant growth regulators (PGRs).

Materials and methods The associative nitrogen fixation strains were isolated from the Rhizosphere of wheat and oat in Gansu (Table1). The ^{15}N analyzer with optical principle was used to determine stable isotopes (NOI7). ^{15}N isotopic dilution method was chosen to determine quantification of association nitrogen fixation bacteria in soil.

Table 1 *The ability of different strains as nitrogen fixers, IAA producers and phosphate solubilizers.*

strains	nitrogenase activity (C_2H_4 nmol/ml.h)	IAA	organic phosphorus (D/r)	inorganic phosphorus(D/r)	P dissolution (ug/ml)
Azospirillus lipoferum O6	351.6	19.2	ND	1.67	82
Azotobacter sp O5	359.4	16.2	1.4	ND	ND
Azotobacter sp W5	512.7	12.2	2.27	ND	ND
Zoogloea sp C6	256.9	15.1	ND	1.25	76
Pseudomonas sp N4	940.5	22.3	1.6	ND	ND
Zoogloea sp W6	312.1	6.33	2	1.07	58
Pseudomonas sp O3	453.9	17.6	1.41	ND	ND

Results N concentration and ^{15}N atom% excess of above ground dry matter of different strains(Table 2).

Table 2 N concentration and ^{15}N atom% excess of above ground dry matter of different strains of Oats.

strains	Above dry weight(kg/ha^2)	N concentration (%)	% Ndfa Fixation N	^{15}N atom% excess	Total N fixation kg/ha^2
Azospirillus lipoferum O6	5615.0	0.67	18.23	1.131	6.8582^{bB}
Azotobacter sp O5	6302.5	0.65	14.11	1.187	5.7803^{bB}
Azotobacter sp W5	8557.5	0.49	11.14	1.228	4.6712^{bB}
Zoogloea sp C6	5702.5	0.58	9.91	1.245	3.2777^{cC}
CK	4700.0	0.48	/	1.381	ND
Pseudomonas sp O3	7215.0	0.63	4.78	1.316	2.1727^{cC}
Pseudomonas sp N4	8565.0	0.58	21.35	1.087	10.6060^{aA}
Zoogloea sp W6	7510.0	0.53	13.10	1.201	5.2142^{bB}

note: CK 148kg/ha urea a.e 2.24% ^{15}N urea atom% excess is 2.24%, dosage is149 kg/ha. ND not detector.

The amount of biological nitrogen fixation was determined to be N4>O6>O5>W6>W5>C6>O3; ^{15}N atom% ranged from 1.0871% to 1.3164%. The range of biological nitrogen fixation was 2.17～10.61 kg/ha; ^{15}N atom% content of above ground dry matter varied for different strains of Oats.

Conclusion N_2-fixing bacterial inoculation increased growth and development of oats, particularly by increasing above ground dry-weight.

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Fractal dimension and variability of soil particle in grassland

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Key words : fractal dimension , variability , soil particle , grassland

Introduction Fractal dimension of soil particle is not only a token of soil particle , but also a index of variability of soil texture . So the study on variability of fractal dimension redound is in favor of describing the distribution of soil texture quantificationally It can also provide a basis in improving desertification and protecting ecosystem in grassland .

Methods and materials the proving ground is in the natural grassland in Wushen county in Inner Mongolia . It is sandy soil , the vegetation are composed of natural sabulicola . the total area of proving ground are 5 .04hm^2 (140m × 360m) , the interval of sampling is 20 meters .

Theory and models fractal dimension of soil particle can be expressed in the following :

$$W(\delta > \bar{d}_1)/W_0 = 1 - (\bar{d}_1/\bar{d}_{max})^{3-D} \quad (1)$$

where $\bar{d}_1$ is mean value between d_i and d_{i+1} ; $W(\delta > \bar{d}_1)$ is the total weight of soil particles more than $\bar{d}_1$; $W(\delta < \bar{d}_1)$ is the total weight of soil particles less than d_1 ; d_{max} is mean diameter of the biggest particle size ; W_0 is the total weight of all soil particles is the fractal dimension .
Semi-variogram can be expressed in the following :

$$\gamma^*(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i + h)]^2 \quad (2)$$

where $\gamma(h)$ is the variogram value at lag distance h , $N(h)$ *is* the number of lag distances , and $Z(x_i)$ is the value of the observation at point x_i .

Conclusions (1) The correlativity between fractal dimension and content of sand particle (d > 0 .1mm) is negative proportion , the correlativity between fractal dimension and content of clay particle (d < 0 .05mm) is negative proportion . It indicated the loss of silt (d < 0 .05mm) result in desertification serious and decrease of fractal dimension , so the fractal dimension is a reflection of loss of soil particles , it can be used to denote the degree of desertification ; (2) The variogram of soil particle is spherical model , variability of soil particle is mainly affected by stochastic factors , and the range of fractal dimension is larger than that of soil particle appreciably ; (3) As a general and representative index of soil particle , the relationship between fractal dimension and distribution of soil particle is very close , so soil particle in different size can be replaced by fractal dimension to describe the variability of soil texture and the degree of desertification , and it is more useful in researching the process of desertification and rule of variability of soil in grassland .

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Changes of mineral nutriments in leaves of two tall fescue cultivars by foliar application of Iron and Zinc under heat stress

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Key words: Heat stress, Iron, Mineral nutriment, Tall fescue, Turfgrass, Zinc

Introduction Heat stress is a major environmental stress that adversely affects growth and metabolism of cool-season plants. Heat stress also lead to direct inhibition of nutrient uptake or cause essential nutrient deficiency and even change the concentrations of basic nutrients (Xu et al, 2006). There has been limited research concerning the mineral nutrient content of different turfgrass species or cultivars. The main objective of this study was to evaluate the effects of Fe and Zn by foliar application on the macronutrient and micronutrient concentrations of two tall fescue cultivars under heat stress.

Materials and methods Healthy sods of tall fescue (*Festuca arundinacea* cv. Barlexas and Crossfire Ⅱ) were collected from field plots at the Flower Cultivation Center, Nanjing University. Grass was grown in plastic pots (12 cm in diameter, 20 cm long) filled with sand and clay (2/1, v/v) in the greenhouse. A 15 ml of exogenous FeEDTA (100 μM), ZnEDTA (100 μM) or distilled water (control) were carried out once a week by spraying each of them onto the leaves for two weeks and then half of treated-pots was transferred into another growth chamber at a temperature of 38℃/30℃ (day/night) for two weeks.

Results and discussions Under heat stress, there was a tendency of increasing in K, Ca and Na concentrations in average for two tall fescue cultivars, but a tendency of decreasing in P concentration in average although there were no statistical differences between some treatments. All the concentrations of macronutrient were within the sufficiency range for both tall fescue cultivars. The K levels for two tall fescue cultivars under all treatments resulted in K concentrations within the sufficiency range of turfgrass species (20.0 to 50.0 g K kg^{-1}). Ca concentrations of 2.1 to 2.9 g Ca kg^{-1} for two cultivars of St. Augustinegrass (McCrimmon, 2004). In present study, the Ca concentrations were somewhat high compared to other studies of both cool and warm season turfgrasses. Under heat stress, Mg concentrations in leaves of two tall fescue cultivars by application of Fe decreased significantly, which were compared to those untreated by application of Fe. However, there were no statistical differences for both tall fescue cultivars by application of Fe and Zn under heat stress. Magnesium is important for turfgrass color and further study needs to be done on it related to the levels that different turfgrasses require under heat stress. Our result indicated that Fe levels in leaves of two tall fescue cultivars varied considerably between cultivars or among treatments, especially by application of Fe and Zn. Zn concentrations of two tall fescue cultivars are similar to the Zn concentrations that have been reported for cool season turfgrass.

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Effects of grass growth stage on metabolisable energy concentration of fresh grass

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Key words: cattle, chemical composition, fresh grass, grass maturity, metaboliisable energy

Introduction Fresh grass is the most important forage for ruminant animals across the world, whilst it is widely recognised that the nutritive value of fresh grass varies considerably with stage of growth. There is little information in the literature on the relationship between stage of growth and nutritive value within the same sward. The objective of the present study was to develop a prediction method for ME concentration of fresh grass from chemical composition.

Materials and methods Fresh herbage was produced from the primary growth of perennial ryegrass swards. Swards were harvested daily at 13.00 h, for a 7 week period, from early growth to late maturity, and offered to 2 groups of dry, non-pregnant dairy cows at a maintenance level of energy intake. Fresh herbage was offered twice daily with one portion given at 14.00 h and the other stored at 4℃ and offered at 09.00 h the following day. The first group of 4 cows was on treatment for 4 weeks, with total collection of faeces and urine from week 2 to 4. During the 4th week, grass for the first group was also offered to the second group of 4 cows, and faeces and urine collected for the second group for the last 3 days. Measurements with the second group of cows continued until the end of week 7. A similar procedure was repeated for the first regrowth from the same swards. Grass ME concentration was calculated using methane energy output, predicted from the equation developed using the same dataset with the present study (Yan, 2008). Weekly mean data were used to examine effects of stage of grass growth on ME concentration.

Results and discussion Data obtained during week 4 (overlap period) were used to evaluate effects of cow group. There was no significant difference in nutrient digestibility between the two groups. As expected, increasing grass maturity from week 1 to 6 increased DM (176 to 236), ADF (225 to 292) and NDF (474 to 542) contents (g/kg DM), while reducing CP (145 to 69), lipid (37 to 17) and GE contents (18.5 to 18.1 MJ/kg DM). Consequently, digestible OM in total DM (DOMD) and ME content (12.4, 12.2, 12.2, 11.8, 11.5 and 10.9 MJ/kg DM) decreased from week 1 to 6. In the UK energy rationing system (AFRC, 1993), DOMD is used to predict ME concentration for forage (ME (MJ/kg) = 16 DOMD (kg/kg)). The same relationship developed using the present dataset indicates a slightly lower coefficient (15.5, $R^2 = 0.71$).

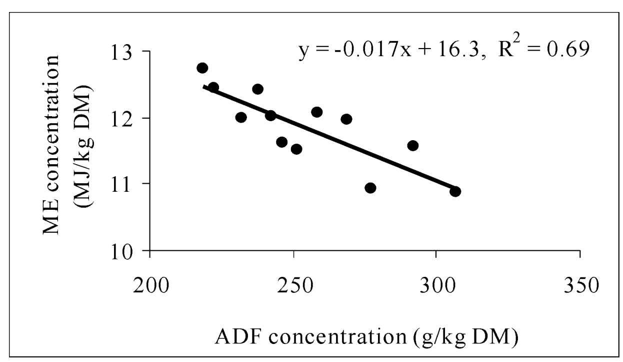

Figure 1 *Relationship between ADF and ME content in fresh grass.*

However, measurement of DOMD requires assessment of digestibility, which is not practical in commercial situations. An alternative option is to predict ME concentration from the chemical composition of the fresh herbage. In the present study, ME concentration was positively related to ($P < 0.001$) CP ($R^2 = 0.69$) and lipid ($R^2 = 0.65$) concentrations, and negatively related to ADF concentration (Figure 1, $P < 0.001$). Using a stepwise technique, a strong relationship was developed to predict ME concentration (Eq. [1]), where WSC = water soluble carbohydrates; unit for GE and ME is MJ/kg DM and for other nutrient g/kg DM.

$$ME = 2.587GE + 0.023DM - 0.055ADF - 0.133Lipid - 0.014WSC - 19.5 (R^2 = 0.93, s.e. = 0.20, P < 0.001) \quad [1]$$

Conclusions The ME concentration of fresh grass was significantly related to DOMD and CP, lipid and ADF concentration. A very strong relationship was developed to predict grass ME concentration from chemical composition.

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Plant community and soil nutrient characteristics of trampling disturbance in a Kobresia humilis community along the road in Naqu, Tibet

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Key words: Plant community characteristics, soil nutrien, Alpine meadow, Tibet

Introduction Plant community characteristics and soil nutrients were investigated in trampling disturbance in a *Kobresia humilis* community along Qi-Zang road.

Materials and methods Eight sample sites in different successional stages were selected. These varied on time of reconstruction of the Qi-Zang road during 1973, 1984, 1991～1996 and 2004, and represent restoration stages 1, 2, 3 to 7, respectively. Grassland within animal pens was selected as a control or stage 8, which represented the climax community. The samples along the road were repeated for 4 times with an interval of 2～20 meters.

The investigation was conducted in August of 2003 and 2004 when the vegetation was most abundant. We determined the plant species, vegetation cover, number of tillers, and frequency (Tilman D & Downing JA., 1994). Soils from eight different sites were sampled at two depths (0～10cm and 10～20 cm). Each soil sample was a composite consisting of five sub-samples collected from each site. Soil OM, TN, AN, TP, AP, TK, AK, pH and CEC were measured.

Results

Quantitative characteristics of the community The main quantitative characteristics of the community increased remarkably during the process of succession, all of them varied logistically except the height. The density increased from from 336ind/m^2 to 4,490ind/m^2. The height of the community increased from 0.58cm to 2.34cm ($H=27.2199/(1+e^{(-(x-25.0249)/6.4637)})$, $R=0.7439$, $n=24$). The coverage of vegetation was increasing with succession ($C=109.5181/(1+e^{(-(x-5.3859)/1.3141)})$, $R=0.9856^{**}$, $n=24$). The above-ground biomass was more than below-ground, but they all increased logistically ($BM_{up}=514.9035/(1+e^{(-(x-8.6405)/2.8705)})$, $R=0.9454^{**}$, $n=24$, $BM_{under}=7511.652/(1+e^{(-(x-7.0389)/1.2766)})$, $R=0.9515^{**}$, $n=24$,).

Plant diversity The plant diversity (y) varied logistically with the stages (t), ($y=a/(1+e^{-(t-t0)/b})$. The plant diversity was low during the early stage, higher during the climax stage, and highest during the intermediate stages.

Soil nutrient Serious erosion occurred after trampling disturbance, and the soil nutrient contents decreased. Along with vegetation recovery, soil nutrient condition improved, with an increase in each nutrient element. But the soil recovery process lagged behind vegetation recovery.

The dynamics of TN, TP and TK are very similar, and significantly interrelated with organic matter. With the biomass changing, pH value changed affecting the available phosphorus complex. The dynamics of available potassium is different compared with total potassium, total nitrogen and total phosphorus, it is high with trampling and stable in the other stages.

Conclusion The main quantitative characteristics of the community increased remarkably during the process of succession. Plant diversity varied logistically with the stages. Soil recovery process lagged behind vegetation recovery.

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Study on the salt resistance of rhizobium in Gansu province

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Key words: ecoregion, alfalfa, rhizobium, salt resistance, Gansu

Introduction Biological nitrogen fixation is a bioprocess second only to photosynthesis and provides 14×10^{10} kg Nitrogen by symbiotic nitrogen fixation to the earth every year, therefore, it has a great effect. Rhizobium strains selected from alfalfa in different areas in Gansu were used to test salt-resistance and select the proper strains for the areas of Northwest China.

Materials and methods Thirty one rhizobium strains, which are beneficial to plant growth, were isolated from two kinds of alfalfa (*Medicago sativa* cv. Longdong and *Medicago sativa* cv. Alogonquin) from different areas in Gansu Province. Experiment was conducted using the culture medium method(White *et al*, 1995).

Results and analysis Major strains are tolerant to 35g/L NaCl. Tests indicate that salinity tolerance of WA24 is the best, and it can grow well in 55 g/L NaCl. The better strains are GL16, QA31-B and WA62A growing with 50g/L NaCl. DA53, QL31B and TL47 can grow in acidic conditions with a pH of 3.5, and DL67, GL21, QA31B, WA32 can grow in alkaline conditions with pH of 12.0. This study indicates that 31 strains treated with acid condition can grow in pH 3.5-5.0; very few can tolerate pH3.5. The pH limit of 31 strains treated with alkali condition is 9.0-12.0. In the test with Kanamycin, 31 strains can grow well in 20mg/L, the strains which tolerated 50mg/L were DL67, DL81, GL16, QA46A, TL22A, TL47, WA24, WL53, WL68. In studies with Acillin, 31 strains grew well in 50mg/L, the strains which tolerated 100mg/L were QL31B and TL47.

Results and discussions In the salt tolerance experiment, 74.5% strains, with stood the concentration of 4.5g/L NaCl. In this experiment, Wuwei WA24 can with stand the highest salt concentration. The measurement with antibiotic showed that DL67, DL81, GL16, QA46A, TL22A, TL47, WA24, WL53, WL68 could tolerate 50mg/L Amikacin sulfate, and QL31B, TL47 could tolerate 100mg/L Ampicillin. Most of them from Longdong alfalfa in Gansu had excellent adaptiveness.

Conclusion The results show that growth of strains decrease with an increase in antibiotic concentration. Generally, it is suggested that the typical continental arid and semiarid environment in which Gansu Province is located is the reason that most of the strains isolated from alfalfa in Gansu had better salt tolerance.

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Investigations on soil fertility of *Medicago varia* and *Bromus inermis* stands

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Key words :*Medicago varia* , *Bromus inermis* , Soil organic matter , Soil available nitrogen

Introduction The effects of forage cropping on soil fertility have not been well determined even though positive results have been reported for some spieces in certain areas (Cadisch et al . ,1994 ; Jianguo Han et al . , 2004) . The objective of this study was to determine the changes of soil organic matter and soil available nitrogen of *Medicago varia* and *Bromus inermis* stands during the subsequent years after establishment .

Material and methods The plots were established at the experimental farm of Inner Mongolia University for Nationalities , in Tongliao , Inner Mongolia on May 8 , 2003 . The initial soil fertility of the 0-30 cm layer : organic matter 18 .36 g/ kg , available N 58 .45 mg/ kg , available P_2O_5 38 .66 mg/ kg , available K_2O 123 .67 mg/ kg . *Medicago varia* was seeded at the rate of 15 kg/ hm^2 in monoculture and 4 .5 kg/ hm^2 in the mixture ; *Bromus inermis* was seeded at the rate of 22 .5 kg/ hm^2 and 15 .75 kg/ hm^2 in the mixture . Soil samples were taken on April 17 , 2005 and April 12 , 2007 and the soil organic matter and soil available N were tested in the laboratory .

Results The greatest soil organic matter accumulation occurred in the *Bromus inermis* stand , and the intermediate accumulation occurred in the *Medicago varia and Bromus inermis* mixture (Table 1) . Soil organic matter of all three layers of all the three stands increased with the advancement of time , reinforcing the opinion that perennial forages (either legumes or grasses) have an important role in soil structure improvement .

Table 1 *Contents of soil organic matter and available nitrogen of three stands .*

Sampling time	Soil layer	Medicago varia		Mixture		Bromus inermis	
		OM	AN	OM	AN	OM	AN
2005-4-17	0-10cm	24 .46bB	57 .49aA	26 .50aAB	56 .80aA	27 .4aA	49 .93bA
	10-20cm	18 .56bB	79 .10aA	20 .48bAB	78 .51aA	23 .31aA	73 .64bA
	20-30cm	11 .68aA	49 .77aA	12 .53aA	50 .44aA	12 .18aA	47 .68aA
2007-4-12	0-10cm	26 .39bA	65 .41bA	28 .75abA	70 .09aA	32 .28aA	57 .73cB
	10-20cm	21 .00bA	60 .32abA	24 .63aA	61 .99aA	25 .22aA	55 .22bA
	20-30cm	17 .14aA	40 .60abA	16 .82aA	45 .80aA	18 .43aA	37 .18bA

Note :Means with different capital letters in same soil layer indicate extremely significant differenc($P<0.01$) ,and small letters ($P<0.05$)for significant difference . OM-soil organic matter(g/kg) ; AN-soil available nitrogen (mg/kg) .

For soil available nitrogen accumulation , the *Medicago varia and Bromus inermis* mixture showed the greatest positive effect , and the *Bromus inermis* stand showed the least . In 2007 , available nitrogen content in the 0-10 cm soil layer of *Medicago varia and Bromus inermis* mixture was 21 .41% higher than that of *Bromus inermis* stand .

Conclusion Both soil organic matter and soil available nitrogen increased gradually in three stands with the advancement of time . Soil organic matter increased most in the *Bromus inermis* stand , whereas , *Bromus inermis* and *Medicago varia* mixture was more beneficial to the accumulation of soil available nitrogen .

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Effects of K^+ on Na^+ uptake and accumulation in a wild Halophyte grass *Suaeda maritime*

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Key words: K^+ transporters, $^{22}Na^+$ influx, Na^+ accumulation

Introduction Limiting Na^+ uptake and accumulation in the cytosol is the key measure to improve plant salt tolerance (Flowers, 2004). However, Na^+ uptake pathways in higher plants are not so clear by now. Wang *et al*. (2007) reported that two distinct low-affinity Na^+ uptake pathways exist in *S. maritima*: Pathway 1 might be mediated by a high-affinity K^+ transporter under 25 mM NaCl that is insensitive to TEA^+ or Cs^+, but sensitive to Ba^{2+} and pathway 2 by an AKT1-type channel under 150 mM NaCl that is sensitive to TEA^+, Cs^+, or Ba^{2+}. Here we reported that the turning-point of external salt concentrations for the two pathways and the effects of K^+ on $^{22}Na^+$ influx and accumulation in *S. maritima*.

Materials and methods 17-day-old seedlings were transferred to non-KNO_3 Hoagland solution supplemented with 3 concentrations (0, 10, and 50 mM) of KCl and various concentrations (2.5 to 200 mM) of NaCl for 3 d before being transferred to equivalent solutions labeled with $^{22}Na^+$ or harvested for measurements of influx or concentrations, respectively. Values are means SD(n=6 for influx or 8 for concentration test) and bars indicate SD ($P<0.05$, Duncan test).

Results Ba^{2+} inhibited $^{22}Na^+$ influx significantly under various NaCl concentrations, however, TEA^+ showed significant effects in reducing $^{22}Na^+$ influx when the external NaCl concentration was above 100 mM (Figure 1). 10 mM KCl had no significant effect on $^{22}Na^+$ influx under various NaCl concentrations, but 50 mM KCl blocked $^{22}Na^+$ influx significantly when NaCl concentration was above 100 Mm(Figure 2). 10 and 50 mM KCl both reduced NaCl concentration in roots under various NaCl concentrations (Figure 3), however, NaCl concentrations in shoots were reduced by 50 mM KCl when external NaCl concentration was below 75 mM and by 10 mM KCl when below 25 mM (Figure 4).

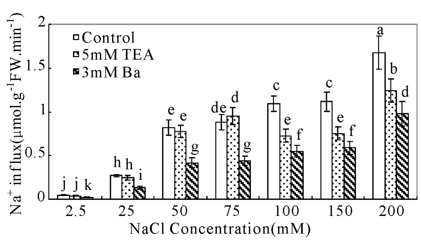

Figure 1 *Effects of TEA^+ and Ba^{2+} on $^{22}Na^+$ influx.*

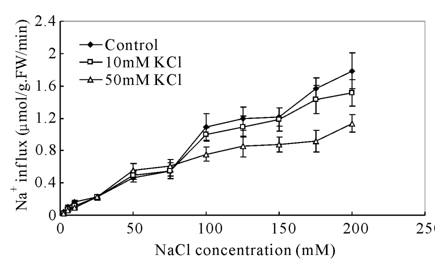

Figure 2 *Effects of K^+ on $^{22}Na^+$ influx under various NaCl concentrations.*

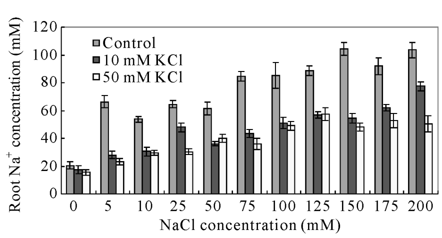

Figure 3 *Effects of K^+ on Na^+ accumulation in roots.*

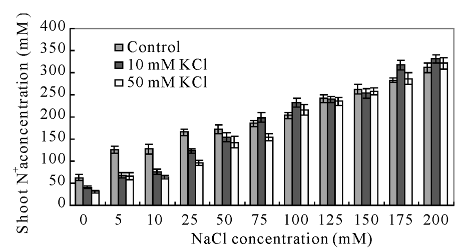

Figure 4 *Effects of K^+ on Na^+ accumulation in shoots.*

Conclusions The turning-point of external salt concentrations for the two pathways was between 75 and 100 mM. K^+ (10 or 50 mM) had no effect on $^{22}Na^+$ influx at concentrations below 75 mM NaCl, but $^{22}Na^+$ influx was inhibited by 50 mM K^+ when the external concentration of NaCl was above 75 mM. However, the affecting mode of K^+ on NaCl concentration in both roots and shoots with increasing external concentration was different from that on $^{22}Na^+$ influx.

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Microbiological quantitive assessment on soil health in a degraded grassland

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Key words: Degraded grassland; Soil health; Biological quality; Microbiological index; Quantitative assessment

Introduction Soil is a vital and finite resource that can maintain to the function of terrestrial ecosystem and represents a unique balance between physical, chenical and biological factors. The phenomenon of soil degradation and soil pollution has becoming more serious, and structure and function of soil ecosystem are disorderly, jeopardize human health and existence. Soil quality and soil health determine the sustainable productivity of biology and quality of environment in future.

Methods The microbiological quality of soil health in different degree degraded typical grassland in Xilin river basin of Inner Mongolia was analyzed by simple microbial biomass and respiration measurements in the soil. Control sites for comparison of results are the best solution for evaluation of soil health, the plant original community by fencing reserve for 23 years that is chosen as an ideal control site of non-contaminated and background soil in the steppe.

Results The results showed that 4 basic parameters: microbial biomass-C (C_{bio}), available organic-C (C_{ext}), basal respiration-C (C_{BR}), potential respiration-C (C_{BR}), and 5 derived parameters: metabolic quotient (C_{BR}/C_{bio}; or qCO_2), respiratory activation quotient (C_{BR}/C_{PR}), potential respiration quotient (C_{PR}/C_{bio}), mineralization quotient (C_{ext}/C_{bio}), and Humic Efficiency (C_{ext}/C_{BR}) could provide enough information for evaluation of the status of soil biological quality. The derived parameters could be used as eco-physiological quotients for assessing soil biological quality. Using these indexes showed the control sites Y2 and Y1 (fencing reserve 23 years) as an ideal control site displayed very high content of the microbial biomass and the lowest metabolic quotient of all soils, and higher respiration and available organic carbon, it was health soil. Light grazing site Y3 (fencing reserve only 5 years) was in an average leavl. Moderate grazing site Y4 (nature grazing out of fencing) displayed below-average microbial biomass with rather lower basal mineralization activity and the humic efficiency was lower for lacking of the appropriate substrate in the soil. The microbes were clearly exposed to the stress effect. Because the energetic requirements are higher; excessive grazing Y5 site (out of fencing) displayed lower microbial biomass carbon and available organic carbon and was no better than Y4 and not healthy. Therefore, microbial parameters have showed great potential to become the early warning and quantity indicators for monitoring the stresses or perturbations in soils ecosystems.

Table 1 *Soil health index-standard of eco-fertility indicator.*

Standard level of eco-fertility	Ⅰ(best)	Ⅱ(better)	Ⅲ(normal)	Ⅳ(bad)	Ⅴ(worse)	Ⅵ(worst)
Microbial biomass-C(mg/kg)	>550	550~401	400~271	270~141	140~80	<80
Sites	Marsh	Y2	Y1, Y3	Y4, Y5		Sands

Conclusions Assessing system of soil biological quality is proposed firstly, key indexes of for assessing soil health contain the eco-fertility, eco-physiology, and eco-resilience parameters has selected. The preliminary graded standard of soil health in steppe has set up. This research has offered the biological basis of land management and soil degradation, and offers the scientific method for studying on toxicology of the contaminated soil, and gets the foundation for the formulation of Health standard of agricultural soil".

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Response of Lanyin Ⅲ zoysiagrass to watering and fertilization

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Key words : Lanyin Ⅲ zoysiagrass , watering , fertilization , soluble sugar , POD , leaf water potential , chlorophyll

Introduction Over-watering and over fertilization often led to poor turf quality (White *et al* ., 1993) . This study was conducted to determine the physiological response of Lanyin Ⅲ Zoysiagrass under water-fertilizer integrated controlling .

Materials and methods 27 pots of Lanyin Ⅲ Zoysiagrass cultivated in the sand dominated root-zone were treated with watering of 3 levels(W1 :20% E_0 ,W2 :60% E_0 ,W3 :100% E_0) as main treatment and fertilization of 3 levels(F1 :N1 .5 g m^{-2} ,F2 :3 .0 g m^{-2} ,F3 :6g m^{-2} monthly at the same N :P :K ratio of 4 ∶ 1 ∶ 2) as secondary treatment and replicated 3 times . Soluble sugar , peroxides (POD) , leaf water potential (LWP) and chlorophyll were measured during drought stress and after rewatering .

Results and discussion

The results showed that controlled watering and fertilization had significant effects upon the physiological characteristics of Lanyin Ⅲ Zoysiagrass . Soluble sugar accumulated dramatically under 20% E_0 watering level , but it kept lower level when watering was sufficient and after rewatering , (Figure 1) .The leaf water potential was significantly lower under 20% E_0 watering level , whereas fertilization had no effects on it in sufficient watering condition (Figure 2) . POD activity was distinctly high when watering was limited , which indicated that drought resulted in Lanyin Ⅲ zoysiagrass injury especially with high fertilization (Figure 3) .Water stress could reduce the synthesis of chlorophyll , however under higher water condition the content of chlorophyll was lower due to dilution of abundant water (Flexas *et al* ., 1999) (Figure 4) .In combination with watering , fertilization and their effects it was concluded that Lanyin Ⅲ Zoysiagrass could grow well under the condition of watering of 60% E_0 and fertilization of N1 .5-3 .0g m^{-2} monthly .

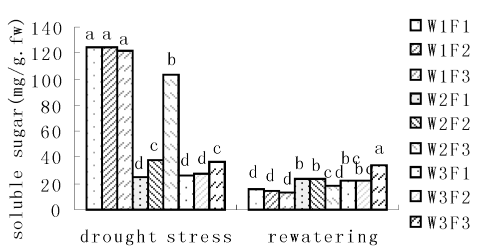

Figure 1 *The effect of different treatments on soluble sugar .*

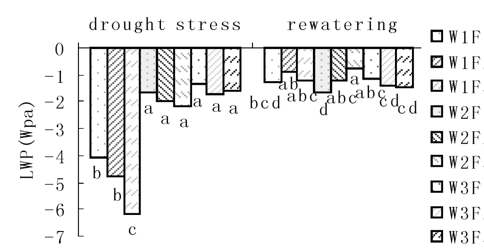

Figure 2 *The effect of different treatments on LWP .*

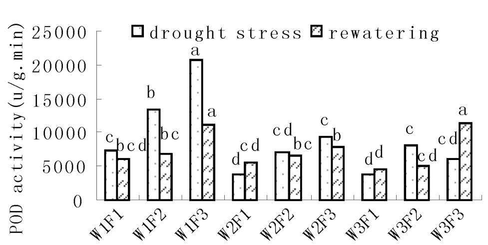

Figure 3 *The effect of different treatments on POD activity .*

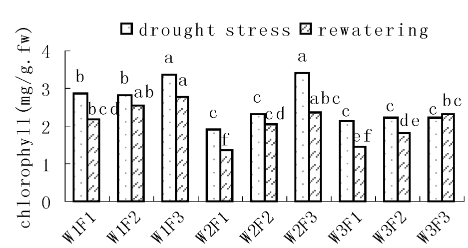

Figure 4 *The effect of different treatments on chlorophyll .*

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Effects of fertilizer and plant density on the fresh biomass of Sudan grass

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Key words : Sudan grass Neinong No .1 ,mathematic model ,yield , planting density , fertilization

Introduction *Sorghum sudanense* Stapf . cv . Neinong No .1 was a hybrid of Sorghum and Sudan grass bred by our group . The objective of this study was to evaluate the effects of planting density and fertilizing level on fresh matter (FM) yield of Neinong No .1 . The optimum cultivation condition was obtained .

Material and methods Sudan grass No .1 was seeded with four randomized replications for 11 treatment plots and one control plot in a greenhouse in 2006 . The area of each plot was $14m^2$. The experimental field located in Huhhot . Data were analyzed with SAS 9 .0 software .

Results and analysis

Regression analysis of FM yield of Sudan grass The relation between FM yield and other factors were analyzed with the regression simulation method at different harvest time . One regression equation was obtained with stepwise regression :

y^2 (FM weight (kg) /2 m^2) = $-3.35695 + 0.03885x_1 + 3.87533x_2 + 0.06993x_3 - 0.36936x_4$

It is clear that the grass height (x_2) plays a major role in Sudan grass production . However , germination rate (x_1) had a minor influence on the FM yield .

Single-factor analysis For two harvest times : July 19 and September 2 , the differences of FM yield between 11 treatment plots and one control plot were not significant ($p > 0.05$) . If analyzed with single-factor analysis of variance , however , the FM yield of Sudan grass in No .9 treatment plot was highest ($p < 0.15$) , which was 14613.97kg/667m^2 .

Conclusion In current study , the results showed that cultivating measurement combination of No .9 plot , in which planting density was 45022 plants/ha and 20kg additional urea was applied to the plot during the growth , was optimum for the maximum yield of FM of tested Sudan grass , which was harvested for four times .

Study on seasonal change of cu in system of soil-grass-livestock on the meadow around Qinghai Lake

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Key words : zone of Qinghai Lake , meadow pasture , system of soil-grass-livestock , Cu , seasonal change

Introduction Seasonal change of Cu in the system of soil-grass-livestock (sheep) was studied on Meadow pasture around the Qinghai Lake . The results will provide the basic data to accelerate seasonal animal husbandry , use reasonably grassland , prevent Grassland degradation and increase the benefit of ecological animal production .

Materials and methods The samples of Soil ,forage , serum in sheep and wool were collected in April , July and October 2005 on Meadow around the Qinghai Lake , the samples were treated with traditional methods in the Lab . The objects were ten wethers in good condition . Content of Cu was determined in 180-80 polarized Hitachi Zeeman atomic absorption spectrophotometer . The data were treated with SPSS10 .0 software by single-factor analysis of variance .

Results and discussion

Table 1 *Change of Cu in the system of soil-grass-livestock in different seasons .*

Season	Soil(mg/kg)	Pasture(mg/kg)	Serum(mg/L)	Pair (mg/kg)	Intake (mg/d)
Winter and spring	20.98 ± 1.25^{A}	6.11 ± 1.79^{b}	1.34 ± 0.45^{a}	1.94 ± 0.35^{C}	2.63 ± 0.76^{B}
Summer	19.37 ± 1.92^{B}	8.91 ± 2.01^{Aa}	1.45 ± 0.63^{a}	4.71 ± 0.54^{A}	13.76 ± 3.10^{A}
Autumn	14.62 ± 1.56^{C}	3.77 ± 2.15^{Bc}	1.09 ± 0.22^{a}	3.75 ± 1.14^{B}	3.60 ± 2.05^{B}

From above table , as to zone around Qinghai Lake , in winter and spring , summer and autumn , Cu content in the soil was within the range of chestnut soil in China , however , this a little lower than the average content of the soil in Qinghai (21 mg / kg) . Therefore , the content in this area was suitable .

Cu is an essential element to the growth of pasture and livestock . Guang-hui Li ,etc thought that the content of Cu above 5 mg / kg could maintain their normal growth , below 3～5mg/kg would be shortage . In our study , Cu content in pasture was normal in the spring and summer , but shortage in autumn around the Qinghai Lake .

Low Cu content could result in lack of Cu in an animal , and lead to many symptoms , such as Anemia , diarrhea , movement disorders and wool bleaching . Zhongchao Zheng found that the Cu requirements for sheep was 7～11mg/kg , but our results indicated that Cu content in pasture was below 6 mg / kg in the spring and autumn , the content couldn't meet the needs of the body .

The normal value of the serum Cu in sheep was from 0 .7～1 .3 mg/L . in our experiment , Cu level in serum of sheep was higher than the normal level in summer . The Cu level was in normal range in other seasons .

The Cu density in wool of healthy sheep was 3.68 ± 0.74mg/kg . in this experiment , the Cu density in wool in winter and spring was lower than that in healthy sheep , so , Cu was shortage . The causes may be long wither , about 7 months .

Conclusion In the system of soil-grass-livestock around Qinghai Lake , The Cu content in the soil was suitable ; Cu content in pasture was normal in the spring and summer , but lack in autumn ; In the spring and autumn , daily intake for Cu couldn't meet the needs of the body ; The serum level in sheep was higher than normal levels in the summer , while , in winter , spring and autumn , the level was normal . Cu in wool was shortage in winter and spring .

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Nutrient hotspots from patch burning in a Namibian rangeland

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Key words: BIOTA, bioassay, firebreak, nutrient hotspots, patch burning

Introduction Although fires have shaped savanna rangelands for millennia, most farmers have controlled lightning induced fires on their farms for past decades, with resultant change in rangeland condition. A few farmers have tried to apply prescribed burning to portions of their farms, mainly to try controlling bushes that have thickened on the land, but very few apply patch burning for biodiversity, such as promoted by Fuhlendorf & Engle (2001). The significance of nutrient hotspots to savanna dynamics has been pointed out by Scholes & Walker (1993). This study, falling under the Biodiversity Transect Analysis in Africa (BIOTA) program, learns from a farmer who applies patch burning.

Materials and methods Patch burning for biodiversity is applied at Farm Otjekongo (21.13°S, 17.93°E) with a mean annual rainfall of about 400mm in Namibia's Thornbush Savanna. A firebreak of 30-40m width is heavily grazed by cattle within moveable electric fencing around the patch of roughly 10ha that then gets burnt with a head fire towards the end of the dry season. Transects of 50m were permanently marked for various measurements, including the lengths of intercepted dung as an index of herbivore pressure. Soil was collected at three burnt patches. At the patch burnt two years previously, soil was only collected from the burnt zone and nearby unburnt control, since the firebreak was no longer visible. At the patch burnt a year earlier soil was also collected from the firebreak zone, while at the patch burnt in the year of sampling, soil was furthermore collected before and immediately after the fire. Soil samples, augured to 15cm at 10 points spaced 10m apart on both sides of a transect, were mixed into the same bag for later distribution amongst 10 pots for radish bioassay to determine overall fertility. Five transects per zone were sampled this way. One radish was grown per pot and harvested after five weeks to measure diameter of the radish, length of the longest leaf, fresh mass (including leaves) and brix of sap squeezed from the radish onto a refractometer. Fuel load, by clipping in 34 randomly placed quadrats of $1m^2$ at the last of the three patches to be burnt, was 1.74 ± 0.29 t/ha of dry grass.

Results Previously burnt patches still attract more large herbivores at least two years after burning. Dung covered $1.29\% \pm 0.46\%$ of the firebreak after grazing compared with $0.08\% \pm 0.04\%$ in the control. Figure 1 shows differences in soil fertility from the fresh mass bioassay. Similar, but less significant, trends appeared from radish diameter, followed by leaf length, while brix showed a slightly opposite trend, with sap of thinner radishes generally more concentrated.

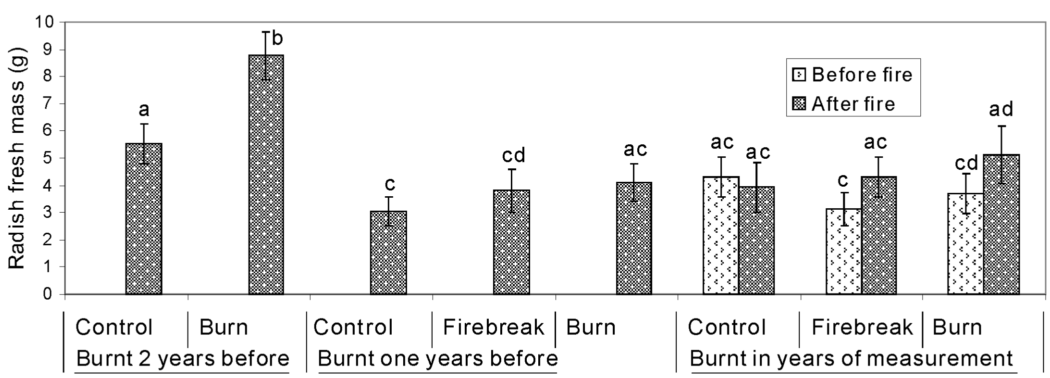

Figure 1 *Fresh mass per radish grown on soils from three patches (each burnt in a different year), grazed firebreaks around two of those patches and unburnt controls nearby (Error bars show 95% confidence limits; Bars do not differ significantly at $p < 0.05$ if they share any letter above them, by Tukey post-hoc test).*

Conclusions The soil was more fertile where a patch was burnt two years earlier, as expected from the shallow calcrete layer evident there. Burning increased its fertility two years later compared with the unburnt control, presumably from dung and urine of cattle and game attracted to the burnt patch. The higher fertilities of firebreaks and more recently burnt patches on deeper sandy loam are not significant at $p < 0.05$, but may become more pronounced over time.

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Conservation tillage influence on topsoil aggregation and carbon content on the Loess Plateau, China

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Key words: soil property, organic carbon, no-till, stubble retention, sustainability

Introduction In the Loess Plateau, the deterioration of the environment and in particular soil erosion are severe. In addition to frequent droughts in the area, soil is characterized as both having poor structural stability and as being infertile. Conservation tillage is believed to have beneficial effects on agricultural production, the environment and the economy. This paper reports the findings of a study which investigated the soil aggregation stability, total carbon, organic carbon and inorganic carbon under different tillage methods, in doing so it has aimed to confirm which tillage method and soil management program is most suited to the Loess Plateau.

Materials and methods This long term conservation tillage experiment was carried out in the western Loess plateau (35°40′N, 107°51′E). Long-term average rainfall was 562 mm. Treatments were conventional tillage (T), conventional tillage with stubble retention (TS), no-till (NT) and no till with stubble retention (NTS). A completed randomized block design with four replications was used. The soil samples were collected after wheat harvest and analyzed for the proportion of water-stable aggregates (>0.25mm) by wet sieving method. Total carbon (TC), total organic carbon (TOC) and total inorganic carbon (TIC) were measured by use of the combustion method with liquiTOC (elementar, Germany).

Results In the 0-2.5, 2.5-5cm layers, the highest water stable aggregate (>0.25mm), organic carbon and total carbon content for were measured under NTS treatment, however for the 5-10cm layer these measurements were highest under the TS treatment. Stubble retention with no-till had a significant effect on increasing the content of water-stable aggregates, OC and TC content for 0-5 cm depth, compared with those under the T treatment. No-till increased the organic carbon proportion within the total carbon pool significantly. There was a significant positive correlation between aggregate and OC content for top soil ($P<0.01$) (see table).

Table 1 *Water stable aggregates proportion and Carbon content under different tillage treatments after seven years implementation.*

Soil depth (cm)	treatment	Water-stable aggregate proportion (%) >0.25mm	OC ($g \cdot kg^{-1}$)	TC ($g \cdot kg^{-1}$)	OC/TC
0-2.5	T	35.51	6.32	16.93	0.38
	TS	26.72	6.96	17.77	0.39
	NT	35.85	7.76	17.68	0.44
	NTS	37.85	9.40	19.08	0.49
	$LSD_{0.05}$	4.72	1.02	1.829	0.075
2.5-5.0	T	19.3	6.40	16.58	0.39
	TS	22.03	5.83	17.30	0.35
	NT	28.83	6.84	17.02	0.40
	NTS	32.03	8.43	18.56	0.46
	$LSD_{0.05}$	4.51	0.94	1.99	0.073
5.0-10.0	T	17.59	6.01	16.79	0.36
	TS	23.53	6.64	17.51	0.38
	NT	21.98	6.00	16.61	0.36
	NTS	18.98	6.6.57	16.97	0.39
	$LSD_{0.05}$	4.9	0.874	1.739	0.072

Conclusion Conservation tillage had obvious effects on soil organic carbon improvement after seven years of implementation. Soil properties under conservation tillage were both more suitable for crop growth and long-term soil sustainability, both of which will be beneficial to developing a more sustainable farming system in the Loess plateau.

Long-term effects of annual applications of N and S fertilizers to grassland on forage yield, root mass, and soil pH, organic C and N on a Dark Gray Chernozem in north-central Saskatchewan

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Key words: Forage yield, N and S fertilization, plant species composition, soil organic C and N, soil pH, soil quality

Introduction Many soils in the Parkland region of Prairie Provinces of Canada contain insufficient amounts of both plant-available N and S for high crop yields. Application of N and/or S fertilizers on grasslands can acidify soil or alter some other soil properties, but also improve soil quality (Malhi et al. 1991). The objective of this study was to determine the effects of long-term N, S and/or K fertilization on forage dry matter yield (DMY), root mass, plant species composition, and soil pH, total organic C (TOC) and N (TON), and light fraction organic C (LFOC) and N (LFON).

Materials and methods A field experiment on a perennial grass stand was conducted from 1980 to 2005 on a Dark Gray Chernozem (Boralfic Boroll) loam soil at Canwood in north-central Saskatchewan, Canada (mean annual precipitation 425 mm). The site had been under annual crops for several years in 1920's or early 1930's, and then allowed to revert to grassland. The dominant grasses at the start of experiment were bromegrass (*Bromus inermis* Leyss), Kentucky bluegrass (*Poa pratensis* L.) and rough hair grass (*Agrostic scabra* Wild). There were five annual fertilizer treatments: 1. no fertilizer (Nil), 2. 112 kg N ha^{-1} (N), 3. 11 kg S ha^{-1} (S), 4. 112 kg N+11 kg S ha^{-1} (NS), and 5. 112 kg N+11 kg S+40 kg K ha^{-1} (NSK). Forage was usually harvested once in each growing season for determination of DMY. Plant species composition in 1994 was estimated using ground cover method. Soil samples in Nil, N, S, NS or NSK treatments were obtained at 5 or 7.5 cm intervals from the 0-15 and 15-30 cm depths in different years for pH, bulk density, and total and light fraction organic C and N. Root mass was estimated by digging out soil from the 0-15 cm depth.

Results and discussion

Dry Matter Yield (DMY) and Root Mass Except in some years, application of N fertilizer increased DMY only slightly over the Nil treatment. The DMY was increased considerably with combination of N and S fertilizers (i.e., NS treatment). This indicated that the response of hay yield to N was impeded by S deficiency in soil, and application of N together with S was an effective way for increasing DMY. However, application of K in addition to N and S fertilizers only had moderate effect on increasing DMY. Like DMY, root mass was greatest in treatments receiving both N and S fertilizers.

Plant Species Composition The composition of plant species changed markedly in various fertilizer treatments after long-term fertilization. In the Nil treatments, land was covered with bromegrass, fine grasses and herbs (dogwood). The S only treatment had vegetation generally similar to Nil, with slightly more vetches. In the N only treatment, the vegetation changed dramatically and there was virtually no bromegrass in the stands. The grass stand changed towards increasing predominantly bromegrass with combined applications of NS or NSK. Bromegrass is a higher yielding species than other grasses, which may have contributed to increased forage DMY due to combined N and S fertilization compared to other species.

Soil pH Soil pH in the surface soil layer was substantially decreased with annual applications of N and S fertilizers. The decrease in soil pH was more when only N fertilizer was applied compared to both N and S fertilizers together. In the 5-10 cm layer, there was some depression in soil pH in the N alone treatment. In the deeper soil layers, soil pH tended to increase with N or NS fertilization in most cases, probably due to downward movement of Ca or other bases to these soil layers.

Organic C and N Storage in Soil Total organic C and total N in soil increased with annual applications of N and S fertilizers together (NS treatment). Annual applications of NS fertilizer treatments increased both LFOC and LFN considerably in the surface soil layer. The NS treatment also increased LFOC and LFN in deeper layers. The increase due to NS application for LFOC as a percentage of TOC and for LFN as a percentage of TN indicated that application of N and S fertilizer could markedly increase light fraction of C and N sequestrated in soil, most likely due to increase in root mass from balanced fertilization (Malhi and Gill 2002).

Conclusions Forage DMY increased considerably with combined application of N and S fertilizers and further improved when K fertilizer was also applied (NSK), while N or S alone had limited effect on the DMY on this soil deficient in both available N and S. Annual applications of N and S fertilizers reduced soil pH in the top 10 cm soil, mainly in the 0-5 cm layer, while there was a tendency for increase in soil pH in some deeper soil layers. Mass of TOC, TN, LFOC and LFN in the 0-15 cm soil increased with NS application. There was a close relationship between DMY improvement and increase in C storage in soil from proper fertilization. The findings suggest that application of balanced fertilization by alleviating all nutrient deficiencies is an appropriate strategy for sustaining high forage yield and increasing C and N sequestration in soil.

Nutrition management in fodder grass production for fisheries in Hubei

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Key words: nutrition, fertilization, fodder grass, fisheries

Introduction The Jianghan plain region of Hubei province is renowned for its ability to supply superior quality rich rice and fish staples. Recent adjustment to China's national agricultural development plan have designated this region as one which is particularly favorable to continued development and expansion of in-land fisheries as a means for local economic improvement. Fresh fodder grass is a crucial feedstock for in-land fisheries. As the fodder grasses usually planted on poor and marginal land, improve its productivity through fertilization has been studied by the authors since 2003.

Materials and methods Field trial of fish grass was located in Datonghu State Farm, on alluvium soil with pH 8.2, OM 1.14%, available N 13.9 mg kg^{-1}, P 13.0 mg kg^{-1}, K 161.7 mg kg^{-1}, respectively. The fish grass was Sorghum Sudanense which is one of the main fish grasses cultivars in the region. Four treatments as: (1) N, (2) NP, (3) NK, (4) NPK with fertilization rate: N 540kg, P_2O_5 150 kg, K_2O 135 kg ha^{-1}. Urea as N source, SSP as P source and KCl as K source. All treatments with 4 repetitions and the plot area was 41.6m^2. Grass seed was sowed on April 13th with rate 67.5kg ha^{-1}. The fish grass was harvested for 5 times on June 12th, July 11th, August 3rd, September 3rd, October 11th, respectively. The nutrient content and some quality index such as protein, fat and fiber contents of grass were tested, To study the effect of feed fish with the grasses from different fertilization treatments on fish growth, fish feeding experiment was also implemented. Plant analysis used routine methods.

Results The result showed that both P and K, when combined with N, increased fresh grasses yield compared to the check (table 1). The highest cumulative yield over 5 harvests was obtained with the NPK combination and it supported a marginally higher yield level for the second harvest period. The economic benefit from NPK treatment also increased net profits to farmers by US$466 ha^{-1}. Grass plant test result showed that plant K, P, Ca, Mg, Fe, Cu, Mn nutrient contents, crude protein and crude fat contents of NPK treatment were higher than other treatments, except crude fibre content. The fish feeding experimental result indicated that NPK treatment obtained highest fish production compared with other treatments.

Table 1 *Effect of fertilization on fish grass fresh yields and nutrient contents and fish growth.*

Treatment	Grass yield (kg ha^{-1})	Grass N%	Grass P%	Grass K%	Fish weight (kg $plot^{-1}$)
N (CK)	66.43 (100*)	2.39 a	0.178 ab	2.37 cd	3.23 c
NP	77.49 (116.6)	2.39 a	0.178 ab	2.35 d	2.24 d
NK	79.90 (120.3)	2.33 a	0.171 b	2.84 ab	4.89 ab
NPK	89.86 (135.3)	2.40 a	0.187 a	2.98 a	5.01 a

* Numbers in parentheses represent percent (%) relative yield.

Conclusions Fertilization could greatly increase the fresh yield of fish grass in Hubei province. Balanced fertilization showed better response from grass yield, quality and economic profit. For fish feeding, he high quality grass from NPK treatment which was relative balanced plant nutrition obtained highest fish production in the experiment. Therefore, balance fertilization for fodder grasses should be recommended in this region.

Study on the relationship between edaphon amount and soil type in desert grassland

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Key words : desert , soil microbial , vegetation type , soil type

Introduction Soil microbial is key regulators pf energy and nutrient flux in ecosystems . Here we examined the type and quantity of soil microorganisms in different soils in Ningxia desert grassland vegetation type . Such information is of basic scientific interest and may be useful in grassland restoration .

Materials and methods Vegetation measurements were made in the desert grassland in Yanchi County . Measurements included plant height , cover , frequency and biomass . Bacteria were examined using a beef extract peptone agar count ; actinomycosis was examined using a Gao medium count , fungi were examined using a Martin's Bangladesh-count agar medium .

Results and discussion Bacteria counts differed depending on soil and vegetation types . Light loam soils had the largest number of bacteria averaging 45.27×10^6 /g dry soil . Light sand had the smallest number of bacteria averaging 8.9×10^6 /g dry soil ; average number of bacteria on loam and sandy loam soils were 27.9×10^6 /g dry soil and 18.63×10^6 /g dry soil , respectively . Different types of vegetation and soil types of actinomyces caused a significant number of changes , and actinomycosis number in the tight sand > the number of actinomyces in sandy loam > the number of actinomyces in light loam > the number of actinomycosis in loam soil . Different types of vegetation and soil types of fungi caused a significant number of changes . The number of fungal in loam was the average maximum about 11.73×10^3 /g dry soil ; the average number of the largest fungi in tight sand was small about 3.03×10^3 /g dry soil ; followed by light loam and sandy loam soil fungi number in the volume were 8.2×10^3 /g dry soil and 3.97×10^3 /g dry soil . Adverse ecological environment and the different texture had different soil fertility ; the different types of vegetation affected its advantages value and the distribution of microbial number corresponding differences . Due to the drought , soil potential fertility and effective nutrient was poor , the soil microbial volume was not high . At the same time the light loam and loam were better physical properties , so microbial content was relatively high . Soil microbial bacteria was exceeding other microorganisms (normally 10^7-10^6 / g dry soil) , actinomycosis(10^5-10^4 / g dry soil) and fungi (10^3 / g dry soil) . But fungi had greater shape individual , according to the volume and the proportion of cells , bacteria and fungi biological effects were the same . Because soil microbial was majority of the heterotrophic bacteria , and their distribution and soil organic matter content is significantly correlated , and physical and chemical properties of soil fertility status on the distribution of microbes have a direct impact , these factors would lead to change in the number of micro-organisms in the soil and composition of the growth and decline change .

Table 1 *Different soil types and vegetation types of microorganisms quantity(/g dry soil) .*

soil types	Bacteria($\times10^6$)	Fungi/($\times10^3$)	Actinomycosis($\times10^4$)
Tight [0]sand	8 .9	3 .03	42 .57
loam	27 .9	11 .73	10 .57
Sandy loam	18 .63	3 .97	26 .13
Light loam	45 .27	8 .2	18 .97

Reference

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Correlations between soil properties and plant growth for special synthetic soils added with five components used in high-and-cut rock slopes

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Key words : rock slope , outside soil spray seeding , orthogonal array designs , synthetic soils , plant , restoration

Introduction It is well known that the outside soil spray seeding (OSSS) is most effective among the various techniques used for re-vegetation of bare rock slopes because of its high mechanization , high efficiency and fast restoration (Albaladejo-Montoro , 2000) . However , study of Esther (2004) showed that though OSSS behaved well on the low and gentle rock slopes whose gradients are less than 45° , it was not effective on high-and-cut rock slopes . Previous studies on OSSS were mainly focused on the improvement of engineering techniques (Fowler and Maddox , 1974 ; Carr and ballard , 1980) . However , the physico-chemical and biological properties of the soils after added different components used for OSSS remain less known . Therefore , We designed a few of synthetic soils with five variables by using orthogonal array method to study the properties of the special synthetic compound soils .

Materials and methods Twenty-five treatments were assigned to tray-planted (40 cm× 30 cm×15 cm) experiments by using an orthogonal array designs OAD_{25} (5^5) matrix with five levels for each factor and five replicates for each treatment . Italian ryegrass was selected as the tray-planted species to assess the status of plant growth . Soil samples for each treatment were collected by using soil core rings (30 mm in diameter and 50 mm in length) . In the experiment , plant biomass , soil pH , organic carbon , total nitrogen and phosphorus and soil invertase activities were used as response functions , respectively . Plant biomass was dried at 65 °C to constant weight and expressed on a weight basis . Above ground biomass was measured with the clipping method at plant maturity and below ground biomass was measured with the washing method . PH was measured by Glass calomel Electrode (Smith and Doran , 1996) . Organic carbon was measured by the methods of Mebius (1960) . Total nitrogen and phosphorus (Bremner and Mulvaney , 1982) . Enzyme activities was analyzed using the method of Schinner and Mersi (1990) .

Results The Pearson s correlation coefficient was used to quantify the strength of relationships existing among all the indices . The *r*-matrix showed that most indices exhibited high and significant relationships between plant growth , soil physico-chemical and biological properties at all concentrations of the five application factors . The plant biomass and showed highly significant and positive correlations with invertase as well as negative correlations with soil pH , total nitrogen and total phosphorous . These results indicated that the high pH and the over-high soil available fertilizers have hurt the plant growth . Considering the correlations between soil physico-chemical and biological properties , soil pH was negatively and significantly correlated to invertase activity , whereas organic carbon showed positively and significantly correlation with invertase activity , which suggested that the effects of soil phsico-chemical properties on soil enzyme activities were significant .

Discussion From the results , we can see that the additive of five amendments significantly affected plant growth and soil physico-chemical and biological properties .

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Effect of gradually water stress and recovery on photosynthesis, transpiration, and stomatal conductance in two plantago species

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Key words: Photosynthesis; Stomatal conductance; Transpiration; Drought stress; Recovery

Abstract Photosynthesis, transpiration, stomatal conductance and leaf water potential characteristics were examined in two plantago species (*Plantago ovata* and *P. psyllium*), with developing gradually water stress for several days after watering and then permitted to recover by re-watering. The photosynthetic rate, transpiration rate, and stomatal conductance decreased rapidly by withholding water for 2 days. After re-watering the rate of recovery of photosynthesis, transpiration, and stomatal conductance decreased gradually as the days without watering became longer. The differences existed in rates of recovery of photosynthesis, transpiration, and stomatal conductance following drought stress. Among the fractional recoveries the highest was photosynthesis, and the lowest was stomatal conductance. Photosynthesis rate following drought stress was rapidly recovered until 2 days after re-watering, and then recovered slowly. The critical time for the recovery of photosynthesis was recognized. The results show clearly a close correlation between the leaf water potential and the recovery level and speed of photosynthesis, transpiration, and stomatal conductance.

Long-term soil nitrogen and carbon change in semi steppe rangelands of golestan national park , Iran

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Key words : exclosure ,long term grazing ,Ah horizon ,rooting depth ,soil color .

Introduction Livestock exclusion induced great changes in the modifications in nutrient cycling of rangelands .The purpose of this study was to study effect of long-term exclosure (46 years) on change of soil Carbon ,Nitrogen and color in Ah (= A_1) (Dormar and Willms ,1998) horizon and rooting depth (Frank et al .1995) of rangeland plants .

Materials and methods Study area located in the semi steppe rangeland of Golestan National Park in North Khorasan Province of Iran .We sampled 3 heavily grazed by sheep and goat and 3 adjacent exclosures ungrazed by livestock for 46 years .Soil sampled from Ah (15 .11 cm average thickness in ungrazed and 9 .94 cm average thickness in heavily grazed) and rooting depth (58 .11 cm average depth in ungrazed and 47 .55 cm average depth in heavily grazed) .

Results and discussion Long-term exclosure increased Ah horizon thickness and rooting depth compared to heavy grazing ($P < 0.01$) also had a significant effect on the N and C concentrations in the Ah soil horizon ($P < 0.01$) .In the rooting depth is not seen difference in C concentration between two areas also N concentration in soils sampled null in two areas .Long-term exclosure influenced changes in soil color of Ah horizon from 10YR $^5/_4$ (yellowish brown)-10YR $^4/_3$ (dark yellowish brown) in ungrazed to 10YR $^6/_4$ (light yellowish brown)-10YR $^5/_4$ (yellowish brown) in grazed .In the rooting depth is not seen significant difference in soil color between two areas .

Conclusions 46 years of long-term exclosure had measurable effect on N and C concentrations in the Ah horizon as compared with grazed areas .These results is supported by Frank et al .(1995) and Reeder et al .(2004) but differ from Berg et al .(1997) who reported long-term exclosure had no measurable effect on C and N concentration in the surface 5-cm of soil .Changes in soil color of Ah horizon can be attributed to either decreased organic matter input into the Ah horizon or the upper part of the B horizon slowly being incorporated into the Ah horizon due to erosional loss of Ah horizon soil or both (Dormar and Willms , 1998) .The Significant differences occurred in Ah horizon .

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Grasslands/Rangelands Resources and Ecology

——Soil-Plant-Animal Interrelationships

Managing natural grasslands in a changing world : grazing ecology insights to accomplish re-oriented management expectations

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Key points :

1. There is an increasing debate regarding the quality of pastoral environment . More than the production *per se* , a series of multifunctional responsibilities have been attributed to the pastoral ecosystems , that they always had , but have only became imperative as the world natural resources became threatened .
2. The quality of the use of a pastoral ecosystem can be interpreted through signals emitted by their biotic and abiotic components . For example , plants and animals show patterns of behaviour that permit inferences about nutrient acquisition status or nature of the competition being faced . As a result , the prevailing strategies of response in a given environment indicate the selection forces involved that , in turn , determine particular adaptive attributes of plants and animals as a response to them .
3. The objective of this paper is to discuss patterns of behavioural responses of plants and animals based on the most common source of disturbance manipulated by human actions in a pastoral ecosystem , the grazing intensity .
4. It is suggested that the recognition and interpretation of plant functional groups and ingestive behaviour of animals should provide the basis for the invention and planning of re-oriented grazing management strategies to construct pastoral environments in agreement with the new expectations and demands of a changing world .

Key words : biodiversity , ingestive behaviour , plant functional types , Brazilian Pampa , sward structure

Threatened natural grasslands , grazing challenges and opportunities : the Brazilian Pampa example

Natural grasslands have been facing contradictory pressures in developing countries . On one hand , there is a need to produce food and contribute to the country's development . On the other , there is the need to preserve the environment and the ecosystem . This dilemma is reaching a crucial point in Southern Brazil . Pampa is the most southern Brazilian biome and represents 2.07% (176,496 km^2) of the national territory (Carvalho & Batello , 2008) . Its subtropical natural grasslands are the most important forage resource for almost 13 million cattle and 5 million sheep . Recent studies have shown that this natural grassland ecosystem is under threat and disappears at a rate of 410,000 ha per year (Nabinger & Sant'Anna , 2007) , with only 33.8% of its natural vegetation cover still remaining (Hasenack et al . , 2007) . The expansion of agriculture (mainly cash crops , forestation , etc .) , along with overgrazing are the most frequent actions threatening this biome (Carvalho & Batello , 2008) .

Pampa is a complex vegetation comprised mainly of grasses (especially *Andropogonea* and *Panicea*) and herbs (small shrubs and trees are occasionally found) with a great degree of biodiversity as Overbeck et al . (2007) estimated the occurrence of 3000 4000 phanerophytes . Grazed grassland communities are heterogeneous and usually show a short inter-tussock stratum of prostrate species that is intensively grazed , and a taller stratum of plants with a more or less patchy distribution . Tussocks are often comprised of tall-tufted grasses with low forage value and other species that are unattractive to grazing animals (shrubs and thorny species) . Thus managers and animals face a very diverse grazing environment to explore in floristic , functional and structural terms .

Humans and grazing animals respond differently to the challenge of exploiting complex pastoral environments (Carvalho , 2005) . Because humans do not know how to deal with heterogeneous environments , nor manipulate their dynamics , they normally tend to replace complex with simpler systems (e.g . mono specific pastures) as a means of increasing control . The consequence of misunderstanding the complexity of natural pastures is the low animal productivity attained (60 kg LW $.ha^{-1}$. $year^{-1}$) , which does not compete efficiently with other economical alternatives of land use . On the other hand , grazing animals , when allowed , are capable of successfully exploring heterogeneity and even benefit from it (Rook et al . , (2004) , since they evolved in complex environments and developed a series of mechanisms that enables them to survive in such environments (e.g . Villalba & Provenza , 2007) . For example , Cortes et al . (2006) pointed out that diverse grazing environments stimulates animals' intake . However , the most common is to find situations where animals face restrictions to their mobility and selectivity (Bailey , 2005) . By selecting forage , animals increase heterogeneity on the swards by reducing the most palatable species with a concomitant increase in the less palatable . This situation worsens and managers usually react by increasing stocking rate and/ or adopting grazing strategies that restrict animal's choices .

In the Pampa Biome the course of history regarding natural grasslands is the same as for other areas of the world (Suttie et al . , 2005) , and is related to an intensification process of the pastoral systems with significant reduction of biodiversity and degradation of natural resources. Nevertheless, the debate and awareness of how these natural resources are being misused is increasing (Nabinger & Sant'Anna, 2007), and maybe it will not be necessary to reach an almost complete deterioration of the ecosystem before important issues like environmental pollution and degradation, biodiversity and extensification start to be seriously addressed (Lemaire et al., 2005). In this context, knowledge of the plant-animal relations in such complex environments is important to describe the nature of and generate interest in the interacting processes under those conditions. This would facilitate communication and getting people aware of how dependent they are on the conservation of those resources. In spite of the difficulties of debating issues like this in developing countries, it is essential to encourage public policies and management actions aimed at striking an adequate balance between the conflicting objectives of production and conservation (Carvalho & Batello, 2008). In South Brazil, preservation of Pampa cannot be separated of their natural vocation, i.e. the economical exploitation of domestic herbivores. As a result, ecological arguments should not be considered without taking into account the need to achieve satisfactory animal productivity. However, there is an opportunity to incorporate ecological variables into the pool of productive" variables used to guide the actual use and management of such ecosystems, that being the purpose of this paper.

Plant-animal relations in heterogeneous environments: focus on plant strategies

It may seem logical that the necessary characteristics for plants to survive in desert habitats are not the same as those required for humid tropical/sub-tropical habitats. This simplistic observation implies that each habitat determines adaptive characteristics to plants that would allow them to exist. The edaphic and climatic potential of the environment in association with the local floristic diversity and its evolution history with grazing and fire, for example, determine the type of vegetation potentially capable of existing in a given habitat. Even though there is a wide range of possible vegetation types, it is the current characteristics of the habitat that will define the type and structure of the existing vegetation. The fact that ecosystems show variable patterns of making nutrients available to plants, as well as the amount and type of predators inhabiting them, allow for the existence of contrasting strategies of growth and resistance (e.g., prostrate sward forming or tall-tufted species, short and long life cycle, fast and low growing plants, etc.). Further, when grazing and other management interventions are considered, there is the definition of a vegetation structure that reflects, at a given point in time, the result of a local selection" process (Carvalho et al., 2007).

Recently, there has been increasing interest in a functional approach for interpreting plant strategies and their impact on ecosystem dynamics (Garnier et al., 2004). The description of the floristic composition and identification of individuals is less important (Sosinski Junior & Pillar, 2004) than identifying groups of plants with similar functions in the ecosystem (Gitay & Noble, 1997). The basic assumption is that the prevailing conditions in a given ecosystem will select the pool of markers (functional types) more correlated with the vital functions of the species (but see Wright et al., 2004). In this context, markers are defined as measurable morphological, physiological and/or propagation traits, and can be classified as response traits", when they indicate responses of plant communities to variations in their environment, or as effect traits", when they indicate the effect of plant communities upon how the ecosystem work (Lavorel & Garnier, 2002). A list of markers has been evaluated by several authors (e.g., Pontes, 2006) as a means of studying plant communities in different observational scales. It has been demonstrated that once efficient markers for functional strategies of plants have been identified, they will become important for diagnosing and managing grasslands (Cruz et al., 2002). For example, response traits related to high soil fertility are high specific leaf area (SLA), high nutrient concentration (particularly N), low leaf dry matter content (LDMC), short leaf lifespan (LLS), and high rates of photosynthesis and respiration (Wright et al., 2005). Species adapted to such environmental conditions usually show high rates of growth and turnover of plant organs. As a result, leaves are short lived and plants have high nutrient requirements. On the other hand, response traits related to low soil fertility are low SLA, low N content, high LDMC, high proportion of cell wall constituents and high LLS (Westoby et al., 2002).

The adaptive strategies of plants to high grazing intensities keep similarities to those related to high soil fertility (Cruz et al., 2002). In fact, strategies for high soil fertility conditions can be considered as tolerance mechanisms to grazing, since they involve responses related to high rates of plant growth (Diaz et al., 2001). Conversely, the characteristics that favour adaptation of plants to low soil fertility conditions are associated with low herbage quality and, consequently, low intake. SLA is negatively correlated with LLS (Westoby et al., 2002) that, in turn, is negatively correlated with nutritive value. According to Pontes et al. (2007), herbage dry matter digestibility has negative correlation with LDMC and positive correlation with SLA, corroborating the propositions of Garnier et al. (2004), which indicate that SLA and LDMC correspond to central traits to diagnose vegetation types. The application of these markers in pastoral environments would allow characterisation and classification of the existing vegetation in terms of potential productivity and nutritive value (Cruz et al., 2002).

The proposition of assessing grasslands through their prevailing plant functional types was tested by Quadros et al. (2006) on a natural pasture in South Brazil. The existing vegetation had been subjected to contrasting grazing intensities (daily herbage allowances of 4, 8, 12 and 16 kg DM/100 kg LW) during 17 years (Carvalho et al., 2007), and their interaction with different conditions of natural soil fertility generated four large functional groups distinguished by LDMC and SLA of the several plant species in each group (Table 1).

Table 1 *Groups of plant functional types based on leaf arca (SLA) in a natural pasture subjeeted to contrsating graling inter sines gwring 17 pears(Quadros et al., 2006)*

Groups	LDMC ($mg \cdot g^{-1}$)	SLA ($m^2 \cdot kg^{-1}$)	Species
A	230	24	*Axonopus affinis, Panicum sabulorum, Paspalum paucifolium*
B	310	16	*Andropogon lateralis G*, Coelorachis selloana, Paspalum paucifolium, Paspalum notatum*
C	380	8	*Andropogon lateralis T*, Piptochaetium montevidense, Sporobolus indicus*
D	500	6	*Aristida spp (A. laevis, A. phylifolia, A. venustula)*

* G=grazed; T=tussock

There was an inverse relationship between LDMC and SLA. Plant species with high SLA and low LDMC could be identified as plants that developed a resource capture strategy (groups A and B), with ability to compete for nutrients, showing high rates of herbage accumulation and low LLS. Phyllochron values of *P. notatum* and *C. selloana* (group B) were lower (Eggers et al., 2004) than those of *A. lateralis* (T) and *P. montevidense* (group C). Plants of the first group were characterised by a stoloniferous growth habit. Groups C and D were characterised by low SLA and high LDMC, suggesting plants with a strategy for resource conservation, with low rates of herbage accumulation and high LLS. These are species that have, in their large majority, a tall-tufted growth habit that, according to Briske & Derner (1998), permits plants to explore and capture nutrients in a diameter larger than that used to release them, resulting in nutrient accumulation right under the vertical projection of the leaf canopy, a strategy called resource monopolization". Quadros et al. (2006) demonstrated that plants types associated with strategies of nutrient conservation occurred on areas where grazing intensity was low. Conversely, plant types associated with strategies of nutrient capture occurred on areas where grazing intensity was high. The authors concluded that the prevailing plant functional type was closely related to grazing management. Halford et al. (2008) studied the same vegetation subjected to contrasting intensities of grazing throughout a 20 year period and confirmed that high long-term grazing intensity significantly modified grassland composition, forming homogeneous overgrazed pastures characterised by a specific species assemblage. On the other hand, lower grazing intensities created more heterogeneous vegetation with grazed and ungrazed areas, but had small impact on floristic composition of grazed areas. Medium grazing intensities increased vegetation heterogeneity by enhancing species richness (Goret, 2005) and creating distinct grazed and ungrazed areas (Halford et al., 2008), enhancing primary and secondary productivity, while very high or very low grazing intensities reduced vegetation diversity and promoted abundance of a few adapted species (Soares et al., 2003).

The available results allow an inference to be made that assessment of plant functional types in a given pastoral environment might be used to understand and interpret the existing driving forces and what their influences on the local vegetation composition are. Based on these, management actions can be thought up which aim at achieving a pre-determined vegetation type and structure necessary for proper animal utilisation in harmony with the objectives planned for that environment.

Plant-animal relations in heterogeneous environments: focus on animal strategies

In natural grasslands subjected to high grazing intensities, it is common that the prevailing plants species have resource capture strategies and avoidance mechanisms to resist grazing. The size and structure of such plants result in little exposure" of the acquired carbon, making more difficult the process of herbage capture by the grazing animal. Under these conditions, daily grazing time can easily exceed 600 minutes (Pinto et al., 2007). Depending on the grazing management, as well as on the floristic composition of the vegetation, this area dominated by a sward forming vegetation can form a mosaic with tussocks varying in frequency, topographic location and in degree of patchiness (Carvalho et al., 2007). The influence of double stratum vegetation on the grazing process was discussed by Gordon (2000). The author reviewed plant-animal relations in communities dominated by *Nardus stricta* and showed how the characteristics of each stratum were inter-related determining intake and diet selection by the grazing animals. In general, the availability of the preferred stratum affects the intensity with which it is used as well as the utilisation of the less preferred stratum, indicating a high degree of complexity that usually limits detailed experimentation and knowledge regarding such ecosystems.

In such heterogeneous environments it has been observed that the grazing process, at its lowest scales of decision, is essentially the same as that in sown temperate swards. For example, Pinto et al. (2007) did not find correlation between grazing time and herbage mass in natural grassland, when herbage mass is estimated on average. However, when only the herbage mass of the inter-tussock vegetation was considered, grazing time increased 67 minutes for each centimetre decrease in sward height. In a pioneer work, Gonçalves (2007) elaborated a reductionist protocol to mimic sward heights of the lower stratum of natural grasslands subjected to decreasing levels of grazing intensity. The author confirmed that the structure of the inter-tussock vegetation affected bite dimensions and intake in a similar manner as reported by sown pastures. The comparison between bite depth of ewes and heifers revealed a linear relationship with sward height and no difference between animal species (Figure 1).

The constant proportionality of herbage removal was observed, as previously discussed by Hodgson et al. (1994). As sward height decreased, bite mass was more negatively affected for heifers than for ewes. Large animals are more handicapped on short swards where bite mass increases more slowly with body weight than do the energetic requirements. Time per bite increased with increasing bite masses, and lesser for heifers, a likely consequence of the larger capacity of cattle to perform compound chew-bite jaw movements in situations of large bite mass (Ungar et al., 2006). Bite mass was the main determinant of intake rate. The reduction in bite mass and intake rate from around 10.0 and 11.5 cm for ewes and heifers, respectively, indicates that C4 forage species need careful control of sward structure in order to optimise herbage utilisation, as pointed out by Da Silva & Carvalho (2005).

In pastoral environments dominated by prostrate species with resource capture strategies, animals alter their dynamics of herbage acquisition, patterns of movement and use of feeding stations (FS). Mezzalira (unpublished data) showed that under such conditions animals increase total grazing time reducing the number of meals but increasing the duration of each meal.

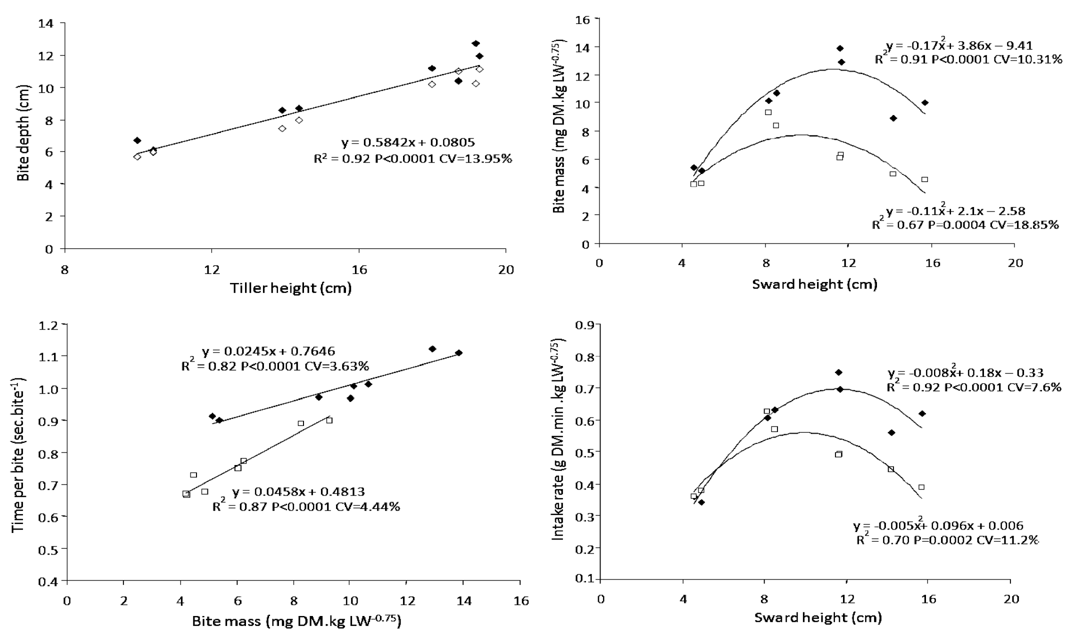

Figure 1 *Ingestive behaviour of heifers (◆) and ewes (□) in natural pastures (Gonçalves, 2007).*

Modifications in patterns of herbage acquisition were also associated with reduction of the number of inter-meal intervals and the angle of animal's trajectory during grazing. The increase in grazing time is a classic response to situations of low herbage mass, while the reduction of trajectory angle during grazing causes animals to spend less time on a limiting grazing site in an attempt to increase the probability of finding a more appropriate one (Prache et al., 1998). Gonçalves (2007) studied patterns of animal movement and herbage search for cattle and sheep on a natural pasture. Both species showed the same pattern of response, but with different magnitudes (Table 2).

Table 2 *Feeding station behaviour of calves and ewes in natural pastures (Gonçalves, 2007).*

Variable	Sward height (cm)				Model*	P	R^2	CV (%)
	04	08	12	16				
Feeding station per minute								
Calves	13.7	9.5	7.0	8.7	Q	<0.0001	0.876	10.55
Ewes	19.0	7.5	9.7	11.2	Q	0.0001	0.791	18.58
Steps per feeding station								
Calves	1.1	1.3	1.8	1.2	Q	0.0057	0.498	19.18
Ewes	1.1	2.4	1.6	1.2	Q	0.0009	0.620	22.15
Bites per feeding station								
Calves	4.8	6.4	7.8	7.2	Q	0.0182	0.695	12.35
Ewes	4.6	8.9	8.4	7.8	Q	0.0008	0.712	13.21

Variable	Sward height (cm)				Model*	P	R^2	CV (%)
	04	08	12	16				
Movement rate (steps .minute^{-1})								
Calves	14.5	13.0	12.0	10.5	L	0.0023	0.497	12.50
Ewes	20.5	17.7	15.7	14.2	L	0.0003	0.649	10.17
Time per feeding station (seconds)								
Calves	4.3	6.4	8.7	6.9	Q	0.0006	0.788	12.92
Ewes	3.1	7.9	6.4	5.4	Q	0.0002	0.706	17.91

* *L= linear; Q= quadratic*

Under intake limiting conditions, both cattle and sheep visit a larger number of FS, harvesting fewer bites and remaining less time on each FS, a behaviour that is in agreement with the Optimum Foraging Theory (Prache et al., 1998). Further, animals move faster, but with fewer steps between FS, indicating an attempt to increasing the rate of encounter with potential FS. Such behaviour is also compatible with the low bite mass obtained in the last bite, taken prior to abandoning the previous FS, which does not allow efficient movement of animals (selection of new FS while processing the last bite harvested). These behavioural responses change in the opposite direction as sward characteristics become more favourable to herbage harvest, reaching a different plateau for each animal species.

The consequence of animals spending more or less time grazing and using a larger or lesser number of FS is that a horizontal structure is created over time, where some patches are grazed more often than others (Laca, 2000). Under continuous stocking, animals are particularly attracted by areas where nutrient concentration is high, being able to memorise and use them more frequently than others (Launchbaugh & Howery, 2005). Thus, a heterogeneous mosaic condition is established. When stocking rate is high in relation to the herbage available on the preferred sites, there is an overgrazing of the preferred species on pastures of complex floristic composition and some high nutritive value species run into the risk of disappearing (Eggers et al., 2004). This is often wrongly interpreted as being a restriction of the grazing method used; generating the general impression that continuous stocking is associated with low productivity, a subjective interpretation that supports the inconsistent paradigm regarding rotational stocking as the best grazing method" (see discussion about perception *versus* experimental evidence in Briske et al., 2008). In this context Carvalho (2005) stated that overgrazing on certain areas would rather be consequence of low opportunity for selection. While an instantaneous high herbage allowance would create heterogeneity, frequent use of the preferred areas and rejection of the less preferred areas creates, in the long term, a condition of high herbage allowance on the total area, but limited on the sites effectively used (Neves, 2008). Since they cannot explore other areas as any other herbivore in a natural environment would, animals have no other alternative than overuse preferred sites. This corroborates the statement of Bailey (2005) that the large majority of problems regarding grazing management derive from an inadequate distribution of grazing and not of the use of incorrect stocking rates.

In fact, Neves (2008) indicated that variations in stocking rate slightly modified the characteristics of the inter-tussock stratum, whose magnitude is smaller than the variations suggested by varying grazing intensities. Regardless of the several combinations of grazing intensity studied, the frequency of FS with optimum structure for herbage capture was inferior to 10% of the total surface of inter-tussock vegetation. Carvalho et al. (2007) described this phenomenon as structural collapse", where the decrease of grazing intensity in plant communities dominated by prostrate growing species with resource capture strategies increase the contribution of such species in terms of herbage mass and height until a certain point, from which the patterns of defoliation and the nature of the competition process change so much that the community starts to give place to another one, usually comprised of tall-tufted species with resource conservation strategies. This indicates that simple manipulation of grazing intensity under those circumstances is not enough to manage the inter-tussock stratum and generate adequate conditions for grazing. Therefore, construction of adequate sward structures for grazing cannot be achieved only through variable stocking, but it needs other management strategies with the objective to construct pastoral environments where diversity of plant functional types and structures would be compatible with production targets.

Thus, as previously discussed for plants, animals also present grazing behavioural signals which could provide a basis for interpreting the richness of a particular pastoral environment and orientate management actions. In this sense, it has been proposed (Gordon & Benvenutti, 2006) that further improvement of animal production from grasslands will need to be associated with the identification and manipulation of animal behavioural responses, favouring the expression of their grazing abilities rather than inhibiting them as it is often the case for antropic interventions.

Concluding remarks

Grazing ecology is rarely treated in a systems context associated with management actions aimed at economical benefits (Soder et al., 2007). In this context, for some natural ecosystems it is important not only to understand how they work and what the mechanisms involved in the grazing process are, but also to evaluate their direct impact on the production and quality of animal products. Consumers demand production systems that respect not only productivity targets, but also exercise environmental responsibility and animal ethics. Kemp & Michalk (2005) outlined the need to redefine the frameworks within which management decisions are made to enhance the overall environmental values of grasslands. In this sense, the interpretation of the pastoral environment quality using plant and animal behavioural responses as well as indicators of soil chemical, physical and biological fitness is of major relevance to orientate management practices that are coherent with the new expectations and demands of a changing world. In this sense, intensity and distribution of grazing have assumed a new dimension, according to which grazing management must be seen as a means to construct adequate and ecologically sound pastoral environments that allow animals to express their wisdom in harvesting nutrients (Provenza et al., 2007) and self-medicate themselves by selecting phytochemicals (Revell et al., 2008) while minimising the energy costs of grazing (Baumont et al., 2005), without jeopardising environmental and production system sustainability. In ecosystems where the conservation of natural resources is achieved through their economical use, the importance of the pastoral environment has to be imposed by means of competitive productive indexes and products with high aggregated value.

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Opportunities to use secondary plant compounds to manage diet selection and gut health of grazing herbivores

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Key points:

1. Grazing herbivores and plants have co-evolved such that plant chemistry and animal metabolism are intimately linked.
2. Whilst conventionally-measured traits of plant nutritive value provide invaluable information to help predict animal performance, there are many situations where knowledge of secondary plant compounds can provide insights into the interactions between plants and herbivores.
3. Secondary compounds can affect diet selection and, sometimes, longer-term feed intake.
4. Secondary compounds can interact with rumen microbes to alter fermentation profiles and can be toxic towards nematode parasites in the gastrointestinal intestinal tract thereby providing a natural' means to help control these important pests.
5. Combining plant traits with knowledge of animal behaviour can aid our design and management of mixed plant assemblies that address both animal production and natural resource management goals.

Key words: Secondary plant compounds, diet selection, gut health

Introduction

Grazing herbivores and the plants they consume interact with each other. The interactions are complex, based on hundreds of plant compounds and plant physical characteristics and the sensory and metabolic systems of animals. The ultimate goal of animals is to consume an optimal combination of nutrients that promotes survival, growth and reproduction. To select an optimal diet, herbivores must find a balance between over-and under-consumption of particular plant species and plant parts. Plants similarly need to find a balance between encouraging and discouraging herbivory. Animals can assist in pollination, seed dispersal, reducing inter-plant competition, and nutrient cycling, but excessive herbivory can severely reduce plant growth. Herbivores and plants have co-evolved, and a complex biological system has emerged to control the interactions (Figure 1). In the following paper, we discuss and provide examples of how plant compounds can influence diet selection, feed intake and gut health of animals, and comment on the implications to designing and managing grazing systems.

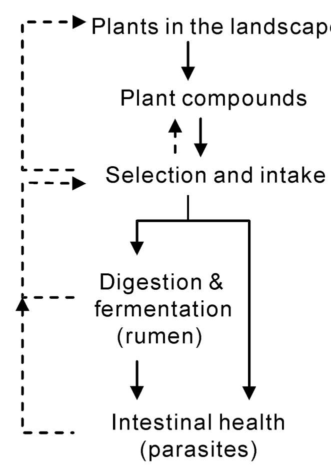

Figure 1 *Schematic representation of the interactions between the landscape, plants and herbivores.*

Plant compounds, diet selection and voluntary feed intake

Plants vary both spatially and temporally in their chemical and physical composition. Consequently, for grazing herbivores to meet their nutritional requirements and avoid the over-consumption of toxins, they must continuously assess characteristics of what they eat, link this to the post-ingestive consequences of eating the plant, and modify their selectivity for particular plants (Provenza et al., 2007).

A critical factor in animal production is the regulation of feed intake. Plant secondary compounds play an important role in regulating intake and influencing diet selection (Villalba et al., 2002; Mote et al., 2007). Animals use sensory perception to discriminate among different plants, and the metabolic feedback from ingested nutrients and/or toxins calibrates the smell, flavour, sight and texture sensations with the positive and negative consequences of eating the food. This enables an animal to acquire preferences for foods that are nutritious and become averse to foods that are either deficient in nutrients or toxic (Provenza 1995).

Although our capacity to measure diet selection and intake is less than ideal, particularly in extensive grazing systems, there is some evidence of sensory discrimination during grazing. For example, when Thomas (2005) offered sheep 20 genotypes of annual plants across three stages of plant phenology, a standard' set of measured traits (nitrogen, sulphur, neutral detergent fibre, acid detergent fibre, water soluble carbohydrates, *in vitro* digestibility, shear and compression energy) accounted for up to 60% of the variation in relative preference values. However, during the vegetative stage, only 20% of the variation could be accounted for by these particular traits. Principal component analysis showed that, at the senesced phase, the legumes that were preferred by the sheep had higher nitrogen content and digestibility, but this trend was not apparent when the pastures were at the vegetative phase. At the reproductive and senesced stages, the nutritive value, or digestibility, of annual plants decline, and hence animals are motivated to select plants with higher than average digestibility. But during the vegetative phase when there was a uniformly high digestibility across all 20 genotypes, other characteristics of the plants were used to discriminate between genotypes. Hence there is the possibility that secondary plant compounds may provide important distinguishing features of the different plant species to the animals. Such a conclusion has been reached with folivorous marsupials offered Eucalyptus leaves (Lawler et al., 1998), where no correlation was found between feeding and several measures of nutritional quality, total phenolics or condensed tannins. However, terpenes and a particular group of phenolic compounds (diformylphoroglucinols) did appear to alter feeding behaviour by acting as deterrents, with the latter being more important.

Another example of how conventional nutritive value traits cannot always account for differences in selection comes from a series of experiment with sheep grazing *Atriplex* spp (saltbush). The selection of saltbush by sheep is known to differ between individual plants (Maywald et al., 1998; Norman et al., 2004). For example, Norman et al., (2004) found distinct preferences for specific saltbushes by young Merino sheep, both within and between species (old man saltbush, *A. nummularia*, and river saltbush *A. amnicola*). The basis for the strong preferences could not be explained by conventional measures of nutritional composition (digestibility or content of fibre, crude protein or minerals). Preferences between individual old man saltbush plants was positively associated with nitrate concentration (250 *v* 98 mg/kg for most preferred *v* least preferred plants), whilst preferences for individual river saltbush plants was positively related to crude tannin content (0.12 *v* 0.09% for most preferred *v* least preferred plants).

Sensory assessment of a food is achieved through sight, smell and taste. The odour of a plant can be a powerful signal to herbivores, but it is an aspect that has not received much attention in livestock production. Livestock species (sheep, goats, cattle and horses) have a more sensitive olfactory system than humans, and hence the power of olfaction in determining intake can easily go unnoticed. Detecting odours can be beneficial in the process of food selection for at least four interrelated reasons. First, odour can be rapidly detected and thereby provides a means to influence feeding behaviour in the short term. Rapid decision-making may be important if a feed source is only temporarily available, as in a competitive feeding situation. Second, the decision to select or reject a particular feedstuff can be made without actually consuming the feed, and thereby avoid toxicosis. For example roe deer used odour to recognise and avoid undesirable plants once they learnt the consequences of eating these plants (Tixier et al., 1998). Conversely, once smelled, preferred plants are rarely refused. Third, the physiology of odour detection allows animals to integrate a complex suite of odours that may reflect the biochemical composition of the food. This may be important in identifying whether a novel species is likely to be of low nutritive value, or toxic, prior to sampling. Although animals can detect individual odorants, the way in which the olfactory system processes information also allows animals to generalise' the inputs to the central nervous system from a mixture of odours. Thus, the olfactory sense is able to distinguish among a practically infinite number of chemical compounds at very low concentrations (Leffingwell 2002). Fourth, neural processes link the detection of odour with memory, and hence the odour profile of a feedstuff can be used in learning and demonstration of learnt behaviour. The links between olfaction and memory allows animals to develop learnt behaviours based on associations between the sensory characteristics of feedstuffs and metabolic experiences; in other words, a characteristic odour profile can trigger memory processes, and thus help an animal assess whether a familiar feedstuff is associated with favourable or unfavourable metabolic consequences following its ingestion.

Examples of volatile plant compounds affecting feed intake include: (i) Preferences in cattle being strongly correlated ($r^2=0.97$) with 6-methyl-5-hepten-2-one, (Z)-3-hexenyl propionate and acetic acid emitted from fresh tall fescue cultivars (Mayland et al., 1997); (ii) Preferences of horses for particular oaten hays being strongly related to the abundance of two volatile compounds released from the hay. One of the volatile compounds was negatively correlated ($r^2=0.77$) to both preference and crude protein content of the hays, suggesting that the horses may have used the odorant to identify and avoid low protein hays. Such a phenomenon would be consistent with the finding that rats can self-select for dietary protein based on olfactory stimuli (Heinrichs et al., 1990). Cox (2004) did not identify the compound unambiguously, but based on preliminary gas chromatography analysis, it appeared to be a naphthalene compound. The second volatile compound was positively related to hay preference in horses ($r^2=0.83$), with preliminary analysis suggesting this compound was a decane, a class of compounds that have been linked to the odours from peaches that attract insects (Natale et al., 2003). It is conceivable that horses also found the odour attractive, or it was positively associated with a favourable nutritional trait of the hay; (iii) Individual volatile compounds accounting for 25-40% of the variation in preferences between different batches of oaten or lucerne hays offered to dairy cows or horses (preliminary data reported in Pain and Revell, 2007). The abundance of particular volatile compounds may be particularly useful in explaining outlier hays'-i.e., those for which animals select considerably more or less than predicted from nutritive value alone.

Secondary compounds and microflora of the gastrointestinal tract

Once ingested, plant compounds interact with the microbes of the gastrointestinal tract. Phytochemicals that can affect rumen fermentation include tannins, saponins and essential oils (Śliwiński et al., 2002; Kamra et al., 2006). Much of the literature has focussed on toxins and anti-nutritional factors that limit the use of plants as feedstuffs (see review of McSweeney et al., 2002). However, secondary compounds may have desirable effects on rumen fermentation by possessing specific antimicrobial, antiproteolytic, antiprotozoal or antimethanogenic properties that positively impact rumen ecology. For example, oral administration of an aqueous extract of saponin from *Biophytum petersianum* reduced ruminal ammonia and increased volatile fatty acid concentrations in goats (Santoso et al., 2007). Similarly, a modest intake of *Acacia cyanophylla* leaves (100 g) consumed before the ingestion of 200 g of soybean meal reduced the ruminal digestion of crude protein and increased the growth rate of lambs (Ben Salem et al., 2005). Plant compounds also have the potential to reduce lactic acidosis, methane production, or influence ruminal biohydrogenation (Vercoe et al., 2007).

Plants with anthelmintic properties are of special interest because of a growing problem of nematode resistance to the chemical anthelmintics in many countries (Besier and Love 2003). Condensed tannins have received the most attention (e.g., Iqbal et al., 2007) but many other active compounds have been identified (Githiori et al., 2006). Condensed tannins are a good example of how a plant compound (or group of plant compounds) can be detrimental at high doses (Makkar 2003; Min et al., 2003), but beneficial at lower doses by protecting fermentable protein from degradation in the rumen (Barry and McNabb, 1999, Ben Salem et al., 2005) or by controlling gastrointestinal parasites (Aerts et al., 1999; Iqbal et al., 2007). Whilst there has been some research on the use of plant extracts to control intestinal parasites, there remains the need to further investigate the use of particular plants under commercial conditions to control parasite burdens. Such research has been initiated by Ramírez-Restrepo et al., (2004) with sheep grazing either tannin-containing pasture species (*Lotus corniculatus*, birdsfoot trefoil) or perennial ryegrass/white clover pasture. More is required as specific environmental conditions and production systems (e.g., grazing rotations) may impact on responses, and there is a need to ensure that antinutritional effects to the host animals do not out-weigh benefits from parasite control (Athanasiadou et al., 2007).

Compounds besides condensed tannins could also be exploited. For example, phytoecdysteroids have been detected in about 6% of all plant species (Dinan 1995). These compounds induce abnormal moulting in many arthropods with lethal effects. Nematodes have a similar hormonal regulation of ecdysis, and phytoecdyseroids may provide a means of defence against free living, plant or animal nematodes (see summary by Soriano et al., 2004). Another class of plant compounds that may have a role in controlling gastrointestinal nematodes are the cysteine proteases (Stepek et al., 2004). These are known to digest nematode cuticles and are inducible by environmental stressors such as salinity (Forsthoefel et al., 1998; Jones and Mullet, 1995) and invertebrate herbivory (Lopez et al., 2007).

We are currently screening about 100 native shrub species for a range of characteristics, including *in vitro* inhibition of parasite larvae as a measure of anthelmintic activity. About 20% of the plants under evaluation reduce larval development to < 40% of controls (A. Kotze and J. O'Grady, unpublished data). As these plant species have not been through any plant improvement program, there is potentially a high degree of variation between individual plants within a species; i.e. different chemotypes. For example, we have tested 100 individual plants of one species growing at one location. Most but not all plants possessed anthelmintic properties (Figure 2). The plants have been scored for morphological traits, and plants toxic to parasites tended to be bigger, more upright in structure, with larger, thicker and darker green leaves—but none of these traits on their own were significantly different between toxic and non-toxic plants. The aim is to further quantify between-plant variation across sites and with plant phenology or maturity.

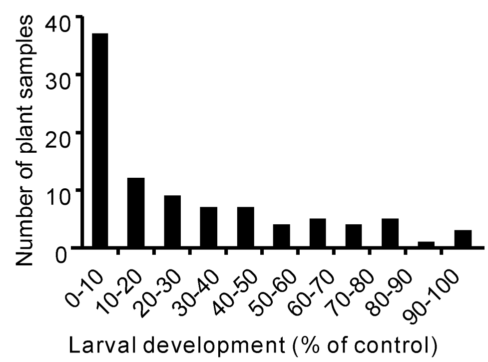

Figure 2 *Variation in the inhibition of parasite larval development in an in vitro screening test of 100 individual plants of one plant species.*

Putting it all together: how plant compounds can influence the design and use of diverse plant mixtures

The nature of interactions between plants and animals influences ecosystem function (Foley and Moore, 2005). There are many examples from non-agricultural systems that have explored aspects of these interactions (e.g., Crone and Jones 1999; Smallegange et al., 2007; Staudt and Lhoutellier, 2007), but there is great scope to build knowledge of interactions between secondary compounds and livestock to design and manage forage systems for the simultaneous benefit of livestock and the environment. In particular, when benefits of secondary plant compounds to herbivores can be combined with other desirable traits of the plants, such as a capacity to tolerate dry conditions and low soil fertility, provide ground cover on soils prone to erosion, or provide out-of-season feed, then we have an exciting proposition to re-design plant assemblies for grazing systems that take into account animal health and landscape function. The challenge is to ensure we optimise both the animals' long term performance and health and the persistence of the desired plant mixture. How can we best incorporate plants with bioactive compounds into grazing systems? This is a particularly pertinent question when one considers that beneficial plant compounds are often detrimental at higher concentrations in the diet, but there are signs it can be done. Frutos et al. (2007) recently reported that grazing goats supplemented *ad libitum* with freshly cut heather were able to self-select the plant such that beneficial effects of the condensed tannins in heather (reduced nematode eggs in faeces, reduced ruminal ammonia and increased VFA concentrations) were not accompanied by anti-nutritional effects often associated with condensed tannins. Indeed, Villalba et al . (2006) have shown that , with conditioning , sheep are able to self-medicate by consuming an appropriate remedy to a specific malaise . Despite the capacity of livestock to self-regulate and possibly self-medicate , livestock managers still have a crucial role to play . Even in low-input systems , there is the opportunity to intervene relatively easily by designing or modifying the plant combinations on offer , the spatial layout of plants , the duration or intensity of grazing . Here , some interrelated basic principles can be used inform our decisions :

(i) The combinations of plants made available to animals will influence intake and diet selection .
Palatability , so often considered a fixed trait for a particular plant , is very much a dynamic phenomenon that depends on the combinations of food on offer and the previous experience the animals have had with them (Provenza 1995) . When animals are offered two or more feeds simultaneously (usually the case with grazing herbivores) , there are at least two levels at which the contrasts between the options can be interpreted by the animal (see Bergvall et al . , 2007) . First , the animals compare the options on offer in real time' , without relying on memory or expectations of the future . Second , the reward (e .g . , nutrient supply) or penalty (e .g . , metabolic discomfort) of consuming one of the feeds is compared with the memory of a previously experience .

(ii) The combinations of secondary plant compounds affect animal responses .
Experiences of secondary plant compounds are strongly influenced by the degree of complementarity or antagonism between compounds (Lyman et al . , 2008a) . Furthermore , the sequence of offering bioactive plants or secondary compounds can influence the response of animals (Lyman et al . , 2008b) . So when considering the impact of plants and their secondary compounds , we need to be mindful that different circumstances may yield different outcomes . If a particular plant is considered to have high concentrations of an undesirable compound , the plant may still be a valuable component of the feedbase if it can be coupled with complementary species . Issues relating to duty of care' (Revell and Revell , 2006) become important here to avoid undesirable outcomes whilst maximising the chances of beneficial effects of incorporating particular plants into the mixture .

(iii) The experiences of animals can strongly influence diet selection .
If we want animals to eat a particular species in the pasture mix on offer , a situation should be created where the animals sample the plant-little by little-and have a positive experience of doing so . The positive experience may be achieved easily if a plant is nutritious , or it may require intervention such as the provision of a supplement (or a complementary plant species) to overcome a nutrient deficiency or avoid toxicosis . A positive experience usually leads to a situation where animals eventually choose to include the plant into their regular diet . An example of the influence of previous experience on selection was shown by Thomas (2005) . In this study , the intake of three pasture species (*Trifolium incarnatum* L , *Biserrula pelecinus* L . , and *Lolium rigidum* Gaud) offered simultaneously to sheep was heavily dependent on what species and what combinations had been offered to the animals in the past .

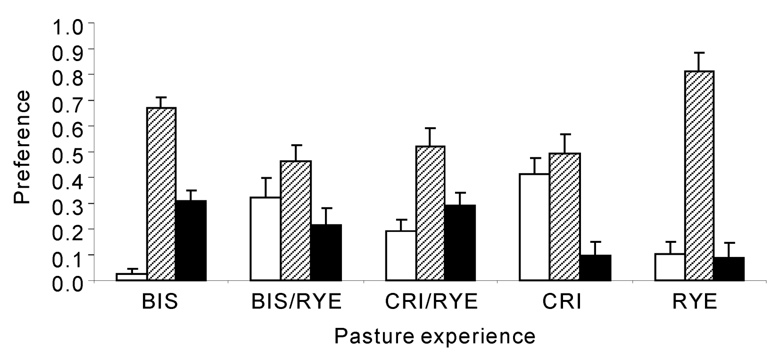

Figure 3 *Relative preference in sheep that had grazed plots for 4 weeks previously sown with either* B . pelecinus *(BIS) or* T . incarnatum *(CRI) or* L . rigidum *(RYE) or* B . pelecinus *and* L . rigidum *(BIS/RYE) or* T . incarnatum *and* L . rigidum *(CRI/RYE) . During the preference testing , the sheep were offered all three species simultaneously : open bars , BIS ; hatched bars , CRI and closed bars , RYE .*

For example , in some cases , animals selected for *B . pelecinus* whilst others almost completely avoid it (Figure 3) . Learnt feeding responses can be developed not only through trial and error , but also by animals observing others . The most powerful example is that of young animals learning from their mother . The offspring observe and mimic the eating behaviours of the older flock or herd members . Young animals tend to be more willing to experiment with novel feeds , so exposing young animals to new foods is more likely to lead to those foods being voluntarily incorporated into their diet (even many years later) than offering novel foods to older animals . The management of grazing herbivores should take into account the capacity of animals to learn about the plants on offer to ensure dietary preferences include a broad range of the plants on offer and to create the opportunity for animals to optimise their nutrition and/or self-medicate .

Capitalising on designed or naturally diverse plant combinations

Livestock production systems must address multiple challenges associated with economic, environmental and social issues. To meet multiple goals there is a need to embrace the challenges of using plant diversity across the landscape. No single plant will achieve all purposes, from the timely provision of nutrients and other benefits to livestock through to managing the natural resources of soil and water. In an attempt to simplify management, we have tended to reduce biological complexity and plant diversity in grazing systems. Yet simplified systems are inevitably incomplete systems that ultimately require more inputs to be sustained. Building in plant diversity across a landscape not only offers opportunities to improve flexibility and meet diverse challenges in land management, but it is consistent with the design' of grazing animals. An enormous opportunity exists to capitalise on emerging knowledge of the role of secondary plant compounds, and in particular their role in the regulation of diet selection, feed intake and gut health. This knowledge should help uncover new opportunities to manage livestock and diverse plant mixtures to improve economic, animal health and environmental outcomes.

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Precision pastoralism-advanced systems for management and integration of livestock and forage resources in the semi-arid rangelands in south eastern Australia

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Key points: Precision pastoralism involves the application of new technology to manage animals according to individual requirements and to assist the management of rangeland resources by matching forage supply with forage demand.

Individual animal management is achieved through the capacity to identify and weigh individual animals as they enter a watering enclosure, telemeter the data to a remote computer, and remotely activate drafting gates based on analysis of a quality assured data set. Alternatively, any other individual attribute (e.g. reproductive status) may be used as basis for remote drafting.

Improved management of forage resources is achieved through a capacity to provide probabilistic estimates of future sustainable stocking rates, and ground cover under the current stocking rate, by forward projection of pasture growth from current conditions. Projections are derived from a pasture growth model parameterised for individual vegetation types within a specific property, and applied at the paddock level. Decisions to increase or decrease stocking rate can then be considered in an objective risk management context.

Key words: stocking, risk, ground cover, liveweight

Introduction Extensive pastoral production systems in Australia have traditionally managed animals, at best, according to overall flock or herd requirements. Attempts to match forage demand with forage availability have often been restricted to stocking rate adjustments only at times of major animal husbandry events (e.g. shearing) although more frequent tactical adjustments have become more common in recent years. Attempts to objectively forecast livestock productivity in relation to forage and animal factors have been virtually non-existent in the pastoral context.

However, technologies are now available to facilitate the management of individual animals, or animal groups, according to their specific requirements, and to address more effectively the central issue of matching forage supply and demand to achieve both optimum animal production and sustainable resource use. Objective forecasting of expected animal production is feasible though less well developed. Collectively, these technologies constitute precision pastoralism. Its application will provide livestock producers with opportunities to improve profitability and enhance sustainability not previously feasible in extensive management systems.

Components of precision pastoralism

Individual animal management Precision management of livestock requires a capacity to uniquely identify individual animals, monitor their performance and apply husbandry measures accordingly. Some aspects of this approach have been available for some time e.g. pregnancy diagnosis, with individual females assigned to groups managed according to their pregnancy status. However, such applications require physical separation of groups. The capacity is now available to electronically record the weight of individually identified animals, telemeter this information to a remote office and activate automatic drafting gates on the basis of specified criteria. This allows the timely application of husbandry practices to individual animals without the need for on-going physical separation. Husbandry practices can also be changed as required on the basis of monitored performance.

Physically, this system involves:

- Access facilities at watering points (spear gates and a race) that force animals to enter the watering enclosure in single file, while passing over a weighing platform; design of the system ensures that animals cannot be excluded from water;
- RFID (Radio Frequency Identification) tags applied to each animal;
- A tag reader installed in the race in parallel with the weighing platform;
- A scales indicator/computer that accepts input from both the tag reader and the weighing platform;
- A connection or other wireless data transfer system that allows downloading of tag number-weight pairs to a remote office computer;
- Software that cleans up the data stream by eliminating spurious data points and calculates an average weight for each animal from the remaining set of accepted weights (Richards *et al*. 2006)
- An automatic drafting race that can be remotely programmed, via the indicator, to draft animals according to tag number once performance data has been analysed and management requirements identified.

This walk-over-weighing system is now operated by one of the authors (TJT) in an extensive grazing operation near Bourke, NSW , to manage an opportunistic livestock trading and fattening enterprise (Figure 1) . The system is portable and the intention is to use it , or its component parts , as required throughout the property . Remote weighing and drafting is used primarily to allocate specified animals to supplementary feed based on their monitored weight gain , and to identity those that have reached a marketable weight . Other applications for the systems include :

- monitoring stock remotely to minimise need for physical checking , particularly when used in conjunction with water level sensors at artificial watering points ;
- monitoring animal performance in relation to individual animal thresholds or targets such as joining weights or market contract specifications ;
- drafting of animals on the basis of other individualistic information (e .g . reproductive status , age or classer assessment) ;
- drafting out animals without tags (e .g . ferals) .

Future applications could include :

- individual application of preventative veterinary treatments ;
- mothering up of ewes and lambs , if this is important in breeding programs , based on the observation that lambs tend to follow ewes over the weighing platform and tag sequences can therefore be related to pedigree (Richards and Atkins , 2007) .

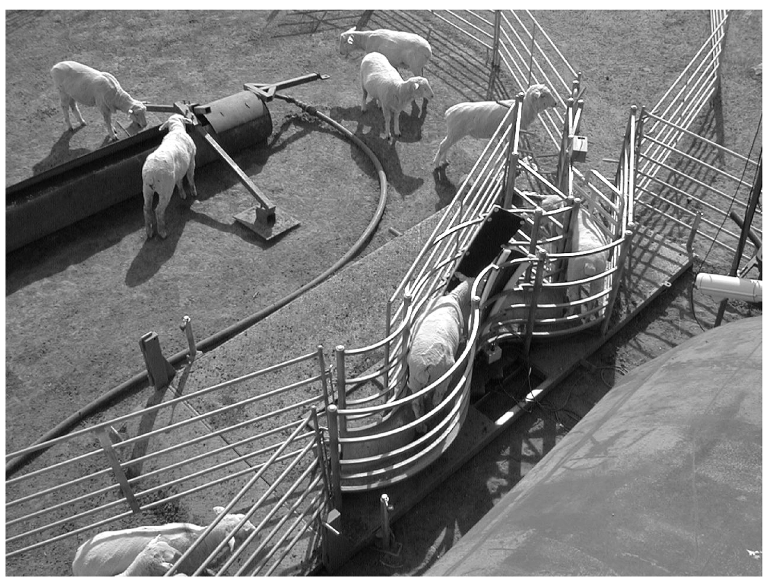

Figure1 *Remote weighing and automatic drafting facility showing the curved race which encourages animals to pass slowly over the weighing platform while entering a watering enclosure , tag reader (located in the race) and drafting gates .*

Precision pasture management Matching forage supply and demand through tactical adjustment of stock density is a fundamental challenge for all grazing systems . Spatial modelling of pasture growth offers a new tool to address this issue in the context of precision pastoralism . Calibration of pasture growth models for individual vegetation types within pastoral properties , combined with mapping of theses units at paddock scale allows probabilistic forecasts of future pasture growth on a paddock basis to be generated from historical climate data . Several generic calibrations of the pasture growth model GRASP (Littleboy and McKeon 1997) are available for western NSW (Richards *et al* . 2001) and can be relatively easily refined for more specific vegetation types by rapid assessment techniques to determine soil water holding capacity in the appropriate depth increments and tree basal area , a key driver of ground storey biomass production , for mapped vegetation types (Alemseged *et al* . 2006) .

We have used this rapid calibration approach to develop a prototype version of the package PaddockGRASP for two extensive properties in western NSW . Once supplied with an updated file of daily climate date in the appropriate format from the SILO data base (http ://www .nrw .qld .gov .au/silo/ppd/index .html) , and initialised for current standing biomass levels based on field observations , the model provides :

- pasture growth estimates , for paddocks and vegetation types within paddocks , for the next 3-12 months at the 20th , 50th and 80th percentile levels ;

Preliminary input screens allow specification of unique characteristics for vegetation types within individual paddocks such as the allowable utilisation percentage, proportion of biomass produced that is palatable (a surrogate for range condition) and proportion accessible to grazing. Stocking history for each paddock is also entered. While alternative probability levels could be chosen, the output of 20th, 50th and 80th values is considered to provide a reasonable representation of pasture growth and ground cover expectations for poor, reasonable and good seasonal conditions respectively.

Given the general acceptance of 40% ground cover as the minimum desirable in the semi-arid rangelands of western NSW (e.g. Campbell and Hacker, 2000; Western Catchment Management Authority, 2005) these data allow the natural resource implications of the current stocking regime to be appreciated in a risk management framework and the same perspective to be brought to tactical decisions regarding sale, purchase or agistment of stock.

The rapid calibration approach outlined above is thought to capture most of the unique characteristics of particular vegetation types (Hacker *et al*. 2007). However, further refinement may be justified but will require a period of least 12 months field observation of standing biomass, using rapid assessment techniques, for validation and finer parameterisation using the GRASP Calibrator (G. McKeon, pers. comm.).

While seasonal risk assessments for pasture growth can be based simply on the historical record, analogue years could also be used for outlook periods when seasonal climate indicators such as the SOI Phase (Stone, 1996) are known to have useful skill. In western NSW this indicator has useful skill in estimating the probability of exceeding median pasture growth for three-month periods beginning June-September inclusive (Hacker *et. al*., 2006).

Forecasting of animal performance Estimation of animal performance based on pasture production estimates from the GRASP model have to date been successful only at the level of annual liveweight change (Hall 1996). Calibration of the model to estimate live weight change over shorter period should be feasible given the capacity now available to obtain frequent liveweights of individual animals. The objective is to produce probabilistic estimates of liveweight change to complement the corresponding estimates of forage growth, sustainable stock densities and ground cover.

Implementation and adoption The walk-over-weighing system is now operational based on off-the-shelf components for animal identification, weighing and telemetry. Software to clean up the data stream has been developed by NSW Department of Primary Industries and is currently in the process of commercialisation.

Without considerable further development, or extensive support, it is unlikely that the PaddockGRASP software could be made available to individual producers. The best means of achieving the widespread adoption of this technology will be by development of web-based access for registered subscribers who would be able to contract the mapping of their properties to commercial companies and who would either draw on an existing library of vegetation type parameter sets, or would again contract the rapid parameterisation of their specific vegetation types to similar companies. Support for the extraction of climate files and maintenance of the software could then be cost-effectively localised in organisation.

Acknowledgements Development of walk-over-weighing has been supported by the Sheep Industry CRC and a Natural Resource Innovation Grant through the National Landcare program to TJT. Development of the PaddockGRASP was supported by Land & Water Australia and Australian Wool Innovation Limited through the Managing Climate Variability and Land Water and Wool Programs.

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Pasture cropping-integrating livestock and crop production for sustainable management of rangelands in south east Australia

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Key words: intercropping, pasture regeneration, farming systems, perennial pastures

Abstract Pasture cropping (PC) is an intercropping technique that was developed by farmers in the Central West region of New South Wales, Australia to retain perennial grasses for summer/autumn grazing. Winter cereal crops are sown directly into summer growing (C4) native pastures (e.g. *Bothriochloa macra* and *Paspalidium jubiflorum*) to exploit their complementary growth phases. The experiment examined the production and environmental differences between grazing pasture (PA), PC and no till (NT) wheat cropping. PC yields were significantly lower than NT and were limited by nitrogen. There was only a minimal reduction in the density and basal area of perennial grasses from PC compared to PA. Gross margin increased from PA to PC to NT, but higher returns were associated with higher annual volatility.

Introduction

The farmer s story The pasture cropping concept was developed in Australia 15 years ago by Colin Seis, an innovative farmer. Colin s family have run their property Winona for nearly 80 years and in that time they developed the farm using introduced perennial grasses, subterranean clover (*Trifolium subterraneum*) and superphosphate fertiliser until about 30 years ago. Each paddock was stocked more or less continually with high stocking rates and substantial inputs were required to maintain production. At that time pastures were quite degraded and dominated by annual grasses and weeds. There was substantial economic pressure involved with continually resowing introduced pastures, and the annual application of superphosphate fertiliser, so Colin made a choice to change. Firstly, he reduced inputs, and then introduced short-duration high intensity grazing. Finally, pasture cropping was an opportunistic attempt to improve farm productivity.

Colin s first attempt at pasture cropping involved sowing a crop of oats (*Avena sativa*) into a dormant stand of summer growing (C4) native grass, dominated by *Bothriochloa macra*, as an inexpensive method of producing winter forage. This turned out to be very successful and it was evident that the crop could be harvested for grain. Over following years, other crops such as cereal rye, wheat and lupins were trialled and the system was developed. Economically, the system has performed as well as, or better than, others on the property. Crop production costs are generally lower as there is less fallowing and land preparation required compared to conventional cropping systems. In addition, up to an extra six months of grazing can be achieved.

In addition to increased profitability the system has delivered some unplanned environmental benefits. It was observed that the pasture cropping process stimulated the recruitment of perennial grasses, substantially enhancing native grass population and diversity. As a result Colin pasture crops a paddock for one to two years, to rejuvenate the pasture, before returning it to grazing for 5 years. His aim is to achieve 100% ground cover 100% of the time, in both cropping and grazing phases, by retaining perennial native grasses. Soil structure has improved, with soil organic carbon levels rising from 2% to 4% from 1997 to 2007 and Winona is a much more profitable and healthy farm.

The science behind the system Grassland and soil degradation are substantial problems in agricultural systems in southern Australia. Degradation is exhibited by a reduction in the level of perennial grasses (exotic or native), a shift to a less desirable composition or a loss of production and ecosystem function (Kemp and Dowling 2000). Reseeding is the most common form of reclamation, although it has high costs associated with inputs and short term loss of production. Management strategies that enhance the recruitment and regeneration of perennial grasses without removing land from production, and / or have low costs, are the key to economic regeneration of degraded land. Retaining perennial grasses in production systems can limit many sustainability problems such as soil erosion, rising water tables that cause dryland salinity and reduce nitrogen leaching.

Intercropping or sod seeding winter cereals into perennial pastures has been used within Australia for a long period of time (e.g. Colman 1966; Cook 1980; Humphries *et al*. 2004; Michalk and Witschi 1977). Pasture cropping is a form of relay intercropping where two or more crops are grown simultaneously for part of their life cycle (Andrews and Kassam 1976; Vandermeer 1989). Generally winter cereal crops are sown directly into summer growing (C4) native pastures (e.g. *B. macra* and *Paspalidium jubiflorum*) to exploit their complementary growth phases and to reduce direct competition (Figure 1). Essentially a productive cereal crop is replacing annual grass weeds. While a lack of fallowing can reduce the accumulation of nitrogen (N) and water over summer, and reduce crop yield, the reduced N and associated soil disturbance may result in native grass regeneration in the following summer due to reduced annual weed competition and a seedbed provided within drill rows.

This study aimed to determine the production and environmental benefits of pasture cropping compared with cropping or grazing alone.

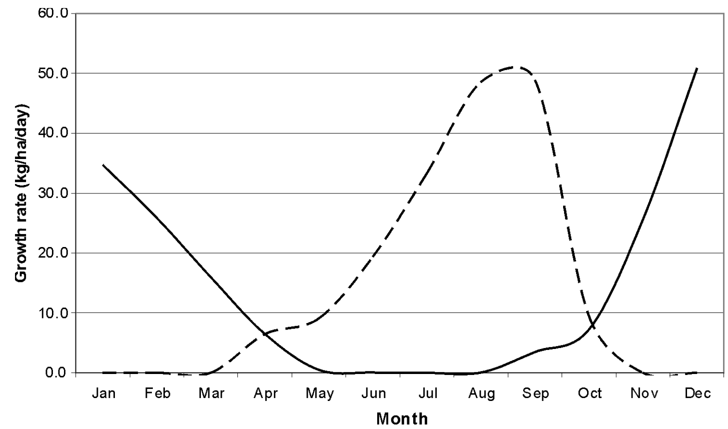

Figure 1 *Average growth rates for* B. macra *(solid line) and an annual pasture/cereal species (dashed line) at Wellington derived from the Sustainable Grazing Systems Pasture Model (www.imj.com.au/sgs) from 1998 to 2004.*

Methods The experiment was located at the Wellington Research Services Centre (WRSC, latitude: -32.5059S; longitude 148.9708E), NSW, Australia. The site is gently undulating (300m a.s.l), with red dermosol soils (Isbell 1996). The mean annual rainfall is 618 mm, evenly distributed throughout the year. Mean maximum daily temperature is 22.8℃ ranging from 31.2℃ in January to 14.1℃ in July. Mean minimum daily temperature is 10.5℃ ranging from 17.5℃ in January to 3.4℃ in July (Table 1).

The trial was run on a *B. macra* dominant pasture (25 plants/m^2), that also contained significant proportions of annual grasses, legumes, broadleaf weeds and other native perennial grasses (e.g. *Austrodanthonia* sp. and *Elymus scaber*). The site had been infrequently cropped or fertilised over the past 30 years, but had been pasture cropped with oats in 2004, prior to the experiment. Three treatments were established and run for the duration of the experiment: Pasture Cropping (PC), No Till cropping (NT), and Pasture (PA). The preparation for PC prior to sowing involved grazing to reduce pasture biomass, and application of 135g/L paraquat + 115g/L diquat 24 to 48 hours before sowing to control emerging annual weeds. Post emergence, grass and broadleaf weeds were controlled as required using herbicides that did not damage perennial grasses (e.g. Chlosulfuron). NT had two glyphosate fallow sprays through summer and a knockdown herbicide prior to sowing that maintained a bare fallow in 2006 and 2007. As the experiment began in April 2005, there was only a short fallow period before sowing in that year for NT. All crops were sown with 60 kg/ha of wheat (*Triticum aestivum*), in one pass to minimise soil disturbance. PC had 50 kg/ha (2005) and either 50 or 100 kg/ha (2006 and 2007) of DAP fertiliser applied at sowing while NT received 100 kg/ha each year. PA had no herbicide, sowing or fertiliser, but was grazed at the same time as PC.

Plots were 50 by 18m in size and were replicated in 3 blocks. Pasture composition and ground cover were monitored at 3 monthly intervals. Pasture composition was determined using the BOTANAL procedure (Tothill *et al*. 1992) in 20×0.1 m^2 quadrats per plot (10 spaced 5m apart across each diagonal). Perennial plant demography was measured in autumn at two fixed quadrats (0.5 m^2) per plot each year. Soil nitrate was monitored in the top 10cm of the soil prior to sowing and at 10cm intervals in the top 100cm in winter 2007.

Plots were harvested using a small plot header in 2005 and 2007, while crop biomass was determined by randomly cutting 3 representative 1m^2 quadrats per plot in 2006 when drought prevented conventional grain harvesting.

Gross margin (GM) analysis incorporating both cropping and grazing enterprises was carried out on the three treatments for each year using 2007 costs and prices (www.agric.nsw.gov.au/reader/budget). Grazing gross margins were developed from the average pasture biomass per ha available during the grazing period (all year for PA; from beginning of the year to sowing for NT and PC), divided by an average sheep consumption of 0.8 kg/head/day, divided by 365 days to obtain a stocking rate per hectare. This value was then multiplied by $16.86 (GM per head for a 21 micron merino wether enterprise) to obtain a GM/ha for the grazing portion of the three systems. Crop GM/ha was determined by subtracting sowing costs (seed, herbicide and fertiliser) and harvesting costs (harvesting, cartage, levies and insurance) from income derived from crop yield. Note that in 2006 no crop yield was obtained in NT and PC and all treatments were grazed.

Analysis of variance (ANOVA) (Genstat 10, Lawes Agricultural Trust Rothamsted) was carried out on wheat yield; total biomass and biomass components (litter, crop, perennial grass, annual grass, legume and other species); ground cover; *B*.

macra plant numbers and basal area; and soil nitrate.

Results

Seasonal conditions Rainfall was above average in 2005 due to substantial rain in the second half of the year, but the late break delayed sowing until 24/6/05 (Table 1). 2006 was an extremely dry year with only 302 mm of rainfall, of which 71 mm fell in the crop growing period (sown 22/6/06) and crops were grazed instead of harvested. In 2007, rainfall was above average from April to June (sown 25/5/07), but substantially below average for the remainder of the crop growing season.

Table 1 *Monthly rainfall 2005-2007 (mm) and mean annual (1946-2004) rainfall (mm) and temperature (℃) for WRSC.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2005	39.1	41.9	26.6	7.0	0.9	102.4	61.0	37.6	114.7	85.3	113.6	38.0	668.1
2006	40.6	81.6	14.2	20.8	1.0	29.0	51.8	9.6	6.4	3.2	13.2	30.8	302.2
2007	13.4	31.2	75.0	50.0	74.6	122.2	22.6	29.4	1.0	0.0	41.6+	n/a	461+
Mean	64.8	60.1	50.6	43.6	48.1	40.3	46.6	49.1	44.3	63.6	57.1	49.9	617.9
T_{max} (℃)	31.2	30.2	27.5	23.2	18.5	14.9	14.1	15.7	19	22.7	26.4	30	22.8
T_{min} (℃)	17.5	17.4	14.9	10.9	7.5	4.6	3.4	4.2	6.6	9.9	12.7	15.9	10.5

Pasture Production and Demography Mean biomass of litter, crop, perennial grass, annual grass, legume and other species, and ground cover for the 3 treatments (Figure 2), showed that maximum biomass obtained on NT and PC was due to the crop, with significantly more crop on NT ($P<0.001$). Annual grasses and other species made increasing contributions to total biomass in PA. While overall there was significantly more litter on NT and PA compared to PC ($P<0.001$), by the end of 2007 there was no significant difference between the treatments. Perennial grasses were mainly evident through summer and were effectively removed in NT by 2007, were greatest on PA overall ($P<0.001$), but were still maintained on PC. Ground cover was maintained at over 80% on PA for most of the experiment, but was significantly lower on NT and PC ($P<0.001$). In late 2007, ground cover was significantly greater on PC compared to NT ($P<0.001$).

There was no difference in the number or basal area of *B. macra* plants in 2005 (prior to sowing) in any treatment (Table 2). *B. macra* plants were completely removed from NT by 2006 but were retained at similar levels in PC and PA. Between 2006 and 2007 older plants tended to decrease and seedlings to increase in both PA and, particularly, PC although the differences were not significant. The basal area of adult plants was significantly lower ($P<0.05$) in PC compared to PA in 2006, but there was no difference by 2007.

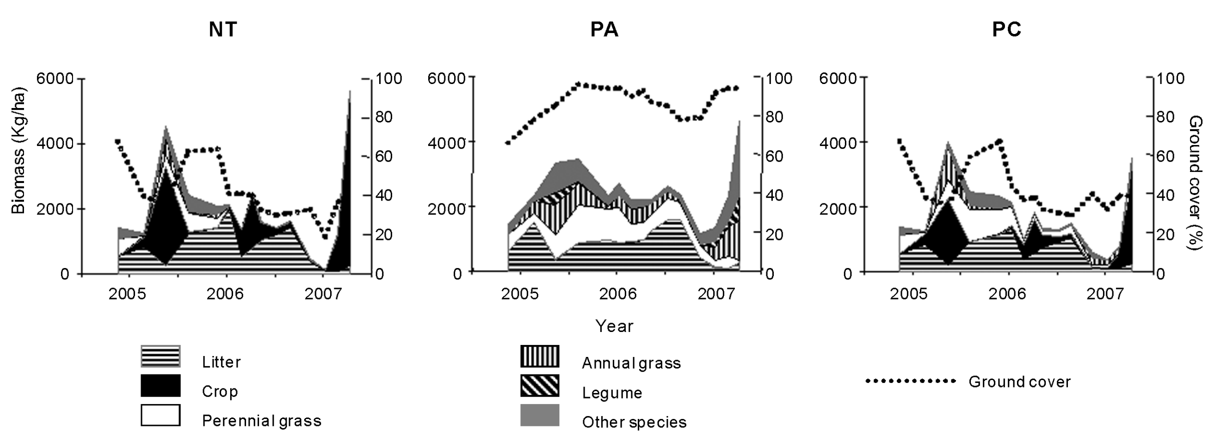

Figure 2 *Mean biomass of litter, crop, perennial grass, annual grass, legume and other species, and ground cover for NT, PA and PC.*

Table 2 *Mean adult B. macra plants and seedlings (plants / m^2) and adult plant basal area (cm^2/ plant) measured in autumn annually in PA, PC and NT (l.s.d. P<0.05).*

Year	Treatment	Adult	Seedling	*Total*	Adult Basal Area
2005	PA	-	-	30	36.6
	PC	-	-	28	35.2
	NT	-	-	20	45.1
	l.s.d.	-	-	*ns*	*ns*
2006	PA	27	4	31	47.2
	PC	22	6	28	19.3
	NT	0	0	0	0
	l.s.d.	*7.58*	*4.77*	*9.83*	*15.61*
2007	PA	22	6	28	30.9
	PC	15	11	26	19.7
	NT	0	0	0	0
	l.s.d.	*18.20*	*6.41*	*12.83*	*14.59*

Nitrogen There was a substantial difference in the level of nitrate in the top 10cm of the soil between treatments prior to sowing in 2006 and 2007 with highest levels in NT and lowest in PA (Table 3). Nitrate in PC was similar to PA in 2006 and to NT in 2007. Nitrate gradients measured to a depth of 100cm in winter 2007 showed similar relativities between treatments, with actual differences most apparent between 30 and 80 cm (Figure 3). There was a strong linear relationship between crop yield and available N in the top 10 cm (mineral N at sowing plus N added in fertiliser) across all treatments in 2005 ($R^2 = 0.95$). Multiple regression analysis with nitrate 0-10cm and 10-80cm described 81% of the variation in crop yield across all treatments in 2007.

Table 3 *Nitrate (mg/kg) in the top 10 cm measured prior to sowing (2005-2007) in PA, PC and NT (l.s.d. P<0.05).*

Treatment	2005	2006	2007
PA	8.8	8.2	23.7
PC	9.5	10.5	40.0
NT	10.9	35.0	52.0
l.s.d	*ns*	*10.7*	*13.7*

Crop Production Grain yield was significantly higher in the NT compared to the PC treatment in 2005 (P<0.001; Table 4). There was a higher crop biomass in 2006 (P<0.001) and grain yield in 2007 (P<0.01) in the NT treatment, with no difference between PC treatments with either 50 or 100 kg/ha of DAP fertiliser.

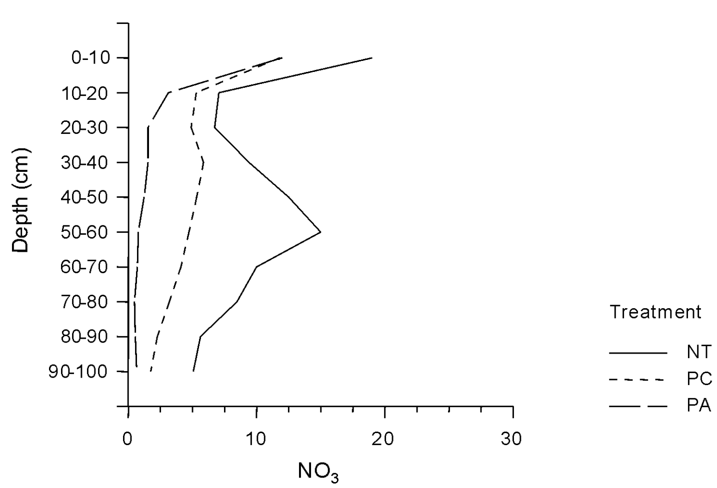

Figure 3 *Nitrate (mg/kg) measured at 10cm intervals to a depth of 100cm in PA, PC and NT.*

Table 4 *Grain yield (2005 and 2007) and crop biomass (2006) measured in NT and PC treatments in B. macra dominant pasture (l.s.d P<0.05).*

Treatment	Fertiliser	2005	2006	2007
	(kg DAP/ha)	Grain (t/ha)	Crop biomass (t/ha)	Grain (t/ha)
NT	100	1.7	1.6	2.7
PC	50	1.2	0.6	1.4
PC	100	-	0.7	1.5
	l.s.d	*0.13*	*0.21*	*0.47*

Gross margin (GM) analysis Over the three years of the experiment on average GM /ha increased from PA to PC to NT (Table 5). Higher returns were associated with higher annual volatility in gross margins. In 2006 crop growth was extremely poor due to very low rainfall and crops were grazed instead of harvested resulting in negative returns for cropping enterprises. Stubble was grazed in the NT treatment throughout the experiment.

Table 5 *Crop, grazing and total GM ($/ha) for NT, PC (50 kg/ha of DAP) and PA.*

Year	NT			PC			PA
	Crop GM	Grazing GM	Total GM	Crop GM	Grazing GM	Total GM	Total GM
2005	195.37	50.70	246.07	118.70	48.44	167.14	64.03
2006	-147.24	48.15	-99.09	-83.78	58.43	-25.35	71.25
2007	326.15	10.51	336.66	124.36	25.64	150.00	60.63
Average	124.76	36.45	161.21	53.09	44.17	97.26	65.30

Discussion The region in which pasture cropping was developed has a-seasonal rainfall that can sustain summer pasture and winter crop growth. In this region conventional farming systems have a fallow period through summer and autumn to store moisture and nutrients for the following winter crop. It was hypothesised that soil moisture would be limited in a pasture cropping system by pasture growth through summer, but data collected in this project (not shown) indicated that this was not the case in this experiment. While soil moisture may have determined differences in grain yield between years, differences in yield between NT and PC systems appeared to be explained primarily by differences in soil N. The site had a history of low fertiliser use which, together with a high density of perennial grasses actively growing through summer, reduced the accumulation of N in the profile of the PC treatment. Lower N levels substantially reduced crop biomass, even when 100 kg/ha DAP was applied to both PC and NT treatments.

Despite the capacity for N to limit production, PC was more profitable than grazing alone over the experimental period, though not as profitable as NT. However, returns from NT were highly variable which presents a challenge to farmers who are trying to maintain a cash flow. Pasture cropping reduced variability in returns due to both an increased contribution from livestock and the saving in crop establishment costs in the dry year 2006. The system also provides flexibility in decision making, an important adaptive advantage in an increasingly variable climate, since the decision to crop can be delayed until just before planting without any forgone production or financial outlay.

Even through the extremely dry years of this experiment, recruitment of *B. macra* was sufficient to replace mortality caused by the cropping process. However, the cropping process reduced the basal area of perennial grasses particularly in 2006, possibly exacerbated by a relatively aggressive sowing method used in 2005 that was rectified in following years. Summer-autumn rainfall was also well below average in each year of the experiment (59% - 2005, 48% - 2006 and 13% - 2007) further limiting the contribution of perennial grasses to the production system. The possibility of rejuvenating pastures without removing them from production attracts farmers to this technique. The system can reduce the risks associated with ground preparation and pasture establishment that is required in conventional crop – pasture rotations.

Most farmers practice this technique in degraded pastures that have a lower proportion of perennial grasses than the experimental site, and a history of higher fertiliser use, which reduces the large influence that N played in this experiment. Our experience of pasture cropping on degraded lucerne paddocks indicates little difference in crop yields between conventional and pasture cropping. In similar circumstances farmers also are finding smaller differences in crop yield between conventional and pasture cropping and that yields are more likely to be moisture driven, improving the relative profitability of pasture cropping when inputs are equal. Pasture cropping is estimated to have been adopted by over 1000 farmers throughout eastern, southern and western Australia and has the capacity to improve the sustainability of large areas of cropping and grazing land.

Acknowledgements The authors would like to acknowledge the contribution made by Daryl Cluff in developing the pasture cropping system in collaboration with Colin Seis. Funding was provided by NSW Department of Primary Industries and Grain & Graze, a national mixed farming systems research program supported by a collaborative partnership between Grains Research and Development Corporation, Meat and Livestock Australia, Australian Wool Innovation Limited and Land & Water Australia. Regional partners in this project include STIPA Native Grasses Association, Central West Conservation Farmers and Central West Farming Systems.

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Interactions of forage quality and physiological state on forage intake of grazing beef cows in autumn

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Key words: beef cattle, forage quality, grazing, intake, lactation

Introduction Intake by grazing cattle is affected by quality and availability of forage and by physiological demands, such as lactation and gestation. However, limited information is available on how these factors interact. We tested the hypothesis that autumn forage intake is altered by the interaction of cow physiological state and forage quality using cows in different stages of lactation and gestation grazing forages varying in digestibility.

Materials and methods Cows calving during late winter ($n=40$, average calving date = February 7) or late spring ($n=40$; average calving date = May 31) were subjected to one of two nutritional environments (seeded pasture or native rangeland) for approximately 60 days during autumn (October through November). Cows grazed one of two replicated pastures of each forage type. Pastures were 26 ha for seeded forage and 71 to 90 ha for native rangeland. Differences in calving season were selected to provide non-lactating cows in mid-to late gestation compared to lactating cows in early gestation exposed to varied nutritional regimens with similar climatic conditions. Forage intake was measured twice (October and November) during the grazing trail using chromic sesquioxide from sustained release boluses as a fecal output marker and indigestible NDF as a digestibility marker. Associated forage and diet quality were defined through laboratory measures on clipped forage and esophageal extrusa. Data were analyzed using mixed model methodology in a fixed model with a 2 (pasture type) × 2 (calving system) arrangement of treatments that included pasture within treatment.

Results and discussion At the first intake measure, cows in the late spring calving system grazing native rangeland ate more ($P=0.02$) forage (expressed as either OM intake in kg/d or as a percentage of body weight) than cows in all other treatment groups (Table 1). Although they consumed more forage, these cows showed a loss in body weight and body condition score. The nutrient demands of lactation did not appear to be completely met by increasing OM intake. Cows in the late winter calving system gained body weight on both pasture types with greater weight gain on the seeded pasture ($P<0.01$), although OM intake was similar between pasture types at both intake measures. Cows changed seeded pastures in November, and the OM digestibility after this change was less ($P<0.01$) than native range. During November, no differences in OM intake were observed for either pasture type or calving system. Gains were greater ($P<0.01$) for calves suckling dams on seeded than native pasture.

Table 1 *Effect of physiological state and forage type on body weight (BW), body condition score (BCS) changes and organic matter (OM) intake (I) and digestibility (D) during a 60-d autumn grazing trial.*

	Late winter calving		Late spring calving		P values for		
	Native range	Seeded pasture	Native range	Seeded pasture	Pasture type	Calving system	Pasture type x calving system
Cow BW, kg							
Initial	603±13	581±13	545±13	533±13	0.20	<0.01	0.72
Change	43±3 ᵃ	60±3 ᵇ	-31±3ᶜ	4±3 ᵈ	<0.01	<0.01	0.01
BCS change	0.3±0.1ᵃ	0.1±0.1ᵃ	-0.8±0.1ᵇᶜ	-0.6±0.1ᵇᵈ	0.58	<0.01	0.06
October							
OMI, kg/d	11.4±0.6ᵃ	10.6±0.6 ᵃ	14.2±0.7 ᵇ	10.8±0.6 ᵃ	<0.01	0.02	0.05
OMD, %	64.5±0.5	66.2±0.4	64.7±0.5	66.9±0.5	<0.01	0.41	0.61
OMI% of BW	1.8±0.1ᵃ	1.7±0.1ᵃ	2.7±0.1 ᵇ	2.0±0.1ᵃ	<0.01	<0.01	<0.01
November							
OMI, kg/d	13.9±0.8	15.8±0.8	14.0±0.8	13.4±0.9	0.43	0.16	0.14
OMD, %	64.9±0.4 ᵃ	59.7±0.4 ᵇ	63.0±0.4 ᶜ	60.0±0.4 ᵈ	<0.01	0.19	0.06
OMI% of BW	2.3±0.1	2.6±0.1	2.6±0.1	2.6±0.1	0.25	0.38	0.17
Calf BW, kg							
Intitial	-	-	168±3	174±3	0.19	-	-
ADG	-	-	0.83±0.02	1.01±0.02	<0.01	-	-

Superscripts indicate interaction effects, a,b $P<0.05$, c,d $P<0.10$

Conclusions Demands of lactation can increase forage intake for cows grazing native rangeland in autumn. However, lactating cows grazing higher quality seeded pasture that supported maintenance of body weight did not differ in intake from non-lactating cows.

Recording the prehensive bite diversity in cows for a dynamic analysis of foraging behavior on diversified vegetation

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Key words : on-farm recordings , ruminants , intake kinetics , feeding behavior , bite-count technique

Introduction Direct observation techniques have been widely used these last 30 years for recording intake of domestic and wild but tamed ruminants (Neff 1974 , Holechek *et al* . 1982 , Meuret *et al* . 1985 , Dumont *et al* . 1995) . Recent improvements allowed for a continuous recording and hence an accurate estimation of intake (Parker *et al* . 1993 , Agreil and Meuret 2004) , but mainly for small-sized ruminants (*i .e* . deer , sheep and goats) . The aim of this paper is to present a coding grid designed for the recording of bites of cows foraging on diversified vegetation .

Material and method The coding grid for cows bites was developed by observing on-farm a flock of heifers , in 2004 (Alpine range , France) . After the familiarization procedure (Agreil and Meuret 2004) , we grouped the diversity of observed bites into bite categories (BC) . At this stage , we looked for physiognomic similarities (nature , shape and size of the selected plant parts) , in order to limit the number of BC . This initial categorization was then sharpened by creating BC , when the observer anticipated major differences in mass or nutritional content . Each BC observed , containing either a single or several species , was manually simulated by the observer during the non-observation days , for determining the dry matter and nutrient contents .

Results and discussion The resulting bite coding grid (Figure 1) form a language" , easily learnt by heart . Codes are monosyllabic and are easy to dictate immediately after the name of the selected botanical species , even during the highest bite frequency periods (over 100 bites/min) . The diversity of bites was satisfactorily described by 36 BC , which nearly as much as the number of BC needed for sheep and goats (Agreil and Meuret 2004) . However , certain special cases required additional information in order to complete the coding process , *e. g.* for variable proportion of dead materials in swards we needed a series of 3 modifiers" superimposed on the basic grid .

Conclusions The bite-coding grid allows for an exhaustive recording of bites during whole meals and days , opening the way not only to an accurate estimation of intake on diversified vegetation , but also to a dynamic analysis of foraging behavior of cows .

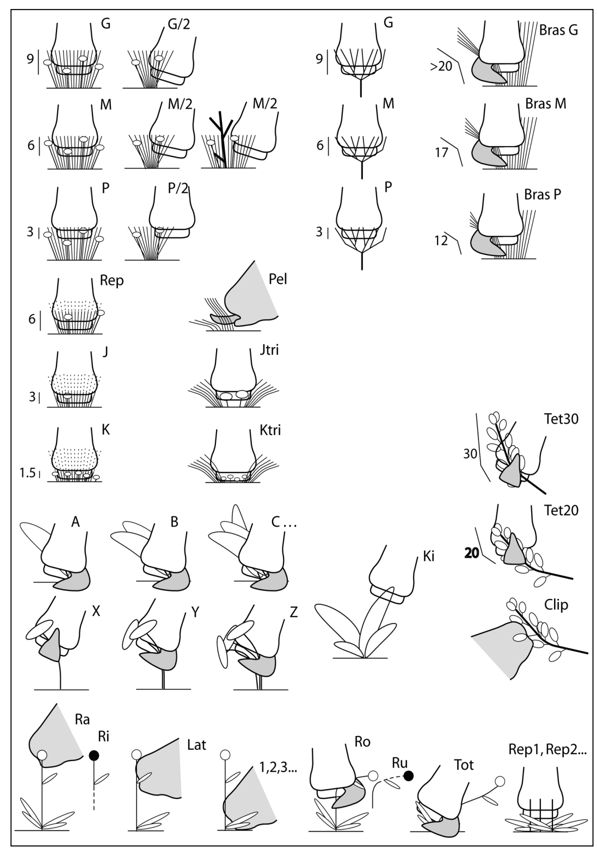

Figure 1 *The coding grid for cows . The plant parts are indicated by small icons that symbolize their physiognomy : fine lines for stems or leaf blades , ovals for tree and shrub leaves , open circles for flowers and black circles for fruits . The length of leaves , laid out but not stretched , is indicated in cm . to the left of the icons . The mono-and bi-syllabic codes dictated during the observation are given to the right of the icons .*

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Intake rate oscillations at the meal scale : the dynamics of feeding choices for coping with diversity on rangelands

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Key words : feeding strategy , Ruminants , Sheep , Diet , Foraging behavior , Intake rate

Introduction On rangelands and natural grasslands , domestic ruminants have to cope with the high diversity of plant species and plant secondary compounds (Provenza and Villalba , 2006) . Foraging responses of ruminants challenged with this chemical and taxonomical diversity have poorly been documented in their dynamic dimension (Gillingham *et al* . 1997 , Agreil *et al* . 2005) . In this study , we aim at modeling the temporal dynamics of foraging during meals , and discuss the results as a contribution to the understanding of ruminants feeding strategies .

Materials and methods Two experiments were conducted in France on sheep (see Agreil *et al* . 2005) . Foraging behavior was recorded by direct and continuous observation of bites (Agreil and Meuret 2004) . Log-transformed intake rate kinetics were analyzed by modeling their variograms (Lajaunie *et al* . 1999) . As experimental variograms were too complex to be fitted by only one basic model of variogram , we used a combination of several basic models . Finally , filter kriging was used for extracting the three components from the observed intake rate kinetics .

Results and Discussion The experimental variograms were satisfactorily modeled by a sum of three basic models : a long-range exponential model , a damped cosine model , and a short-range exponential model . Intake rate time series can thus be interpreted as the sum of three components , respectively structured by :(1) an exponentially decreasing dependence , which can be considered negligible for lags longer than 20 min ;(2) correlation coefficients that are successively positive and negative , generating an oscillating pattern , with pseudo-periods of respectively 19 .6 and 14 .7 min for experiments 1 and 2 ; (3) an exponentially decreasing dependence , considered negligible for lags longer than 2 min . The three components were extracted by filter kriging the observed log-transformed time series of each bout (see an example on Figure 1) . Temporal patterns could be interpreted as the quantitative consequence of the foraging strategies of ruminants faced with diversified vegetation . Oscillations , which are frequent in biological systems , are sustained and not damped in our case . Oscillating patterns of intake (pseudo-period about 20 min) may represent transient aversions to specific plant secondary compounds (PSC) which saturate detoxification and elimination pathways in the animal (Provenza and Villalba , 2006) . Transient reductions in food intake may reflect critical threshold of PSC in blood plasma that initiates an aversion . This would allow for processes of detoxification and elimination to take place . Once concentrations of PSC are below critical thresholds , the animal will resume eating the species associated with the specific PSC (Foley *et al* . 1999) . Some of the species tested in the present study contain alkaloids (*e .g* . *Genista cinerea* , *Genista purgans*) which through the pharmacokinetic processes described may reflect the cyclic patterns .

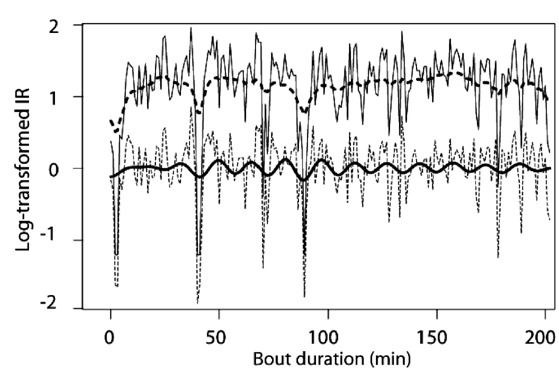

Figure 1 *Filter kriging during one bout , as an example . The log-transformed intake rate time series (thin solid line) is represented with the filtered trend (thick dotted line) , the oscillating component (thick solid line) and the short-range (thin dotted line) .*

Conclusions Our results provide insights on the dynamics of the foraging process , which could help to link short-term feeding choices with their nutritive and toxicological consequences .

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The effects of grazing on the vegetation of typical steppe in Mongolia Plateau

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Key words : grazing system ; ecological indicators ; typical steppe

Introduction Rotational grazing systems are widely used in Inner Mongolian grasslands . The vegetation characteristics were compared between continuous and rotational grazing systems (Savory 1980) . In this study , we selected the typical steppe in Inner Mongolia and Mongolia to compare the vegetation difference in different grazing systems in order to assess the effect of vegetation on grazing systems .

Materials and methods The vegetation characteristics of typical steppes in Dongwu Banner in Inner Mongolia , China (45°27′ N , 117°04′E) and Su He Bater Province in Mongolia (45°44′N ,115°43′E) were measured at the same time to compare the difference under different grazing systems . We mainly used herder's house as the starting point and located three transects , every transect angle is 120 . Three to five quadrats (1×1 m^2) data were collected and analyzed using SPSS13 .0 .

Results *Stipa krylovii* is the dominant species and the results showed in Table1 . The result showed that the height and coverage of vegetation in Mongolia *Stipa krylovii* tupical steppe (nomadic grazing) were higher than Inner Mongolia (consecutive grazing) .

Table 1 *Vegetation characteristics of* Stipa krylovii *typical steppe in two sites .*

Grazing system \ Vegetation	Height(cm)	Coverage(%)
Mongolia(nomadic grazing)	9.0 ± 3.2^a	9.8 ± 6.7^a
Inner Mongolia(consecutive grazing)	5.8 ± 1.5^b	3.8 ± 1.5^b

Note : different letters indicate significant differences at $P<0.05$ level .

Conclusions Nomadic grazing in Mongolia is better than consecutive grazingin Inner Mongolia .

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Sward structure and foraging behaviour of cattle grazing reproductive tropical pastures

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Key words : sward structure , foraging behaviour , cattle , tropical pastures

Introduction The rate of nutrient intake (RNI) is an important determinant of animal performance for grazing animals that depends on diet quality and instantaneous intake rate (IIR) . In turn , diet quality and IIR are the outcome of the interaction between animal size and structure of the sward . Stems can be a dominant component of reproductive tropical pastures . The aim of this study was to test the hypothesis that foraging behaviour of younger/smaller steers would be less affected by the increase in the physical strength and density of stems compared to older/larger cattle , which are less able to be selective while foraging .

Materials and methods Steers were offered artificial microswards (0 .24 m^2) consisting of leaves (20 cm long ; 800 m^{-2}) and stems (25 cm long) of *Panicum maximum* . The treatments consisted of a factorial combination of two cattle ages (1 and 3-year-old steers of 324 and 605 kg LW) and four levels of stem tensile resistance at 400 stems m^{-2} in Experiment 1 or four densities of stems of high tensile resistance in Experiment 2 (0 , 100 , 200 and 400 stems m^{-2}) . The experiments had a randomized complete block design with tree steers per age . The steers were allowed to take eight bites from the swards , and the proportion of stems in diet , bite mass , IIR , diet DM (dry matter) digestibility and digestible DM IIR were measured (Benvenutti *et al* ., 2007) . Non-linear regression analysis was used to test the relationship between stem tensile resistance or stem density and the animal response variables .

Results There was a highly significant negative effect of both stem resistance and stem density on the proportion of stem in diet , bite mass , IIR and diet DM digestibility for both animal age groups ($P < 0.001$) ; this negative effect was stronger in mature animals . All animals became more selective , avoiding the stems , as the tensile resistance and density of stems increased . This had a positive effect on diet quality for both animal age groups ; however , it had a strong negative effect on bite mass , IIR and digestible DM IIR , particularly in mature animals (Figure 1) .

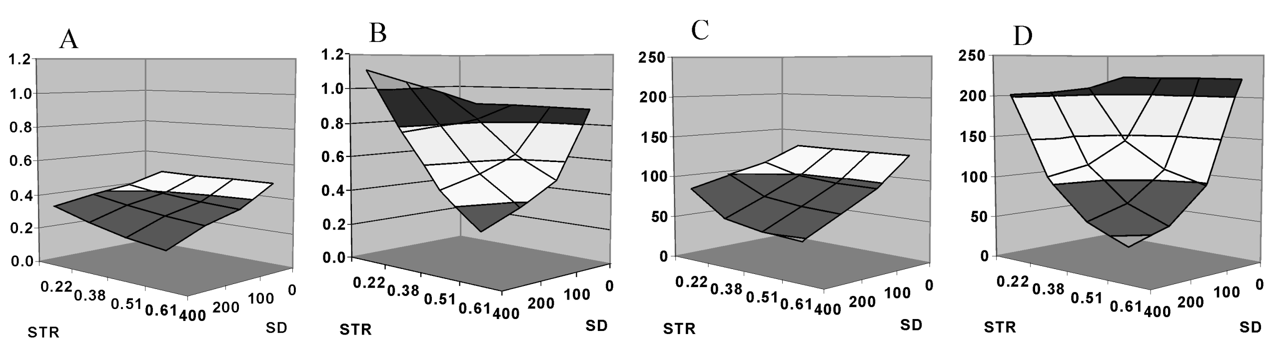

Figure 1 *The effect of the stem tensile resistance (STR) (kN) and stem density (SD) (stems/m^2) on bite mass (A ,B) (g DM) , and digestible DM IIR (C ,D) (mg DM/kg live weight/min) of 1-(A ,C) and 3-year-old (B ,D) steers grazing microswards of* Panicum maximum *comprised of leaves and stems .*

Conclusions The foraging behaviour of older/larger steers was more strongly affected by increases in the physical strength and density of the stems in tropical swards than was that of younger/smaller animals . This indicates that younger animals would have a nutritional advantage over the older animals when grazing reproductive tropical pastures containing a high density of stems of high tensile resistance .

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Measurement at pasture of intake, digestibility and chemical composition of the diet of nursing ewes, using Faecal NIRS

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Key words: pasture, diet quality, intake, digestibility, faecal NIRS, suckling ewes, Tropics

Introduction To improve efficiency of animal production at pasture, the evaluation of the diet *in situ*, is a prerequisite. Faecal NIRS can be a good alternative to estimate the diet quality of grazing animals, by providing a rapid, low cost and highly reproducible diagnostic (Review of Shepherd and Walsh, 2007). The objective of this study was to use the faecal NIRS method calibration previously realised for rams in stalls, to evaluate at pasture the diet quality of suckling ewes. The consistency of the estimates using faecal NIRS was evaluated by comparing the estimated diet quality, to milk production of to pasture characteristics, since no existence of any reference method to measure the diet at pasture.

Materials and methods A trial with 12 grazing suckling ewes was carried out for 5 lambing periods (LP), on a *Digitaria decumbens* pasture rotationally-managed for 28 days re-growth period. Faecal samples were collected per ewe three times per LP, using faecal bags and analysed using a Foss NIRSystem 6500 monochromator. From faecal spectra several parameters were determined using previously published faecal NIRS calibrations: organic matter digestibility (OMD), organic matter intake (OMI), digestible OMI (DOMI), the crude protein content of the herbage ingested (CPi). Simultaneously, the individual milk production (MP) of the ewes, and the pasture characteristics were measured: the biomass, the CP content of the herbage (CPh) and the leaf mass. The relationships between the diet quality, the milk production and the characteristics of the pasture were analyzed.

Results OMI and DOMI (g/kg LW $^{0.75}$) were higher at the 1st and the 4th LP ($P<0.01$, Table 1). OMD and CPi varied in an opposite way, being higher at the 2nd an the 5th LP ($P<0.01$), as the CPh and the leaf mass. Compared to the milk production, the estimates of OMI and DOMI varied in the same way (Figure 1), whereas OMD was negatively correlated to MP ($r=-0.56$, $P<0.001$). Compared to characteristics of the pasture, OMD and CPi were positively correlated with CPh ($r=0.28$, $P<0.03$; $r=0.50$ $P<0.001$), whereas the ADFi decreased with the CP content of the herbage offered ($r=-0.54$, $P<0.01$).

Table 1 *Characteristics of the diet of grazing nursing ewes estimated using faecal NIRS: organic matter (OM) intake, OM digestibility, digestible OM intake (DOMI), and chemical composition of the herbage ingested, the crude protein (CPi). In a row, means with a common superscript letter are not different, P < 0.05. R.S.D: residual standard deviation of the model.*

	LP1	LP2	LP3	LP4	LP5	R.S.D
Intake	83.3^{a}	68.5^{b}	63.3^{b}	85.3^{a}	47.9^{c}	0.99
OMD	64.9^{c}	67.4^{b}	66.3^{bc}	65.6^{bc}	70.5^{a}	0.94
DOMI	58.5^{ab}	53.3^{b}	42.7^{c}	61.9^{a}	36.8^{d}	0.98
CPi	15.9^{c}	16.8^{b}	16.5^{bc}	16.4^{bc}	18.2^{a}	0.79
ADFi	33.1^{b}	34.2^{a}	32.7^{b}	32.9^{b}	32.7^{b}	0.43
ADLi	3.1^{bc}	3.5^{a}	2.8^{c}	2.9^{c}	3.2^{bc}	0.32

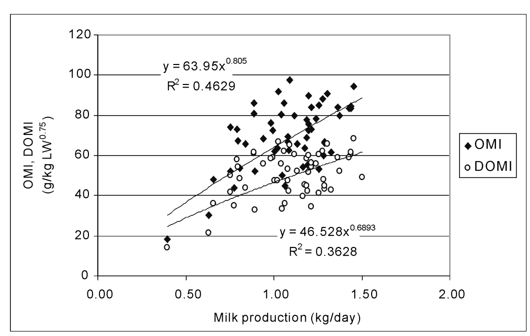

Figure 1 *Daily milk production (MP, kg/day), according to the organic matter intake (OMI, kg/day), measured per grazing nursing ewes over 5 lambing periods.*

Conclusions The positive relationships between OMI, DOMI and MP, suggest that the estimates using faecal NIRS calibration, provide consistent estimates of the diet at pasture. The different evolution of OMI and DOMI compared to that of OMD and CPi illustrate how it is important to measure several parameters to characterise the diet. This shows also the need of a useful tool to measure nutrition in real grazing conditions.

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Improvement of manure quality and crop yields by cattle supplementation

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Key words : mineral supplementation , manure , crop yield

Introduction Animal and crop productivity are limited by mineral deficiencies in the Sahel (Cissé et al . , 1996) where millet (Pennisetum glaucum) and groundnut (Arachis hypogaea) are two major food and cash crops . Livestock are is also soil fertilizing agents by nutrient recycling from excretions (Hiernaux and Rivera , 1996) . A trial was conducted to assess the effects of application of the manure from cattle supplemented with rock phosphate and/or nitrogen on crop growth and yield in a pearl millet-groundnut rotational system .

Material and methods The study was conducted in the dry season from February to June on 60 pasture-grazing cattle alloted in a control (Group 1) and three supplemented groups . Cattle received 75 g/animal/d of Thiès rock phosphate in 30 L of water in Group 2 , 500 g of 4% urea-treated millet stover and 1 kg of peanut cake and 800 g of millet bran/animal/d in Group 3 , and combined diet offered inGroups 2 and 3 treatments for Group 4 . Cattle body condition was monthly scored (Cissé et al . ,2003) and manure produced during the night daily recorded , collected and sundried . The experiment on farm was a millet (var . souna 3)-groundnut (var . Fleur 11) rotational cropping system with 5 treatments : control (no manure) , manure from unsupplemented animals (Group 1) , and manure from cattle of Groups 2 , 3 and 4 , respectively . During the rainy season , manure was applied at 4 t/ha to the millet crop . Groundnut was planted the following year without renewing manure application . Parameters of plant growth and yield were measured at 24 , 52 days and at harvest .

Results and discussion The experiment showed important change in body condition score (BCS) according to the supplement given to cattle . Controls lost ($P<0.05$) 0 .9 point in BCS (3 .6 *vs* 2 .7) , while cattle supplemented with rock phosphate mixed in water maintained their BCS at 3 .5 points . Animals from Groups 3 and 4 groups gained ($P<0.01$) 0 .7 (2 .8 *vs* 3 .5) and 0 . 9 point (3 .1 *vs* 4) of BCS , respectively ; this being in part due to the high energy content of their diet . After 28 days of growth and at harvest , millet and groundnut plant population was not significantly influenced by manure application . At 52 days , manured plants were slightly taller than the controls . Enriching manure resulted in a positive response in number of leaves and groundnut plant height (Table 1) . Millet grain yield increased from 24 to 68% , depending to the diet offered to animals . The control without manure provided the lowest yield and the highest production was obtained with additional supply of P and N by manure . However , compared to the production of plots manured by control animals , the gain in millet grain yield due to manure enriched in P and N (i .e . , 264 kg/ha) was higher than the sum of the gains due to supplementation either in P (73 kg/ha) or in N only (92 kg/ha) . The residual effect of manure on groundnut yield represented 11 to 25% over yield from the unmanured plots . This trial assessed several advantageous of supplementation . However , a better response on crop yields could be expected with the confining of animals in fields , due to an increase in nutrients cycling (Powell et al . , 1994) both from fecal and urinary excretions .

Table 1 *Effect of manure on number of leaves/plant 52 days after planting*[1] *, plant height and grain yield .*

Treatment	Direct effect on millet		Residual effect on groundnut			
	Grain yield , kg/ha	% increase	Number of leaves[1]	Plant height , cm	Grain yield , kg / ha	% increase
Control	599c	-	51 .93a	19 .09a	683b	-
Manure of 1rst group	744b	24	51 .80a	20 .79c	742ab	9
Manure of the 2nd group	817b	36	52 .56a	20 .16b	756ab	11
Manure of the 3rd group	836b	39	57 .55b	20 .27b	842ab	23
Manure of the 4th group	1008a	68	58 .75b	21 .24d	857a	25

Means followed by different letters in the same column are different at $P<0.05$.

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Changes in the physiology of tall fescue during regrowth

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Key words : herbage quality , regrowth , tall fescue

Introduction Tall fescue (*Festuca arundinacea* Schreb .) is a widely utilised dairy pasture species due to its wide range of adaptability (Langer , 1990) , but little is known about the effect of leaf stage based defoliation management on this species . Grazing management decisions should be based on an understanding of the physiological changes that occur in the grass plant throughout the regrowth cycle . The aim of the present study was to investigate changes in tall fescue during regrowth to establish a basis for optimum defoliation management of tall fescue pastures .

Materials and methods Glasshouse treatments consisted of one preliminary harvest followed by 5 sequential harvests when each new leaf had regrown , up to the 5-leaf stage (5 live leaves per tiller) . Leaf tissue , stubble tissue below 50 mm and roots were collected at each harvest . Root and stubble samples were analysed for water-soluble carbohydrates (WSC) , and metabolisable energy (ME) was calculated using dry matter (DM) digestibility measurements of leaf material .

Results and discussion A positive linear relationship ($r^2 \geqslant 0.61$) between stubble WSC levels and the regrowth capacity of tall fescue confirmed that WSC reserves play an important role in the entire plant regrowth cycle following defoliation . Leaf and root regrowth commenced at a similar time in tall fescue plants following defoliation , with both leaf and root DM yields reaching their pre-defoliation levels between the 2-leaf and 3-leaf stages . Root growth increased until the 4-leaf stage and then stabilized , while leaf growth continued to increase until the 5-leaf stage of regrowth . Leaf and root growth , therefore , appeared to be assigned equal priority for energy allocation , unlike perennial ryegrass (*Lolium perenne* L .) , for which leaf regrowth has a higher priority for allocation of WSC reserves following defoliation compared with roots (Donaghy and Fulkerson , 1998) . This finding is in agreement with the work of Kemp et al . (2001) , who found that tall fescue allocated more of its biomass to roots and pseudostem compared with perennial ryegrass . The ME concentration of tall fescue decreased with increasing leaf stage (Table 1) , due to decreasing digestibility of plant tissue with age .

Table 1 *Stubble dry matter (DM) (mg/tiller) , root and leaf DM (mg/plant) , and leaf metabolisable energy (ME) (MJ/kg DM) before defoliation and at each corresponding leaf regrowth stage .*

Leaf regrowth stage (leaves/tiller)	Stubble DM (g/plant)	Root DM (g/plant)	Leaf DM (g/plant)	Leaf ME (MJ/kg DM)
0	0 .87	1 .50	3 .94	10 .7
1	0 .69	0 .80	0 .56	11 .3
2	0 .89	1 .29	2 .48	10 .9
3	0 .89	1 .65	4 .37	10 .4
4	1 .17	2 .19	6 .75	10 .1
5	1 .44	2 .09	7 .11	9 .2
LSD (P = 0 .05)	0 .29	0 .62	0 .91	0 .2

Conclusions These results emphasise the dichotomy of this species , with relatively frequent defoliation at the 2-leaf stage required to maintain an ME concentration above 10 .5 MJ kg^{-1} DM , contrasting with relatively infrequent defoliation at the 4-leaf stage required to maximise pasture production and persistence . A field study investigating the rotational grazing of tall fescue at different leaf regrowth stages would be valuable to confirm the most effective range of grazing intervals in the field .

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Evaluation of impacts of livestock grazing intensity on plant biodiversity in the western Chang Tang National Natural Reserve , Tibet , China

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Key words : grazing intensity , biodiversity , Chang Tang , China

Introduction In an arid or semi-arid region , such as the western Chang Tang area of the northwest Tibetan Plateau , herbivore grazing could be expected to have little impact on plant biodiversity if the system exhibits non-equilibrium characteristics at a large scale (Behnke & Scoones 1993) . However , in some places where high mountain ranges are located , such as in the Aru Basin (33°45′-34°25′N and 81°55′-82°40′E) , wetter microclimates occur within arid regions . Here the system would possibly be in a state of equilibrium , and the plant species richness should vary significantly along a grazing pressure gradient . To understand how livestock grazing intensity affects local plant biodiversity is therefore important for identifying ecosystem properties and can inform selection of appropriate policies for managing the ecosystem .

Materials and methods Grazing gradients radiating out from nomad summer camps were used to examine the effects of livestock grazing pressure on vegetation . Ten transects of 200 m length each were randomly placed in low and highly grazed areas . Twenty quadrats , each 0 .25 m^2 , were spaced at 10 m intervals along each transect for vegetation measurements . Vegetation data were separated into three categories , total , graminoids , and forbs (including dwarf shrubs) . Soil samples collected from low and highly grazed sites were analyzed for chemical composition .

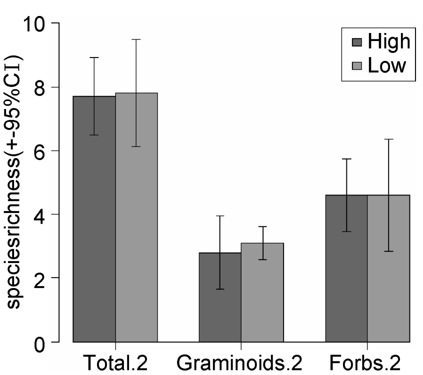

Figure 1 *Bar plot with 95% of confidence intervals (CI) illustrating differences in species richness (numbers of species along a 200 m transect) for total species , graminoids and forbs between the highly grazed and low grazed areas in the western Aru Basin on the northwest Tibetan Plateau .*

Table 1 *DCA with Monte Carlo Permutation test results for conditional effects of environmental variables .*

Variable	Var .N	λ	F-ratio	P value	variance explained
Elevation	18	0 .21	4 .00	0 .002	0 .21
Forb species richness	25	0 .12	2 .40	0 .008	0 .12
Species richness	7	0 .11	2 .38	0 .006	0 .1
Grass species richness	24	0 .07	1 .56	0 .098	0 .07
Slope	17	0 .05	1 .32	0 .19	0 .05
Grazing intensity	2	0 .06	1 .5	0 .114	0 .06
Aspect	16	0 .05	1 .23	0 .265	0 .05
Latitude	19	0 .03	0 .77	0 .594	0 .03
pH	8	0 .03	0 .8	0 .548	0 .03
N	9	0 .03			
K	10	0 .03			
P	11	0 .03			
Organic material	12	0 .03			
Total N	13	0 .03			
Total P	14	0 .03			
Total K	15	0 .03			

A total of 490 permutation tests were performed by setting options in Canonical Correspondence Analysis (CCA) using Canoco for Windows 4 .5 .

Results and discussion All comparisons between high and low grazing sites indicated that grazing intensity is not a significant factor impacting plant biodiversity (Figure 1) . A Monte Carlo Permutation test showed that elevation was the most significant abiotic environmental variable in explaining floristic variation (Table 1) . Moisture and elevation gradients were also important .

Conclusions This study indicates that grazing intensity has a limited impact on plant species richness , suggesting a domination of non-equilibrium rangeland vegetation characteristics in what is probably one of the moistest parts of the western Chang Tang plateau . Thus , the efficacy of current rangeland management policies , which are based on equilibrium ecosystems characteristics , should be questioned . A more realistic approach , using flexible and opportunistic strategies , needs to be formulated to manage livestock and wildlife in this non-equilibrium ecosystem .

How does sward height and quality affect the choice of feeding sites and intake in horses ?

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Key words : horses , pastures , intake , feeding choices , sward characteristics

Introduction Grass represents a large part of the diet of horses , which has important consequences for their nutritional management . However , little is known of the factors affecting horse daily intake and patch selection at pasture , including the effect of basic vegetation characteristics such as sward height and quality . As plants grow and mature , their fibre content increases involving a decline in quality . Optimal foraging models predict that herbivores should trade-off between sward accessibility , which determines intake rate , and sward quality , which determines diet digestibility and crude protein content (Fryxell , 1991) . In 2006 , we quantified the choice of feeding sites and intake levels when sward height varied , while keeping a constant high quality . In 2007 , we tested whether these choices and intake levels differed when height and quality varied simultaneously . Our hypothesis is that horses will express a preference for feeding sites allowing the higher nutrient intake rate .

Materials and methods In both years , three groups of 2-yr-old saddle horses (n=9 in 2006 , n=6 in 2007) were grazed on a semi-natural pasture that was managed to produce three contrasting swards , in a Latin-square design (three periods) . In 2006 , the swards differed in height and were of the same quality (short =6 cm , intermediate =11 cm and tall =17 cm ; fibre content=49% NDF) . In 2007 , the swards varied simultaneously in height and quality (short good = 7cm-56% NDF , medium intermediate =13 cm-60% NDF and tall poor 80 cm-62% NDF) . The different swards were offered to the animals either alone or in pair-wise tests . Preferences were established from the time spent grazing each sward in pair-wise tests . Daily food intake was measured individually using faecal collection on swards offered alone in 2006 and on each pair-wise test in 2006 and 2007 . Instantaneous intake rates were determined on each sward offered alone for both years using trays .

Results and discussion In 2006 , the animals spent 65-95% of their daily feeding time grazing on the taller sward where they realised the highest dry matter (DM) instantaneous intake rates . In 2007 , sward quality decreased across the periods (the tall poor matured , from 60 to 64% NDF) resulting in contrasting preferences between first and last periods . In the first period , horses spent 62-80% of their 24h feeding time grazing on the taller swards and confirmed year 1 results . In the second and third periods , they gradually switched onto the shorter swards (55-70% of their daily feeding time) even if instantaneous intake rate of digestible DM remained higher on the taller sward . At that time , crude protein (CP) content of the taller sward had , however , decreased to 7% which was not enough to cover horses requirements . Figure 1 illustrates the evolution of horse choices at a daily scale between the short and tall swards . During the first hour of testing , horses selected the intermediate sward where digestible protein intake rate was maximized (medium intermediate =2 .2 g digestible CP/mn > short good and tall poor =1 .5 g digestible CP/mn) . Daily voluntary intake of digestible DM and total feeding time were not affected by sward height or by pair-wise choices and averaged 13 g DM/kg LW/day and 14 h/day .

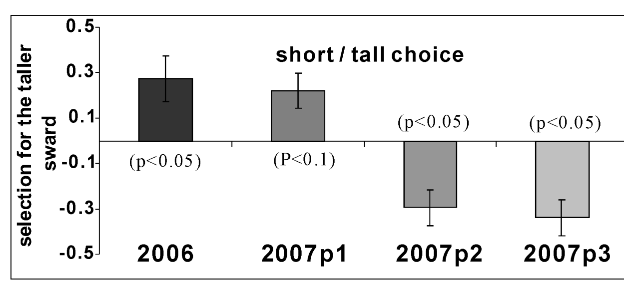

Figure 1 *Selection for the taller sward in the short / tall choice by the log10 of the ratio (time spent grazing on the taller sward / time spent grazing on the shorter sward) , in 2006 and in 2007 (periods 1 to 3) .*

Conclusions When swards did not differ in quality (or differ slightly) (2006 and 2007 first period) , horses selected the taller swards where they realised higher DM instantaneous intake rates . When taller swards matured (last two periods of 2007) , the horses shifted their preferences to high-quality short swards even if instantaneous intake rates of digestible DM remained higher on the taller sward . It therefore appears that sward quality (especially CP content) overrides the effect of sward height , in agreement with previous field observations (Menard et al . , 2002) .

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Behaviour of fallow deer and sheep on large unit fen pastures in north east Germany

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Key words : Fallow deer , sheep , common pasture , behaviour , winter

Introduction The fodder grown on fen pastures is hardly any more completely consumed by fallow deer during the vegetation period . Reasons to favour winter pastures of sheep are the reduced costs for the production of hay , the maintenance of buildings and the input of labour .

There is only small information available concerning the grazing behaviour of jointly grouped fallow deer and sheep in winter .

Material and methods The study of the joint keeping of fallow deer and sheep on winter pastures were carried out in a fen area near Berlin . The jointly grouped sheep and fallow deer were counted and registered by the pasture activities in the winter periods of 1999/2000 (I) and 2000/2001 (II) . There were approximately 0 ,5 large animal units , which corresponds to 250 kilograms of animal living mass per hectare . From November till late February , the grazing activities of sheep and the fallow deer were visually observed in a two-weeks rhythm at intervals of five minutes over the day-light periods of day . The statistical assessment of the data material was aided by SPSS software which is based on the application of a 2-factorial variance analysis (A×B-n) . correlation coefficients (Pearson) .

Results and discussion We found marked differences between sheep and fallow deer in different features . Sheep spend altogether much longer time for eating than fallow deer (Table 1) .

Table 1 *Ethological analyses of behaviour on winter pasture (I and II) .*

Distinctive mark	X Species total (n=10)		t-Test species and year	Marginal difference correlation
	Fallow deer	Sheep		
Total ingesting time ($min \cdot d^{-1}$)	218 .0	345 .6 *	38 .4	54 .3
Mean grazing time ($min \cdot d^{-1}$)	173 .7	233 .8 *	60 .0	84 .9
Mean frequency of grazing periods ($n \cdot d^{-1}$)	2 .8	3 .2 *	0 .78	1 .10
Mean duration of hay intake ($min \cdot d^{-1}$)	44 .3	111 .8 *	43 .6	61 .7
Mean frequency of hay intake periods ($n \cdot d^{-1}$)	1 .7	3 .4 *	1 .01	1 .43

Although the animals were jointly kept in a paddock , no common ingestion rhythm developed between fallow deer and sheep , with the individuals of both species grazing mainly in their own groups . The two groups of animals usually ate hay independently of one another . While the one group was eating , the other one either rested/ruminated , or grazed . There was only one instance when rivalry development over fodder . In this case , the sheep group forced the fallow deer away from the hay racks . The animals of the two groups of species (race Skudden by sheeps) under examination are well adapted to the prevailing climatic condition (Fischer et al . 2007) .

Conclusions The results obtained show that the animals maintained their species-specific ingestive behaviour despite common keeping . As compared to fallow deer , the sheep spent markedly longer time with ingestive activities . There were only rare instance of rivalry and conflict (over grazing positions or hay-feeding points) between the two species .

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Effect of horse grazing under different stocking rates on the selection of feeding patches

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Key words: grazing, horse, stocking rate, spatial heterogeneity, patch choice

Introduction Stocking rate is a key management variable influencing the structure and composition of pastures. In turn, the spatial heterogeneity of grassland vegetation determines the abundance and quality of food resources for the animals. While horses play an increasing role in the management of grasslands in Europe, our knowledge concerning their use of pastures under different stocking rates is limited. Therefore, during two years we analysed the seasonal patterns of patch selection by horses grazed at two stocking rates in a mesophile grassland of central France (elev. 430 m).

Materials and methods In the high stocking rate treatment, five adult saddle horses per plot were continuously grazed over the whole grazing season, giving a stocking rate of 1000 kg/ha. Three horses grazed each plot in the low stocking rate treatment (600 kg/ha). Six 2.7 ha experimental plots were created, so that each treatment could be replicated three times according to a randomised block-design. Each year, 24 h observations (scans at 5-min intervals) were conducted on three occasions between early June and the end of September on three animals in each group. The proportion of the different bite types in the diet (Vegetative Short [VS]: ≤4 cm, Vegetative Intermediate [VI]: 5 to 8 cm, Vegetative Tall [VT]: ≥9 cm, Reproductive or Dead grass [R/D]) and their selection (proportion of a bite type in the diet relative to its proportion in the plot) were analysed in a model for repeated measurements including the main effects of stocking rate, block, year, season, and the interactions between stocking rate and block, stocking rate and year, stocking rate and season, and year and season.

Results and discussion Horses spent a large part of their feeding time on tall vegetative patches (Table 1). However, in agreement with the Forage Maturation Hypothesis (Fryxell, 1991), they selected intermediate vegetative regrowth more than the shorter or taller patches ($p<0.01$). They also avoided tall, reproductive patches with these becoming more mature (Table 1). Although horse selection for short and intermediate patches was not significantly affected by season, the horses spent more time feeding on short swards in summer and in autumn and increased their use of intermediate swards during the grazing season. Selection for short and intermediate vegetative patches was also more pronounced in plots grazed at the low stocking rate. Horses thus exhibited a typical patch-grazing pattern (Adler et al., 2001), continuously using previously grazed areas of high nutritive value. As already observed in cattle grazing fertile, mesophile swards (Dumont et al., 2007), this patch-grazing pattern was more pronounced at the lower stocking rate, which is expected to reinforce the spatial heterogeneity of the pastures.

Table 1 *Mean proportion of each bite type included in the diet and Jacobs' selection index for horses according to stocking rate and season.*

	Stocking rate (SR)		s.e.	P	Season (S)			s.e.	P	SR×S
	High	Low			June	July	Sept			P
Proportion of bite type										
VS	0.147	0.078	0.002	**	0.019a	0.159b	0.159b	0.024	***	<0.1
VI	0.293	0.218	0.018	*	0.169a	0.258b	0.338c	0.020	***	NS
VT	0.500	0.621	0.023	**	0.737a	0.453b	0.494b	0.029	***	NS
R/D	0.060	0.083	0.012	NS	0.075a	0.130b	0.009c	0.015	***	**
Jacobs' selection index										
VS	−0.03	+0.23	0.07	*	−0.05	+0.28	+0.07	0.13	<0.1	NS
VI	+0.21	+0.46	0.03	***	+0.31	+0.36	+0.35	0.06	NS	<0.1
VT	−0.09	−0.07	0.04	NS	−0.01a	+0.03a	−0.25b	0.09	**	NS
R/D	−0.36	−0.50	0.16	NS	−0.26a	−0.38ab	−0.63b	0.10	*	NS

Values within lines with different letters are different at $P<0.05$; * , $P<0.05$; ** , $P<0.01$; *** , $P<0.001$; NS, not significant
For Jacobs' index, bold characters indicate bite types selected for (>0) or avoided (<0) (Student's *t*-test).

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Palatable grasses have higher relative growth rate and competitive ability than unpalatable grasses in the Patagonian steppe

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Key words : grazing, desertification, arid steppe, palatability

Introduction In Patagonia, sheep grazing triggered processes of desertification of different magnitude (León y Aguiar, 1985). In the Patagonian shrub-grass steppe, grazing caused substitution of palatable species by unpalatable ones. Coughenour (1985) proposed that there is an evolutionary convergence between those adaptations allowing plants to tolerate water and nutrient deficits, and those conferring tolerance against herbivores. Plant populations evolved under severe resource limitations would have low relative growth rates and adaptations against both nutrient and water deficits and also against herbivory (Chapin *et al.*, 1993). The objective of this work was to evaluate the relative growth rate (RGR), water consumption and competitive ability of two grass species of the Patagonia steppe with contrasting palatability.

Materials and methods We conducted an experiment under glasshouse conditions, with a factorial arrangement that included three factors: species (*Bromus pictus*, palatable, *vs*. *Stipa speciosa*, unpalatable), competition (intraspecific *vs*. interspecific) and water availability (constant field capacity *vs*. initial field capacity without any posterior watering). We harvested aerial parts and measured soil water content at 81 and 102 days before emergence.

Results Palatable *B. pictus* showed a greater RGR than unpalatable *S. speciosa* in the interval between the beginning of the experiment and the first harvest (0-1) and in the average of all the experiment (0-2) while there were no significant difference between-species differences in the interval between the first and the last harvest (1-2) (Figure 1). Accordingly, the palatable species had greater water consumption than the unpalatable one ($P < 0.05$). Finally, the palatable species reached a greater number of tillers per plant when it grew under interspecific competition than when it did under intraspecific competition. Instead, *S. Speciosa* showed the opposite response (Figure 2). Similar responses to those described for the tillers per plant were recorded in the number of total leaves, live leaves and aerial biomass per plant, supporting the hypothesis of a greater competitive ability of palatable *B. Pictus* over unpalatable *S. speciosa*.

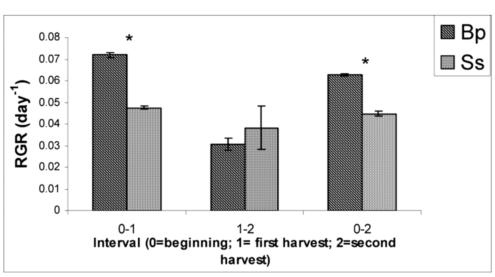

Figure 1 *Maximum relative growth rate of each species. 0-1: beginning to first harvest; 1-2 first to last harvest; 0-2 average of the whole experiment. *: significant differences between species ($P < 0.05$).*

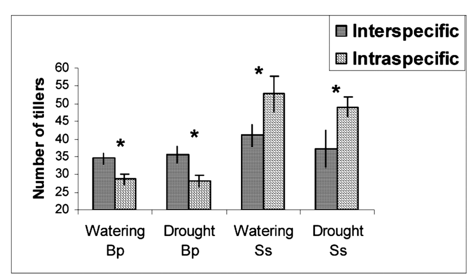

Figure 2 *Number of tillers in <u>B. pictus</u> (BP) and <u>S. Speciosa</u> (SS), growing under interespecific and intraespecific competition and in condition of watering and drought. *: significant differences between competition levels for each species and water availability level.*

Conclusions Palatable *B. pictus* had greater maximum relative growth rate, water consumption and competitive ability than unpalatable *S. speciosa*.

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The potential cost of discrimination in diet selection by grazing herbivores

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Key words: ruminant, clover, discrimination, selection

Introduction While the general patterns of diet selection by grazing herbivores have been frequently discussed in the literature, very little is known on the effect of the local abundance and assemblage of plant families on their subsequent defoliation by the animals. In diverse pastures, where several plant species coexist on a small spatial scale, diet selection will partly depend on the discrimination abilities of the animals. The ability of sheep to discriminate between ryegrass and white clover has been demonstrated using an indoor test (Edwards et al., 1997). Here, we propose a sward-based method to study the selection of white clover by cattle and sheep in a pluri-specific grassland, according to whether it can be easily distinguished within the sward or not. This leads us to discuss the potential cost of discrimination processes in the diet selection of grazing herbivores.

Materials and methods This experiment was conducted in 2006, on six plots grazed since 2005 at the same low stocking rate by either sheep (5 ewes on 1100 m^2) or cattle (2 heifers on 2200 m^2) in a rotational grazing system, with five rotations per year (April, May, July, Sept. and Nov.). Plant community of the experimental plots was moderately diversified (15-20 plant species per plot) and white clover represented 6% of the vegetation on a volume-basis when measurements began. We indirectly estimated the selection of clover by using 20 fixed grids distributed over the six plots using a stratified sampling based on clover abundance (high: 40% *vs*. low: <20%) and local assemblage (mainly grasses+clover *vs*. forbs+grasses+clover). The grids (60 x 80 cm) were composed of 48 square units (10 x 10 cm) within which we recorded before and after each of the last four grazing rotations, the abundance of clover as the proportion of covered surface, using a visual note ranging from 0 to 6. Clover abundance at the grid scale was analysed by using the mixed procedure of SAS and a model accounting for the effects of initial abundance, assemblage, herbivore species and rotation number as the repeated factor.

Results and discussion This sward-based method confirms that both sheep and cattle actively select clover in diverse pastures. Sheep exerted a stronger selection pressure on clover than did cattle ($p=0.02$) as shown by an average of 50% lower proportion of clover in grids grazed by sheep over the grazing season. This is consistent with the selection of higher quality foods by the small ruminants and their greater ability to graze selectively. In May, consumption of clover was greater in grids where it was initially abundant ($p=0.03$), with smaller differences after July between grids with initially high or low clover abundance (Figure 1a). The local assemblage also affected the evolution of clover in grids. Clover depletion tended to be greater when associated mainly with grasses than when associated with both forbs and grasses ($p=0.09$) (Figure 1b).

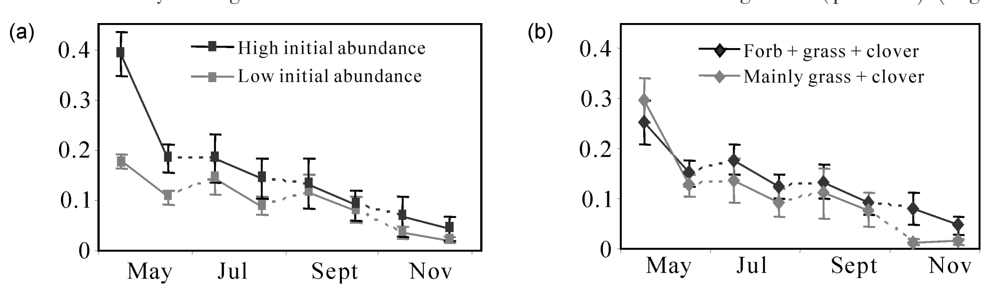

Figure 1 *Evolution of clover proportion through grazing rotations (before and after each one) according to (a) its initial abundance and (b) local assemblage.*

This result observed in both sheep and cattle (herbivore species x assemblage: $p=0.7$) may partly result from the difficulty of grazing herbivores to discriminate between clover and forbs when closely mixed due to more similar morphological traits compared with grasses.

These results suggest that the selection pressure on white clover would be greater when it is more easily distinguished into the sward, whether due to higher local abundance or to less similarity with associated plant types, based on either morphological or nutritional traits.

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Growing grass for greener grazers :herbage management for improved N utilisation of grazing cows

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Key words : herbage quality , high-sugar cultivar , *Lolium perenne* , N application rate , regrowth period

Introduction Grazing is accompanied by localised deposition of nitrogen (N) in urine and dung patches , which can contribute to losses of N to water and air . The N utilisation of cows can be manipulated through diet composition . In Ireland , this diet consists mainly of grazed grass . Therefore , the main way to manipulate the diet is through grassland management . Previous studies have investigated the impact of single herbage management tools on herbage composition and sometimes cow N efficiency . In this paper , we aim to identify grassland management systems to optimise the N efficiency of grazing bovines .

Materials and methods In order to study the direct impact of herbage management on bovine N efficiency we linked the Cornell Net Carbohydrate and Protein System model to a herbage intake quality model (Hoekstra et al . , submitted) . Plot experiments provided input data for the model ; field experiments at farmlet scale with contrasting herbage management regimes were used to evaluate the model . The herbage management tools evaluated were : fertiliser N application rate , length of the regrowth period and diploid high sugar grass cultivar (cv Aberdart) . All calculations were performed for three seasons : early , mid and late season .

Results and discussion Results from the model and field experiments showed that the crude protein (CP) concentration of the herbage ingested during grazing is the main factor for improving bovine N efficiency , with the optimum CP concentration lying between 13-15% DM (Figure 1) . At CP levels above 15% , the supply of N was in excess of the energy supply and could not be utilised by the animal , whereas at CP levels below 13% , the supply of N limits milk production , resulting in lower N use efficiency . Fertiliser N application rate in interaction with length of the regrowth period were shown to be effective tools for manipulating the CP concentration of herbage ingested during grazing (Figure 2a) , with rotation length having a more pronounced effect at high levels of fertiliser N application . The modelled efficiency of N utilisation for milk production as affected by N application rate (14-56 kg N ha^{-1} rotation^{-1}) and length of regrowth period (3 to 7 weeks) ranged from 23 to 37% during early and mid season and from 21 to 26% during late season (Figure 2b) .

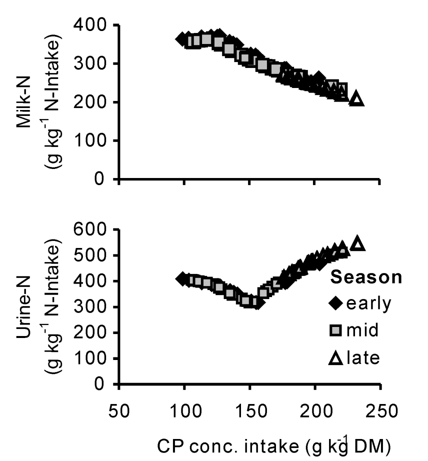

Figure 1 *Modelled relation between the CP concentration in the intake and a) Milk-N and b) Urine-N (g kg^{-1} N-Intake) during early , mid and late season .*

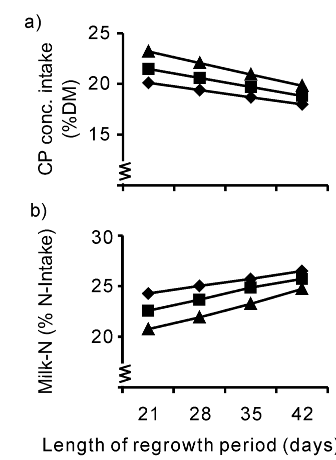

Figure 2 *Modelled effect of N application rate (◆ 14 , ■ 36 and ▲ 56 kg N ha^{-1} rotation^{-1}) and length of regrowth period on a) the CP concentration of the intake , and b) the milk N efficiency during late season .*

The high-sugar grass cultivar did significantly increase the water soluble carbohydrate (WSC) concentration in the ingested herbage . However , this did not affect cow N efficiency , as the increase in WSC was at the expense of neutral detergent fibre rather than CP (data not shown) .

Conclusions The CP concentration of ingested herbage is the main factor for improving the N efficiency of grazing bovines and this can be effectively manipulated through fertiliser N application rate in interaction with the length of the regrowth period . Diploid high-sugar cultivars do not appear to be effective for improving the bovine N utilisation . It is recommended that the model will be extended to include a herbage yield and an intake component . This will allow the model to be used to design herbage management systems to optimise N utilisation on a yearly basis .

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The effect of legumes on stability and quality of yield in long-term grazing use

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Key words: white clover, lucerne, grazing, yield, quality

Introduction The presence of any legumes in grassland communities appears to result in increased above ground biomass (Spehn *et al.*, 2002). Legumes usually produce a higher content of crude protein than grasses (Halling *et al.*, 2002). The objective of our experiment was to evaluate effect of legumes on stability and quality of yield over several years in different swards.

Materials and methods During 1998—2006 a randomized block design field trial was carried out on a loamy *Endocalcari-Epihypogleyic Cambisol* near Dotnuva, Lithuania (55°24′N, 23°50′E). Soil pH varied from 6.5 to 7.0, humus content was 2.5-3.2%, available P 50-80 mg and K 100-150 mg kg^{-1}. The treatments involved different swards consisting of white clover (*Trifolium repens* L.), lucerne (*Medicago sativa* L.), perennial ryegrass (*Lolium perenne* L.), meadow grass (*Poa pratensis* L.) and *Festulolium* hybrid. The grazing season lasted from the beginning of May until middle of October with four grazing rotations. During 8 years of experimentation climatic conditions differed to a great extent: grazing periods 2000, 2001, 2004 and 2005 were normal, 1999 wet, 2003 dry, and 2002 and 2006 very dry and warm.

Results and discussion The total annual dry matter (DM) yield was primarily affected by the climatic conditions and less by sward composition (Table 1 and Table 2). The swards responded differently to seasonal conditions. The DM yield in 2002, 2003 and 2006 was markedly lower than in all other years. Nevetherless swards consisting of legumes had higher yield than pure grass swards without nitrogen fertilization. Only lucerne based swards had in all years (excluding 2002) a higher total and legume yield. The yield of white clover in dry seasons declined more than that of lucerne and grasses or forbs. The effect of legumes in different swards on crude protein content reflected their effect on DM yield (Table 2). Crude protein content in all swards met animal requirements.

Table 1 *Total dry matter annual yield of different swards and its persistence over eight years of use, t ha^{-1}.*

Swards	1999	2000	2001	2002	2003	2004	2005	2006
1 *T. repens/L. perenne*	6.12	5.49	5.02	2.58	2.69	5.26	4.74	2.74
2 *T. repens/L. perenne/P. pratensis*	6.56	5.36	5.16	2.47	2.20	4.73	5.25	2.93
3 *M. sativa/L. perenne/P. pratensis*	7.55	8.87	7.19	3.04	5.59	8.63	8.24	4.52
4 *T. repens/M. sativa/L. perenne*	6.96	8.11	6.56	3.02	4.76	7.04	7.03	4.77
5 *L. perenne/N_0*	3.23	4.45	4.73	3.12	2.31	4.38	5.21	3.13
6 *L. perenne/N_{240}*	7.54	7.10	4.51	3.04	4.20	7.72	5.70	4.26
7 *T. repens/Festulolium hybrid*	6.74	6.21	5.36	2.60	2.53	4.97	4.76	2.94
$LSD_{0.05}$	0.511	0.421	0.398	0.615	0.366	0.497	0.466	0.591

[1] Sward persistence index—last 2 years yield ratio to first 2 years, LSD—least significant difference ($p<0.05$)

Table 2 *Legume annual yield and crude protein content in total yield of different swards.*

Swards	Dry matter t ha^{-1}							Crude protein g DM kg^{-1}						
	1999	2000	2001	2002	2003	2005	2006	1999	2000	2001	2002	2003	2005	2006
1.	2.99	0.84	1.76	0.57	0.19	2.50	0.23	186	156	202	167	181	236	192
2.	3.48	1.10	2.13	0.74	0.19	2.58	0.20	193	156	203	173	175	220	208
3.	5.25	5.92	4.69	1.58	4.04	5.42	2.97	226	213	213	170	215	224	199
4.	4.04	2.71	3.58	1.63	3.04	3.74	2.91	206	183	216	189	217	227	202
5.	—	—	—	—	—	—	—	124	144	191	145	154	222	201
6.	—	—	—	—	—	—	—	187	158	216	196	247	235	230
7.	2.40	1.08	1.87	0.50	0.17	2.18	0.14	182	140	199	155	196	215	196
$LSD_{0.05}$	0.214	0.135	0.193	0.163	0.190	0.244	0.286							

Conclusions Lucerne based swards had a higher total and legume yield and showed a positive effect on stability of grazing swards over eight years. The grassland consisting of legumes can be productive and protein rich without mineral N and reduce external inputs.

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Effect of chicory and plantain on cadmium levels in lambs

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Key words: *Cichorium intybus, Plantago lanceolata*

Introduction Cadmium (Cd) is a widespread contaminant of soils in New Zealand due to historical use of phosphate fertilisers manufactured from rock phosphate with high levels of Cd (Loganathan *et al*. 2003). Herb forage species are increasingly used in pastures for their high nutritive value, but they are also known to accumulate high concentrations of micronutrients and, therefore, could potentially accumulate Cd. Our objective was to examine the Cd concentration in the herbage intake and liver of lambs grazing pastures incorporating chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*).

Materials and methods The experiment was at Palmerston North, New Zealand on a Tokomaru silt loam soil with a long history of annual superphosphate applications. The three pasture treatments were: herb (chicory Choice, plantain Ceres Tonic, red clover Sensation, white clover Tribute); pasture+plantain (tetraploid perennial ryegrass Stirling (AR1), white clover Tribute, plantain Ceres Tonic); and pasture (tetraploid perennial ryegrass Stirling (AR1), white clover Tribute). There were three replicates with 25 Romney ewe lambs (5 months old) and 1.6 ha per replicate. Grazing management provided ad lib intake by lambs. Hand plucked herbage samples replicating lamb intake were taken from cages after each grazing, and liver biopsy samples were taken from the same 10 lambs per replicate at the start, middle and end of the experimental period (see Table 1).

Results and discussion Cd concentrations of the plucked samples estimating herbage eaten were highest in the herb, intermediate in the pasture+plantain, and lowest in the pasture treatment ($P<0.05$, Table 1). This result shows the herb species have a greater uptake of Cd than ryegrass and white clover (Lee *et al*. 1996). However, the Cd concentration in the liver was not different between the treatments over the two months. The lambs on the herb treatment grew at 192 ± 5.0 g liveweight/day compared with 93 ± 4.1 g liveweight/day on the other treatments inferring that their herbage and Cd intake was greater, but the extra Cd was not retained in the liver. The reason for the apparent lack of coupling between Cd intake and retention in the liver requires further investigation, but is possibly due to antagonistic effects of other trace elements, particularly zinc.

Table 1 *Cadmium concentration (elg Cd/g DM) in herbage and lamb liver.*

Sample Type	Sample Date	Herb	Pasture + plantain	Pasture
Herbage	22nd Feb	361[a]	298[a]	224[a]
	1st Mar	506 ± 140.1	275 ± 108.4	110 ± 18.8
	15th Mar	557 ± 20.0	295 ± 61.4	121 ± 13.2
	29th Mar	657 ± 76.9	332 ± 35.9	148 ± 31.7
	12th Apr	754 ± 121.9	583 ± 47.1	180 ± 51.3
Liver	22nd Feb	137 ± 26.9	145 ± 41.8	154 ± 19.5
	13th Mar	141 ± 17.2	296 ± 40.4	227 ± 26.8
	19th April	242 ± 51.7	280 ± 56.8	290 ± 49.2

[a] no replicates for first sample date

Conclusions Cadmium concentration was elevated in the pasture treatments incorporating chicory or plantain, but over two months the cadmium concentrations in the liver of lambs were not increased.

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Effect of four fertiliser regimes on the persistence of perennial native grasses

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Key words: Temperate perennial native grasses, persistence of native perennial grasses, native pasture fertiliser strategies

Introduction It is often said that too much fertiliser will cause native grasses to die out but is it the fertiliser that causes such losses? Perennial native grass pastures will generally respond to fertiliser, provided they contain a responsive legume. This is particularly true of those with a significant component of wallaby grass (*Austrodanthonia* spp), microlaena (*Microlaena stipoides*) or redgrass (*Bothriochloa macra*). Garden *et al*. (2001), using wether sheep, suggests annual grasses reduce wallaby grass when higher rates of fertiliser are used. This paper provides data on the persistence of several native grasses following 12 years of fertiliser application at several different rates with a different livestock enterprise.

Materials and methods The work was carried out on a 66 ha site in the central tablelands of NSW (altitude 900m and mean annual rainfall 795mm) from 1995 to 2006. The soils are shallow, acidic (pH_{Ca} 4.2) and shale derived. Soil phosphorus and sulphur levels were initially very low. The pastures are dominated by wallaby grass, with microlaena, wheat grass (*Elymus scaber*), some perennial ryegrass, subterranean clover, *Vulpia* spp and soft brome (*Bromus mollis*). The paddocks were set stocked to enable economic data to be collected from the spring lambing, 2^{nd} cross, prime lamb enterprise. Stocking rates were raised on all annually fertilised paddocks to utilise the extra feed grown, yet maintain high lamb growth rates.

The control" paddock received 125 kg/ha single superphosphate (8.6% P & 11% S) every third year in line with common practice and carried 5 ewes/ha. Two other paddocks received high fertiliser inputs of either water-soluble, single superphosphate (SSP) or reactive phosphate rock (RPR)-420 kg/ha SSP or 300 kg/ha RPR & gypsum, which provided equal amounts of S & P in 1995 and 250 kg/ha/year SSP or RPR/sulphur blend in 1996 and 1997. For the last nine years, 180 kg/ha of the relevant products (based on 2 kg P/ewe carried) was applied. Two other paddocks received either 140 kg/ha SSP or 100 kg/ha RPR annually and one other paddock only received this rate of RPR only for the first three years. This paddock has been cell grazed" with no fertiliser for the last 10 years.

Before the trial commenced, permanent transect lines were established in each paddock to monitor species presence and persistence at ten $1m^2$ fixed quadrats using a 10 cm square mesh grid (1000 points/paddock). This has been repeated annually. In addition, pasture composition is recorded every spring and autumn using the end-point stick" method.

Results and discussion Species composition changed with the seasons and climatic conditions and end point data showed legumes in spring increased from 5% in 1995 to 25% with all high fertiliser rates, while the 1 year in 3 and cell grazed paddocks only rose to 13% legume. Annual grasses in spring remained relatively stable at 10% vulpia was more prevalent in the 1 year in 3 and cell grazed paddocks, whereas soft brome dominated in the high and annual input paddocks.

The% basal presence data in Table 1 shows sown perennials and microlaena generally declined in all paddocks due to very dry conditions in 2006. Wallaby grass increased in all paddocks except the annual input ones where a sheep camp effects and excess competition from ryegrass adversely affected the persistence. Total native perennial counts rose 65% in the high input paddocks but only 23% and 13% respectively in the 1 in 3 and Cell paddocks

Table 1 *Perennial Grass Persistence (% basal presence) over 12 years—Comparison of Four Fertiliser Regimes.*

Fertiliser Regime	High Input		Annual Input		1 in 3 Input		Cell (nil for 10 yrs)	
Species / Year	1995	2006	1995	2006	1995	2006	1995	2006
Austrodanthonia	321	620	486	470	427	508	318	410
Microlaena	75	22	2	2	11	23	148	133
Elymus	10	5	15	4	3	12	18	6
Sown/Naturalised	118	54	80	55	130	39	25	18

Conclusions These results show that wallaby grass responds positively to fertilisen whichis not detrimental euen at higt rates, provided an appropriabe enterprise and graxing srrategy B used to controb and utrlise the growth of annuals.

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Influence of dietary forages on the fatty acid profile of rumen digesta, milk and meat

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Key words: biohydrogenation; botanically diverse forages; fatty acids; plant secondary metabolites

Introduction Forage feeding increases the n-3 polyunsaturated fatty acid (PUFA) content in milk and meat. In particular, clover and botanically diverse forages have the potential to improve the milk and intramuscular (IM) fatty acid (FA) profile in terms of human nutritional recommendations (Lourenço et al., 2007). Here, we intend to integrate literature results on milk and IM FA of dairy cows or lambs fed leguminous rich or botanically diverse forages as compared to forage products from more intensively managed grasslands. Information on rumen FA is used to suggest potential explanations for differences in FA end product composition.

Materials and methods Milk FA results (proportion of milk total FA) were divided into three data sets: 1) red clover (RC) (n=6) *vs*. ryegrass based diets (n=6); 2) white clover (WC) (n=7) *vs*. RC forages (n=7) and 3) botanically diverse (BD) (n=7) *vs*. grass based diets (n=6), which were compared statistically using a mixed model with study as a random effect and weighing of the variables by the number of observations in each study (St-Pierre, 2001). Studies on dietary forage type in relation to rumen biohydrogenation (4 experiments) and intramuscular FA profile (6 experiments) were too few and diverse to integrate in an overall statistical analysis and are summarised to give an overview of general trends. The reader is referred to Lourenço et al. (2007) for the complete reference list of the individual studies.

Results and discussion In general, RC forages resulted in lower C18:3 n-3 apparent biohydrogenation (Figure 1), whichwas reflected in higher milk C18:3 n-3 proportions compared to ryegrass forages (Table 1), despite the similar C18:3 n-3 intake. Nevertheless, long chain PUFA in IM fat remained similar in ruminants fed RC and ryegrass diets (Figure 2). Compared to grass based diets, feeding BD forages resulted in higher C18:3 n-3 milk proportions (Table 1) and IM fat long chain PUFA proportions (Figure 2), although rumen C18:3 n-3 apparent biohydrogenation did not differ (data not shown). Moreover, higher rumen C18:1 t11 proportions were found for ruminants fed BD forages (4.59 g/100 g FA) compared to ruminants fed grass based forages (2.72 g/100 g FA). It is evident that feeding BD forages affects rumen FA metabolism, but changes could not always be associated with differences in the proximate chemical composition of the pastures or their PUFA content. Other factors might play a role, such as plant secondary metabolites, but only few for e.g. polyphenol oxidase in RC-have been studied for their effect on rumen FA metabolism.

Table 1 *C18:3 n-3 intake (g/d) and milk C18:3 n-3 proportions (g/100 g total milk FA) in the milk of dairy cattle fed either botanically diverse forage based diets, intensive ryegrass, red or white clover products (†$P<0.1$; * $P<0.05$).*

	Ryegrass	RC	WC	RC	Grass based	BD
Intake C18:3 n-3	92.1	115.6	136	171†	147	116
Milk C18:3 n-3	0.555	1.05*	0.956	0.893	0.788	1.06*

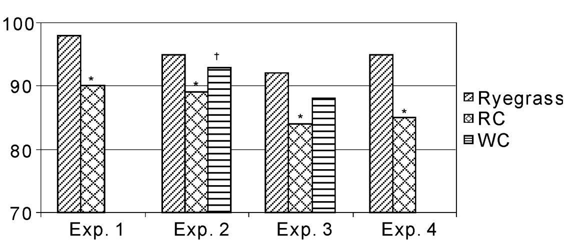

Figure 1 *C18:3 n-3 apparent biohydrogenation (g/100g) for ryegrass, RC and WC forages (adapted from Lourenço et al., 2007) † $P<0.1$; * $P<0.05$.*

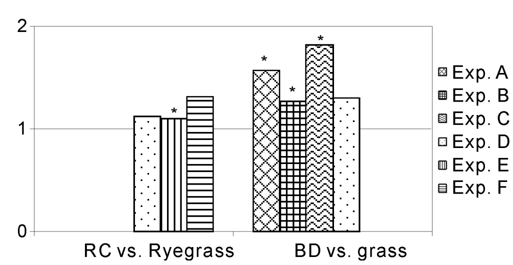

Figure 2 *Ratio of the proportions of total PUFA in the IM fat of animals fed RC to ryegrass and fed BD to grass based forages (adapted from Lourenço et al., 2007) * $P<0.05$.*

Conclusions Botanically diverse forages have the potential to change the PUFA content of ruminant products, which is associated with changes in the rumen and animal endogenous FA metabolism. Plant secondary metabolites are hypothesized to cause the observed differences, but more research on this topic is needed.

Fencing effects on biodiversity changes in desertified grassland in Hulunbeir ,China

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Key words : desertified grassland , fencing effect , biodiversity , Hulunbeir grassland

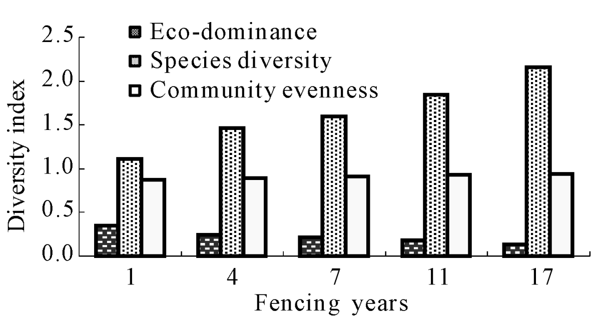
Introduction Hulunbeir grassland is the best grassland in China , but since the last 20 years , the grassland desertified in a large area . Fencing as a major grassland rehabilitation and reconstruction measures have been widely adopted in the world .

Materials and methods Located in Wangong Town , which belongs to Chenbaerhu Banner , Hulunbeir City of Inner Mongolia , the experiment sites were selected .Samples were collected in desertified grasslands of fenced 1 year , 4 years , 7 years ,11 years and 17 years , respectively .Plant community and biodiversity were measured .

Results The coverage of vegetation , the height of herbaceous layer , and the density and biomass (including aboveground biomass and belowground biomass in the depth of 30cm) , showed a significant lineear regression (Table 1) . Species richness and species diversity is improved drastically , the species richness index is fit with the dualistic function($r = 0.9919$,$p < 0.01$) (Figure 1) .

Table 1 *Regression relationships between community structure and fencing time .*

Items	Regression models	R^2	R	P
Coverage (Y_C)	$Y_C = 0.0015X^3 - 0.1034X^2 + 2.9622X + 4.3182$	0.7697	0.8773	<0.01
Height (Y_H)	$Y_H = 8.1871 \mathrm{Ln}(X) + 15.621$	0.9626	0.9811	<0.01
Density (Y_D)	$Y_D = 18.534 e^{0.837X}$	0.9392	0.9691	<0.01
Biomass (Y_B)	$Y_B = 29.217X^3 - 284.37X^2 + 830.21X - 539.41$	0.9751	0.9875	<0.01
Root weight (Y_R)	$Y_R = 13.925X^3 - 163.05X^2 + 617.93X - 431.64$	0.9904	0.951	<0.01



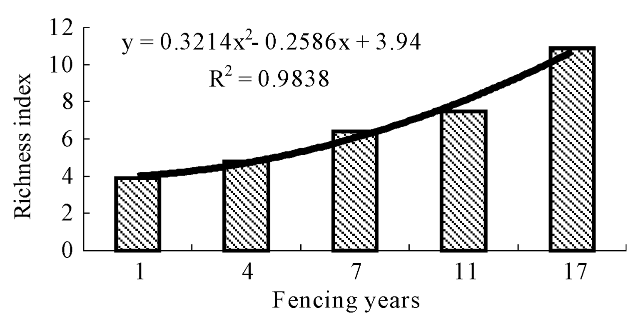


Figure 1 *Changes of richness , dominance , biodiversity and evenness of community species in different years after enclosing .*

Conclusions Fencing changed the desertified grassland community composition .The species richness increased continually , the structure of community improved . Species biodiversity and community evenness has been escalated .

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Evaluation of a beef cattle finishing simulation model for intake and live weight gain prediction under different herbage and maize grain allowances

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Key words: evaluation, model, intake, beef cattle, herbage allowance

Introduction Most animal grazing models require in advance measures or estimates of animal intake and feed quality to predict animal performance. An intake model linked to an animal performance model are the key components for whole-farm simulation. Model evaluation is not a straightforward issue as individual herbage and maize grain intake are not always readily available. The objective of this study was to develop and to evaluate a beef cattle finishing model for predicting herbage intake and animal performance under different herbage and maize grain allowances.

Material and methods Intake and diet selection in the model are functions of grazing management, sward and animal characteristics and are represented formally by a Potential intake (I_P), an intake associated to rumen fill capacity (I_F) that incorporates DM digestibility (D) of the herbage and D and amount of supplement. Finally factor (O-1, f_{HA}) linked to leaf allowance (kg DM/100 kg LW) and leaf mass (kg DM/ha). Herbage intake (I_H) is estimated as $I_H = \{Min(I_P . I_F) f_{HA}\}$. When maize grain is fed, I_H is corrected for substitution rate (SR). The SR is estimated in a two-step procedure from unsupplemented intake. Live weight gains and the updated animal liveweights are estimated daily i.e. simulated animals gain or loose weight, depending on their nutritional balance associated with animal characteristics and the corresponding individual ME and CP eaten daily (Freer *et al*. 1997). The model was evaluated (Mayer & Butler 1993) against experimental data shown in Table 1 (Machado 2004) obtained from a combination of herbage allowances (2.5 to 7.5 kg DM/100 kg LW) and maize grain allowances (from 0 to 1.2 kg DM/100 kg LW) where intakes was estimated from a combination a n-alkane and 13C markers.

Table 1 *Experimental data for model evaluation.*

	Exp.1	Exp 2
Animal class	heifers	steers
Duration (d)	49	57
Treatments (replicated)	4	6
Pre-grazing leaf mass (kg DM/ha)	2452	682
Pre-grazing sheath & stem mass (kg DM/ha)	1866	1011
Pre-grazing dead mass (kg DM/ha)	1013	658

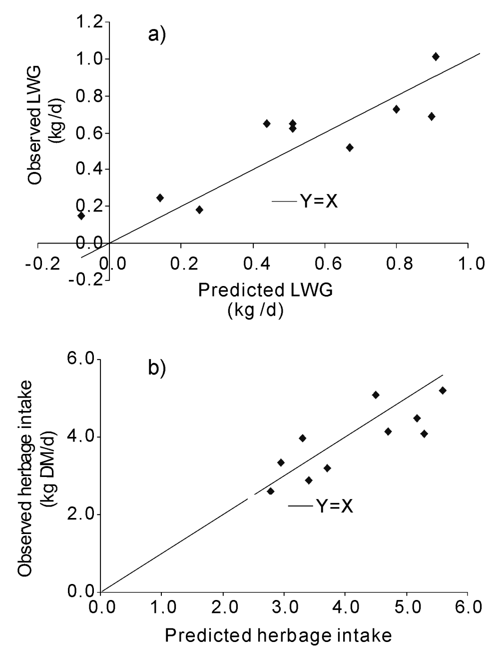

Figure 1 *Regressions of observed data on predicted (model) results for a) LWG and b) Herbage intake.*

Results Figure 1 shows the fitted regressions without an intercept (intercepts were not significantly ($P>0.05$) different from zero), where a significant ($P<0.05$) agreement was obtained between modelled and observed experimental values for LWG (slope 0.98 ± 0.08, R^2 0.93) and herbage intake (slope 0.93 ± 0.04, R^2 0.98).

Conclusions The model in its present state of development can reproduce experimental information under a wide range of grazing conditions (including maize grain supplementation) with acceptable accuracy and without bias.

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Broad spectrum of plant species grazed and browsed by cattle in Bolivian subtropical mountain forests

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Key words: biodiversity, Boliviano-Tucumano, Criollo, subtropical mountain forest, nature reserve

Introduction In Southern Bolivia, Department of Tarija, the suptropical Boliviano-Tucumano mountain forests are used as winter grazing areas for cattle by local livestock keepers. When the dry season starts (April/May), forage offer declines on the village-near grassland areas where the cattle usually graze during the rainy season, and the cattle are moved to the mountain forests (transhumance system) and stay there until the forage offer of the grasslands in the valleys increase again with the first rainfalls and higher temperatures at the beginning of the rainy season (Oct/Nov.) The subtropical forests provide forage even in the critical dry period and are therefore the only possibility for local smallholders to maintain their herds throughout the whole year. Little knowledge exists concerning the diet of the cattle in these mountain ecosystems. This study investigated plant species selection by cattle during the entire period of cattle grazing and browsing in the Boliviano-Tucumano mountain forests. The results can help to reconcile livestock management and nature reserve conservation.

Materials and methods The study was conducted in two mountain forest areas in the *Reserva Nacional de Flora y Fauna Tariquía*, which are traditionally used for cattle grazing by local livestock herders during the dry and the prehumid season. The natural vegetation type of the region is *Boliviano-Tucumano subandean semideciduous and seasonal evergreen vegetation* (Navarro 2004), with the predominant tree species belonging to the *Myrtaceae* family. Plant cover and composition was assessed at the beginning of the dry season (bd), at the end of the dry season (ed) and in the prehumid season (ph) applying a point-line method. Plant selection was determined by direct observations and bite counts. Data collection was realised once a month during May to November in both study sites, by following randomly selected adult female Criollo cattle during 4 to 5 consecutive days during daylight hours. The number of bites per plant species was recorded every 6 minutes during a 1-minute period of actual observation. Based on that, the frequency of selection of all plant species occurring in the area was analysed, and—relating these data to the occurrence frequency of the plant species—a preference ranking of the plant species was performed.

Results The results of the plant cover assessment, with 453 different plant species registered, document the floristic diversity of the study sites within the Boliviano-Tucumano mountain forests. A total of 370 different plant species were grazed and browsed by the cattle in both areas, which means that more than 80% of the plant species occurring in the area were grazed or browsed by the animals during the dry and prehumid period. Despite this broad spectrum of plant species consumed by the cattle, certain species were especially preferred and made up the major part of the diet. The grass *Ichnanthus cf. pallens* contributed more than 20% to the diet of the cattle, with decreasing importance towards the end of the observation period. While some plant species contributed to the diet during the whole observation period, the preference of other plant species differed between seasons. These seasonal selection patterns seemed to be associated with the phenological stage of the respective plant species, as well as with their availability.

Conclusions The results confirm the importance of the subtropical Boliviano-Tucumano mountain forests for local livestock farming. The high plant species diversity found in this ecosystem is reflected in the high number of plants species selected by the cattle. Nevertheless, it becomes apparent that specific plant species were highly preferred, and that their significance changed during the grazing season due to climatic conditions and availability. A detailed evaluation of the forage plant species is needed, especially concerning their nutritional value and their occurrence and spatial distribution. Furthermore, the ecological role of the most preferred plant species and their reaction on the elevated grazing pressure should be further evaluated, as well as their capacity of regeneration and reproduction. Both, local livestock herders and nature conservationists can profit from the results of this study regarding preference for and pressure on the different plant species occurring in the *Boliviano-Tucumano subandean semideciduous and seasonal evergreen vegetation*.

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Comparison of vegetation composition under different grazing intensities in Golestan National Park and vicinities , Iran

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Key words : canopy cover , forage production , grazing , sheep , gazelle , protected areas

Introduction A lack of understanding concerning rangeland carrying capacities in the Middle East is a major problem leading to rangeland degradation . The primary objective of this research is to determine the effects of excluding sheep and gazelle on vegetative canopy cover and species composition .

Materials and methods To compare vegetation composition with different levels of grazing we used three sites : 1) livestock exclusion and limited gazelle grazing (Mirzabylou plain) , 2) moderate sheep grazing (Ghorkhoud Protected Area) , and 3) heavy sheep grazing (Spakhou village grazing unit) . Random 1-m^2 plots were established at systematic distances radiate from water points/ villages . The number of plots varied from 30 to50 depending on the area of each site . Dry matter biomass within each life form (grass , forb , and shrub) and canopy cover by species were recorded .

Results The results showed that in Mirzabylou plain with 440 kg/ha dry matter , shrub and forb increased with distance from water . Based on observations were made around water points , the gazelles usually preferred browsing shrubs . In the Ghorkhoud protected area which is moderately grazed based on permits , we estimated 320 kg/ha dry matter . As we move from uplands to low lands near main road , forbs decreased and shrubs increased . The forbs were present and grazing had a uniform distribution . In the vicinity of Spakhou village , the above ground biomass is about 188 kg/ha dry matter . The forbs and grasses grazed to the surface , shrubs were abundant (Figure 1 and Table 1) .

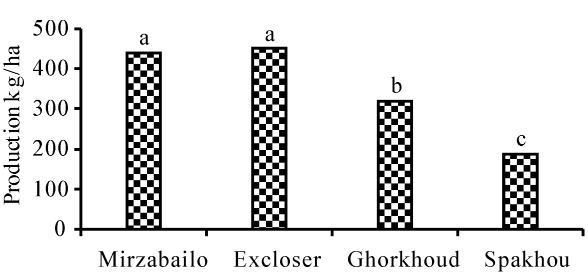

Table 1 *Canopy cover of different life forms under four grazing intensities .*

Life form	Canopy cover (percent)			
	Mirzabailou	Exclosure	Ghorkhoud	Spakhou
Shrub	15 .0[a]	20 .0[a]	10 .0[ab]	16 .0[b]
Forb	4 .7[a]	5 .0[a]	7 .8[b]	4 .0[a]
Grass	14 .0[a]	14 .5[a]	9 .0[b]	1 .5[c]

Figure 1 *Biomass under four intensity of grazing intensities .* Based on our estimates , this range can carry 225 sheep and goats , but is currently grazed 5380 AU . We estimate the carrying capacity of Ghorkhoud rangeland at 457 AU which is equivalent to the permits issued by the National Range and Forest Organization . As far as the Mirzabylou range unit is protected from sheep and goat grazing and the numbers of gazelles are 184 which are below the carrying capacity and could be increased to 650 gazelles .

Conclusions In our study wild ungulates like gazelle appear to have little impact on vegetation , but large numbers of domestic livestock have lead to overgrazed conditions .

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'Alpine meadows' of the Tibet Plateau are a synanthropic pseudoclimax

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Key words: grazing, *Kobresia* sedge mats, Qinghai-Tibet Plateau, rangeland ecology

Introduction Alpine meadows (Atlas of Tibet 1990) extent over the humid south-eastern half of the Tibetan Plateau covering ca. 450,000 km with 2-3 cm tall golf course-like Cyperaceae mats. The turfs of the endemic *Kobresia pygmaea* protect the headwaters of major Asian rivers against erosion, and are the most important rangelands for the Tibetan yak pastoralists. Their distribution ranges between 38°N and 28°N. They form the earth' highest plant communities (5960 m, Miehe 1989) and occupy south-facing pastures down to relative 800 m in the forest belt of the outer declivity of the Plateau. With respect to their large altitudinal range of nearly 3000 m and a latitudinal distribution of 1400 km the *Kobresia* pastures show a great uniformity in structure. They are widely believed to be natural (e.g. Song et al. 2004) despite the overall presence of livestock. We challenge this assumption.

Results and discussion The most elucidating feature is that the dominating species have their main above-surface phytomass beyond the grazing reach of large herbivores. The dominance of these small species is apparently grazing induced. Results from grazing exclosures in the southern and north-eastern highlands that we have maintained since 1997 and 2002, respectively revealed that taller grasses emerging from a bud bank overgrow the Cyperaceae mats once grazing ceases (see Figure 1).

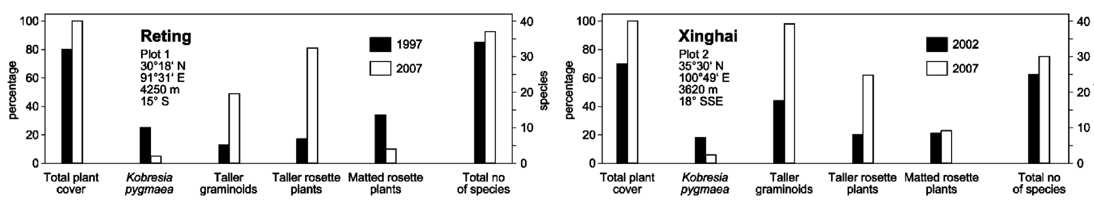

Figure 1 *Changes of grassland structure after grazing exclosure.*

Experiments in the Haibei Alpine Meadow Research Station (37°37′N/101°19′E, 3200 m) revealed that the relatively tall *Kobresia humilis-Festuca*-grassland is replaced by *Kobresia pygmaea* and rosette plants under increased grazing pressure. Reverse trends are experienced here as well: Controlled low stocking rates resulted in the recovery of taller forage plants while rosettes and cushions of grazing weeds disappear (Zhou et al., 2005). Palaeo-ecological findings of identified charcoal (Kaiser et al., 2007) and pollen-analyses (Herzschuh et al., 2006) support the conclusion that early pastoralists burned forests to get rangelands. It is, however, not clear whether forests were directly replaced by mats of *Kobresia pygmaea*. First ^{14}C datings of *Kobresia pygmaea*-bearing topsoils are available from 31°29′N/92°00′E (ca. 4500 m) and 30°04′N/86°56′E (ca. 5050 m): Macroremains and pollen extracted from the turfs give evidence of a modern turf genesis. Bulk-soil datings from the lowermost part of the turfs have a Late Holocene age comprising the last c. 2000 years. The turfs result from the transformation of pre-existing topsoils comprising a secondary penetration and accumulation of roots (Kaiser et al., 2008).

Conclusions Palaeo-ecological investigations, surveys of forest relics, preliminary results of grazing exclosures and the dominance of certain plant life forms support our view that the Kobresia pastures are a synanthropic pseudoclimax replacing tall grassland and forests. The turf cover as well is grazing induced.

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Optimal sward height for production in twin and triplet ewes

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Key words: lamb growth, lamb birth weight, nutrition

Introduction Low birthweight lambs are associated with lower survival rates and lower weaning weights thereby limiting potential returns to sheep farmers. The nutritional requirements for both singleton- and twin-bearing ewes are well established and Morris et al. (2004) identified 4 cm as the optimal sward height for single- and twin-bearing/rearing ewes under continuous grazing systems. However, the feeding requirements of triplet bearing/rearing ewes under pastoral grazing conditions have only recently been researched in New Zealand.

Materials and methods In study one, 96 twin-and 90 triplet-bearing Romney ewes were randomly assigned on day 64 of pregnancy (P64) to four replicated sward height treatments (2, 4, 6 and 8 cm sward height). At parturition (L1) the ewes were reassigned to two (4 cm and 8 cm) replicated sward heights until weaning at L87. In study two, 80 twin-and 56 triplet-bearing ewes were randomly assigned to two replicated sward heights (2 and 4 cm) from P70 to P107. At P107 the ewes were re randomised to the two swards heights until parturition generating four sward height treatments (2-2, 2-4, 4-2 and 4-4 cm). After parturition ewes were offered 4 cm pastures.

Results Study one ewes grazing the 2 cm sward height during pregnancy were significantly ($P<0.01$) lighter at P99 and P132 and at L1 than ewes grazing 4, 6 or 8 cm swards. These ewes also had significantly lower dry matter intakes, condition scores and ultrasonic backfat depths (data not shown). Lambs born to ewes grazing the 2 cm swards during pregnancy were also lightest at birth ($P<0.01$) but sward height during pregnancy or lactation had no effect on lamb weaning weight or lamb survival to weaning. In study two lambs born to ewes grazing 2 cm during pregnancy were lighter at birth and weaning than ewes grazing 4 cm swards during pregnancy (Table 1). Switching feeding level from 2 cm to 4 cm sward height at P107 resulted in lamb birth and weaning weights similar to those lambs born to ewes grazing 4 cm swards throughout pregnancy. Sward height had no effect on ewe maternal behaviour score. Lambs born to ewes grazing 2 cm swards throughout pregnancy exhibited behaviours associated with a greater drive to maintain contact with their dam than lambs born to well-fed ewes during the same period in both mid and late pregnancy. These types of behaviour have previously been associated with lower lamb survival rates.

Table 1 *Effect of lamb birth rank and sward height offered to ewes during pregnancy on lamb birth and weaning weight (kg) (±SE). Differing superscripts are significantly different ($P<0.05$).*

	Birth weight	Weaning weight
Twin	4.5b ±0.1	25.2b ±0.3
Triplet	3.8a ±0.1	21.7a ±0.1
Sward height		
2—2	3.9a ±0.1	22.2a ±0.5
2—4	4.2ab ±0.1	23.5ab ±0.5
4—2	4.0a ±0.1	23.4ab ±0.5
4—4	4.4b ±0.1	24.7b ±0.5

Conclusions These results achieved on lowland predominately ryegrass/white clover swards suggest that ewes rearing twins and triplets should be grazed on pastures of 4 cm or better during pregnancy to achieve optimal birth weights, however there is no nutritional benefit in feeding above 4 cm in terms of lamb live weight. If feed is limiting ewes can be fed on 2 cm swards for the first two thirds of pregnancy provided 4 cm swards are available in last third of pregnancy.

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Impact of grazing intensity on feed intake, herbage mass, and animal productivity in the steppe of Inner Mongolia, China

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Key words : sheep, grazing intensity, semi-arid grassland

Introduction In Inner Mongolia in the north-east of China the grassland steppe is traditionally used for grazing. In the last three decades overgrazing by sheep led to a sparely cover of vegetation in winter and enables soil erosion and hence degradation of the grassland. The aim of this study, which is part of a Sino-German DFG research project, is to evaluate the effect of grazing intensity (GI, sheep/ha) on grassland and animal performance and to determine an optimal grazing intensity, which realizes a high animal and grassland performance in a sustainable way.

Materials and methods Grazing experiments were conducted from July to September in the Inner Mongolia steppe in 2005 and 2006 with six different stocking rates (1.5, 3.0, 4.5, 6.0, 7.5, and 9.0 sheep/ha) and two replications. Six sheep per plot were given titanium dioxide (TiO_2) as marker in the first ten days of each month and faecal grab samples were obtained from day 6 to 10. Faeces were analysed for crude protein to estimate the organic matter digestibility (dOM) with a regression equation (1), and for TiO_2 (2) to estimate the total faecal output and hence the organic matter intake (OMI). After each sampling period, daily live weight gain (LWG) of all sheep was determined. Herbage mass (HM) was determined by cutting the sward at 1 cm above ground level on three representative areas in each plot.

Results and discussion The HM decreased with increasing GI ($P=0.033$) as shown in Table 1. The dOM, OMI, and DOMI were not different between the GI's. However, OMI and DOMI per ha increased with increasing GI ($P<0.001$). The LWG per sheep was not influenced by GI ($P=0.155$). However, LWG per ha increased with increasing GI ($P=0.039$).

The LWG per sheep was highest on the lowest GI's and tended to decrease with increasing GI, whereas LWG per ha was highest on the GI with 9.0 sheep per ha. Accordingly, the highest OMI and DOMI per sheep were obtained on the lowest GI's and tended to decrease with increasing GI whereas the maximum OMI and DOMI per ha were found on the highest GI's. All parameters were significantly influenced by year and period. The influence by year may due to the great variability in precipitation between the years, which affects the herbage quality like dOM (55.3% in 2005 and 58.5% in 2006), CP (9.5% in 2005 and 13.8% in 2006) and NDF (72.1% in 2005 and 67.7% in 2006).

Conclusions The results show the strong impact on GI on grassland productivity. On the short term, heavy grazing lead to high OMI, DOMI, and LWG per ha. However, on the long term negative effects of high GI's on the grassland productivity are expected and, therefore, this study should be continued for further years to show the long term effect of GI and to determine the optimum for a sustainable use.

Table 1 *Effects of grazing intensity on herbage mass, digestibility of organic matter, feed intake, and live weight gain by sheep and by ha.*

	Grazing Intensity						Level of significance				
	1.5	3.0	4.5	6.0	7.5	9.0	SEM	GI	P	GI x P	Year
dOM (%)	57.9	56.9	56.9	56.4	56.4	55.9	0.63	0.368	<0.001	0.989	<0.001
OMI (g/sheep/d)	1271	1271	1258	1191	1017	1214	61	0.157	0.008	0.190	0.036
DOMI (g/sheep/d)	736	727	719	676	576	682	37	0.153	<0.001	0.410	0.008
LWG (g/sheep/day)	96	104	83	72	67	69	9.4	0.155	0.042	0.087	<0.001
HM (kgDM/ha)	1232^{a}	1001^{ab}	526^{ab}	606^{ab}	423^{ab}	370^{b}	143	0.035	<0.001	0.045	<0.001
IOMha (kg/ha)	1.91^{a}	3.81^{b}	5.66^{c}	7.15^{c}	7.52^{c}	10.89^{d}	0.32	<0.001	0.006	0.468	0.035
IDOMha (kg/ha)	1.10^{a}	2.18^{ab}	3.23^{bc}	4.06^{c}	4.26^{cd}	6.11^{d}	0.21	<0.001	<0.001	0.401	0.007
LWG (g/ha)	164^{a}	319^{ab}	379^{ab}	432^{ab}	495^{ab}	623^{b}	65.5	0.039	<0.001	0.003	<0.001

[abcd] Means of grazing intensity with different superscript differ ($P<0.05$)
GI=Grazing intensity; P=period; GI x P=interaction between grazing intensity and period

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Plant root depth of tropical perennial grasses in a temperate environment

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Key words: tropical grass, soil water, roots

Introduction The influence of perennial grasses on the soil water balance has been determined by measuring the pattern and depth of soil drying achieved by plant roots (Murphy and Lodge 2006). Pasture species having a greater plant root depth and an increased ability to use available soil water may produce more herbage mass, and so increase livestock production. The North-West Slopes region of New South Wales (NSW) is classed as a temperate environment, but it has warm to hot summers and a summer dominant rainfall distribution. Summer active species, such as tropical perennial grasses, may be suited to this environment to utilise available soil water during the summer season.

Materials and methods An experimental site was established on a red chromosol on the North-West Slopes of NSW (31°16′S, 150°52′E, 490 m alt., 671 mm AAR) to compare soil drying and plant root depth of some introduced and endemic perennial grasses. Four treatments including three tropical species (*Digitaria eriantha* cv. Premier; *Chloris gayana* cv. Katambora; *Bothriochloa bladii* cv. Swann) and a mix of native species (*Austrodanthonia bipartita* cv. Bunderra; *B. macra*; *Dicanthium sericeum*; *C. truncata*) were randomly allocated to plots (6 x 9 m) across three replicates. Treatments were established in December 2005 by seeding at a rate of 2 kg/ha of germinable seed into a prepared bed at a depth of 10 mm. A single aluminium access tube was installed in the centre of each plot to a maximum depth of 1.7 m and a calibrated neutron moisture meter was used to measure volumetric soil water content (m^3/m^3) at 0.2 m depth intervals. Soil water content was measured through the growing season at 3-week intervals from 1 September 2006 to 31 May 2007. Maximum depth of drying and subsequently plant root depth was interpreted as the depth where drying of >0.02 m^3/m^3 was achieved (Murphy and Lodge 2006).

Results and discussion Soil water content at the start of the growing season was near to field capacity, with a mean value of 551 mm ensuring a high amount of plant available water for each treatment. By May 2007, Katambora dried the soil to a depth of 1.6 m (Figure 1). Swann and Premier showed drying to lesser depths of 1.4 and 1.2 m, respectively (Figure 1). Depth of drying under native grasses was considerably shallower at 1.0 m. These data indicated that plant root depth was at least 1.6 m for Katambora, 1.4 m for Swann, 1.2 m for Premier and 1.0 m for native grasses.

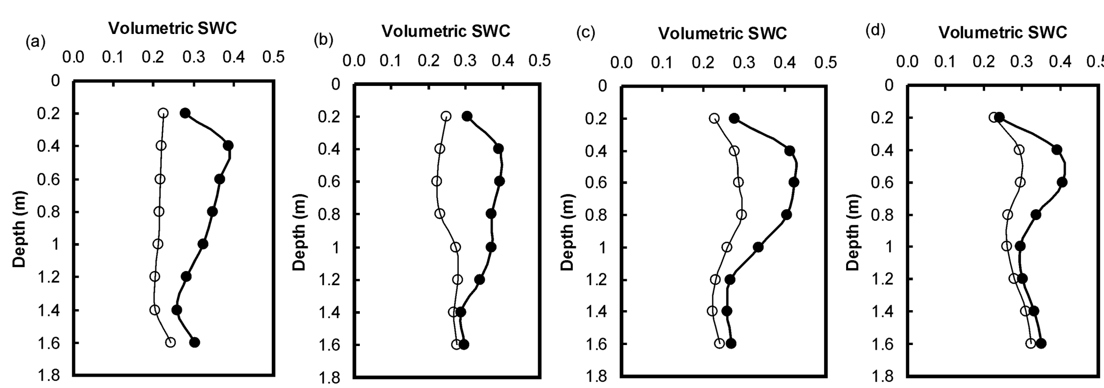

Figure 1 *Volumetric soil water content (SWC) at the start (1 September 2006, ●) and end (31 May 2007 ○)* of the growing season for (a) Katambora, (b) Premier, (c) Swann and (d) native grasses.

Conclusions In the temperate environment of the North-West Slopes of NSW, three introduced tropical grasses extracted soil water through the growing season to a greater depth than a mix of native perennial grasses. These preliminary results indicate that the tropical species are potentially well suited to make use of available water in summer in this environment.

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The productivity and hay requirements of beef cattle in a Year-Round grazing system in North Cameroon

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Key words: productivity, hay requirements, beef cattle, grazing system

Objective This research was conducted to evaluate a replicated (n=2) year-round grazing system's hay needs and animal production compared with a replicated (n=2) conventional (minimal land) system over 3 years. Because extended grazing systems have decreased hay needs for the beef herd, it was hypothesized that this year-round system would decrease hay needs without penalizing animal production.

Methods In the minimal land (ML) system, two replicated 8.1-ha smoothbrome grass-orchard grass-birds foot trefoil (SB-OG-BFT) pastures were rotationally stocked with six mature April-calving cows and calves and harvested as hay for winter feeding in a drylot. After weaning, calves were finished on a high-concentrate diet. Six mature April-calving cows, six mature August-calving cows, and their calves were used in the year-round (YR) grazing system. During the early and late summer, cattle grazed two replicated 8.1-ha SB-OG-BFT pastures by rotational stocking. In mid-summer and winter, April-and August-calving cows grazed two replicated 6.1-ha, endophyte-free tall fescue-red clover (TF-RC) and smooth bromegrass-red clover (SB-RC) pastures, respectively, by strip-stocking. In late autumn, spring-calving cows grazed 6.1-ha corn crop residue fields by strip-stocking. Calves were fed hay with corn gluten feed or corn grain over winter and used as stocker cattle to graze SB-OG-BFT pastures with cows until early August the following summer. First-harvest forage from the TF-RC and SB-RC pastures was harvested as hay.

Results Body condition scores of April-calving cows did not differ between grazing systems, but were lower ($P<$or$=0.03$) than those of August-calving cows from mid-gestation through breeding. Preweaning calf BW gains were 47 kg/ha of perennial pasture ($P<0.01$) and 32 kg/cow ($P=0.01$) lower in the YR grazing system than in the ML system. Total BW gains of preweaning calf and grazing stocker cattle were 12 kg/ha of perennial pasture less ($P=0.07$), but 27 kg/cow greater ($P=0.02$) in pastures in the YR grazing system than in the ML system. Amounts of hay fed to cows in the ML system were 1,701 kg DM/cow and 896 kg DM/cow-stocker pair greater ($P<0.05$) than in the YR grazing system.

Conclusions Extended grazing systems in the Midwest that include grazing of stocker cattle to utilize excess forage growth will decrease stored feed needs, while maintaining growing animal production per cow in April-and August-calving herds.

Role of grazing cattle on seed dispersal of plants in a hill pasture 1 . Effect of sward structure on grass seed ingestion by cattle

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Key words : germinability , grazing cattle , seed dispersal , seed ingestion , sward structure

Introduction Seed dispersal by defecation of grazing herbivores is one of the significant factors in vegetational change (*e .g .* , Janzen , 1984 ; Archer and Pyke , 1991) . It is well known that the seeds of certain plant species are ingested by grazing herbivores and disseminated through the digestive tract . Recent studies conducted in Japanese hill pastures have shown that grazing cattle dispersed majority of seeds of monocotyledons such as *Carex albata* (Watanabe *et al .* , 2000 ; Obara *et al .* , 2005) . In this paper , we examined factors affecting seed ingestion by cattle using a sward-based measurement to learn timing of seed ingestion by cattle relative to seed maturity .

Materials and methods

Relationship between seed maturity and the timing of seed ingestion by cattle A hill pasture grazed by 10 beef cattle was used in our study . Fifty seedheads of three grass species (*Anthoxanthum odoratum* , *Poa pratensis* and *C . albata*) were tagged during late spring and the frequency of defoliation by cattle were recorded at 2-5 day intervals until late June . Seed germinability (30 days incubation in 15℃/12 hr light and 25℃/12 hr light) of the 3 species was also investigated by sampling of 30 seeds on each day measurements were obtained .

Sward canopy structure of 4 monocotyledon species in their reproductive stage Plots (20 cm×20 cm each) were located in vegetation patches where *A . odoratum* , *Agrostis alba* , *C . albata* and *P . pratensis* were dominant in the pasture , on the first day of the study . Mean height of leaf mass and seedheads were measured at 10-37 day intervals during the grazing season .

Results and discussion *A . odoratum* seeds were defoliated by cattle in mid-to late May , whereas in June when the seeds matured no seed consumption by cattle was observed . In contrast , the seeds of *P . pratensis* and *C . albata* were grazed after seeds were mature .

Measurements in sward canopy structure showed that , while the height of seedheads in *A . odoratum* and *A . alba* was significantly higher than that of leaves , the height of seedheads in *C . albata* and *P . pratensis* was almost same as that of leaves (Figure 1) . The results suggest that it is difficult for grazing cattle to choose leaf mass over seedheads from the sward canopy structure in which both leaves and seeds are contained within a same grazing horizon , particularly if the density of tillers having seedheads is high .

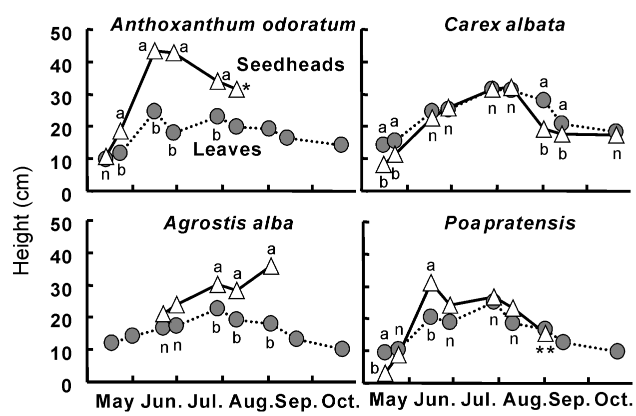

Figure 1 *Mean height of leaves and seedheads in the 4 monocotyledons . Values with different letter in each date represent significant difference (Tukey's test , $P<0.05$) . n : not significant . * :n= 1 , ** :n= 2 (seedhead data) .*

Conclusions Plant architecture with the height of seedheads equivalent to vegetative tillers is an effective strategy for *C . albata* and *P . pratensis* to disperse the seeds via grazing animals , because the frequency of defoliation of matured seeds by animals increases .

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Role of grazing cattle on seed dispersal of plants in a hill pasture 2 . effects of ruminal digestion on seed germinability of five plant species

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Key words : abomasum , digestion , microbial attachment , rumen , seed dispersal

Introduction Plant seeds , after ingested by grazing herbivores , are exposed to gastro-intestinal digestion . While there have been reports on the change of germination rate of plant seeds by passage in the alimentary tract (*e .g .* , Ocumpaugh and Swakon , 1993) , there is still scarce information on the effects of ruminal (microbial) and abomasum (enzymatic) digestion on seed germinability of herbaceous plants . The aim of this study was to examine how the ruminal and abomasal digestion affect seed germinability of 5 major plant species common to Japanese hill pastures .

Materials and methods A hundred mature seeds of *Dactylis glomerata* , *Trifolium repens* , *Zoysia japonica* , *Anthoxanthum odoratum* and *Carex albata* were exposed to a two-stage *in vitro* digestion technique (Tilley and Terry , 1963) . To simulate ruminal digestion (step I) , the seeds were incubated with grass hay in dilute ruminal inoculum (20% of strained ruminal fluid collected from a single dairy cattle fed grass silage and 80% of mineral buffer solution) under anaerobic condition for 24 or 48 hrs . To simulate post-ruminal digestion (step II) seeds were incubated for 8 hrs in 0 .2% Pepsin-HCl solution . After these treatments , germination rate of control and treated seeds were measured according to methods described in the previous study (Obara *et al .* , 2008) . Seed surface characteristics were observed by using a scanning electronic microscopy (SEM) .

Results and discussion Germination rate of *D . glomerata* , *Z . japonica* , *A . odoratum* and *T . repens* significantly decreased by the combination of step I and II , and 48 hrs incubation at step I ($P < 0.05$) (Figure 1) . In contrast , significantly greater germination rates were observed for longer incubation times in *C . albata* seeds . There may be some factors which promote the germinability of *C . albata* seeds in the rumen and abomasums , such as acidic and enzymatic seed sacrification . From SEM we observed few ruminal bacteria attached to the surface of *C . albata* seeds whereas attachments to the surface of the other 4 plant seeds were numerous . This indicates that seed surface of *C . albata* is resistant to microbial digestion while post-ruminal digestion may contribute to increasing germinability .

Conclusions Our results indicate that ruminal and abomasal retention promotes germinability of *C . albata* seeds . Seed surface characteristics that inhibit microbial attachment in the rumen probably have a important role promoting ruminant dispersal of *C . albata* seeds via the gastro-intestinal tract .

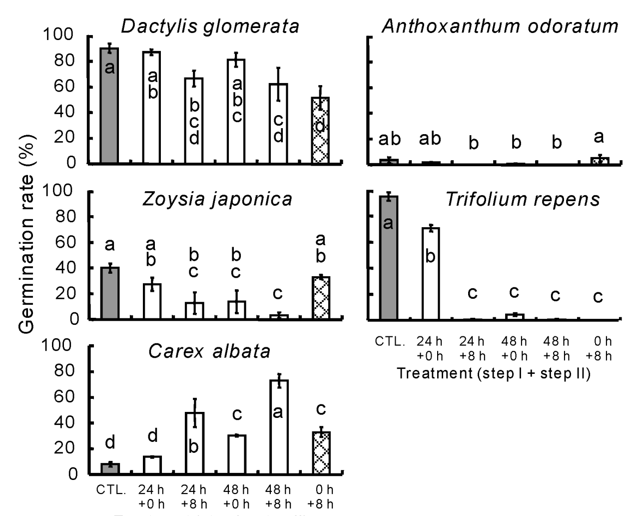

Figure 1 *Germination rate of the seed from 5 plant species post in vitro ruminal (step I) and pepsin/HCl (step II) digestion .*
Mean values with different letters differ ($P < 0.05$, Tukey's test) .

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Combining biodiversity enhancement of temperate grassland with sustainable organic production of traditional breed livestock

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Key words: Biodiversity, Organic grazing, Pasture management

Introduction Since 2004 wildlife conservation initiatives have been combined with sustainable organic rare breed livestock and woodland production on Mabley Farm, which occupies 80 ha on the Woolhope Dome-a Biodiversity Enhancement Area in Herefordshire near the England-Wales border. Financial incentives come from the Higher Level Environmental Stewardship scheme of the England Rural Development Programme. The climate is temperate oceanic. The soil is base-rich brown earth derived from Silurian limestone, pH 5.4-6.0. The estate comprises parkland and wood-pasture (24 ha), permanent grassland (17 ha), water-meadow (6 ha), semi-natural coppice-with-standards woodland (17 ha), coniferous plantation (13 ha) and orchard (3 ha). Management was designed to enhance biodiversity by grazing and mowing, recycling soil nutrients via urine and dung, and microhabitat creation by poaching. The livestock are Old English Longhorn cattle and Wiltshire Horn sheep. These are traditional breeds, which are well adapted to utilising species-rich meadows, have higher infestation resistance and cold weather tolerance than modern breeds, and produce large carcasses of succulent meat. Stocking rates are lenient, at 0.5 cattle or 4 sheep per ha. Excess herbage is harvested as hay for winter feed and for sale. Pasture and woodland management are integrated—the woodland supplying fencing for the fields as well as sustainable yields of timber, coppice materials, firewood and charcoal for sale. Habitat diversity has been enhanced by pond restoration and hedgerow management. The Farm also acts as an open-air classroom", hosting a programme of educational visits. The flowering plant flora and the invertebrate and vertebrate fauna of the grasslands have been continually monitored from 2004 to 2007. Variations in species frequency have been noted with particular attention given to species of conservation importance.

Results 261 species of flowering plants (excluding grasses and sedges) were recorded late 2007. 4 species were new records since 2004, including the Red Data species *Orchis morio*. 46 spp. showed substantial increases (x2-x3) in frequency, whilst a further 65 spp showed smaller increases. Individual fields showed between 1.2% and 8.3% increases in species-richness. The greatest increases (x10-x100) were shown by *Cirsium acaulon*, *Lotus corniculatus*, *Mentha aquaticum*, *Plantago lanceolata*, *Prunella vulgaris*, *Succisa pratensis* and also by the pteridophyte *Ophioglossum vulgatum*. Substantial decreases (>50%) were shown by 9 spp, and smaller decreases by 11 spp. 25 taxa of the fungal genus *Hygrocybe* (characteristic indicators of unimproved species-rich meadows) were recorded, including the rare species *H. citrinovirens*, *H. intermedia*, *H. olivaceous*, and *H. punicea*. Other taxa were: Lepidoptera 43 spp.; Aves 22 spp., including the rare species *Athene noctua*, *Emberiza schoeniculus*, *Picus viridis* and *Tyto alba*; Amphibia 5 spp., including *Titurus cristatus*; Mammalia 15 spp., including 3 spp. Chiroptera. Livestock production was calf yields at close to 100 per 100 cows, and lamb yields at an average of 180 per 100 ewes. Hay was harvested at *ca* 4500 kg/ha.

Conclusions The results show that significant biodiversity gains can accrue in just three years under this grazing and hay cutting regime. Floristic species showing increased frequency are those known to benefit from lenient grazing or mowing (Wells & Cox, 1993). Our observations contrast with the equivocal results of the EU Forbioden Project (Scimone et al., 2007), where lenient grazing did not always produce gains in species richness. However, our faunal records are consistent with its findings (Wallis De Vries et al., 2007). The records of *Hygrocybe* spp suggest that the site may be rated as of national importance, using the mycological indicator scheme of Rald (1985).

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Role of grazing cattle on seed dispersal of plants in a hill pasture 3 . seasonal variation of locations of defecation by cattle and its effects on germination of seeds in dung pats .

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Key words : dung pats , environmental condition , grazing cattle , location , seed germination

Introduction Plant propagule dispersal by grazing herbivores is dependent on animal movements and defecation patterns in the landscape . Location of seed-laden dung can affect seed germination and plant establishment due to heterogeneous environmental conditions (*e .g .* , solar radiation and moisture conditions ; Akber *et al* . 1995) . In this study , we investigated the effects of spatial and seasonal variation in a grazing pasture on seed germination rate and seedling survival of seeds embedded in dung pats .

Materials and methods

Seasonal variation of the location of defecation by grazing cattle Two experimental areas (Area I and II , 200 m×4 m each) were selected within a 30 ha paddock where 69-115 cows with 38-46 calves were rotationally grazed . Soil type is nonallophanic Ando soil , and vegetation in both areas was similar except Area II included 42 .5% in coverage of broad-leaved forest . After the grazing period in May , August and October in 2005 , the degree of shading (*i .e .* , lenient shading (LS) ; shading proportion of shading area by plants was <25% , medium shading (MS) ; 25-75% and heavy shading (HS) ; >75% and dominant plant species were recorded for all fresh dung pats in each area .

The effects of environmental condition of dung on seed germination rate and survival of the seedlings *Trifolium repens* , *Poa pratensis* and *Zoysia japonica* seeds were mixed with dung of a single dairy cow fed grass silage (neither anti-parasitic medication nor ionophores were dosed) , respectively (1 ,500 seeds/1 ,200 g of fresh dung pats , n=3) . The dung pats (φ=20 cm) were placed on a pasture , after cutting the sward to a height of 3 cm . Two treatments ; *i .e .* , sunshine (SUN , photosynthetic photon flux density (PPFD) = 667 μ mol/s · m^2) and shading (SHA , PPFD was controlled to be same as understory of the forest ; 16 μ mol/s · m^2) were established , and the number of germinating seeds and seedlings mortality were recorded from 21 June to 5 September , 2005 , at a 7-10 days interval . The temperature and moisture condition in the dung were monitored using WatchDog™ sensors and data loggers (Model 400 ; Spectrum Technologies , Inc .) .

Results and discussion While most dung pats were located in sunny place (LS ; 62-91%) , the proportion of HS increased in August (17%) compared to June (3%) and October (0%) . This was due that cattle rested and defecated in shaded areas such as forested locations to avoid high daytime temperatures in summer (Yasue *et al* . , 2000) . Variation of temperature in the dung pats was drastic and maximum value exceeded to 40 C in SUN in daytime ; whereas , variation was moderate in SHA . Moisture content in dung also drastically changed in SUN in association with precipitation , whereas that in SHA was almost saturated over the experimental period . Seed germination rate was greater for SUN than SHA in all plant species (Figure 1) , however , most of the seedlings died during the experimental period in both treatments . This was probably due to high temperature in SUN and deficiency of solar radiation in SHA .

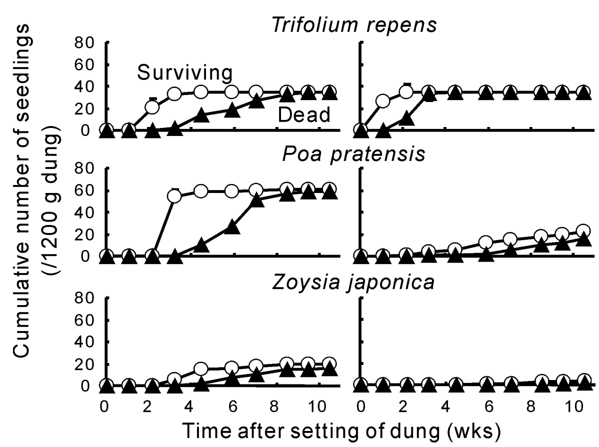

Figure 1 *Cumulative number of seed germination (○) and death (▲) of seedlings in SUN (left) and SHA (right) .*

Conclusions Location of dung pats severely affects environmental conditions in the dung and therefore plant propagule conditions . The results suggest that both sunny and shading places are inappropriate to establishment of seedlings of the herbaceous plants . More moderate shading created by tall grasses surrounding a dung patch may provide proper environmental condition for seedling establishment .

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Role of grazing cattle on seed dispersal of plants in a hill pasture 4 . effects of dung patch on environmental condition in dung and seedling establishment

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Key words : cattle dung , environmental condition , seed germination , survival , ungrazed area

Introduction Our previous study indicated that most seedlings of herbaceous plants germinated from dung pats died in both sunny (SUN) and shading (SHA) places , due to high temperature in SUN and deficiency of solar radiation in SHA , in a 10-week periods from early summer to early autumn (Ogura *et al* . , 2008) . This suggests that more moderate shading created by tall grasses surrounding a dung patch provides proper environmental condition for seedling establishment . In this study , a field experiment was conducted to examine if a dung patch provided proper environmental condition for seed germination and seedling survival .

Materials and methods *Trifolium repens* , *Poa pratensis* and *Carex albata* seeds were mixed with dung of a single dairy cows fed grass silage (neither anti-parasitic medication nor ionophores were dosed) , respectively (1 ,500 seeds/1 ,200 g of fresh dung pats , n=3) . Two treatments ; *i .e .* , sunshine (SUN) and dung patch (DPA) were established on a pasture dominated by *Dactylis glomerata* . The dung pats (φ=20 cm) were placed on the pasture in areas where the sward was cut to a height of 3 cm . In SUN , the sward surrounding the dung pats was cut at the height of 8 cm , before the experiment and at 2 weeks intervals during the experimental period ; whereas , in DPA , the sward height was 40 cm at the beginning of the experiment and no cutting treatment followed . The number of seedlings germinated from the dung pats and seedling mortality were recorded from 4 August to 29 September , 2006 . The temperature and moisture conditions in the dung were monitored (Ogura *et al* . , 2008) .

Results and discussion Maximum temperature exceeded to 40℃ in SUN , whereas temperature fluctuations were small in DPA . Moisture content of dung responded to precipitation in both SUN and DPA , meaning that there was no obvious difference of moisture content in dung between the treatments . Seed germination and its survival differed among plant species (Figure 1) . In *T . repens* , seed germination rate was greater for SUN than DPA , but most of the seedlings died during the experiment . In *P . pratensis* , 34 .0 seedlings/dung pat germinated and 22 .7 seedlings/dung pat survived in DPA , which were greater than in SUN . The inconsistency of the survival of seedlings in SUN compared to the previous study (Ogura *et al* . , 2008) is probably due to the difference of the season when the experiment began . In *C . albata* , seed germination rate was greater for SUN (6 .3 seedlings/dung pat) than DPA (3 .3 seedlings/dung pat) , and most of the seedlings survived in SUN . The result suggests that sunny place is beneficial to seed germination and the survival of the seedlings in *C . albata* .

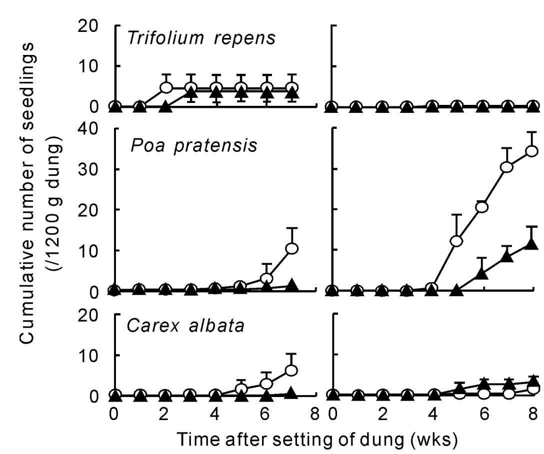

Figure 1 *Cumulative number of seed germination (○) and death (▲) of seedlings in SUN (left) and DPA (right) .*

Conclusions While the dung patch may protect the seedlings from high temperature and dryness in summer in *P . pratensis* , the results suggest that sunny place may be beneficial to seed germination and the survival of seedlings in *C . albata* . From the previous (Obara *et al* . , 2008a ; 2008b ; Ogura *et al* . , 2008) and the present study , it is concluded that *C . albata* is adapted for seed dispersal by ruminants .

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Long-time effects of grazing on Patagonian rangelands (Argentina)

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Key words: sheep, grazing, soils, nutrients, erosion

Introduction Rangelands in the area of the Magellan Strait, southern Patagonia, are dominated by tussock grasslands of Festuca gracillima. The Open Tussock Grassland State seems stable, and may endure grazing with little physiognomic changes, but at some step irreversible transitions to dwarf-shrub steppes of Nardophyllum brioides take place.

Materials and methods A tussock grassland (Moy Aike Chico, Santa Cruz, 170 mm rainfall) was subjected to 11 years of controlled grazing in an experiment with two 40-ha paddocks at stocking rates of 0.60 (high), 0.20 ewes/ha/year (moderate) and a 2 ha exclosure (equivalent to 1.56 AUM ha-1, 0.50 AUM ha-1 and 0 AUM ha-1) starting in 1987. In 1999, fences were removed and the area returned to normal production grazing regime (0.50 ewes/ha). Six 400 m-2 monitoring plots were established per treatement, and three of them were randomly selected to be fenced off. Vegetation and soil differences between these areas were monitored in years 2000, 2002 and 2006. Vegetation was sampled with point-intercept method (500 points), and composite samples of topsoil (10 cm) were drawn for physical and chemical analysis. One-way Analysis of Variance and Duncan contrasts were performed. Letters in Results section indicate significant differences for treatments in 2006 ($P<0.05$).

Results and discussion Most grazing effects generated in the 1987-1999 stocking treatment persisted after seven years of uniform treatments. Grazed and ungrazed plots in the 1999-2007 period did not differ significantly, so the results are reported jointly. Significant differences were still observed in 2006 in percentage of Bare Soil (30.9a high stocking, 24.2b moderate and 21.3b in exclosure), Litter (13.6b, 16.1b and 22.1a respectively), Short Grasses (16.2b, 23.4a and 22.6a), Dwarf Shrubs (21.3a, 16.8ab and 12.6b) and Shannon-Wiener diversity index (-1.33b, -1.47a, and -1.39ab). Cover of dominant tussock grasses and herbs were not significantly different in 1999. Soils in the grazed treatments still showed in 2006 lower percentages of fine particles such as Clay (13.1a, 11.2b and 10.3b), Fine Silt (13.5b, 14.2ab and 15.3a), Coarse Silt (5.4c, 7.8b and 10.6a) and Very Fine Sand (15.0b, 17.4a, 17.6a), but were enriched in coarse particles including Fine Sand (25.3a, 25.4a and 23.2b), Medium Sand (16.9a, 14.8b and 14.8b), Coarse sand (7.9a, 6.4b and 6.4b), and Very Coarse Sand (3.0a, 2.9a and 1.8b). The lower levels of organic carbon in grazed treatments that were evident in 2000 no longer differed significantly in 2006 (1.47, 1.46 and 1.60%), but significantly different contents of Total Nitrogen (0.14b, 0.15b and 0.17a) and P (15.5b, 24.2a and 18.7b) were observed.

Conclusions The 11 year period of high stocking rates did not generate physiognomic changes in the Magellanic steppes, as these systems seem to persist in Stable States (Oliva et al., 1998), but subtle effects such as a reduction in palatable grass cover and diversity, the increase in dwarf shrubs, reduced soil fertility (N and P) and coarser soil textures (probably because intense winds eroded fine particles away from unstable grazed soil surface) were evident after 7 years, regardless of the grazing management in the recovery period. The results indicate the importance of gradual processes with long-lasting and cumulative effects on vegetation and soil of these perennial-dominated tussock grasslands, and underline the importance of careful long-time management in order to assure sustainable sheep grazing.

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Grazing impacts on the dynamics of two long lived perennial grasses in tropical Australia

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Key words: *Bothriochloa ewartiana*, *Chrysopogon fallax*, demography

Introduction *Bothriochloa ewartiana* (desert bluegrass) is a long lived perennial grass which is important for the northern Australian pastoral industry, however, little is known of its basic population demography. Interim results from an extensive grazing study indicated that rainfall had a greater impact than grazing pressure on the dynamics of *B. ewartiana* (Orr and O'Reagain 2005) but suggested that a more pronounced grazing impact may emerge with time. This paper reports further data on the continuing impacts of rainfall and grazing on *B. ewartiana* and also on another long lived perennial grass *Chrysopogon fallax* (golden beard grass).

Materials and methods A large grazing study was established in 1997 in open *Eucalyptus* savanna at Wambiana, Charters Towers (20°34′S, 146°07′E), northern Australia to asses the impacts of 5 grazing strategies on animal production and resource condition. In 1998, 20 permanent quadrats (50 × 50 cm) delineated 40 *B. ewartiana* and a variable number of *C. fallax* plants to examine their persistence under constant light 8 ha/Animal Equivalent (AE) and heavy stocking (4 ha/AE) and rotational wet season resting (6 ha/AE) with33% of the pasture rested annually. (The rotational stocking treatment was changed to 9 ha/AE in 2003 and the heavy grazing treatment to 6 ha/AE in 2005). The dynamics of *B. ewartiana* and *C. fallax* are charted annually by charting the survival of original plants along with that of recruited seedlings (Orr and O'Reagain 2005). Plant survival was analysed using a proportional hazards survival model (Cox 1972).

Results and discussion Seasonal rainfall (October-March) between 1998-1999 and 2000-2001 was above the long term mean (513 mm) while rainfall since 2001-2002 has been below the long term mean (Figure 1). Seedling recruitment of both species between 1998 and 2007 has been minimal such that the persistence of both species is due almost entirely to the presence of the original plants. Survival of the original *B. ewartiana* plants has been reduced ($P<0.05$) by heavy grazing particularly after 2005 (Figure 1a) while survival of the original *C. fallax* plants has been reduced ($P<0.05$) by light and rotational grazing particularly after 2002 (Figure 1b).

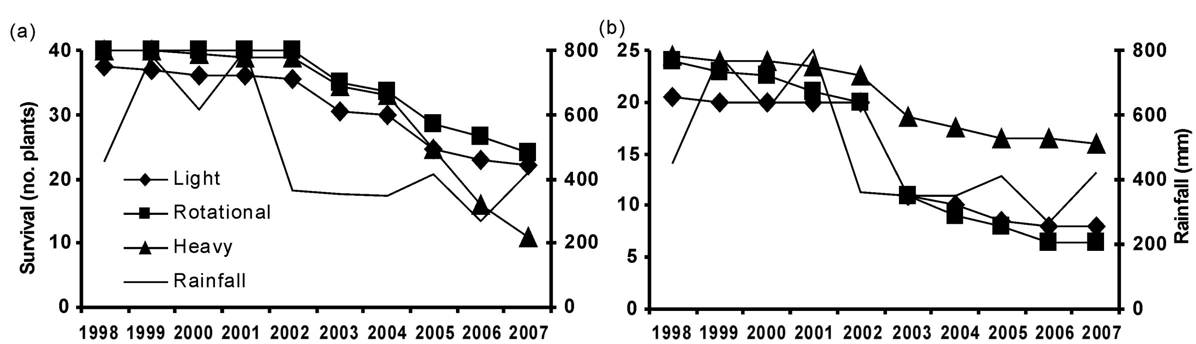

Figure 1 *Changes in the survival (number of plants) of (a)* B. ewartiana *and (b)* C. fallax *in relation to seasonal rainfall (October-March) (mm) between 1998 and 2007 under 3 grazing strategy at Wambiana.*

Conclusions Contrary to previous findings, these results indicate a clear impact of grazing pressure with increasing grazing pressure reducing the survival of *B. ewartiana* but increasing that of *C. fallax*. These current results also emphasise the importance of long term research in drawing valid management conclusions.

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Linear analysis method to calculate the specific forage ingestion by livestock

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Key words : pasture species , traceability , palatability indices

Introduction Native pastures include normally tens of species most of which are good forages . Measurements of massive biomass grazed are easy , whilst the calculation of specific ingestion is very difficult , nonetheless to know how much of each species is grazed by livestock can be useful to improve calculations of pasture carrying capacity and it is useful to research on traceability , in fact some pasture plants contain traceable components but they are not grazed and consequently the compounds are not found in the final produce , be it meat , milk or cheese . Several methods are used (Hodgson et al , 1981) but all are not precise : observations of livestock at grazing are done at distance from plants , animals fistulas change very much the grazing behaviour of livestock , twin sample areas and separate weighing take too long time and need many repetitions . We propose a simple method based on measurement of the massive biomass ingested and calculation of the percentual specific ingestion by the number of bites along lines of botanical analysis .

Materials and methods We chose 3 pastures of different complexity (39 species in flat land , 65 in mountain , 78 in hill) . The biomass was measured in each pasture in sample areas of 1 m^2 . After 5 days grazing we identified the species that had bitten leaves within 5 cm of distance from analysis points set at distance of 20 cm along lines of 20 m (Daget and Poissonet , 1971) . The quantity of bites received per species was pondered with the frequency of the species , this data was used to calculate the percentage of specific ingestion , finally the specific ingestion was multiplied by the total biomass to calculate the quantity of biomass ingested per species . This trails considered only the 15 most frequent species (5 per pasture) . The results we got by this method have been compared with specific indices of forage quality calculated con previous researches and known from literature (Pardini et al ., 2007) and indicative of the probable ingestion rate .

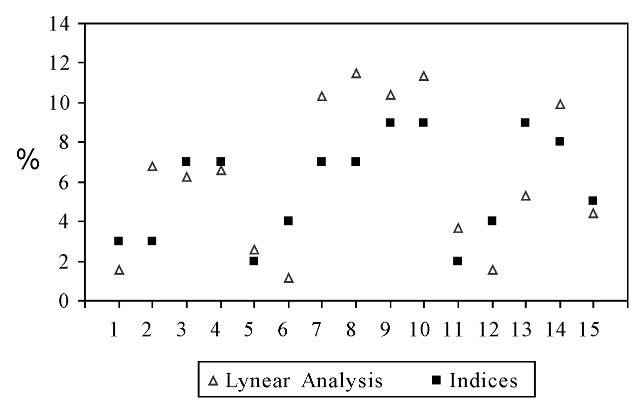

Figure 1 *Grazing percentage and forage quality indices .*

Results and discussion The specific ingestions calculated are very similar to the theoretical ingestion derived by palatability indices (Figure . 1) . The proposed method has distinguished species normally not much ingested like *Bromus erectus* (1) , *Holcus lanatus* (5) and *Plantago lanceolata* (11) because of little palatability , from those more palatable and normally more ingested like *Dactylis glomerata* (3) , *Festuca pratensis* (4) , *Lolium multiflorum* (7) , *L .perenne* (8) , *Medicago sativa* (9) , *Phleum pratense* (10) , *Trifolium repens* (13) , *Vicia sativa* (14) .

Conclusions There good similarity between the ingestion rates and the quality indices , consequently we consider the proposed method sufficiently reliable for quick analysis especially also because easy and rapid . However it should be further controlled in different seasons and environmental conditions , especially because the appreciation and ingestion of a species is related to the rest of the botanic composition of the pasture .

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Relationship between different grassland types and their volatile patterns to enhance the traceability of Italian typical alpine dairy products

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Key words: mountain dairy production systems, pastoral vegetation, traceability markers

Introduction Defining operative models for the characterization and valorization of mountain typical cheeses is a major topic in Italian Alps, in order to overcome the structural difficulties of mountain livestock farms. The Pro-Alpe Project was carried out to investigate the main components of food chain (pastoral resource, dairy cattle, milk production, processing and quality, cheese characteristics) and the relations among them, aiming at defining traceability models from pasture to cheese and obtaining technical information to improve the efficiency of Italian alpine production systems. The Project preliminary results achieved at the end of the first year are presented in this paper.

Materials and methods The food chain was investigated in two sites, Piedmont and Venetia Alps, each with two different vegetation types. Each one was characterized using 42 transects of 50 point quadrat. The 4 types were evaluated, both from the ecological point of view, on the basis of an indirect analysis performed applying to species Landolt indices, and computing average indices for each transect (weighted on species relative abundance). Ecological gradients among coenosis were analysed by PCA using Landolt indices as variables. Extraction of volatiles compounds was performed by steam distillation and the obtained essential oils analysed by GC and GC/MS and by using solid phase microextraction (SPME/GC/MS).

Results The dominant species of the 4 vegetation types were (relative abundance in brackets): (FPAs) *Agrostis tenuis* (15%), *Achillea millefolium* (12%), *Trifolium repens* (11%); (FMAs) *Festuca nigrescens* (14%), *Agrostis tenuis* (9%), *Potentilla crantzii* (8%); (FSt) *Festuca nigrescens* (27%), *Alchemilla vulgaris* (13%), *Phleum alpinum* (7%); (TSt) *Trifolium alpinum* (37%), *Nardus stricta* (22%), *Carex sempervirens* (12%). The 4 vegetation types were well differentiated from an ecological point of view (Figure 1), with some similarity between FPAs and FMAs. Preliminary chemical analysis showed that volatiles were ascribed at several different chemical classes of compounds of which terpenes (ranging from 2.6 to 581.6 mg/g of fresh weigth in the different vegetation types), aldehydes (5.3-13.9), alcohols (7.6-24.6) and esters (1.1-14.1) were the most abundant. Chemical analysis on grass and on milk obtained from cattle fed exclusively on a single vegetation type, allowed to identify a number of compounds most interesting at defining traceability models (Table 1).

Table 1 *Quantity of terpenes, found both in grass μg/g of fresh weight) and milk (not reported here), differentiated by vegetation type.*

	Compounds	FPAs	FMAs	FSt	TSt
GC/MS μ/g fw)	limonene	216.1	834.6	-	< 0.1
	p-cymene	-	-	-	0.1
	caryophyllene	16.2	11.9	1.0	0.1
	bicyclogermacrene	7.2	2.4	0.1	10.2
SPME (Log area count)	limonene	8.40	8.43	-	-
	p-cymene	-	-	-	2
	caryophyllene	2	1	5	3
	bicyclogermacrene	-	-	-	3

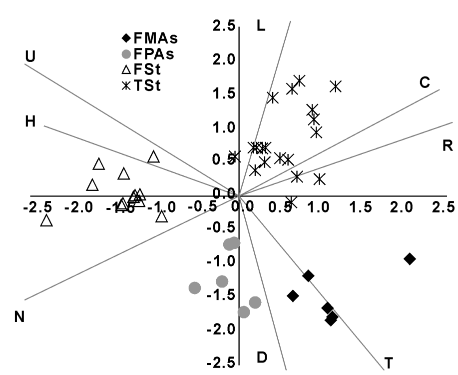

Figure 1 *Vegetational survey in the ecological space represented by* 1^{st} *(x-axis) and* 2^{nd} *(y-axis) component (cumulate variance: 75%) of the PCA. Variables: Landolt indices: brightness (L), temperature (T), continentality (C), soil moisture (U), soil reaction (R), nitrogen needs (N), humus (H), soil dispersion (D).*

Conclusions Results here presented are necessarily preliminary: in the first year, the goal was centred on the feasibility of the setting up of the whole Project and experimental design was simplified compared with the one of subsequent years. Nevertheless, if we focus on compounds found both in grass and milk (compounds that could be markers for traceability of typical Alpine dairy products), the wide variability existing between vegetation types suggests that it is possible to enhance the traceability in mountain dairy production systems. More refined analysis (now in progress) should strengthen this hypothesis. Precise determination of botanical and ecological differences between vegetation types studied and their comparison with differences in volatile patterns, will point out at which extent the approach proposed could be used to assess traceability of mountain typical products.

Experiences with grazing the new annual pasture legume *Biserrula pelecinus* L. in southern Australia production benefits and risk of photosensitisation

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Key words: *Biserrula pelecinus*, pasture legume, photosensitivity, grazing preference

Introduction *Biserrula pelecinus* (L.) is a species of annual legume located in the Galegeae tribe of the Leguminosae family. It is endemic to the Mediterranean basin and was first commercialised as a pasture plant in Australia in 1997. It is often used in a ley farming system where it self-regenerates from persistent seed banks after one or more cereal crops. Its key features are high seed production, high hard seed content, small seeds, deep root system and acid soil tolerance (Loi et al. 2005). Biserrula has a high protein content, particularly as a dry feed and is tolerant of heavy grazing by sheep and cattle. Sheep will preferentially avoid grazing biserrula in some circumstances (Revell and Thomas 2004) and it has been associated with cases of photosensitivity when it dominates the sward. We tested the hypothesis that the aversion response is a function of elevated rumen ammonia resulting from the high protein content of biserrula herbage.

Materials and methods The hypothesis was tested by measuring the performance of sheep that grazed green biserrula only or given access to biserrula plus either additional nitrogen as lupin grain (450 g/hd/day) or additional energy as oat grain (580 g/hd/day). The field experiment was conducted near Narrogin, Western Australia (lat 32°56′S, long 117°49′E) a region with winter dominant rainfall. Fifty-four weaner sheep (three grazing treatments, six sheep per treatment, three replicates) with prior experience of biserrula were allowed to graze biserrula for six weeks from mid-August and measured for growth, plasma urea nitrogen (converted to rumen ammonia according to McMeniman 1990) and clinical signs of photosensitisation. Each grazing pot was 0.25 ha and initial sheep liveweight was approximately 40kg.

Results and discussion The crude protein (CP) content of biserrula pasture was 23% and digestibility was 76.5% (falling to 68.1% after six weeks). The lupin supplement was 35% CP, 93.7% digestibility and the oat supplement was 9.7% CP and 71.8% digestibility. Animals took up to a week to become accustomed to supplements (longer with oats). Plasma urea nitrogen stabilised after two weeks. Signs of photosensitization on the face, ears and tail appeared after two weeks. Sheep grew faster when offered supplements, regardless of the effect on rumen ammonia (Table 1). The lower growth rate of sheep grazing only biserrula (more pronounced towards the end of the grazing period) indicates an aversion response. Photosensitisation appears to result from ingestion of particular secondary compounds (i.e. Type I condition).

Table 1 *Effect of protein and energy supplements on productivity and health of sheep grazing biserrula pasture.*

Treatment	Rumen ammonia (mg/100ml)	Liveweight change (g/hd/day)	Sheep with signs of photosensitisation	Sheep with severe photosensitisation
Biserrula control	77	81	15	9
Biserrula+lupins	98	154	4	1
Biserrula+oats	68	130	6	3
lsd ($P=0.05$)		42		

Conclusions The hypothesis that the high protein content of biserrula elevates rumen ammonia in sheep leading to an aversion response was not supported. Provision of a supplement helped overcome the aversion to grazing biserrula and reduced the incidence of photosensitisation. Analysis and identification of secondary compounds in biserrula is on-going.

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Grazing disturbance a benefit to species diversity in re-established native grass stands

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Key words: seeding mixture, native plants, grazing, species richness, biodiversity

Introduction In western Canada, increasingly land is being taken out of annual crop production and returned to perennial cover, in part due to an aging producer population but also the recognition of improved sustainability of perennial systems. A portion of the reseeded perennial cover has been native plant material. Seeding mixtures of species have included only a single species to over 100 species. Recommendations for utilization of seeded native grassland species have ranged from a year to establish prior to grazing to no grazing to be allowed. This series of studies set out to determine the possible benefits of seeding a simple seven species mixture versus a more complex fourteen species mixture and the impact that grazing might have on the resulting plant communities.

Materials and methods A 2 × 2 factorial experiment with 4 replicates was initiated in 2001. Sixteen paddocks (2 ha each) were seeded to either a simple six species mixture of cool season grasses plus a native legume or fourteen species icluding the seven from the simple mixture plus warm season grasses and 2 shrubs species. The grazing factor had two utilization levels; either 40-50% utilization or 60%-70%. The seeding rates were 75 pure live seeds (PLS) m^{-2} for the simple while the complex had 99 PLS m^{-2}. Within each paddock an area (3.6 m × 3.6 m) was excluded from grazing. Cattle grazing commenced in 2002 in the month of June until September. Grazing followed the same pattern for 2003 and 2004. Plant compositions, bare ground and litter cover were determined for each of the grazed portions of the paddock using 10 randomly selected sampling points ($a^{1/4}$ m^2) on a diagonal transect. A single random sampling point was used for the exclosures. From the plant compositions a Simpson's Index was calculated. Data was analyzed using Proc GLM and Tukey's test for mean seperation from SAS Institiute, Inc. (2000). Data presented is from the final year of the study, 2004.

Results and discussion The complex species mix had 12% less ($P<0.05$) litter. Within the exclosures there was no bareground and 38.9% litter cover. This was significantly ($P<0.05$) different than the grazed areas which had 44.9% bareground and 17.2% litter cover. The complex species mixture was composed of 66% wheat grasses while the simple mixture was composed of 97% wheat grasses for the final year 2004. The exclosures were dominated by one or two species while the grazed areas had greater respresentation of the seeded species. Within the grazed areas the species that dominated were different then exclosures. Simpson's index increased from 0.86 to 0.94 within the exclosure while the grazed increased from 0.93 in 2002 to 0.96 in 2004. The exclosure Simpson's Index value 0.94 differed ($P<0.05$) from the grazed area value 0.96. These trends agree with reported trends within the literature for grasslands which are grazed versus those which are not. The increase in species richness is due to opening of the canopy to allow access less dominant species access to resource such as light. This is indicated by decreased bareground and increased litter within the exclosures. One would expect limitis to the benefits of grazing for species richness. Overgrazing, afterall, is well known to dramatically decrease species number. One would have expected to see some reduction in the more intensively utilized pastures but no impact on plant composition was noted ($P>0.05$). This would suggest a 4 year study is inadequate to observe deleterious grazing impacts from the higher utilization. This would be in agreement with earlier work done on pre-existing mixed grass prairie (Schellenberg et al., 1999) in which no negative impacts to production were noted after high utilzation over a 7 year period under the similar climatic conditions.

Conclusions Disturbance, in the form of cattle grazing, would be beneficial for maintaining plant diversity in new seedings. This benefit being the result of a more open canopy resulting from grazing and preventing complete dominance of a few seeded species over the complement of seeded species.

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The influence of tree thinning on grass dry matter yield, with and without grazing by herbivore game species in the Marakele Park, South Africa

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Key words: bush encroachment, grasses, productivity, savanna

Introduction In semi-arid savannas of South Africa an increase in woody plant density (bush encroachment) results in the suppression of grasses. Bush encroachment is of great concern in the Marakele Park and a mechanical tree thinning program was applied during 2002/03. There were, however, concerns about the effectiveness of this measure, especially in view of high numbers of grazing game species that were re-introduced into the park. The objective of the study was to quantify the effect of the mechanical tree thinning on grass dry matter (DM) yield in areas protected from and exposed to grazing.

Materials and methods Marakele Park is located adjacent to the Marakele National Park in South Africa. Three vegetation types based on the dominant species were identified: *Acacia mellifera-Grewia flava* (Am-GF), *Combretum apiculatum-G. flava* (Ca-GF), *A. erubescens-Dichrostachys cinerea* (Ae-Dc). Two experimental plots (100 x 200 m) were demarcated in each vegetation type, one each in a thinned (Treatment) and an untreated (Control) plot. Enclosures were placed randomly in each plot and yield determinations done by cutting at the end of the 2004/05 season. Tree density of each plot was quantified in terms of Evapotranspiration Tree Equivalents (1 ETTE=leaf volume equivalent of a 1.5 m tree) (Smit 1989).

Results In areas exposed to grazing the grass DM yields in the Treatment plots did not differ substantially from the Control plots (Table 1). This is confirmed by non-significant ($P>0.05$) relations between tree density and grass DM yield (Table 2). In contrast, much higher grass DM yields were recorded in areas protected from grazing (Table 1), though the differences between the control and treatment plots were still relatively small. The ineffectiveness of the tree thinning treatment is again demonstrated by non-significant ($P>0.5$) relations between tree density and grass DM yield (Table 2). With the exception of annual grasses this relation was mostly positive, which suggest that trees at these densities and in the absence of grazing, contributed positively to the grass DM yield. This was mainly due to the strong association of *Panicum maximum* with the canopies of trees, notably those of larger trees.

Table 1 *Total grass DM yield in areas exposed and protected from grazing at the end of the 2004/05 growing season in the various experimental plots.*

Exp plot	Tree density (ETTE ha^{-1})	DM yield (kg ha^{-1}) Exposed	DM yield (kg ha^{-1}) Protected
Am-Gf (T)	8 691	1 055	2 662
Am-Gf (C)	10 331	1 357	2 068
Ca-Gf (T)	4 551	847	1 363
Ca-Gf (C)	7 799	891	1 216
Ae-Dc (T)	4 328	533	1 204
Ae-Dc (C)	8 676	1 067	1 237

(T)-treatment plot, (C)-control plot

Table 2 *Regression analyses of the relations between the DM yield of grasses in the areas exposed and protected from grazing (dependent variable) and tree density (independent variable).*

Grasses	Regression equation	r	n	P
	Exposed			
Annual	$y=26.033+0.002309x$	0.018	6	0.677 ns
Perennial	$y=185.87+0.062170x$	0.434	6	0.158 ns
Combined	$y=201.77+0.102300x$	0.442	6	0.149 ns
	Protected			
Annual	$y=141.96-0.01379x$	-0.779	6	0.431 ns
Perennial	$y=-1854.0+0.37430x$	0.959	6	0.183 ns
Combined	$y=-1690.4+1.27100x$	0.906	6	0.278 ns

ns=non-significant $P>0.05$.

Conclusions The objective of the initial tree thinning treatments to increase grass DM yield was not achieved and this is ascribed to the nature of the tree thinning operation and the high grazing pressure. It is concluded that the tree densities of the treatment plots were still too high to have a significant effect of grass DM yields, partly due to re-encroachment that occurred since the initial tree thinning operation. Furthermore, the current grazing pressure appears to have effectively neutralised the anticipated positive effect of the reduced competition from the woody layer. This emphasises the importance of conservative stocking rates during the implementation of restoration measures such as tree thinning.

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Vegetation response to grazing management in a Mediterranean grassland : a long-term synthesis

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Key words : grazing , long-term , Mediterranean grassland , plant functional groups

Introduction A long-term synthesis (13 years) on the effects of cattle grazing management on the structure and composition of a Mediterranean grassland in north-eastern Israel is presented . This study provides new insights on the response of the vegetation to rainfall and grazing management .

Methods The relationships among plant functional groups was studied in the context of the effects of grazing pressure of the most recent and former grazing seasons , as well as on the rainfall amounts of the most recent and previous rainfall seasons . Treatments included manipulations of stocking rates (moderate , heavy and very heavy) and of grazing regimes (continuous vs . seasonal) , in a factorial design .

Results Inter-seasonal rainfall variation was a dominant factor in the expression of different grazing treatments on the structure of the plant community . Species diversity was significantly affected by grazing treatments and their effects were stronger in years with dry springs . Grazing effects were stronger on tall annual grasses and annual legumes in wet rainfall years . In dry springs and years , an increase in plant cover was noted in crucifers and thistles with increasing grazing intensity . A reduction in cover of tall grasses was correlated with an increase in cover of less palatable groups such as annual and perennial thistles as well of prostate and shorter groups such as annual legumes and short annual grasses . Cover of functional groups composed by hemicryptophytic species were less variable (lower CV) , in response to grazing treatments compared to functional groups with annual species .

Conclusions Increasing grazing intensity produced a shift in dominance of less palatable functional groups and was rainfall dependant . However , persistency of tall grasses and more palatable species support the idea that Mediterranean grasslands are highly resilient . This long-term study shows that the community is rather stable in spite important variation in grazing pressures and rainfall conditions . Grazing pressure could be increased compared to current management pressures , however , the effects of rainfall conditions should be included in the managerial protocols to prevent a reduction in forage quality of the grassland .

Short-term response of preferred and unpreferred species to sheep grazing in a Patagonian steppe

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Key words : Sheep grazing , cover , preferred , species , unpreferred , species

Introduction Patagonian steppes are subjected to severe grazing-induced desertification processes (León & Aguiar 1985) , usually leading to the dominance of unpreferred plant species at the expense of preferred ones (Cingolani *et al* . 2005) . It is commonly accepted that grazing constitutes a selective pressure favourable to unpreferred plants , more stress tolerant than preferred ones (Chapin *et al* . 1987) . However , this hypothesis was rarely based on short-term field measurements under known grazing pressures . Here we tested general hypothesis in the Patagonian steppe by measuring the change in plant cover of preferred and unpreferred species along a growth season under known grazing pressures .

Materials and methods The experiment was done from October 2005 to February 2006 in the Experimental Farm of INTA at Río Mayo (Chubut province , Argentina) . We measured specific plant cover by the lineal interception method on permanent transects located at 3 plots of 100-150 ha subjected to different stocking rates . Within each plot , 3 transects were located at different distances from the watering point in order to encompass a wider gradient of grazing pressures . On each transect we counted faecal pellets and transformed the mean stocking rate of each plot to the stocking rate of each transect (effective stocking rate ; ESR) , proportionally to the number of faecal pellets . We analyzed the effect of grazing on the cover of preferred and unpreferred plant functional types (PFT) , and of preferred *Poa ligularis* (PLIG) and unpreferred *Stipa speciosa var . major* (SSM) , by multiple linear regressions , with time under grazing and effective stocking rate as independent variables .

Results According to the hypothesis the cover of the Preferred PFT and that of PLIG-decreased significantly with time under grazing , while that of Unpreferred PFT and that of SSM-did not vary with time under grazing . In addition , the cover of PLIG decreased as effective stocking rate increased (Figure 1) .

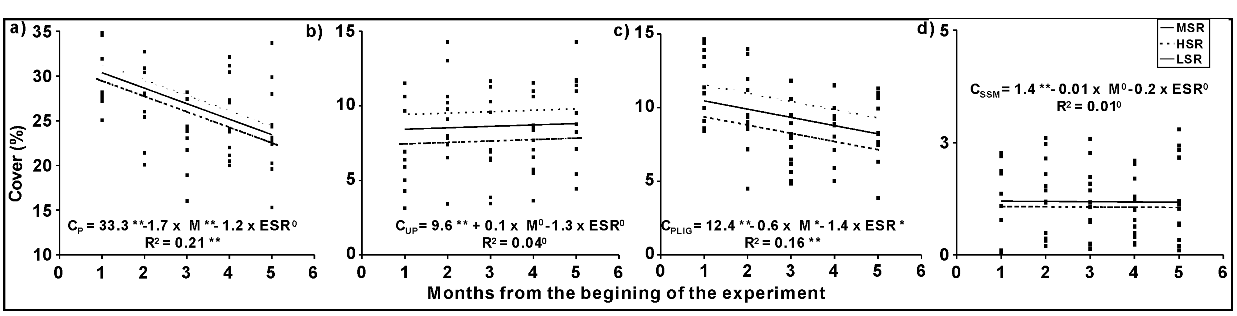

Figure 1 *Plant cover of Preferred PFT (a) , Unpreferred PFT (b) , preferred* Poa ligularis *(c) and unpreferred* Stipa speciosa var . major *(d) as a function of time under grazing . MSR= mean effective stocking rate (coarse line) , LSR=*0 . 2 × *MSR (thin line) , HSR=*1 .8 × *MSR (dotted line) .*
** : $p<0.01$; * : $0.01<p<0.05$; ^{0} : $p>0.05$

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Beef cattle performance on *Panicum maximum* pastures under two levels of fertilization in Brazil

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Key words: guineagrass, forage mass, savanna, nutritive value, Oxisol

Introduction The low soil fertility is the most important limiting factor hampering the intensification of beef production in Savannah areas. According to Macedo (1995) the low base saturation and low P soil content are the two factors directly related to pastures productivity and its sustainability. After having these two deficiencies corrected the productivity is dependent on nitrogen fertilization. Thus, the objective of this work was to evaluate levels of fertilization on *Panicum maximum* pastures.

Materials and methods The experiment was carried out on an Oxisol at the National Beef Cattle Research Center, Campo Grande, Brazil, from October 2004 to May 2006. The experimental design was a randomized block design with subdivided plots with three replications. The main plots were formed by two levels of soil fertility: LFL to maintain fertility on 50% base saturation, 8 mg/L of phosphorus and 80 mg/L of potassium; HLF-to maintain fertility on 70% base saturation, 12 mg/L of phosphorus and 100 mg/L of potassium. The subplots were formed by 150 (N150) and 300 (N300) kg/ha of nitrogen. Twelve modules, of *Panicum maximum* cv. Tanz nia, measuring 1.125 ha each were utilized, and divided into six paddocks (0.188 ha). Each module was submitted to a rotational grazing characterized by pre-grazing condition of 70cm sward height and a post-grazing residue of 40 cm height, and was grazing by four yearling steers. Additional steers were allocated and removed from each paddock according to forage mass to assure the planned residues. Forage samples, before and after grazing, were taken. The animals were weighted at 28-day intervals. Data was analyzed according to GLM-SAS and averages were compared by the Tukey test.

Results There was no interaction involving the main effects ($P>0.05$) for average daily gain (ADG), stocking rate (SR), liveweight gain (LWG) per area and all sward characteristics. The ADG and SR on LFL were similar to those observed on HLF pastures. However, the pastures that received N300 accumulated more forage with higher nutritive value than those which received N150 (Table 1). Consequently, N300 pastures sustained higher SR and the steers performed better, which resulted in greater productivity than those pastures with N150 (Table 2).

Table 1 *Means for forage dry matter (DM), percentages of leaf blade (LB), stem (S), crude protein (CP) and in vitro organic matter digestibility (IVOMD).*

Cultivars	N150	N300
DM (kg/ha)	4640^{b}	5210^{a}
LB(%)	69.8^{a}	70.0^{a}
S(%)	16.5^{a}	17.8^{a}
CP(%)	16.0^{b}	18.2^{a}
IVOMD(%)	68.0^{b}	70.6^{a}

Means followed by the same letter in the row are not different ($P<0.05$), by the Tukey.

Table 2 *Means for average daily gain (ADG), stocking rate (SR), gain per area (GA), rest period (RP) and grazing cycles (GC).*

Cultivars	N150	N300
ADG(g/day)	685^{b}	770^{a}
SR(AU* /ha)	5.03^{b}	6.59^{a}
GA(kg/ha)	845^{b}	1.264^{b}
RP(days)	30.1^{b}	24.9^{a}
GC(no.)	5.8^{b}	7.4^{a}

Means followed by the same letter in the row are not different ($P<0.05$), by the Tukey.
* Animal unit

Conclusion After correcting soil fertility, assuring 50% of base saturation, 8 mg/L of P and 80 mg/l of K the guineagrass production is dependent on nitrogen fertilization.

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Effect of grazing intensity on photosynthesis and soil respiration of alpine grassland in Tibet

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Key words : alpine grassland , Northern Tibet , grazing intensity , photosynthesis , soil respiration

Introduction Naqu locates at the northern Tibet , and also the higher part of Tibet . Alpine grassland is one of the dominant grassland systems at Tibet Plateau . But how the effect of grazing on its photosynthesis and soil respiration is still not very clear . To understand the relationship between them will help to evaluate the sustainable development of grazing capacity and CO_2 emission from this system .

Materials and methods The site was on a typical Alpine grassland . The experimental plots were separated by net wall . There are four grazing intensity treatments that is no sheep as check (T_0) , 2 sheep (T_2) , 3 sheep (T_3) and 5sheep (T_5) , which represented no grazing , less grazing , current grazing and over grazing level , respectively . The plots were divided into 3 parts inside for shifting grazing every 10 days . There are 3 replications in this grazing intensity experiment . The canopy photosynthesis rate was measured by Li-6400 portable photosynthesis system by using transparent chamber . And the soil respiration rate also measured by Li-6400 portable photosynthesis system by using soil respiration chamber . The measurement was taken at sunny day of middle August , which is the most dominate weather type and the most thriving season of the year . The measurement was taken every 2 hours from 10am to 5pm in a continuous 3 days period and the average results were given .

Results The photosynthesis rate under difference grazing intensity has obvious difference as shown in Fig1 . The descend order is T_2 , T_3 , T_5 and T_0 . It seems that less grazing will stimulate the photosynthesis rate and overgrazing will slow down this trend . As to the diurnal photosynthesis rate , T_2 and T_3 has almost have same tendency , that is , from morning to noon it ascend quickly , then it keeps almost stable , until 4pm , after that it drops quickly . As to T0 and T_5 , the tendency is similar and about 2 hours delay . Fig2 showed that the soil respiration also different from each other . The soil respiration rate of all treatments dropped rapidly from morning to noon , and then keep flat . T_0 and T_2 were much higher than T_3 and T_5 .It may result from the balance of sheep trample and the respiration of grass root . More sheep , and lower soil respiration .

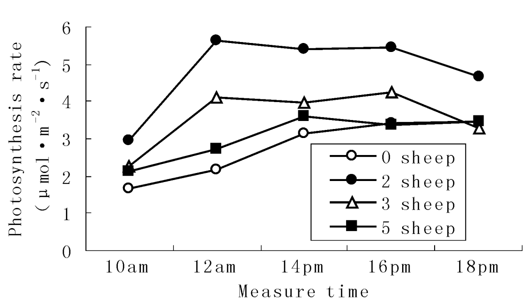

Figure 1 *Photosynthesis rate of different grazing intensity .*

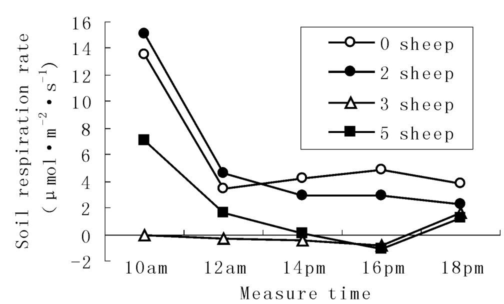

Figure 2 *Soil respiration rate of different grazing intensity .*

Conclusions Based on different grazing intensity experiments , the results showed that proper grazing intensity can stimulate the photosynthesis rate , overgrazing will slow down this trend ; Soil respiration rate will decrease with higher grazing intensity .

Testing non-equilibrium theory : Effects of grazing on plant community composition and soil nutrient availability in dry southern Mongolian steppes

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Key words : non-equilibrium theory , diversity , small mammals , livestock , soil conditions

Introduction Large parts of the Central Asian rangelands are dry at mean precipitation levels of <200 mm , and show a pronounced interannual variability in climate (CV $>30\%$) . The *non equilibrium*-(or *disequilibrium*- , Gillson & Hoffman , 2007) *theory* of rangeland science predicts for such environments that climate is the main control with biotic factors including grazers' impact being driven by , rather than driving variables . In this view , degradation threat should be small in dry regions . We tested these assumptions by monitoring vegetation composition in grazed and ungrazed sites in southern Mongolian desert steppes over 8 subsequent years . Our focus was on the relative importance of interannual climate variability vs . grazing impact/exclusion . Ongoing discussions on the possibility of degradation occurring even under *non-equilibrium* conditions prompted us to assess whether grazing alters soil conditions and if possible changes indirectly affect rangeland health .

Materials and methods Studies were conducted in southern Mongolian desert steppes that receive well below 200 mm annual precipitation (mainly summer) . We used permanent grazing exclosures and adjacent controls to monitor vegetation development . Transect studies radiating away from traditional high impact sites were employed to assess long-term effects of gradients in livestock activity . We also determined the impact of burrowing small mammals (Mongolian Pika , *Ochotona pallasi*) on vegetation and site conditions . Results pointed to effects of nutrient limitation so we also conducted an NPK fertilization experiment and added fertilizer at equivalents of 10 and 20 gN/m (100 & 200 kgN/ha) .

Results Exclosure studies demonstrated a pronounced interannual variability in plant community composition and productivity , which were related to the variability in precipitation . Grazing also had significant effects on community structure , but these were small compared to the rain effect . Studies along transects of 2 km length also showed no effects of grazer activity on plant community compositions along the land use gradients (Stumpp et al ., 2005) . They gave , however , evidence for nutrient translocation as small livestock (mainly goats and camels) release nutrients particularly phosphate—at some few high impact points . Exclosure studies also indicated soil and nutrient accumulation in fences .

Small mammals consumed a fraction of aboveground biomass comparable to the uptake by livestock , and pikas also translocated nutrients . They operate on scales of few metres and concentrate N and P on their burrows thereby counteracting large-scale nutrient dislocation by livestock . Vegetation on burrows differed in composition and was more productive than the surrounding steppe (Wesche et al ., 2007) .

After fertilization , uptake of nutrients was increased though far from complete and nutrients accumulated in the soil . Plant biomass and flower production varied strongly with annual precipitation levels (annual totals 2004-189 mm , 2005—113 mm , 2006—ca . 150 mm) , but fertilization always led to a two-to threefold increase in productivity and reproduction .

Conclusions Our results confirmed the importance of abiotic controls on plant community composition and performance implied by the *non-equilibrium theory* . Auxiliary data showed that populations of livestock and small mammals indeed showed pronounced interannual fluctuations , and evidence for strong direct effects of grazing on vegetation is indeed limited . However , livestock withdraws nutrients from the rangelands and the fertilization experiment showed that rangeland performance is at least co-limited by nutrients even in dry years . These results point to an indirect pathway of pasture degradation that has hardly been assessed in Central Asia . Data also support the notion that focusing on precipitation alone is an oversimplification even in dry rangelands , and thus the *non-equilibrium theory* needs improvement .

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The use of faecal NIRS to monitor diet quality different grazing systems in tropical savannas

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Key words: animal nutrition, NIRS, tropical savannas, grazing systems

Introduction Nutrition is the major factor influencing animal production in grazing systems, however it is very difficult to monitor in extensive systems. This is especially so in northern Australia which has distinct wet and dry seasons, large paddocks with highly heterogeneous pastures and the likelihood for selective grazing. Faecal NIRS is one method to monitor diet quality in these extensive systems (Givens et al., 1997). Here we present data that illustrates the considerable seasonal differences in nutrition across four different grazing systems and discuss this in relation to collection methods and inter-animal variation that occurs.

Materials and methods As part of a large paddock scale study investigating aspects of grazing management in the tropical savannas of northern Australia, faecal samples were collected monthly to determine diet quality through NIRS. Grazing systems investigated included set stocking (SS), set utilisation (SU), wet season spelling (WSS) and cell grazing (CG). Twenty fresh faecal samples were ground-collected from each treatment and aggregated, with a representative sample removed, dried at 60℃ for 48 hours and analysed by NIRS. Additional opportunistic collection and analysis also occurred.

Results and discussion Figure 1 shows the dietary crude protein figures from the 2004 to 2007 faecal NIRS samples in the different grazing systems. ANOVA analysis showed there was no significant difference between the grazing systems at the 95% confidence level. The main conclusion that can be drawn is that season was the dominant factor influencing animal nutrition.

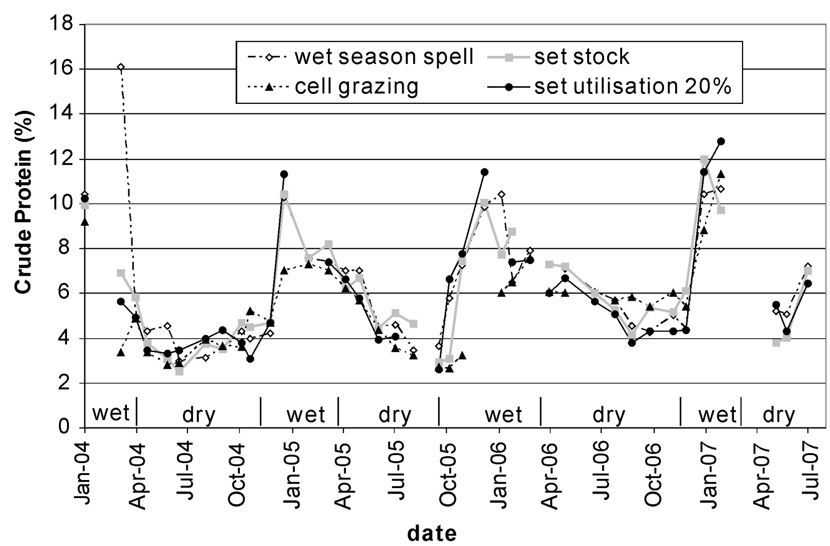

Figure 1 *Crude protein levels from four different grazing systems.*

The mean monthly figures provided valuable data to inform overall nutrition management. However, by aggregating the samples to provide means alone, the potential value of the data is reduced as no measure of variation is provided.

An opportunistic collection occurred in April 2006 with between 29 to 31 samples collected from cattle within each of the different grazing systems. The samples were not aggregated and means of dry matter digestibility and crude protein were generally similar to the routine monthly samples. However for CG, the mean of the non-grass component of the diet in the opportunistic samples was 20% (range 24%) compared with the routine monthly collection figure of 40%. Across the grazing systems the non-grass component of the diet varied from 20% (WSS) to 50% (SU). Over the long-term, this observed variability may have proved decisive in differentiating between the different grazing systems.

Conclusions Rainfall had a marked influence on diet quality as expected. Across the trial, no significant effect of grazing system on mean diet quality was observed. However, collection and analysis of individual faecal material within each grazing system indicated distinct variations between animals for a number of dietary factors, probably reflecting the variability in individual animal choice of areas grazed within the large paddocks and grazing systems employed. While significantly different levels of available protein were not observed in the different grazing systems, consideration of the variability in other dietary factors may have proved decisive in an analysis of the grazing systems.

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Soil-plant indicators for determining the impact of management on the stability of grasslands in cattle exploitation

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Key words: indicator, stability, grasslands, management.

Introduction The degradation of grasslands is a phenomenon of global transcendence (Holzer and Krechbaun 2001), and the development of indicators for monitoring their productive and ecological impact in an easy and trustworthy way is a present challenge. Therefore, the objective of this work was to select indicators of the soil-plant stability in grasslands under cattle exploitation.

Materials and methods The study was performed in 2002, 2003 and 2004 in the Institute of Animal Science, Havana, Cuba. Two grasslands ecosystems were evaluated: a) a silvopastoral system based on Leucaena leucocephala/Panicum maximum on Ferrasol soil, and b) a mixture of creeping legumes on Oxisol soils. Seventy soil indicators were determined such as structure, resistance to penetration, value n, organic matter, content of nutrients and subterranean phytomass. Also, fifty plant indicators were determined such as botanical composition, biomass availability, bromatologic composition, density, new and old species and biodiversity. Principal component analyses (Torres et al., 2003) was used for the selection of indicators..

Results The productivity of both systems improved during the test period (Table1). The soil indicators selected corresponded well with the type of soil (Alonso 1997), and showed corresponding improvements in value with improvements in pasture productivity in both pasture systems. This illustrates that soil and vegetative factors have close correspondence, and that management can have a positive ecological effct. The indicators 1) density of basic pasture, 2) biomass availability, 3) distribution of aggregates in humidness, and 4) subterranean phytomass were identified as the most significant in both grasslands, even though they are on different soils types and have different plant cover.

Table 1 *Soil-plant indicator selected in each grassland, performance and range of values with 95% of probability.*

Grassland	Indicators		2002	2003	2004	±SE Sign	Range of Values
Silvopastoral	Distribution of aggregates in humidness from 1 to 5 mm (%)		0.38^{a} (25.1)	0.54^{b} (39.8)	0.79^{c} (58.5)	0.03^{***}	58.7-58.9
	Value n		0.32^{b}	0.31^{ab}	0.26^{a}	0.01^{*}	0.24-0.28
	Subterranean phytomass from 35	Dry	0.41^{a}	0.62^{b}	0.71^{b}	0.04^{***}	0.64-0.79
	to 42 cm (g 100 cm^{-3})	Rain	0.39^{a}	0.68^{b}	0.70^{b}	0.04^{***}	0.62-0.78
	Density of *Panicum maximun*	Dry	5.8^{a}	6.3^{a}	9.2^{b}	0.05^{***}	8.6-9.5
	(plant m^{-2})	Rain	6.1^{a}	6.4^{a}	7.8^{b}	0.04^{***}	7.9-9.0
	Total Biomass availability	Dry	4.3^{a}	5.8^{b}	4.1^{a}	0.03^{**}	5.4-6.3
	(t DM ha^{-1})	Rain	6.2	6.6	6.4	0.07	6.0-7.1
Mixture of creeping legumes	Plasticity índex (%)		27.1^{b}	20.2^{a}	23.3^{a}	1.07^{*}	37.6-37.9
	Distribution of aggregates in humidness from 1 to 2 mm (%)		18.02^{a} (8.1)	15.47^{b} (10.0)	20.05^{c} (18.5)	0.08^{*}	34.5-34.6
	Subterranean phytomass from 35	Dry	0.47^{a}	0.48^{a}	0.72^{b}	0.04^{***}	0.62- 0.78
	to 42 cm (g 100 cm^{-3})	Rain	0.36^{a}	0.40^{a}	0.66^{b}	0.03^{***}	0.59-0.72
	Legumes(%)	Dry	81.82^{b}	83.29^{b}	57.94^{a}	0.09^{***}	83.2-83.3
		Rain	84.12^{c}	75.42^{b}	77.24^{b}	0.3^{**}	77.2-77.3
	Biomass availability	Dry	2.75^{a}	2.99^{b}	3.48^{c}	0.03^{**}	2.6-3.4
	(t DM/ha)	Rain	3.23^{a}	3.98^{b}	4.55^{c}	0.02^{**}	3.4-4.4

$^{***}p<0.001$; $^{**}p<0.01$; () Original means; data transformed according to $\sqrt{X}$.
Means with different letters within rows differ significantly at $P<0.05$ (Duncan, 1955)

Conclusions Rangeland quality and productivity can be monitored by a relatively small group of indicators. The study also showed that management improved grasslands productively and ecological stability.

Effects of *Haloxylon* plantation on some soil characteristics and vegetation cover

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Key words : *Haloxylon* plantation , soil characteristics , control region , Qom province .

Introduction Because of its geography and frequent strong winds , about 80 percent of Iran has dry and semiarid climates . In this area soil erosion and desertification threaten water and soil resources . Plantations of *Haloxylon* have been established to stabilize sand dunes , reclaim degraded lands and reduce wind erosion damage in the Hossein Abad-e-Mishmast region of Qom province . The objective of the research was to evaluate *Haloxylon* plantation effects on soil characteristics and vegetation cover .

Material and methods Four sites were selected in each plantation and in control (unplanted) regions . Sampling was undertaken using a randomized-systematic method . Three transects of length 500 m were established in each site and 10 plots were selected in each transect . Floristic list , cover percentage and number of plants were recorded within each plot . Also , yield , density , frequency and species composition were determined . A soil profile was dug in each transect , and soil texture , organic matter , electrical conductivity (EC) , acidity (pH) , phosphorous , nitrogen , sodium and potassium were measured . T-tests were used to compare the soil characteristics between any two regions .

Results and discussion Percentage cover , yield and homogeneity of vegetation increased and species composition was better in plantation lands than in the control regions . Also , there were significant differences between soil characteristics except for soluble sodium . Organic matter , potassium , phosphorus and nitrogen were higher in plantation lands than in control regions . In addition , in plantation lands , alkalinity and salinity were increased more than the control region .(Table 1)

Table 1 *Comparison of soil characteristics in Haloxylon plantation regions and control regions in the Hossein Abad-e-Mishmast area .*

soil characteristics	depth	control region	*Haloxylon* plantation region	Result
EC ds/m	First	0 .7025	0 .85	*
	Second	0 .9075	1 .25	**
pH	First	9 .225	9 .6	**
	Second	9 .7	9 .925	**
Organic matter (%)	First	0 .5075	0 .685	***
	Second	0 .4575	0 .49	**
Nitrogen (%)	First	0 .0725	0 .115	**
	Second	0 .0350	0 .0045	n .s
Potassium(ppm)	First	45 .25	64 .75	**
	Second	36	51 .5	**
Phosphorus (ppm)	First	55 .17	60 .5325	**
	Second	54 .5325	56 .02	*
Sodium (ppm)	First	553	509	n .s
	Second	1164 .50	1016 .75	n .s

Conclusions *Haloxylon* plantations have positive effects on some soil characteristics and microclimate of the area , increasing both the yield and percentage of vegetation cover , and the organic matter , potassium , phosphorus and nitrogen contents of the soil . Atkham Shoara (1994) and Bailey (1970) reported similar results . In addition , in plantation lands , alkalinity and salinity were increased more than the control region .

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Sward allowance at early lactation of primiparous dairy cows : IV-Body condition score and reproductive parameters

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Key words: early lactation, primparous dairy cows, anestrus, body conditions score

Introduction The resumption of ovarian cyclicity after parturition is closely related to the negative energy balance in this period; the time to the beginning of the recovery of the energy balance is positively correlated with the time to first ovulation (Butler et al. 1981). The reinitiation of ovarian cyclicity was delayed in primiparous cows and this was consistent with longer intervals from parturition to first service and to conception in these animals (Meikle et al. 2004). Grazing first calving cows have a decreased reproductive efficiency, since they recover from the negative energy balance period with more difficulty than multiparous cows. Dry matter intake (DMI) is a main factor affecting energy balance and thus, anoestrus length. DMI under grazing is largely determined by sward state (Chilibroste et al., 2005). In this study the effect of daily sward allowance on the evolution of body condition score (BCS), postpartum anestrus length and on the diameter of the dominant follicle (DF) was investigated in primiparous cows under grazing conditions.

Materials and methods The experiment was carried out at the EEMAC Research Station, Agronomy Faculty, Uruguay (30° S). Primiparous dairy cows (n=44, BW=595±41 kg, age at calving=2.96±0.11 years and BC=3.7±0.3) were blocked by BW, age and BC, and randomly assigned from calving up to 60 days in milk to one of the following treatments (n=11 each): Control with a 100% TMR diet (*ad libitum*) and the grazing treatments, high (HA, 30 kg DM cow day^{-1}), medium (MA, 15 kg DM cow day^{-1}) and low sward allowance (LA, 5 kg DM cow day^{-1}). The grazing treatments were supplemented with TMR to cover their maintenance requirements. All the cows were individually supplemented at 18:00 h with a mixture of corn silage (10 kg) compound feed (4.8 kg) and grass hay (0.4) on a fresh weight basis. Cows were milked at 5:00 and 16:00 h and were allowed to graze between 8:00 and 15:00 h every day on a 7-days rotation schedule on a pasture of mixed grasses and legumes. BCS was registered weekly (scale 1=emaciated, 5=fat). The initiation of ovarian cyclicity after calving was determined when progesterone plasma levels were above 1 ng/ml in blood samples taken twice a week the diameter of the DF was measured 57 days postpartum by transrectal ultrasonography (Aloka 500, transductor 5 MHz). BCS was analysed as repeated measurements in time using Proc MIXED of SAS v. 8. The length of postpartum anestrus and the diameter of the dominant follicle were estimated by Proc GLM (SAS) and the probability of reinitiation of ovarian cyclicity by Proc Genmod (SAS).

Results and discussion Even if all cows lost BCS during the experiment, the control group presented significantly higher BCS (3.33±0.04) than HA group (3.18±0.3), which in turn was higher than MA and LA groups (3.05±0.03 y 3.07±0.03 respectively). Treatment was highly correlated with BCS at the time of reinitiation of ovarian cyclicity (r=-0.61, p<0.0001), and BCS at this time was inversely associated with the length of postpartum anestrus (r=-0.39 P=0.01). Thus, cows with higher BCS presented shorter intervals calving to first ovulation. Treatment effect did not reached significance on postpartum anestrus length, values for Control, HA, MA and LA groups were (days): 29±14, 29±14, 30±15, y 34±17 respectively. The DF diameter on 57 days popsartum was lower in LA group than for the HA, MA and control group (9.33 vs 14.4, 14.6 and 12.8 mm respectively p=0.01). The diameter of the DF was also correlated with the loss of BCS during the first 30 days postpartum (r=-0.54 P<0.001): cows that lost less BCS presented a larger DF.

Conclusions The different sward allowance determined distinct energy balances that were reflected in the BCS, which in turn was related with the reproductive parameters measured in this study.

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Change of regrowth of *Seripidium transiliensis* Poljak. in different grazing disturbance

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Key words: *Seriphidium transiliense*, disturbance of grazing, regeneration, dry yield, density

Introduction *Seriphidium transiliense*, super xerophyte semi-shrub, whose distribution center in Xinjiang of China (Lin, et al, 1991), was widely distributed 500~1500 m above sea level in north Xinjiang, and was constructive species of desert and desert steppe communities. The *S. transiliense* desert was not only the important spring-autumn pasture in Xinjiang, but also the serious degenerate pasture. In order to establish reasonable grazing intensities, the change of regrowth of *S. transiliense* were studied.

Materials and methods The study site was located low mountain of north slope of Bogeda mountain in Urumqi, Xinjiang (E87°46′~87°47′, N43°49′~43°53′, 840~1110 m above sea level, annual mean temperature is 6.4℃, rainfall is 236 mm). Simulated grazing treatments were initiated on 1 of April to 1 of June in 2006. Four grazing intensities were designed, namely light grazing (mowing with stubble height of 5 cm, LG), moderate grazing (mowing with stubble height of 2 cm, MG), heavy grazing (mowing with stubble height of 0cm, excluding lignified old stem, HG), extreme grazing (mowing with stubble height of 0cm, including lignified old stem, EG). Each plots of simulated grazing intensities were 1 m^2, replicate 5. Dry weight, regeneration height of *S. transiliense* and density of community was measured in all experiments every 15d. Analysis of variance (ANOVA) was performed for differences through Duncan.

Results and discussion
Dry weight of *S. transiliense* under different grazing intensity was showed in Table 1. The dry weight of *S. transiliense* had significant difference among four grazing intensities ($p<0.05$) and the order was EG>HG>MG≈LG (Table 1). The dry weight on EG, HG was higher (compared with MG, respectively significant increase of 880%, 474%), but it was unadvantageous to the continual utilization of *S. transiliense* desert.

Table 1 *Dry weight of* S. transiliense *under different grazing intensities* (g/m^2).

Treatment	Date of grazing (day/month)				
	1/4	15/4	1/5	15/5	1/6
LG	0.57^{c}	2.50^{c}	1.67^{c}	8.66^{c}	21.19^{c}
MG	3.63^{c}	9.94^{c}	10.78^{c}	20.37^{c}	32.90^{c}
HG	68.23^{b}	83.93^{b}	54.67^{b}	82.88^{b}	56.71^{b}
EG	165.0^{a}	121.6^{a}	112.4^{a}	129.2^{a}	114.93^{a}

Regeneration speed of *S. transiliense* appeared similar para-bola trend with the increase of grazing intensity, and the highest was at MG (Figure 1), which indicated that moderate grazing could promote the vegetative growth of forage (Yang, et al, 2005; Wu, et al, 2005). Compared with that of between 15^{th} April and 1^{st} May, Regeneration speed of *S. transiliense* between 1^{st} May and 15^{th} May on LG, MG, HG, EG respectively increased 82%, 21%, 49%, 232%, which was possibly correlative to temperature and rainfall.

Grazing intension had a little effect on the species of *S. transiliense* desert, and the density of subordinate grass increased with grazing intensity. After grazing on 15^{th} May, the density of *S. transiliense* on LG, HG, EG decreased 26.76%, 22.75%, 82.03%, but that increased 12.21% on MG (Figure 2), as further indicated MG was fit to the continual development of desert.

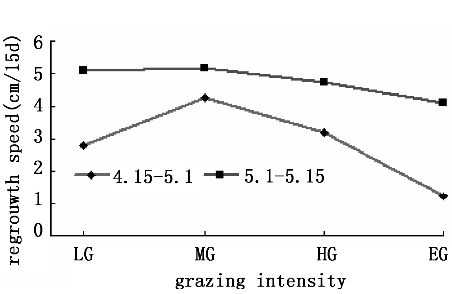

Figure 1 *Different regeneration speed after simulate grazing.*

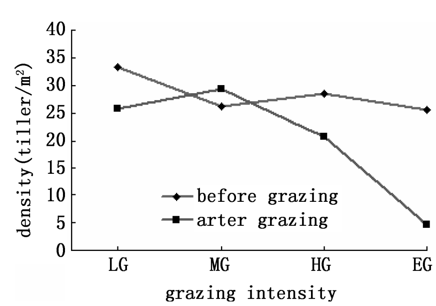

Figure 2 *Density of* S. transiliense *contrust before and after grazing.*

Conclusions Compared with dry weight, regeneration speed of *S. transiliense*, density and species of community among four grazing intensities, moderate grazing was propitious to the continual development of *S. transiliense* desert pasture.

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Different grazing manner effects on ecological indicators of the typical steppe vegetation in Mongolia plateau

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Key words : grazing system ,ecological indicators ,typical steppe

Introduction Study on nomadic civilization grazing principle and modern technology , rotational grazing system are better than those with the continuous grazing in Mongolian plateau . Ecological indicators (the height , the cover degree and the importance value) are higher than those continuous grazing(Savory 1980) . In this study , we mainly selected Dong wu county typical steppe Inner Mongolia . As a result show that require grassland vegetation ecological indicators in typical steppe have a difference . Rotational grazing system have well impression about ecology protection , how to establish rational grazing and distribute system , Suggestions for further study are discussed .

Materials and methods Taking Mongolia plateau vegetation ,mainly investigated places are Dong Wu town Inner Mongolia typical steppe(45°27′N ,117°04′E) and Su He Bater province Mongolia typical steppe(45°44′N ,115°43′E) . In this study , we mainly used herd family with starting point and line out three string , every line angle is 120 .We selected 3 to 5 target point ,target point area is $1x1m^2$ and we determine vegetation ecological indicators in the target point . The data were analyzed using SPSS13 . 0 .

Results *Stipa krylovii* is mostly genus in the typical steppe , the following result is ecological indicators of *Stipa krylovii* steppe .

Table1 *Comparing ecological indicators of* Stipa krylovii *typical steppe in two countries .*

Ecological Indicators / grazing system	height(cm)	coverage(%))	Important value
	average(Std . Deviation)	average(Std . Deviation)	average(Std . Deviation)
Mongolia (nomadic grazing)	9 .0(3 .16)[a]	9 .83(6 .68)[a]	50 .62(22 .78)[a]
Inner Mongolia (consecutive grazing)	5 .83(1 .47)[b]	3 .76(1 .54)[a]	25 .63(18 .14)[a]

Explain : different letters indicate significant differences at $P<0.05$ level .

Conclusions The result show that Mongolia(nomadic grazing) *Stipa krylovii* higher than Inner Mongolia(consecutive grazing) . Across One-way ANOVA , vegetation height exist significantly difference($P<0.05$) , coverage and important value are no significant difference . We concluded that nomadic grazing Mongolia for vegetation resumption has better effect than consecutive grazing Inner Mongolia .

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Effect of management on the productivity of chloris gayana in the rangelands of uganda

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Key words: Rangeland, Chloris gayana, management, herbage

Introduction The productivity of Chloris gayana is affected by several factors, especially weeds in the degraded rangelands of Uganda where most grasses are native and have been overgrazed (Sabiiti et al. 2004). The major weeds are Tagetes *minuta*, *Cymbopogon afronardus*, *Lantana camara* and *Imperata cylindrica* which affect the growth and development of Chloris *gayana* in the cattle corridor, in Mbarara District, Uganda in the rangelands. The aim of the study was to find out the extent to which these weeds affect the productivity (seed yield and herbage) of *C.gayana* under rangeland conditions.

Materials and methods An experiment with several treatments (no weeding, weeding, and shade, late planting) was conducted in Kazo County in Kiruhura District in order to find the effect of management on the productivity of *C. gayana* in the rangelands of Uganda. Data on seed yield and dry matter yield of *C.gayana* were determined. These were considered critical parameters and would reflect the growth and development of the grass under study.

Results and discussion The results of seed yield and herbage production are presented in Figure 1 and Table 1, respectively. It is very clear that a treatment with two weeding significantly produced more seeds than all other treatments and this was also true with herbage yield in Table 1. There appears to be a relationship between herbage production and seed yield. The majority of pastoralists in this cattle corridor do not mange their pastures and take them granted and it is not surprising that large areas have been overgrazed and invaded by weeds (Mugasi et al., 2000).

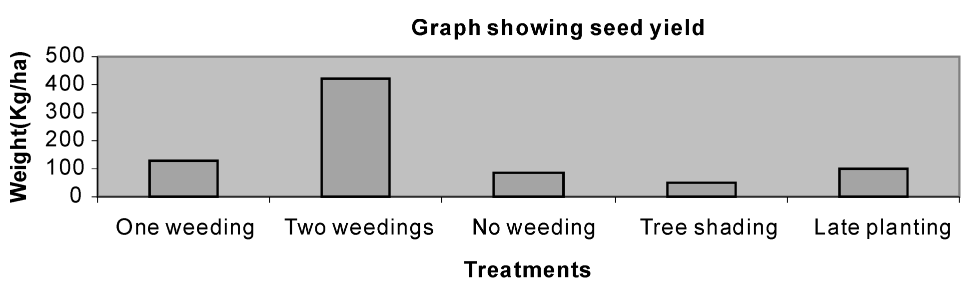

Table 1 *Mean Herbage dry matter (DM) Kg/ha.*

Treatment	Measurement (KgDM/ha)
1st weeding	4,263
2nd weeding	7,350
Not weeded	1,020
Grown under tree shade	622
Late planting	2,205

Conclusions The productivity of *C.gayana* is enhanced by proper management and weeding more than anything else produces the best performance of the grass species in these rangelands to replace native grasses which are less nutritious. Pastoralists need to be advised that pastures require care if they have to remain productive.

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Sward allowance at early lactation of primiparous dairy cows : I-Milk yield and composition

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Key words : grazing , sward allowance , early lactation , primiparous dairy cows

Introduction Grazing the whole year round represents the dominant feeding system in Uruguayan dairies . The inter-relationship between pasture and the grazing ruminant is a dynamic , two-way process . The quantitative , qualitative and structural aspects of the different plant species present in the pastures influence the plant material ingested by the animal , which in turn modifies the plants remaining and their subsequent production and fate (Chilibroste et al . , 2005) . Farm surveys carried out at dairy farms in Uruguay have shown that individual milk production levels are under the breed milk production potential , specially in first lactation dairy cows (Chilibroste et al . , 2004) . This experiment was carried out to understand the impact of daily sward allowance on milk production and composition of early lactation first calving dairy cows grazing temperate pastures .

Materials and methods The experiment was carried out at the EEMAC Research Station , Agronomy Faculty , Uruguay (30° S) . Primiparous dairy cows (n=44 , BW=595±41 kg , age at calving=2 .96±0 .11 years and BC=3 .7±0 .3) were blocked by BW , age and BC , and randomly assigned from calving up to 60 days in milk to one of the following treatments (n=11 each) : Control with a 100 % TMR diet (*ad libitum)* and the grazing treatments , high (HA , 30 kg DM cow day^{-1}) , medium (MA , 15 kg DM cow day^{-1}) and low sward allowance (LA , 5 kg DM cow day^{-1}) . The grazing treatments were supplemented with TMR to cover their maintenance requirements . All the cows were individually supplemented at 18 :00 h with a mixture of corn silage (10 kg) compound feed (4 .8 kg) and grass hay (0 .4 kg) on a fresh weight basis . Cows were milked at 5 :00 and 16 :00 h and grazed between 8 :00 and 15 :00 h on a 7-days rotation schedule for each individual treatment a pasture of Tall fescue (*Festuca arundinacea)* , Birdsfoot trefoil (*Lotus corniculatus*) and White clover (*Trifolium repens)* . Sward mass before and after grazing was estimated with a rising plate meter (ASHGROVE) using the double sampling technique (Haydock and Shaw , 1975) . Individual milk production was recorded daily while milk samples were taken during 4 milking each week and one representative weekly milk sample was analysed for protein , fat and lactose with a milko-scan (Foss Electric® , 133b) . Milk yield and composition were analysed as repeated measurements in time using Proc MIXED of SAS v . 8 .

Results and discussion Mean sward availability during the experiment was 2750 275 kg DM . Sward utilization was 47 , 61 and 73 % of the allowed sward mass for HA , MA and LA , respectively . The average daily production differed ($p<0.01$) among groups , being highest in the Control group (26 .1±0 .37 L) , HA group (24 .1±0 .33 L) , followed by MA (22 .9±0 .42 L) and LA (18 .9±0 .42 L) . Both milk protein and fat content decreased with days in milk . Milk protein content (g/kg) was significantly higher for the control group (3 .31±0 .049) but did not differ among grazing treatments , while protein yield (kg . cow .day^{-1}) was significantly higher for HA (0 .74±0 .019) and MA (0 .69±0 .024) than LA (0 .56±0 .023) . The opposite trend was observed for fat content , control group had less fat percentage , and no difference were found among grazing groups . As expected , fat yield (kg cow day) was significantly lower for LA group (0 .89±0 .04) than for HA (1 .06±0 .03) and MA groups (1 .01±0 .04) , ($p<0.01$) .

Conclusions Sward allowance positively affected milk-yield of early lactation primiparous dairy cows although not enough to attain the production level of a 100% TMR feeding system (Control group) . Milk response to sward allowance was 0 .51 L per extra kg DM when the daily allowance moved from LA to MA . Differences in milk components concentrations like fat and protein were less evident among grazing treatments although fat and protein milk yield were depressed in the LA treatment . Cows in the control group (100 % TMR) were able to combine higher levels of milk production and protein content than the grazing treatments irrespective of sward allowance .

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Sward allowance at early lactation of primiparous dairy cows : II-Ingestive behaviour

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Key words: sward allowance, ingestive behaviour, early lactation, primiparous dairy cows

Introduction Grazing the whole year round represents the dominant feeding system in Uruguayan dairies. The negative energy balance that occurs during the transition period in dairy cows is more severe in primiparous cows (Meikle et al. 2004). The main factor affecting the negative energy balance is dry matter intake (DMI) which under grazing is largely determined by sward state (Chilibroste et al., 2005). We are not aware of plant-animal interface studies involving early lactation primiparous dairy cows under grazing. This experiment was carried out to understand the impact of daily sward allowance on ingestive behaviour at early lactation of first calving dairy cows grazing temperate pastures.

Materials and methods The experiment was carried out at the EEMAC Research Station, Agronomy Faculty, Uruguay (30° S). Primiparous dairy cows ($n=44$, $BW=595\pm41$ kg, age at calving $=2.96\pm0.11$ years and $BC=3.7\pm0.3$) were blocked by BW, age and BC, and randomly assigned from calving up to 60 days in milk to one of the following treatments ($n=11$ each): Control with a 100% TMR diet (ad libitum) and the grazing treatments, high (HA, 30 kg DM cow day^{-1}), medium (MA, 15 kg DM cow day^{-1}) and low sward allowance (LA, 5 kg DM cow day^{-1}). The grazing treatments were supplemented with TMR to cover their maintenance requirements. Cows were milked at 5:00 and 16:00 h and were allowed to graze between 8:00 and 15:00 h every day on a 7-days rotation schedule on a pasture of Tall fescue (*Festuca arundinacea*), Birdsfoot trefoil (*Lotus corniculatus*) and White clover (*Trifolium repens*). Each treatment was placed on independent plots. On experimental weeks 2, 4, 6 and 8 each treatment was observed during three alternate days every 15 minutes and the number of cows grazing, ruminating or in other activities recorded. The same weeks during three intervening days 4 individual cows of each treatment were observed every 10 minutes and the observed activities (grazing, ruminating, others) recorded. Probability for different activities were analyzed with a General Lineal Model as repeated measurements in time (GENMOD of SAS v. 8) while bite rate was analyzed as repeated measurements in time using Proc MIXED of SAS v. 8.

Results and discussion Bite rate tended to be lower ($p<0.1$) in LA treatment (24.1 bites/minute) when compared with HA and MH (26.8 bites/minute). Allocation of time on grazing activities increases significantly ($p<0.01$) with days in milk. The mean values for grazing activities on days 14, 28 and 50 were 57, 64 and 71%, respectively. During the first moth of lactation primiparous dairy cows expend half of the allowed grazing time on grazing activities irrespectively of sward allowance, which suggest a strong physiological control on grazing time. Bite rate increased significantly ($p<0.01$) with days in milk. Mean values for bite rate during days 14, 28 and 50 were 21.5, 29.2 and 38.3 bites/minutes, respectively.

Conclusions Primiparous dairy cows require at least 4 to 6 weeks to exhibit regular values for grazing time allocation and intake rate. This trend although non independent from sward condition is mainly driven by day in milk which suggests a strong physiological feedback regulating DMI under grazing conditions for primiparous dairy cows.

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Monthly activity centres of african elephants in a small game reserve

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Key words: African elephants, centre of activity, home range, harmonic mean, marula

Introduction Due to habitat heterogeneity and environmental variation, the home range and habitat utilization of African elephants varies in different years and different seasons, not only in large protected areas but also in small reserves (Shannon et al., 2006). Although there are many studies on seasonal changes of elephant home ranges, no articles on finer temporal shifts within elephant home ranges are published. Monthly movement rhythms should provide more detail on elephant foraging and its impacts and help the conservation and management of both elephants and their habitats, especially in small reserves.

Materials and methods Radio and satellite collars on the elephants were fitted by a veterinary surgeon in a humane manner, and in accordance with laws governing animal anticruelty in South Africa. All elephant locations were projected into UTM 1983 (Zone 36) datum. Since the datasets are sampled differently, the analyses include only the first daily location and separated by sex. Using these data, monthly harmonic mean centres of elephants were determined using ArcView Animal Movement Analyst Extension (the number of divisions of the X axis: 100).

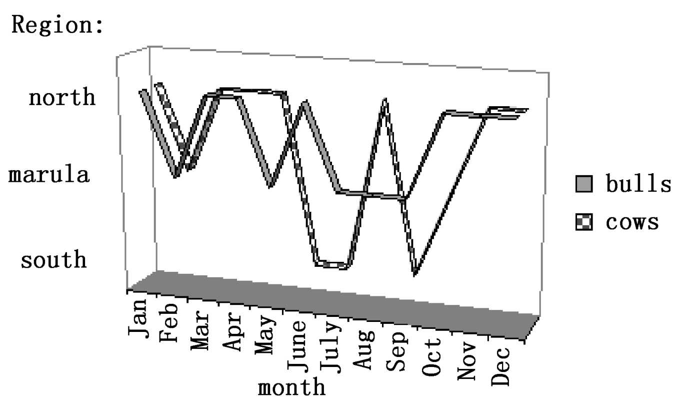

Figure 1 *Generalised cadence of elephant monthly harmonic mean centres of activity.*

Results For both bulls and cows the elephants are more active in the northern PGR, compared with oscillations to other regions in other months. These monthly regional preferences are generally consistent across years and a generalised cadence pattern is given in Figure 1. For bulls the monthly cadence in activity is primarily between the northern PGR and the high marula densities area. The cow herd activity oscillates between the northern region and the southern PGR. These patterns of activity are partly disrupted in the dry months i.e. activity centres are more widely distributed. In February both bulls and cows are found in the central part of the PGR which appear to relate to the marula distribution area (Figure 1). For the months adjoining months January and March they are in the north. From late April or May, elephant activity centres shifted from the north. From September or October when the first spring rains fell elephant activity centres shifted back to the north (Figure 1). Bull and cow activity centres were only close together in the wet season from November to February (Figure 1).

Conclusions Our results show that elephant activity over that period had similar month-by-month rhythms in different years, which appeared to be related to rainfall, vegetation, distribution of cow herd, marula (*Sclerocarya birrea*) fruiting and hunting. Food appears to play an influencing role in the elephant movements. Monthly activity centres of both bulls and cows were more widely distributed in the dry months than in the wet months. Bulls keep relatively close to the herd only in very wet months. There is a close association between fruiting of marula and the distribution of elephants in February. Rainfall appears to have an indirect but influencing impact on elephant ranging behaviour. Knowledge of elephant monthly movements is not only helpful for the design of suitable management strategies but could be used for the estimation of minimum size for a small reserve.

Effects of livestock grazing on soil moisture and rangeland vegetation cover in upland grasslands of Iran

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Introduction Soil moisture holding capacity plays an important role on vegetation establishment and growth in rangelands . Rangeland plants are grazed by livestock and in the mean time soil surface gets compacted which adversely affect soil infiltration . In the most of cases the present range condition is the result of the previous management applied (Ferrero , 1991) . Thurow et al . (1986) indicated that the biomass of the available vegetation plays an important role in soil infiltration rate of rangeland . The short and long term grazing period impacts on infiltration rate of the soil in rangelands was investigated by Weitz and Wood (1986) .

Materials and methods The experiment was conducted in Hanna Station rangeland located in northeastern part of Isfahan , Iran The experiment was carried out for two years (2004 and 2005) . Soil moisture holding capacity and vegetation cover dynamics were measured in three rangeland sites of heavily grazed (critical area) , moderately grazed (key area) and not grazed (reference area) . Soil moisture was measured (standard method) on monthly basis (early May to early September) and Vegetation cover as well as infiltration rate (double ring methods) were measured at the start (early May) and the end of the grazing season (early September) . All the measurements were repeated for two years (2004 and 2005) . Treatments were arranged in split plots in time and location and the data were analyzed using Completely Randomized Block Design with four replications .

Results and discussion The infiltration rate followed a decreasing trend from early grazing to season (early May) to the end of the grazing season (early September) (Table 1) . The average vegetation cover in reference area was 67 .2% in early May which more than half of it (37 . 6%) belonged to cool season grasses and the rest was occupied by forbs (Table 1) . By the end of the grazing period the grass component of the vegetation in all sites significantly decreased . The percent of bare ground in key and critical area in early May was 24 .8% and 77 .5% , which increased to 60 .3 and 92 .6% , respectively . The higher organic matter in reference (3 .9%) and key (3%) areas compared to critical area (1 .7%) well explains the better ability of soil in these sites to store more moisture during grazing season . The adverse impact of early and high intensity grazing on organic matter content of the soil was indicated by Naeth et al . (1991) . There is a significant relation between increased livestock trampling and decreased soil infiltration as well as increased soil compaction (although is not linear) . The trend of soil moisture decrease through grazing season was slower (0 .7% / month) in top soil (0-15 cm) compared to lower layer of 15-30 cm (1 .2%) . The higher organic matter content in upper layer of the soil profile well defines its better moisture holding capacity (Figure 1) .

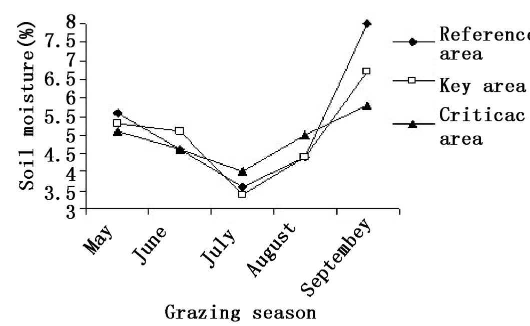

Figure 1 *Meansoil moisture varlation during grazing season in different range sites in 2004 and 2005 .*

Table 1 *Mean vegetation composition (percentage) and infiltration rate (mm/minute) of rangeland under different long term grazing intensities .*

Rarge site	Grazing period																			
	May										Septenmber									
	Vegetation composition				Measuring time						Vegetation composition				Measuxing time					
					1	5	10	30	60	90					1	5	10	30	60	90
	Grass %	Forbs %	Litler %	Bare ground%	infiltration ratel (mm/minute)						Grass %	Forbs %	Litler %	Bare ground%	infiltration ratel (mm/minute)					
Reference area	37 .6	29 .6	25 .1	7 .7	19	7	4	3 .5	3	2 .5	9 .5	9 .6	73 .6	7 .3	11	6	4	3 .5	2 .5	2
Key area	16 .5	38 .8	19 .9	24 .8	12	3 .5	2 .5	2	2	2	10	28 .2	10 .5	60 .3	9 .5	5 .8	3 .5	2 .5	2	2
Critical area	1 .0	16 .3	7	77 .7	11	35	3	15	1	0 .5	1 .0	3 .6	3 .3	92 .6	9 .5	4	2 .9	2	1 .8	1 .5

Effects of supplemental feed and white-tailed deer density on vegetation

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Keywords: foraging, forbs, habitat, species richness

Introduction Southwestern Texas is at the xeric edge of the range of white-tailed deer (*Odocoileus virginianus*) in North America. Land managers commonly provide dry, pelleted feeds to increase white-tailed deer nutritional status. Provision of pelleted feeds may alleviate constraints on foraging time, enabling herbivores to selectively feed on the most palatable plants, potentially resulting in habitat degradation (Murden and Risenhoover 1993). We tested the hypothesis that compared to no supplemental feeding, provision of pelleted feed results in habitat degradation. We predicated an interaction between increasing density of white-tailed deer and feeding treatment, in which high density and supplemental feeding reduces canopy cover of forbs and shrubs eaten by deer and reduces forb species richness compared to low density and no supplemental feeding.

Materials and methods The experimental design was a randomized, complete-block with a block at each of 2 locations 37 km apart. Two 486 ha sites were subdivided into six 81 ha paddocks separated by 3.1 m tall fences. Pelleted feed (~20% crude protein) was randomly assigned to 3 of the 6 paddocks at each location. In 2004, 10, 25, or 40 white-tailed deer were randomly assigned to an enclosure with pelleted feed provided *ad libitum* and an enclosure with no pelleted feed. Twenty 50-m transects were randomly established within each enclosure. We estimated canopy cover of forbs and shrubs and forb species richness during summer 2004-2007. Plants palatable to deer were determined in bite count experiments. Data were analyzed using repeated measures analysis of variance with the difference between mean canopy cover and species richness from 2005-2007 and these values on the initial sampling date as the dependent variables. Supplemental feeding treatment, white-tailed deer density, and the feeding x density interaction were independent variables.

Results There was no treatment x density interaction ($P > 0.05$) for any of the dependent variables. Canopy cover of palatable forbs declined about 4% in paddocks with no supplemental feed, averaged across sampling dates and densities, but did not decline relative to canopy cover at the beginning of the study in paddocks with supplemental feed (Figure 1). Differences in canopy cover of shrubs and forb species richness between 2005-2007 and 2004 were similar ($P > 0.05$) between feeding treatments (Figure 2). None of the dependent variables differed significantly ($P > 0.05$) among white-tailed deer densities, averaged across feeding treatments and sampling dates.

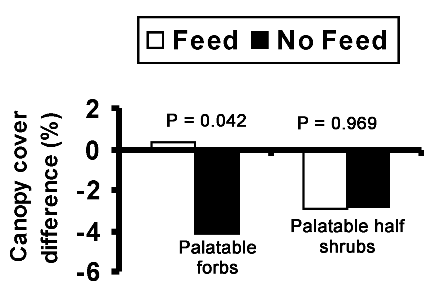

Figure 1 *Difference in canopy cover of palatable forbs and half shrubs between the mean of the subsequent sampling dates and the initial sampling date, averaged across densities.*

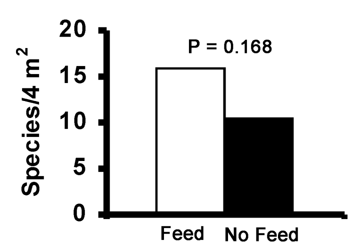

Figure 2 *Difference in herbaceous species richness between the mean of the subsequent sampling dates and the initial sampling date, averaged across densities.*

Conclusions In contrast to our hypothesis, supplemental feeding appeared to alleviate foraging pressure on palatable forbs. Our results should be considered preliminary because extreme annual variation in rainfall may have ameliorated impacts of supplemental feed and white-tailed deer densities on vegetation.

Acknowledgment Research supported by T. Dan Friedkin, Comanche Ranch, The Neva and Wesley West Foundation, Faith Ranch, Stuart Stedman, Houston Safari Club, and the Houston Livestock Show and Rodeo. Assistance of Will Moseley, Kent Williamson, Matthew Moore, and other students is gratefully acknowledged.

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Correlations between soil properties and plant growth for special synthetic soils added with five components used in high-and-cut rock slopes

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Key words: rock slope, outside soil spray seeding, orthogonal array designs, synthetic soils, plant, restoration

Introduction It is well known that the outside soil spray seeding (OSSS) is most effective among the various techniques used for re-vegetation of bare rock slopes because of its high mechanization, high efficiency and fast restoration (Albaladejo-Montoro, 2000). However, the study by Esther (2004) showed that though OSSS behaved well on the low and gentle rock slopes whose gradients are less than 45°, it was not effective on high-and-cut rock slopes. Previous studies on OSSS were mainly focused on the improvement of engineering techniques (Fowler and Maddox, 1974; Carr and ballard, 1980). However, the physico-chemical and biological properties of the soils after adding different components used for OSSS remain less known. Therefore, we designed a few synthetic soils with five variables by using an orthogonal array method to study the properties of the special synthetic compound soils.

Materials and methods Twenty-five treatments were assigned to tray-planted (40 cm×30 cm×15 cm) experiments by using an orthogonal array design $OAD_{25}(5^5)$ matrix with five levels for each factor and five replicates for each treatment. Italian ryegrass was selected as the tray-planted species to assess the status of plant growth. Soil samples for each treatment were collected by using soil core rings (30 mm in diameter and 50 mm in length). In the experiment, plant biomass, soil pH, organic carbon, total nitrogen and phosphorus and soil invertase activities were used as response functions, respectively. Plant biomass was dried at 65℃ to constant weight and expressed on a weight basis. Above ground biomass was measured with the clipping method at plant maturity and below ground biomass was measured with the washing method. PH was measured by Glass calomel Electrode (Smith and Doran, 1996). Organic carbon was measured by the methods of Mebius (1960). Total nitrogen and phosphorus were determined by the methods of Bremner and Mulvaney (1982). Enzyme activities were analyzed using the method of Schinner and Mersi (1990). The Pearson's correlation coefficient was used to quantify the strength of relationships existing among all the indices.

Results The *r*-matrix showed that most indices exhibited high and significant relationships between plant growth, soil physico-chemical and biological properties at all concentrations of the five application factors. The plant biomass showed highly significant and positive correlations with invertase as well as negative correlations with soil pH, total nitrogen, and total phosphorous. These results indicated that the high pH and the too much soil available fertilizers have hurt plant growth. Considering the correlations between soil physico-chemical and biological properties, soil pH was negatively and significantly correlated to invertase activity, whereas organic carbon was positively and significantly correlated with invertase activity, which suggested that the effects of soil physico-chemical properties on soil enzyme activities were significant.

Discussion From the results, we can see that the addition of five amendments significantly affected plant growth and soil physico-chemical and biological properties.

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Grazing and drought interactively influence total plant density

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Key words: heavy grazing, Inner Mongolian steppe, net primary productivity, plant height

Introduction Great changes have taken place in vegetation in Inner Mongolian steppe due mainly to overgrazing in the past four decades. Overgrazing and N losses in combination with altered soil physical parameters and water availability further have been shown to exert strong impact on plant productivity, total density and height (Cingolani *et al.*, 2005). In addition to grazing disturbance, drought also can significantly affect species height and density due to diferent drought resistant or tolerant ability. However, drought and grazing always interactively influence the ecosystem processes in grazing ecosystems.

Material and methods Our experiment was conducted at one site protected from grazing since 1979 (UG79), at one moderately grazed (MG) and one heavily grazed (HG) site in Inner Mongolian steppe. At peak biomass time in 2004, 2005 and 2006, plant material of 1 m x 1 m ground area was cut with grass shears down to the soil surface at these three experimental sites. 10 replications were done in each site. Additionally to the number of species, height, number of tillers and number of individuals were recorded before harvesting.

Results There was no significant interaction of plant height between grazing and year ($P < 0.001$) (Table 1). Plant height decreases with increasing grazing intensity. Plant height has no significant diference in two dry years 2005 and 2006. Grazing and year interactively affect total plant density ($P < 0.001$) (Figure 1). In all three years, total plant density was highest at site HG and lowest at site UG79 and was higher in 2004 than in 2005 and 2006.

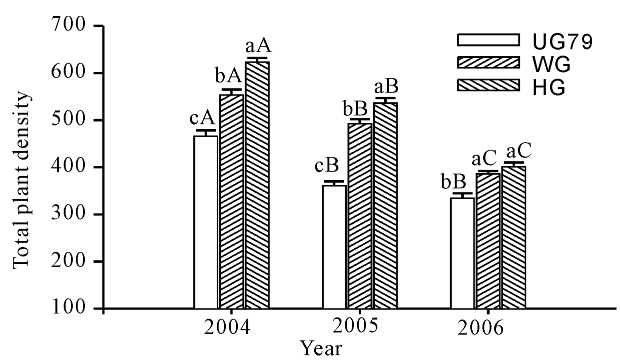

Figure 1 *Total plant density at three differently managed sites. Symbols are as Table 1.*

Table 1 *The average height of community (cm) at differently managed sites. Significant differences between grazing and years are indicated by different small and capital letters, respectively.*

Sites	2004	2005	2006	Average
UG	31.0	25.0	22.7	26.2 a
WG	29.3	20.6	23.1	24.3 a
HG	11.0	7.0	6.8	9.0 b
Average	23.8 A	17.5 B	17.6 B	

Conclusions Heavy grazing leads to lower plant height and more small individuals. Drought reduces total plant density more at site HG than site UG79, suggesting heavy grazing with a prolong drought can seriously deteriorate grassland.

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Estimation of bermudagrass forage intake from canopy spectral absorbance measurements using hyperspectral radiometry

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Introduction Grazing animals on forage have a lower cost of gain than animals fed in feedlot on mixed rations. However nutrient levels of warm-season forages frequently fall below animal requirements, thereby necessitating protein and/or energy supplementation. Conventional methods of estimation of forage quality are slow and labor intensive processes. Recent work has suggested that it is possible to assess pasture forage quality in real-time, which allows stocker operators the technology to quickly recognize the need for supplementation (Starks et al., 2005). However, uncertainty exists in the determination of actual nutrient deficiencies due to difficulties in estimation of forage intake in grazing animals. Therefore, the objective of this study was to evaluate the potential for the estimation of forage intake in grazing animals utilizing hyperspectral forage canopy light absorbance.

Materials and methods Hyperspectral forage canopy absorbance was estimated on eight plots in each of three 1.2 ha common bermudagrass pastures weekly over a period of 9 weeks from June through early August, 2005 using an SE590 spectroradiometer (Spectron Engineering, Denver, CO, USA) and/or an ASD FieldSpec FR spectroradiometer (Analytical Spectral Devices Inc., Boulder, CO, USA). Forage in each plot was harvested weekly using a sickle mower and weighed amounts were fed to one of 12 individually penned lambs. Dry matter was estimated for both forage fed and forage refused for two 24-hr periods each week and dry matter intakes were calculated for each lamb. Hyperspectral data from the ASD Fieldspec was converted to wavebands corresponding to wavebands from the SE590. Dry matter intakes were expressed as a percent of body weight and corrected for fixed effects and time and subsequently regressed on forage canopy wavelengths (range of 410 nm to 1010 nm) using the stepwise MAXR regression procedure (SAS, 2000). Dry matter intakes as a percent of body weight were also regressed on forage canopy light absorbance using partial least squares procedures (SAS, 2000).

Results The best 10-, 20-, 30-, 40-, 50-, and 60-variable prediction models yield R^2 values of 0.27, 0.49, 0.61, 0.73, 0.81, and 0.92, respectively (all $P < 0.01$). The plot of actual vs. predicted dry matter intake for the best 60-variable model is given in Figure 1. Partial least squares regressions yielded R^2 similar to the 60-variable model.

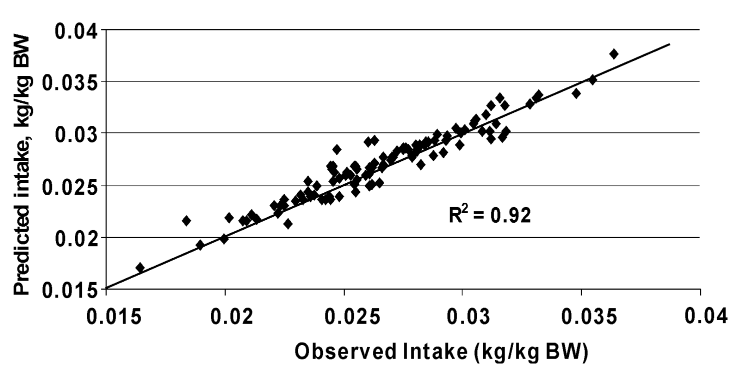

Figure 1 *Plot of observed vs. predicted (60 wavelength model) dry matter intake, kg/kg.*

Conclusions Pasture forage dry matter intake as a percentage of body weight can be predicted using forage canopy absorbance estimates from hyperspectral radiometers. In conjunction with forage quality estimates, it appears possible to precisely estimate nutrient balance of grazing animals and provide precision supplementation to meet production targets.

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Comparison of forage quality of *Astragalus effusus* Bunge at three growth stage , management systems

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Key word : Rangelands ,*Astragalus effusus* Bunge ,forage quality , grazing intensity ,Iran

Introduction Among more than 800 , *Astragalus* species that are existed in Iran , a few of them are forb , palatable and contribute to the feeding of livestock , including *Astragalus effusus* Bunge . As a grazing tolerant , nutrient rich and prostrate species that have an undeniable role in soil conservation and animal feeding , it deserves serious consideration . This study aims at investigation of forage quality of this species at three , growth stage and management systems .

Material and methods This study was conducted in Chaharmahal-va-Bakhtiari province (50° , 41′ N and 32° , 43′ E , ca . 320 ha , 2144m *a .s .l .*) , Iran . Within this area , three management systems including exclosure , moderate grazing (1-year rest-rotational grazing system with 1 AU/ha) and extensive grazing (whole year grazing with 1 .7 AU/ha) are implemented . Within each management system one representative area was selected and within that , one transect of 50-m long was established . At three growth stages including vegetative , flowering and seeding , 5 samples along each transect was randomly selected , cut at ground level and put in paper bags and bring into laboratory for chemical analysis . Samples were oven dried at 65℃ , ground to pass through a 0 .8-mm screen . The Crude protein (CP) content was determined using the Kjedahl method (AOAC 1984) . Crude Fiber (CF) was determined using the method described by AOAC (1984) . Data analysis was done by SPSS v .15 (SPSS Inc . , Chicago , USA) using a full factorial model , where growth stage and management systems were regarded as fixed factors and CP and CF were separately considered as dependent variables . Mean comparisons were done using Tukey's test .

Result and discussions As indicated in Figure 1 , the highest CP was found at moderate grazing in vegetative stage , where CF was at medium level , relative to other growth stages . In flowering and seeding stages , the percentages of CP was also relatively high , where , CF was medium to high . Though the number of flowers at flowering stage in extensive grazing was considerably lower than in moderate grazing and exclosure , the CP was highest in this stage and CF was lowest . This might be explained by two facts : 1) in extensive grazing , this species as a tolerant species , tries to compensate defoliation by recovering photosynthetic portion , therefore , the new stems and leaves would have a relatively higher CP , as in vegetative stage , and 2) in extensive grazing , the urination of livestock is high , thus , the amount of N and consequently CP increases . Considering the amount of CP and CF in three growth stages , it seems that moderate grazing is a better option than the other two management systems to increase forage quality .

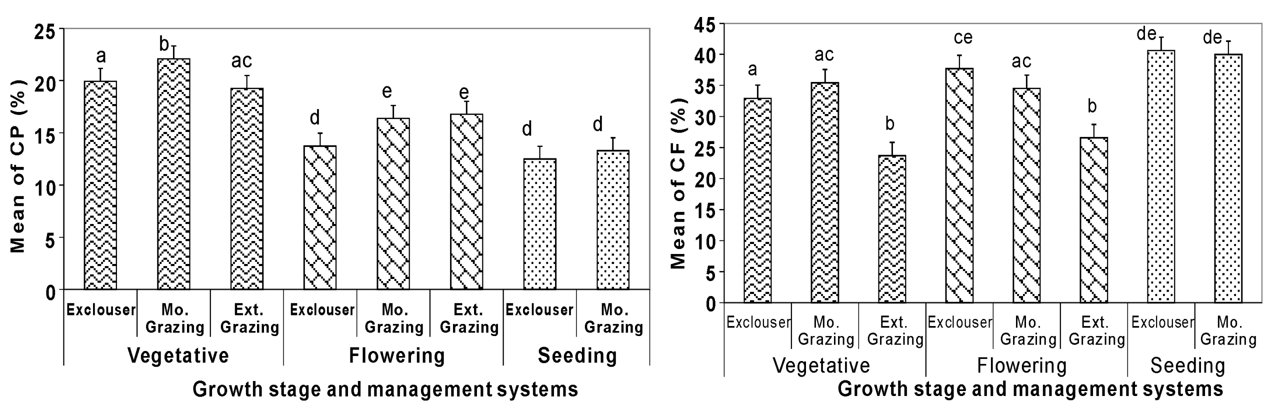

Figure 1 *Crude protein (CP) and crude fiber (CF) as two indicators of forage quality at three growth stage and management systems . Different small letters above bars show significant ($P \leqslant 0.05$) differences between values .*

Conclusion Overall , it seems that moderate grazing is a better management option than exclosure and extensive grazing in forage quality point of view .

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Evaluation of grazing intensity effects on mineral nutrients grassland soils (a case study grassland Golestan province of Iran)

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Key words: grazing intensity, mineral nutrients, reference (control) site, key (moderately grazed) site, critical (heavily grazed) site, grassland

Introduction Soil is one the most important factors to resistance of Rangeland area and prepares an adequate nutrients and moisture for this ecosystem during all seasons. Effect on soil chemical elements and plants flora are the most important damages in grassland due to over grazing.

Bauer, 1987 reported that organic carbon in heavily grazing was lower than control area, According Frank etal,. 1995, there were no significant differences between control, heavy and medium grazing on decrease of soil nitrogen. Menezes etal, 2001 also studied same report, between these treatments.

Materials and methods Sampling The watershed was sub-divided into three sub-sample areas according to grazing history and condition: a reference (control) area has been exempted of livestock grazing for over 30 years (1970-2004). Stocking rate for the moderately grazed (key site) and heavily grazed (critical site) sites were 1 and >3 sheep ha^{-1}, respectively, for 30-years. Sub-sample areas have similar climatic conditions, topography, soil texture and parent materials. Data were recorded in a single representative area of 5 hectares for each range condition category during the grazing season and all through the year from 2003 to 2005. Each representative sampling area of 5 hectares was subdivided into 5 notional strata of 1 ha each according to the slope gradient from top to bottom, and numbered from 1 to 5. Data were collected from five replicates (one in each stratum).

Annual mixed soil samples from all representative sampling areas were collected at 3 different periods (August, December and April) from March 2003 to the same time in 2005 (7 periodic soil samples for each soil layer of 0-15 cm and 15-30 cm). In each sampling period 15 mixed soil samples from representative sampling areas were collected by steel cylinders of 1 meter height and 60 mm diameter. The range of total nitrogen, absorbable phosphors and absorbable potassium of soil were measured in the laboratory according standard methods.

Statistical analysis SPSS software was used for statistical analysis.

Results Statistical analysis showed that there was significant differences between range of total nitrogen, absorbable phosphors and absorbable potassium of soil in different depth and time periods ($P<0.05$) also statistical analysis showed that the amounts of total nitrogen, absorbable phosphors and absorbable potassium of soil in depth of 0-15 cm was more than 15-30 cm.

Discussion and conclusion The amount of total soil nitrogen in control area was more than other area such as critical and key sites especially in depth of 0-15 cm during two years because of plant bloom and maximum Root growth in the surface. Grazing intensity will caused absorbed phosphors in the soil because of increases of natural fertilizers due to cattle.

The amount of potassium also will be decreased during over grazing in the control area because of potassium transfer from depth to surface of soil in these points.

Acknowledgment The author would like to thanks colleagues at the Islamic Azad University, Qaemshahr branch for their helps and supports.

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Methane emissions from Inner Mongolian Cashmere goats at different dietary nutrient levels

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Key words: maintenance level, Ad libitum, Inner Mongolian Cashmere goat, Methane, SF_6 tracer technique(SF_6)

Introduction Inner Mongolian is a dominating breeding base of Cashmere goats in China. According to the statistics yearbook, the population of total Cashmere goats was 28.087 million and 38% of the goats are in Inner Mongolia(2005), which exist on desert grassland with poor biogeocoenosis, where the Ash, crude fiber and lignin contents of pastures is higher than that of other grassland, so the special breed of Cashmere goat was acclimated. Inner Mongolian Cashmere was named the best inartificial fiber and economic value is considerable. So the numbers of Cashmere goats were increasing year by year, but the methane emission of Cashmere goats was still evaluated by models in China and the data of in vivo had not been reported by now. So the objective of this study was to measure methane emission of Cashmere goats on maintenance level and at ad libitum intake using SF_6 tracer gas technique, in order to obtain methane emission exactly to provided datum for programming methane emission list and feasible Mitigation Strategies.

Materials and method 8 Cashmere goats were 1.5 years old and weighed 30±1 kg(mean SEM). The experiment was designed as a randomized complete block with two treatments, i.e on maintenance level and at ad libitum intake, with four goats in each block individually. The experiment consisted of a 21-d pre-experiment stage and a 15-d experiment stage; The diets consisted of 20% Alfalfa +80% Chinese Leymus and Licking brick (containing minerals, and vitamins), the residual pastures of ad libitum should be more than 15% of total dry matter intake. The diet was offered twice daily at 5:30 am and 5:30 pm respectively and free to water. Quantities of feed offered and refusals were recorded daily for each animal and Samples of diets and refusals were retained weekly for determination of DM content. Methane emission was measured by SF6 trace technique according to Kristen Johnson (1994). The concentration of methane was determined by Gas Chromatography(GC-9A), Det(FID), 200℃; Inj, 120℃; Col, 65℃; Standard, 20.36 ppm; the sample (0.02ml) was injected onto the GC column via a dead volume gas Micro liter Syringe. The concentration of SF_6 was determined by Gas Chromatography(GC-2014), Det(ECD), 300℃; Inj, 100℃; Col, 60℃; Standard, 97.00ppt; the sample (1ml) was injected onto the GC column via a dead volume gas Micro liter Syringe.

Results Methane emission of Cashmere goats at different dietary nutrient levels showed in table 1, Daily CH4 emissions per animal was fed Alfalfa/Chinese Leymus pastures were greater at ad libitum intake than on maintenance level ($P<0.05$), but methane emission expressed every kilogram DMI is not significant different ($P>0.05$) and MCR is higher on maintenance level than at ad libitum intake($P<0.05$).

Table 1 *Methane emission of Cashmere goats at different dietary nutrient levels.*

Item	Maintenance level	Ad libitum	Significant
DMI, kg/d	0.581±0.107	0.839±0.088	P<0.05
g/(goat.d)	10.43±1.67	15.07±2.62	P<0.05
g/kg of DMI	18.06±1.44	17.71±1.48	NS
MCR, %	8.98±0.42	6.28±0.17	P<0.05

Conclusions Methane emission of Cashmere goats increased with increasing of DMI; when Cashmere goats were fed Alfalfa/Chinese Leymus pastures, the methane emission was 10.43g/d (maintenance level) and 15.07g/d (ad labium), which were indexes of methane emission list for Cashmere goat in China.

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Grazing behaviour of yak (*Bos grunniens*) in warm-and cold-season paddocks of *Potentilla fruticosa* alpine rangeland in Northern Qinghai-Tibetan Plateau

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Key words : yak , grazing behaviour , two-season-rotational grazing , alpine rangeland , Qinghai-Tibetan Plateau

Introduction Authors have been investigating the behaviour of yaks (*Bos grunniens*) , botanical diversity and material circulation in rangelands of Qinghai-Tibetan Plateau (Hasegawa *et al* ., 2006 ; Song *et al* ., 2006) . Two-season-rotational grazing system between warm-and cold-season paddocks is increasing in Qinghai-Tibetan Plateau under settlement policy of nomads by Chinese government . In this study , grazing behaviour of yak cows was investigated in northern rangeland of Qinghai-Tibetan Plateau to evaluate the two-season-rotational grazing system .

Materials and methods This study was carried out in August and December , 2005 in warm-and cold-season paddocks (WSP and CSP) of *Potentilla fruticosa* alpine rangeland in Mengyuan Prefecture , Heibei State , Qinghai Province , China . Behaviour of 3 yak cows was observed on the grazing time and bite numbers in a patch and the numbers of steps in a patch , between feeding stations and between patches . Positions of 5 yaks were recorded by GPS .

Results WSP was significantly greater than CSP ($p<0.001$) in bite number per patch , bite rate in a patch , number of feeding station per patch and number of steps within a patch , and was significantly smaller than CSP ($p<0.01$) in number of steps between patches (Table 1) . Those two were not different in other items . Figure 1 shows the distribution of yaks in WSP and CSP . Distance of yaks from gateway of night paddock averaged 449.2 m in WSP and 334.2 m in CSP .

Table 1 *Grazing behavior of yak cows in rotationally grazed warm- and cold-season paddocks in alpine rangeland .*

Item	WSP[1)]	CSP[2)]	p[3)]
No . of patches observed	218	367	-
No of patches visited , patches/min	0.9	1.0	ns
Grazing time , sec/patch	55.9	52.4	ns
Bite number , bites/patch	67.4	37.2	***
Bite rate within a patch , bites/sec	1.2	0.7	***
No . of feeding stations , FS/patch	7.1	5.9	***
No . of steps within a patch , steps/patch	6.1	2.5	***
Step rate within a patch , steps/sec	0.17	0.16	ns
Moving time between patches , sec	10.5	8.6	ns
No . of steps between patches , steps	4.4	5.8	**
Step rate between patches , steps/sec	0.86	0.85	ns

Values are expressed as mean . [1)] WSP : paddock grazed in warm seasons and [2)] CSP : paddock grazed in cold seasons by yaks for over 20 years . [3)] * $p<0.05$, ** $p<0.01$, *** $p<0.001$ and ns= no significance by Wilcoxon test .

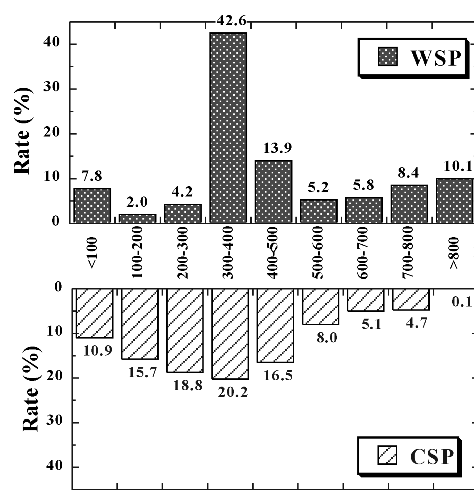

Figure 1 *Distribution of yaks in WSP*[1)] *and CSP*[2)] *by the distance from gateway of night paddock .* [1 2)] *Refer to Table 1 .*

Conclusions Behavioural difference of yaks between WSP and CSP was considered to show that yaks were not able to compensate the decreases of edible plants and intake even by changing grazing strategy in CSP .

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Grassland management for year-round grazing with regard to organic beef production in the warm regions of Japan

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Key words: organic farming, year-round grazing, *Panicum maximum*, *Lolium multiflorum*

Introduction Recently, Japan has been producing surplus manure because feed has been imported at 19 million TDN t/year despite the meager amount of manure that has been exported. The technique of using more manure in grasslands along with an appropriate ecosystem comprising the soil-plant-animal cycle is necessary. Organic farming technique is a typical example of such a method that uses only manure to maintain the fertility of farmlands. In this study, we considered the appropriate amounts of cattle and chicken manure that need to be applied in order to achieve productivity similar to that achieved by chemical fertilizer application; grazing grasslands of Guineagrass (*Punicum maximum* Jacq.) and Italian ryegrass (*Lolium multiflorum* Lam.) were studied to evaluate grassland productivity based on the daily gain of steers.

Materials and methods Two fields subjected to organic and conventional grassland treatments were used for the study. The conventional grassland (CG) treatment involved the use of chemical fertilizers and herbicides. For the Guineagrass grassland, chemical fertilizers were applied at rates of 10 kg/10 a and 5 kg/10 a×2 NPK as basal and supplementary applications, respectively; the rate of basal and supplementary applications for Italian ryegrass was 5 kg/10 a×4 NPK. The organic grassland (OG) treatment involved the use of cattle and chicken manure but no agrochemicals. Manure was applied at the same rate as that for the CG treatment, and cattle and chicken manure were used for both basal and supplement al applications. Italian ryegrass was sown on 20 Sep. at 6 kg/10 a, and Guineagrass (cv. Natsukomaki), on 20 Apr. at 2 kg/10 a. Two Japanese Black steers and a Japanese Brown steer were grazed on Italian ryegrass from 14 Nov. to 4 Jun. under the rotational grazing method (2—4-week cycles), and on Guineagrass from 4 Jun. to 2 Oct.. Concentrate was fed at approximately 2kg/head/day through the grazing period. Herbage samples were clipped within a 1 m×0.5 m frame at a stubble height of 5 cm. The samples were classified based on Guineagrass and dried at 70℃ for 48 h for measuring dry matter (DM) weight.

Results and discussion The production and consumption of Italian ryegrass were similar for the OG and CG treatments; however, the production and consumption of Guineagrass was lower as a result of the OG treatment than the CG treatment (Table 1). The daily gain of beef steers that grazed on Italian ryegrass were 1.08 and 1.00 kg/day for the OG and CG treatments, respectively. The daily gain from Guineagrass grazing were 0.87 and 0.75 kg/day for the OG and CG treatments, respectively. Live weight of beef steers that grazed on OG-treated grass was increased from 187 to 509 kg at the end of the year-round grazing period from 14 Nov. to 2 Oct.; the feed was at a concentration at 0.62 0.46% of the body weight. The production of Guineagrass was lower under the OG than the CG treatment; however, the daily gain as a result of grazing on OG-treated grass was higher than that for CG-treated grass. The increase in CP corresponding to the decrease in leaf length from April to July has been reported (Togamura et al). The average plant length of OG-treated Guineagrass was 5.1 cm shorter than that of CG-treated Guineagrass; this was one of the reasons for the higher daily weight gain observed in the case of grazing on OG-treated grass compared to CG-treated grass.

Table 1 *Productivity obtained using organic and conventional grassland treatments for Italian ryegrass and Guineagrass.*

	Production (gDM/m^2)	Consumption (gDM/m^2)	Daily gain (kg)	Live weight: Initial weight (kg)	Live weight: Weight on completionof the study (kg)	Feed concentration: (kg/head/day)	Feed concentration: (% body weight)
Italian ryegrass (14 Nov.—4 Jun.)							
OG treatment	1056.9	997.2	1.08	187	406	1.76	0.62
CG treatment	1094.6	1028.1	1.00	171	375	1.69	0.68
Guineagrass (4 Jun.—2 Oct.)							
OG treatment	1100.8	984.7	0.87	406	509	2.03	0.46
CG treatment	1415.5	1283.4	0.75	375	464	1.99	0.50

Conclusion The productivity based on the daily gain of steers in grasslands treated by the application of cattle and chicken manure was similar to or higher than that in those under the conventional treatment.

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Sheep recognize chewing easiness of grass leaves prior to prehension through sensing bending strength

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Key words: bending, biting force, impulse, shearing, sheep

Introduction Grazing animals choose plant parts which can be eaten quickly with ease. Grazing animals usually remove only uppermost parts of plants because of different resistances to defoliation imposed by the physical structure of plant tissue. The objective of this study is to clarify the effect of bending and shearing strengths of orchardgrass leaves on foraging behavior and analyze biting forces and impulse created by sheep.

Materials and methods Grazing trials were carried out using two Suffolk wethers aged 1.5 years. The same sward board previously reported by Hongo et al. (2004) and Hongo et al. (2007) was used for artificial construction of swards. During the grazing trials, fresh leaves of orchardgrass was cut in the early morning. Each leaf blade was clipped into three parts (basal, middle and apical parts). Five and ten leaves per loadcell were offered to sheep. Three-directional biting forces were measured when sheep foraged leaves. After grazing trials, bending, tensile and shearing strengths of leaves were measured. Bending strength (S) was given by the expression:

$$S = F_{max} L/4$$

where F_{max} is the maximum bending force and L is the span distance between two supports.

Results and discussion Total leaf length was 641 ± 26 mm. There were significant differences between three parts with respect to leaf width, thickness of midrib and cross-sectional area.

All mean values of biomechanical properties were significantly higher in the basal part than in the apical part, except tensile stress. Tensile stress was not significantly different between three parts. There was a significant correlation between bending strength and shearing work of fracture (Figure 1). It has been suggested that shearing property may be important during chewing of leaves. It strongly suggests that sheep *may recognize chewing easiness of leaves prior to prehension through sensing bending strength bite and adjust leaf number into a mouth and biting force. This hypothesis was supported by the result that* 72% of total 427 bites were completed by only one peak biting force.

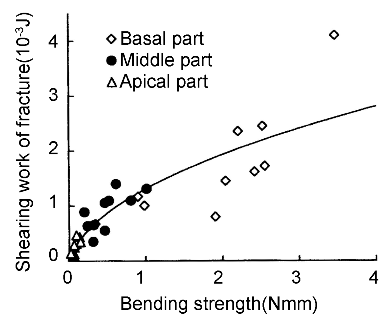

Figure 1 *Relationship between bending strength and shearing work of fracture at basal, middle and apical parts of orchardgrass leaves. Correlation equation was as follows:*
$Y = 1.5X^{0.5} - 0.19$
($r = 0.87$, $df = 28$, $p < 0.001$)

Sum of biting impulse was significantly different between three parts. Sum of biting impulse was 3.3 and 4.7 times higher at the middle and basal, respectively, than that at the apical part (Figure 2).

To assess the benefit/cost ratio in foraging behaviour, intake efficiency (DM weight per biting impulse) was calculated (Figure 2). The intake efficiency was significantly higher at the apical part than the middle and basal parts.

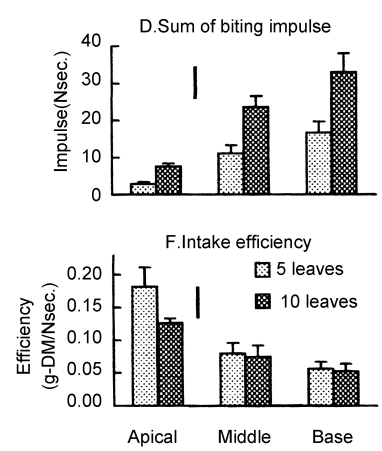

Figure 2 *Sum of biting impulse and intake efficiency (DM weight per biting impulse) in foraging basal, middle and apical parts of orchardgrass leaves.*

Biting force per one leaf created by sheep was 4.0-10.5 N. Tensile strength of one leaf was 17-69 N and shearing strength of one leaf was 1.3-4.4 N. These results suggest that sheep could break-down leaves principally by shearing force.

Conclusions Sheep may recognize chewing easiness of leaves prior to prehension through sensing bending strength bite and adjust leaf number into a mouth and biting force.

At prehension, sheep may break-down leaves principally by shearing force.

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Effect of grazing intensity and time on diet composition and intake of herbage in grazing sheep

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Key words : diet composition , intake , herbage , sheep , grazing intensity

Introduction Nutrient intake is the major determinant of nutritional status and production performance for grazing animals , The nutrient status of the herbivore depends on the nutritive value of the pasture available , botanical composition of the consumed diet and the intake of animal(DOVE ,1996) . In order to utilize pasture efficiently , both the quality of the herbage and the quantity consumed by animals should be known . Objectives of the present experiment were study the effect of stocking rate and time of grazing on diet composition and intake of herbage .

Materials and methods The study was conducted in semi-desert grassland in Siziwang Banner of Inner Mongolia . the total number of plant species recorded was about twenty species . *Stipa breviflora Griseb* , *Artemisia frigida Willd* and *Cleistogenes songorica Ohwi* were the dominant plant species in this area .

Treatments comprised two stocking rates (1 .82 and 2 .71sheep/hm^2) and three separate occasions (June , September and November) . 12 sheep (35kg liveweight) were grazed on natural grassland in 2004 .Pasture intake and diet composition for each sheep were determined by the n-alkanes technique(Mayes et al ,1986) .The animals were dosed twice daily with gelatine capsules containing 120mg of n-alkane C_{32} for fifteen days prior to and during the fours days of faecal collection . Alkane concentrations (C27 , C29 ,C31 , C32 and C33) were determined in faecal samples and pasture by gas chromatography . Non-negative least-squares procedure was used for assessing diet composition .

Results and discussion under the same grazing period , pasture intake of grazing sheep decreased with increase of the stocking rates ,The lowest intake was observed in November with heavy stocking . under the same stocking rates ,pasture intake decreased with pasture growth , Probably because of the lack of pasture on offer and its low quality during the winter .in addition Seasonal changes in botanical composition of herbage also affected intake of grazing sheep . The results showed that herbage intake was affected by grazing management ,herbage intake was higher for moderate grazing compared to heavy grazing , Grazing season had a relatively great effect on herbage intake .

Table 1 *Pasture intake of grazing sheep under two stocking rates(kg/d) .*

Item	1 .82sheep/hm^2			2 .71sheep/hm^2		
	June	September	November	June	September	November
Intake	1 .77±0 .11^{ab}	1 .71±0 .03^{ab}	1 .14±0 .14^{c}	1 .82±0 .06^{ab}	1 .52±0 .01^{b}	1 .07±0 .03^{c}

^{a,b,c} within a row means with different superscripts($p<0.05$)

Figure 1 showed the proportions of each dietary component averaged over the period from June to November 2004 .At two stocking rates grazing sheep had significantly high proportion of *Artemisia frigida Willd* 、*Cleistogenes songorica Ohwi* and low proportion of *convolvulus ammannii Desr* . *Stipa breviflora Griseb* was found lowest and almost not present in the diet in November .This could be related to diet selection by grazing sheep . The n-alkane technique revealed that grazing sheep had a predominant *Artemisia frigida Willd* diet ,The proportion of *Artemisia frigida Willd* in the diet achieved above levels of 0 .80 at two stocking rates .

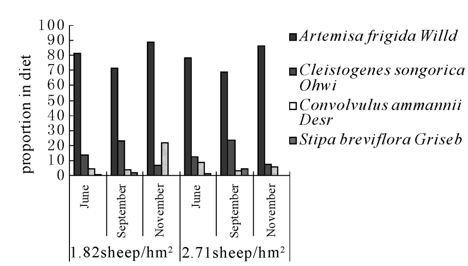

Figure 1 *Grazing sheep diet composition .*

Conclusions Grazing intensity and time had important role on diet composition and herbage intake in grazing sheep ,and grazing time had a relatively great effect .

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Seasonal changes on trace elements and analysis of their sufficiency or lack in Soil-Forage-Animal ecosystem in stud farm around Qinghai Lake

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Key words: Qinghai, trace element, content, soil-forage-animal ecosystem, seasonal changes

Introduction The study on research and utilization of trace elements about soil-forage-animal ecosystem in Qinghai province was little before, which limited the development of pleateu husbandry at a certain extent. So, we did the experiment about the seasonal changes of the system. It has significant meaning to take full advantage of superior natural conditions, increase local economic returns and improve ecological environment.

Materials and methods Six trace elements (Cu, Mn, Fe, Zn, Mo, Se) analyzed came from water, soil, edible grass (gained by fistula set on esophagus), wool and other organs in sheep such as plasma, liver, skeleton, etc. in Sanjiaocheng stud farm around Qinghai Lake. Cu, Mn, Zn, Fe were tested by ZAAS of 180-80 type and Mo, Se by OS of JP-2 type, statistical analysis was made by SPSS 11.5.

Results (1) The contents of Cu, Mn, Fe, Zn, Mo, Se vary with season. From genenal level, the soil is in critical lack of Cu (10.81±0.23~15.09±0.78 mg/kg), the same conclusion as Zhang C.J. (Zhang C.J., 1998); abundance of Fe (808.5 ~ 13085 mg/kg), serious lack of Se (0.08~0.31 mg/kg) and Mo is lower than normal level (Li G.H., 1995); (2) According to Grass Classification index (Zhou Z.Y., 1990; Li G.H., 1995), in edible grass, contents of Cu, Mn, Fe, Zn, Mo are all higher in summer than in autumn and than in winter, except for Se; Contents of Fe (43.51±32.25~385.81±183.16 mg/kg), Mn (27.94±7.58~102.92±33.70 mg/kg) are higher and Zn (8.33±3.09~32.96±8.56 mg/kg), Mo (0.31±0.06~0.93±0.21 mg/kg) are in critical lack condition in three seasons, but it lacks Cu (27.94±7.58 mg/kg) in winter and lacks Se (0.01±0.07 mg/kg) in summer specially; (3) Contents of six trace elements in sheep hair changed with season too. The change regulation of Fe (92.83±24.86~283.46±218.69 mg/kg) is the same as in soil and in edible grass, that is in normal level (Li G.H., 1995). Cu (1.87±0.32~4.51±1.61 mg/kg), Mn (4.17±2.15~10.36±4.87 mg/kg), Zn (75.65±10.04~101.19±7.31 mg/kg), Mo (0.016±0.09~0.52±0.14 mg/kg) are all lower than normal level (Li G.H., 1995), Se is enough (0.30±0.19 mg/kg) in summer while lack seriously (0.002±0.079 mg/kg) in winter, which is significantly lower than value of lack, 0.079mg/kg (Li G H, 1995) ($p<0.01$); (4) The content level in sheep is nearing lack of Cu, plenty of Fe, and serious lack of Se from plasma and other organs such as liver, heart, lung, etc. of three seasons.

Conclusion The soil is in the condition of lack of Cu, Zn, Mo, Se in the stud farm around Qinhai Lake. In edible grass, expect for Cu is lack in winter and Se lack in summer, Mn and Fe can meet animal need completely while Zn and Mo meet the need basicaly. It is in such nutritional condition for sheep that the level of trace elements is plenty of Fe, lack of Cu, nearing lack of Zn, Mo and serious lack of Se. The trace element additive including Cu, Zn, Mo, Se is suggested to supply for grazing sheep in the stud farm around Qinghai Lake.

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Phosphorus accumulation in soil surface under Japanese lawngrass (*Zoysia japonica* Steud .) pasture

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Key words : P accumulation , Japanese lawngrass , P adsorption , P mineralization

Introduction Much attention is paid to the pasture of Japanese lawngrass in Japan because it is maintained with saved labor and without tillage or fertilizer . To clarify the mechanism of such sustainable production , nutrient flow in the pasture has to be investigated . Kaneko *et al* . (in press) suggested that P might be accumulated from the deeper soil profile into the soil surface in the pasture of Japanese lawngrass . The aim of this study is a comparison of soil P distribution from soil surface to 1 m in depth between the places of Japanese lawngrass and the places of other sward characteristics in the same pasture . This comparison enables us to discuss the P accumulation into soil surface by Japanese lawngrass plant .

Materials and methods This experiment was conducted at a Japanese lawngrass predominant semi-natural rotational grazed pasture for Japanese Black breeding cattle on Silic Andosols with an inclination of 5 6 degrees in Field Museum Tsukui (Kanagawa prefecture) of Tokyo University of Agriculture & Technology . Soils were taken at five points in dominated (JL) and not dominated (NJL) by Japanese lawngrass respectively , on 8th May 2007 . At each point , soils were taken from four soil profiles (1st : 0-25 cm , 2nd : 25-50 cm , 3rd : 50-75 cm , 4th : 75-100cm) . The soil were sieved through a 2 mm screen and air-dried . Air-dried soil was used to determine total P (TP) , modified Bray No . 2 P (BP) , Olsen P (OP) , water-soluble P (WP) , phosphatase activity (PA) , total carbon (TC) , total nitrogen (TN) and soil pH . All P was determined colorimetrically by the ammonium molybdate method .

Results and discussion Table 1 illustrates the values of measurements in four soil profiles of Japanese lawngrass pasture . Differences between 1st layer and deeper soil profiles in all measurements were significant ($p < 0.05$) . TP , BP and OP under JL tended to be higher than under NJL at 1st and 2nd layer , though the differences were not significant . TP and BP under JL tended to be lower than under NJL at 3rd and 4th layer . These suggested that P accumulation , especially inorganic P accumulation , in soil surface might be higher under JL than NJL . BP under JL was lower than under NJL at 3rd layer ($p < 0.01$) . At 3rd layer , pH under JL was also lower than under NJL ($p < 0.01$) . The difference in the pH may have affected the difference in the BP . The tendency of lower TC under JL than under NJL suggested lower organic matter of soil under JL . PA values suggested the higher ability of the soil P mineralization at 1st layer than deeper soil profiles and the similar ability of the soil P mineralization under JL with NJL .

Table 1 *The values of measurements in soil profiles of Japanese lawngrass pasture .*

Layer (cm depth)	Total P ($g\ kg^{-1}$)		BP ($mg\ kg^{-1}$)		OP ($mg\ kg^{-1}$)		Total carbon ($g\ kg^{-1}$)		PA ($\mu mol\ g^{-1}\ h^{-1}$)		pH	
	JL	NJL	JL	NJL	JL	NJL	JL	NJL	JL	NJL	JL	NJL
1st (0-25)	2 .68	2 .37	134 .6	102 .2	104 .5	66 .7	37 .3	41 .2	3 .23	3 .38	5 .96a	5 .78b
2nd (25-50)	1 .52	1 .41	37 .3	32 .6	41 .5	26 .5	27 .7	29 .6	1 .23	1 .27	6 .32	6 .29
3rd (50-75)	1 .05	1 .12	5 .1a	6 .5b	5 .8	5 .2	22 .5	26 .7	1 .06	1 .07	6 .20a	6 .38b
4th (75-100)	1 .09	1 .19	6 .2	7 .5	6 .5	5 .5	25 .7	30 .9	1 .48	1 .11	6 .28	6 .34

Each value is mean value of 5 points measurements . JL : Japanese lawngrass dominated . NJL : Non-Japanese lawngrass dominated . BP : modified Bray No 2 method P . OP : Olsen method P . PA : acid monophosphatase activity . Letters indicate significant differences ($p < 0.05$) .

Conclusions The distributions of TP , BP and OP suggested that inorganic P was accumulated into the soil surface under JL more than under NJL . Mineralization of organic P and inorganic P adsorption rate of soil on Andsols might have played important roles on the P accumulation in soil surface under Japanese lawngrass pasture .

Reference

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The effects of fermentation and split application of liquid swine manure on dry matter yield of Italian ryegrass and subsequent soil quality

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Key words: dry matter yield, soil quality, Italian ryegrass

Introduction Liquid swine manure is a low-price organic fertilizer. According to Song et al. (2006), the application of unfermented liquid swine manure(ULSM; high DM %) to winter crop increased dry matter yield more than that of fermented liquid swine manure (FLSM; low DM %), although there was no difference in soil quality between two DM concentrations. One time application of too much animal manure resulted in unbalanced soil base, salt contamination, and soil nutrient loss (Bracker, 1982). Studies were carried out to evaluate the effect of fermentation and split application of liquid swine manure fertilizer on the dry matter yield of Italian ryegrass and subsequent soil quality.

Material and methods Experiments were conducted in a forage crop field in Jeju Livestock Institute for Promotion, from November 2005 to May 2006, using split plot design. The main-plots consisted of two kinds of liquid swine manure fertilizer such as the unfermented LSM and the fermented LSM, while the sub-plots were composed of two times fertilizer application such as 100% basal fertilizer(BF) and the 50% BF and 50% top dressing(SA).

Table 1 *Dry matter yield and crude protein content as affected by application of liquid swine manure.*

TRT	DMY kg/ha	Crude protein Content(%)
Fermented		
BF*	2,538	10.1
SA**	2,583	10.4
Mean	2,561	10.3
Unfermented		
BF	9,662	9.6
SA	7,914	10.6
Mean	8,788	10.1
Main	0.010	0.770
Sub.	0.263	0.292
M×S	0.242	0.628

BF*: basal fertilizer, SA**: split application

Table 2 *Soil characteristics as affected by application of liquid swine manure in the pasture plot.*

TRT		OM	TN	Ava.	Exch.Cation(cmol/kg)			
		—%—		mg/kg	K	Ca	Mg	Na
Fermented								
BF*	5.6	136.9	0.80	57.3	0.79	2.62	1.41	0.23
SA**	5.5	134.2	0.75	44.3	0.82	2.58	1.39	0.19
Mean	5.6	135.6	0.78	50.8	0.81	2.60	1.40	0.21
Unfermented								
BF	5.6	134.2	0.76	36.9	0.71	2.51	1.20	0.20
SA	5.6	134.5	0.71	33.3	0.66	2.67	1.08	0.18
Mean	5.6	134.4	0.74	35.1	0.69	2.59	1.14	0.19
Main	0.838	0.075	0.004	0.254	0.266	0.680	0.096	0.103
Sub.	0.452	0.013	0.211	0.395	0.863	0.991	0.748	0.167
M×S	0.181	0.007	0.982	0.627	0.630	0.881	0.827	0.502

Results and discussion Italian ryegrass showed a significantly higher DM yield(70%) with the application of ULSM (Table 1) than with FLSH application(1.8DM %) ($p<0.01$). A similar result was obtained by Song et al.(2006). It is likely due to higher total nitrogen and total phosphorus contents of ULSM than in FLSH. The total N content of the soil in the field treated with FLSM (Table 2) was significantly higher than that with ULSM treatment ($p<0.01$). The split application of LSM significantly increased the soil OM contents, higher than with 100% BF application($p<0.05$).

Conclusions The application of unfermented swine liquid manure with a high DM content resulted in significant increases in Italian ryegrass DM yield, but the total N content of soil was lowered in the field applied with unfermented swine liquid manure than in the field applied with fermented swine liquid manure with a low DM content. The split application of liquid swine manure increased the soil OM contents, higher than with 100% basal fertilizer application.

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Processes in plant-soil system of coastal grasslands induced by management practice

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Key words: productivity, soil organic carbon, restoring of coastal grasslands

Introduction Coastal grasslands, on the west coast and islands of Estonia, are widespread but during the last 50 years reeds and bushes have overgrown the area, causing decrease in open coastal areas. The cause of diminishing coastal grasslands in Estonia is changes in agriculture. Agricultural practice has switched from extensive land use to intensive use to ensure the stabile quality and increasing productivity of fodder. The quality and yield from coastal grasslands is highly variable, dependent on soil properties, weather conditions, and plant associations, as well as on management practice. Management in coastal areas comprises mostly grazing but also cutting in some areas where the conditions for use of machinery are suitable. The goal of the work was to investigate the influence of management on coastal grasslands plant associations and soil characteristics.

Materials and methods In the West-Estonia coastal district 14 areas were selected with regard to coastal grassland management: continuously managed, restored, and not managed for long (for at least 15 years). Sample squares (20 in every 10 meters) were placed in an transect to investigate plant association parameters: botanical composition, species density, and productivity. By soil development, a depth of humus horizon was measured, and samples were taken to analyse the content of organic carbon (by Tjurin method). The stock of carbon was calculated according to the bulk density, depth of humus layer and content of organic carbon.

Results and discussion Soil-and biomass-forming conditions will change markedly based on management practices, cutting, or grazing. The trampling of cattle and their consuming biomass will change the amount of litter, the microclimate, soil moisture, and air conditions——the humification process will accelerate. Plant associations dominating in managed grasslands were *Deshampsia-Caricetum nigrae*, *Elytrigietum repentis* and *Junco-Claucetum*. By restoring of coastal grasslands the changes in plant cover are fast, the biomass production will be lower mostly due to disappearing of plant associations having hudge biomass like *Phragmitetum australis* and *Festucetum arundinaceae-Phragmitetum* prevailing in not managed grasslands. The number of species was highest on managed grassland and lowest in not managed whereas the restored grassland stayed between of them. Biomass productivity was similar for managed and restored grasslands (3 t ha^{-1}) and was much higher in not managed grasslands (6.3 t ha^{-1}) (Figure 1B).

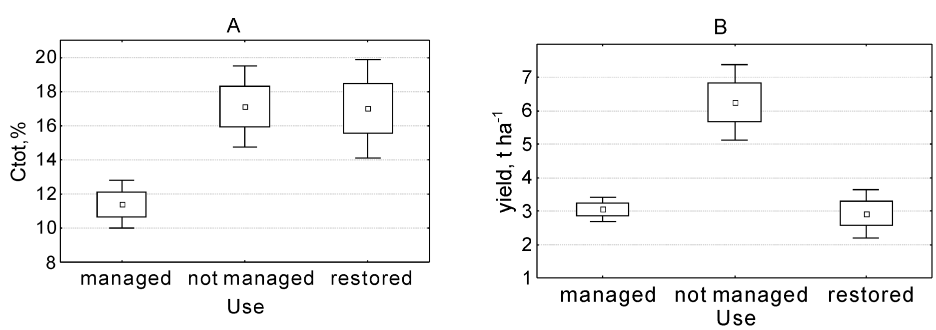

Figure 1 *The content of organic carbon in top layer of coastal grassland soils (A); and the plant biomass (yield t ha^{-1})(B) by different management regime; mean, mean ± SE, mean ± 1.96* SE are presented on the figures.*

By restoring the management practice in coastal grasslands the speed of changes in soil characteristics is quite slow despite to remarkable reduce of organic matter added to the soil. The content of organic carbon in topsoil shows similar values (17%) by not managed and restored grassland being significantly higher as in managed grassland soil (11%) (Figure 1A). Wet (stagnic) conditions are not favourable for organic matter mineralization and therefore these areas are restoring carbon. The stock of organic carbon in managed grasslands reached up to 67 t ha^{-1} where the share of carbon accumulated to the top layer of soil was 66%. Carbon sequestration was similar for not managed (136 t ha^{-1}) and recently restored grasslands (122 t ha^{-1}). The share of carbon in top layer was between 24 and 30%, so that mostly the carbon was stored in deeper horizons in soil profile.

Conclusions Restoration of coastal grasslands will have quick influence on aboveground biomass and number of species, changing it more similar to the managed grasslands. Soil characteristics have not so quick response to the restoration of management, as the most investigated indicators stayed similar to the not managed grasslands.

Long-term cattle grazing effects on soil chemistry in the Rough Fescue grassland

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Key word: Rough Fescue grassland, soil OC, soil nitrogen, soil phosphorus, soil pH, soil soluble ions

Introduction The Rough Fescue grasslands in western Canada are highly productive but sensitive to summer grazing. This can lead to overgrazing and subsequently soil degradation, which includes increased soil crusting, reduced soil infiltration, and enhanced soil erosion susceptibility (Manzano and Návar, 2000), which results in the loss of soil nutrients. Therefore, an experiment was conducted to investigate the effects of 58-yr of cattle grazing on soil properties in a Rough Fescue grassland.

Materials and methods The study site was at the Department of Agriculture Research Substation, Stavely, Alberta Canada with a semiarid climate. Annual mean precipitation was 494mm (from 1997 to 2007). The vegetation is classified as the Fescue Grassland (*Festuca campestris* (Rydb.) Association. Soil is Orthic Black Chernozemic and has a clay-loam to loam texture. Three treatments were established in 1949 consisting of fields representing a (i) non-grazed exclosue (CK), (ii) moderate grazing (MG), and (iii) heavy grazing (HG). The fields (MG and HG) were grazing by cattle from about May 15 to November 15 at 2.4 and 4.8 animal unit month ha^{-1}, respectively. In May 2007, Soil C, N, P, pH, electrical conductivity (EC) and water soluble ions were determined to the 60 cm depth for each treatment. The MIXED procedure from SAS (SAS Institute Inc. 2005) was used to analyze the data as a randomized complete block design with grazing effects. Tukey's test was used for all mean comparisons.

Results Soil organic carbon (OC), total P (TP) concentrations and Cl^- at all depths were higher ($p<0.05$) in the CK than in the grazing treatments whereas the total N (TN) concentration at all depths was lower ($p<0.05$) in the CK than in the grazing treatments (Tables 1and 2). Soil soluble K^+ at all depths was higher ($p<0.05$) in HG treatment than CK and LG treatments, Soil pH values were higher ($p<0.05$) in grazing treatments than in the CK (Table 1). There was no grazing effect ($p>0.05$) on soil EC, available N (NO_3 N and NH_4 N) and available P (AP) concentrations, soluble Mg^{2+}, Na^+ and SO_4^{2-} at all depths (Tables 1 and 2).

Table 1 *The effect of long-term cattle grazing on soil pH, EC, C, N and P concentrations in the Rough Fescue grassland.*

Indicators	P	CK	MG	HG
pH	0.00	6.45b[1]	7.10a	7.30a
EC($dS\ m^{-1}$)	0.20	0.12a	0.17a	0.19a
OC(%)	0.01	5.57a	4.58b	4.29b
TN(%)	0.04	0.52b	0.60a	0.59a
TP($g\ kg^{-1}$)	0.10	0.85a	0.74b	0.77ab
NO_3 N ($mg\ kg^{-1}$)	0.22	3.62a	5.47a	5.86a
NH_4 N ($mg\ kg^{-1}$)	0.52	7.85a	8.61a	8.30a
AP($mg\ kg^{-1}$)	0.44	3.08a	4.19a	3.73a

Table 2 *The effect of long-term cattle grazing on soil soluble ions ($mg\ kg^{-1}$) in the Rough Fescue grassland.*

Indicators	P	CK	MG	HG
Ca^{2+}	0.10	28.26a[2]	82.93a	59.26a
Mg^{2+}	0.29	5.69a	9.31a	8.42a
Na^+	0.13	19.31a	12.27a	12.95a
K^+	0.02	21.98b	25.23b	38.71a
Cl^-	0.02	27.25a	19.53b	16.79b
SO_4^{2-}	0.34	13.23a	9.77a	11.04a

[1 2] Means within row having different lower case letters are different at $P<0.05$ probability levels.

Conclusions Fifty-eight years of cattle grazing had a major impact on the concentration of soil nutrients in the Rough Fescue grassland. Soil C and P significantly decreased ($p<0.05$) both in the MG and HG treatments compare to CK. Loss of C and P in soil is indicative of soil deterioration and suggests that HG is not sustainable.

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Diet selection and intake of yak (*Bos grunniens*) in warm-and cold-season paddocks of *Potentilla fruticosa* rangeland in northern Qinghai-Tibetan Plateau

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Key words : yak , diet selection , intake , two-season-rotational grazing , alpine rangeland , Qinghai-Tibetan Plateau

Introduction Two-season-rotational grazing system between warm-and cold-season paddocks has been spreading as accompanied by the decline in nomadism in Qinghai-Tibetan Plateau . It was reported for this system that deterioration of vegetation was greater in warm-season paddock than in cold-season paddock (Li *et al* ., 2006 ; Li *et al* ., 2007) . In this study , diet selection and intake of yak (*Bos grunniens*) cows were investigated in the rangeland of northern Qinghai-Tibetan Plateau to evaluate the two-season-rotational grazing system .

Materials and methods In warm-and cold-season paddocks (WSP and CSP , respectively) in *Potentilla fruticosa*-dominant alpine rangeland of Mengyuan Prefecture , Heibei State , Qinghai Province , vegetation was evaluated by line transect and quadrat methods . All of feces of 3 yak cows was collected during 3 consecutive days to evaluate diet selection by microscope technique and intake by AIA method in August and December , 2005 .

Results Thirty seven species of plants appeared in WSP and 44 in CSP . Yak grazed 19 plant species in WSP and 16 in CSP . *Kobresia* spp in WSP and *Poa* spp in CSP were greatest in proportion in diet (PD) value but *Astragalus* spp was greatest among plant species in Preference index (PI) and Ivlev's electivity index (IEI) values in WSP and CSP (Table 1) . PD value was significantly correlated with proportion in paddock value both in WSP and CSP ($r=0.909$, $r=0.934$, respectively , $p<0.0001$) , however was low in correlation with PI and IEI ($p>0.05$) . Herbage intake of yak cow was 33.4 gDM/kgBW/day in WSP which was significantly greater than 20.5 gDM/kgBW/day in CSP ($p<0.05$) .

Table 1 *Selection by yaks of major herbaceous plants in rotationally grazed warm-and cold-season paddocks in* Potentilla fruticosa*-dominant alpine rangeland .*

Species (genus)	Proportion in paddock[1]		Proportion in diet		Preference index		Ivlev's electivity index	
	WSP[2]	CSP[2]	WSP	CSP	WSP	CSP	WSP	CSP
Kobresia spp .	22.67	7.55	28.85	13.26	1.27	1.76	0.12	0.27
Poa spp .	13.94	24.07	22.09	35.92	1.58	1.49	0.23	0.20
Ptilagrostis dichotoma	6.99	2.91	6.95	2.28	0.99	0.78	0.00	-0.12
Elymus nutans	5.61	8.60	5.52	8.28	0.98	0.96	-0.01	-0.02
Leontopodium nanum	6.64	3.31	5.35	6.92	0.81	2.09	-0.11	0.35
Astragalus spp .	1.96	1.11	5.29	6.33	2.70	5.70	0.46	0.70
Stipa purpurea	2.25	9.45	5.21	14.06	2.32	1.49	0.40	0.20
Lancea tibetica	2.81	0.56	3.20	0	1.14	0.00	0.06	-1.00
Polygonum spp .	2.25	5.77	3.11	1.91	1.38	0.33	0.16	-0.50
Carex spp .	4.17	7.04	2.87	2.54	0.69	0.36	-0.18	-0.47
Potentilla spp .	9.29	2.79	2.79	1.36	0.30	0.49	-0.54	-0.34

[1] Importance value ; [2] WSP : paddock grazed in warm seasons , and CSP : paddock grazed in cold seasons by yaks for over 20 years .

Conclusions It was suggested that diet selection by yak was affected by vegetation greater than palatability of plant speces and herbage intake of yak was not sufficient for fertility especially in CSP .

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Alternative perennial legumes on acid soils in southern New South Wales, Australia

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Key words: herbage yield, frequency, persistence, farming system

Introduction Farming systems in southern NSW have traditionally relied on annual pasture legumes in phased rotation with crops to act as a disease break, restore soil fertility and soil structure and provide high quality feed for livestock. Lucerne (*Medicago sativa* L.) is the most widely grown perennial legume in the mixed farming system due to its high nutritive value to animals and its ability to fix nitrogen. However, lucerne is unable to grow on acid soils, or poorly drained soils, or in areas where grazing is not well controlled. Alternative perennial legumes are needed to incorporate into phased farming systems to increase profitability and achieve sustainability.

Materials and methods Twenty best-bet" perennial legume species/accessions (entries, Table 1) were selected based on previous work on acid soil and waterlogged soil (Li *et al*. 2007) and evaluated at Berremangra (34°46′07″S, 148°27′06″E, alt 342 m) near Bookham in New South Wales, Australia. The long-term annual rainfall is 667 mm. Soil type is a dermosol (Isbell 1996) with pH_{Ca} 4.7 at 0-5 cm and 4.5 at 10-20 cm. The exchangeable Al was 5% and 13.2% for 0-5 cm and 5-10 cm, respectively. Seedling numbers at establishment, herbage yield and plant frequency were measured in 2005-2007.

Results The site was highly acidic with a short period of waterlogging in winter during wet year. When established in 2005, the site received above average rainfall, followed by 2 years of drought with less than half the long term average rainfall. Two *Lotus corniculatus* accessions (Goldie and composite) and *Trifolium uniflorum* demonstrated superior persistence and productivity (Figure 1). *Trifolium uniflorum* was the only species with a satisfactory ground cover (frequency of 16.3%) in the third autumn after two years of drought (data not shown). *Lotus tenuis* and *T. fragiferum* SA42951 had moderately high frequency, but very low herbage yield. The soil was too acid for lucerne to survive.

Table 1 *Perennial legume species evaluated at Berremangra near Bookham, New South Wales in 2005-2007.*

ID	Species	ID	Species
1	*Cullen australasicum SA*4966	11	*Medicago sativa cv. Aurora*
2	*C. tenax SA*35778	12	*M. sativa caerulea SA*38052
3	*Dorycnium hirsutum SA*33717	13	*M. sativa falcata composite*
4	*D. pentaphyllum composite**	14	*M. sativa SA*38082
5	*Hedysarum boutigynanum SA*13265	15	*M. suffruticosa SA*6529
6	*Lotus corniculatus Composite*	16	*Onobrychis viciifolia cv. Othello*
7	*L. corniculatus cv. Goldie*	17	*Securigeria varia SA*17002
8	*L. corniculatus cv. Steadfast*	18	*Trifolium fragiferum SA*38076
9	*L. cytisoides SA*12951	19	*T. fragiferum SA*42951
10	*L. tenuis composite*	20	*T. uniflorum composite*

* Composites represent 2-4 accessions selected to represent the variation within a species.

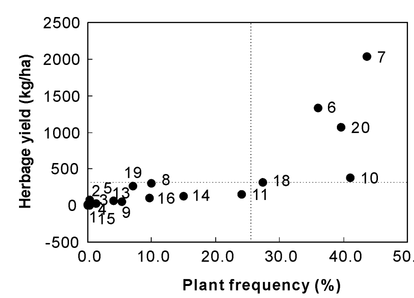

Figure 1 *Relationship between plant frequency and herbage yield for sown species in year 2. Entry numbers for each point correspond to the ID numbers given in Table 1. Dotted lines indicate the 5 highest ranked entries either to the right of the vertical line or above the horizontal line.*

Conclusions *Lotus corniculatus* Goldie was the most productive cultivar with the greatest persistence that is suitable for the hostile environment tested. Further breeding/selection work is needed to improve flowering and seed set in the low latitude areas due to short day length. *Trifolium uniflorum* may be useful to provide ground cover in sloping landscapes to protect against soil erosion, and as a perennial legume component in perennial grass or annual pasture mixtures for intensive grazing enterprises. But seed harvest of this species would be very difficult due to its very prostrate growth habit.

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Antagonistic interactions between foliar endophytes and root mycorrhizal symbionts of *Lolium perenne*

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Key words: Quantitative PCR, high sugar ryegrass, phosphorus supply

Introduction Lack of information on grass-endophyte-mycorrhizae interactions, mainly due to technical limitations for accurately estimating fungal concentrations, hampers our understanding of the symbionts effects on host metabolism and growth. By using quantitative polymerase chain reaction (qPCR) (Rasmussen et al., 2007), the complex interactions have been studied in perennial ryegrass cultivars differing in sugar content and under different phosphorus (P) supply levels.

Materials and methods The experiment consisted of 2 grass cultivars (high sugar, control) ×3 *N. lolii* endophyte treatments (nil, Lp19, AR1) ×3 mycorrhizal treatments (nil, *Glomus mosseae*, *G. intraradices*) ×2 P levels (high, low) ×10 replicates. Plants were grown in sand medium for 12 weeks in a climate chamber. Concentrations of endophytes in blades and stubble, and of mycorrhizas in roots were estimated by qPCR of genomic DNA, using endophyte specific chitinase, *G. intraradices* specific alkaline phosphatase and a *G. mosseae* specific phosphate transporter as target genes.

Results Under low P supply, mycorrhizal concentrations were significantly lower in endophyte infected plants compared to endophyte-free controls, and higher in the high sugar cultivar compared to the control cultivar (Figure 1). Endophyte concentrations in both leaf blade (Figure 2A) and stubble (Figure 2B) were significantly reduced by *G. mosseae* (mos), but not by *G. intraradices* (intra) compared to mycorrhizal-free controls (nil). Endophyte concentrations were also lower in the high sugar cultivar as well as under high P supply.

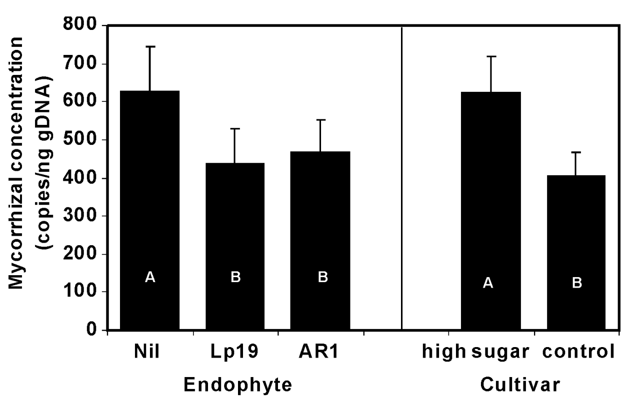

Figure 1 *Treatment effects on mycorrhizal fungal concentration under low P conditions.*

Conclusions Our results are direct evidence for antagonistic interactions between foliar endophytic and root mycorrhizal fungi. It was also shown that the degree of colonisation by both fungal symbionts in ryegrass associations is regulated by the carbohydrate content of plants and by phosphorus levels in soils.

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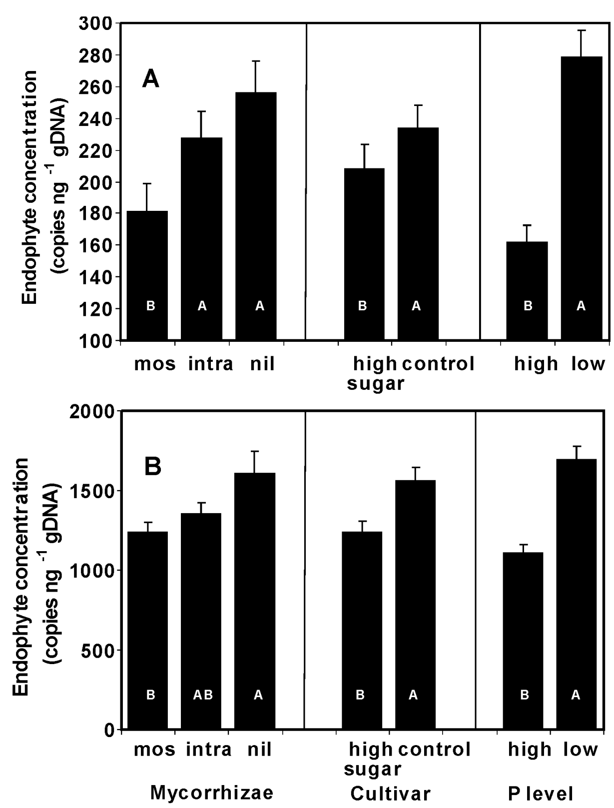

Figure 2 *Treatment effects on endophyte fungal concentration in leaf blade (A) and stubble (B).*

Dynamics of seedling emerging and survival rates of *Stipa baicalensis* steppe :community under two utilizing regimes

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Key words: *Stipa baicalensis* steppe, seedling, survival rate, grazing, hay-making

Introduction The emergence and survival of seedlings are the bases of grassland innovation. Seedlings were produced from seed rains, or soil seed bank. Only when seeds germinate in soil, then become seedlings, grow into juvenile plants, and finally develop into mature plants that could affect the characteristics of community. The seedling emerging and survival were affected by many factors like management (Brys, 2004). *Stipa baicalensis* steppe was utilized through grazing and hay-making. Both regimes had different effects on producing and survival of seedlings.

Materials and methods The study was undertaken in a *S. baicalensis* steppe near Wulagai River in the eastern Inner Mongolia meadow steppe. The steppe was divided into two paddocks by the fence-one grazing paddock (GP) that was grazed by sheep and cattle yearly for many years and one hay-making paddock (HP) where the plants were mowed for hay in each autumn for three years and was grazed shortly in winter. In each paddock a 2500 m^2 study site was selected and thirty five 1/4 m^2 quadrats were randomized fixed inside of the site respectively. Same perennial plant species were observed in HP and GP site, and no annuals were found. The observation was carried out for two growing years. Six observations were done in First year (rainfall 486 mm), and three in Second year (rainfall 190 mm). On each observation all new seedlings were labeled by different colourful metal points one by one and mortality seedlings were recorded.

Results In the First year most seedlings emerged after middle of June because concentrated rainfall kept the soil moisture suitable. The numbers of new seedlings between any two observations and accumulated new seedlings, as well as survival seedlings in HP site were significant higher than in GP site ($p<0.01$) (Table 1). Also HP site had higher seedling survival rate. In spring of the Second year the wintering rates of total seedlings in HP and GP were 36.0% and 17.7% respectively. Based on total seedling numbers on Sep. 10 before winter the survival rates were 17.9% and 8.6% for Aug. 10 observation, and 14.5% and 4.6% for Sep. 10 respectively, showed significant difference ($p<0.01$). Because of the dry weather in Second year the total new seedlings in both HP and GP were only 90.3/m^2 and 74.7/m^2.

Table 1 *New emerged, accumulated, survival and accumulated survival seedlings (no./m^2) and their survival rate.*

Seedlings	May 30		Jun 15		Jul 1		Jul 15		Aug 25		Sep 10	
	HP	GP	HP	GP	HP	GP	HP	GP	HP	GP	HP	GP
New emerged s.	1.2	0	0.4	0	56.8	30.8	90.8	33.2	63.6	32.4	97.2	47.6
Accumulated s.	1.2	0	1.6	0	58.4	30.8	149.2	64.0	213.2	96.4	310.0	144.0
Survival s.	0	0	0	0	48.8	23.2	84.4	23.2	61.6	28.8	97.2	47.6
Survival rate(%)					85.9	75.3	93.0	69.9	96.9	88.9		
Accumulated survival s.			1.2	0	50.0	23.2	134.4	46.4	196.0	75.2	293.2	122.8
Accumul. survival(%)			75.0		85.6	75.3	90.1	72.5	91.9	78.0	94.6	85.3

Conclusions Different regimes had different effects on steppe seedling emerging and survival. The total survival rates in both HP and GP were very low. Steppe for hay-making was considerably better to keep seedling quantity than for Grazing. So it is necessary to practice both regimes rotationally in one steppe in some regular years.

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Sward allowance at early lactation of primiparous dairy cows : III-Metabolic profiles

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Key words : early lactation , primparous dairy cows , metabolic profiles

Introduction Major adaptive changes occur during the transition period (3 weeks before and after calving) to cope with the high energy demands of lactation . This transition from pregnant nonlactating state to the nonpregnant lactating state represents a dramatic change for the cow , as nutrients requirements exceed dietary intake potential , and thus , a state of negative energy balance is established to provide additional substrate for milk production . First calving cows recover from the negative energy balance period with more difficulty than multiparous cows (Meikle et al . 2004) and this factor is usually more dramatic under grazing conditions . Dry matter intake (DMI) is a main factor affecting energy balance , and sward state largely affects DMI under grazing (Chilibroste et al . , 2005) . The metabolic variations that occur during the peripartum period can be monitored by the concentration of some metabolites in blood . In this study the effect of daily sward allowance on metabolic profiles and its relation with milk production and evolution of body condition score (BCS) was investigated in primiparous cows under grazing conditions .

Materials and methods The experiment was carried out at the EEMAC Research Station , Agronomy Faculty , Uruguay (30° S) . Primiparous dairy cows (n=44 , BW=595±41 kg , age at calving=2 .96±0 .11 years and BC=3 .7±0 .3) were blocked by BW , age and BC , and randomly assigned from calving up to 60 days in milk to one of the following treatments (n=11 each) : controls with a 100% TMR diet (ad libitum) and the grazing treatments , high (HA , 30 kg DM cow day^{-1}) , medium (MA , 15 kg DM cow day^{-1}) and low sward allowance (LA , 5 kg DM cow day^{-1}) . The grazing treatments were supplemented with TMR to cover their maintenance requirements . All the cows were individually supplemented at 18 :00 h with a mixture of corn silage (10 kg) compound feed (4 .8 kg) and grass hay (0 .4) on a fresh weight basis . Cows were milked at 5 :00 and 16 :00 h and were allowed to graze between 8 :00 and 15 :00 h every day on a 7-days rotation schedule on a pasture of mixed grasses and legumes . BCS was registered weekly (scale 1=emaciated , 5=fat) . Blood samples were taken every weekly from one month before to 2 months after calving . Plasmatic levels of total protein , albumin , urea , non esterified acids (NEFA) , β-hydroxybutyrate (BHB) and cholesterol , determined every 2 weeks during the experimental period . BCS and metabolites were analysed as repeated measurements in time using Proc MIXED of SAS v . 8 .

Results and discussion In all groups NEFA levels increased around calving and were associated with loss in the BCS . NEFA levels were higher in HA and MA reflecting more lipid mobilization which is in line with an important BCS loss observed in these groups during the first two weeks after calving . The BHB increase was observed later than NEFA increase which could be related to cetogenesis , but also with diet composition since in the Control group (100% TMR) BHB concentrations were lower than the grazing groups . Cholesterol , total protein , and albumin concentrations decreased around calving probably due to the lower intake during this period (Cavestany et al . 2005) . Cholesterol levels were higher in HA and MA than in LA , and it is known that cows in better energy balance (BCS) have more cholesterol levels . On the other hand , Control cows presented the lowest cholesterol levels and had the highest BCS : this could indicate that other factors such as nutrition have a direct effect on cholesterol concentrations . Urea concentrations were higher in control and HA groups , which were the groups with the best nutritional offer . A similar trend occurred in plasma protein levels , but it was significant only in Control cows .

Conclusions This study shows that different sward allowances determined different metabolic profiles which were associated not only with BCS but also with nutrient intake .

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Soil-plant-animal interrelationships and the mineral status in grazing cattle with the new agro ecological conditions in Cuba

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Key words : interrelationships , soil and plant nutrition , agro-cological

Introduction In Cuba , cattle grown in areas with different nutritional deficiencies in nitrogen and minerals . Environmental conditions , the management practices , and salt and salinity have differing affects on the soil and plant quality which is reflected in animal production and reproductive responses .

Results In the present paper soil-plant-animal interrelationships and the mineral status were studied in west and east grazing cattle areas in Cuba . The principal soils in both regions were acid or lightly acid and pH values varied from 4 .5 to 6 .5 . The organic matter contents differed between the areas and the principal averaging below 3 .5% . An important relationship was found between the soil pH and the mineral concentration in grasses . In eastern areas the available P in soils was below the critical limits , and the concentration in grasses varied from 0 .09 to 0 .15% . The Mn decreased when soil pH increased and the animal requirements in general were not satisfied In the central region there was a notable Cu deficiency in plants which affected the reproductive behavior and milk production in heifers and dairy cows . In theeastern region we found P , Na , Zn , Cu , and Fe deficiencies , and these were related with blood indices and reproductive responses . The utilization of a premix of the deficient minerals increased the haemoglobin and hematocrit levels in blood and reproductive responses .

Conclusion It is concluded that the environmental conditions affect the soil-plant-animal relationship and the mineral status in grazing cattle areas . At present , the mineral supplementation practices such as feeding nutritional blocks and legumes , mineral salt added to basal diet , and the silvopastoral system are used in order to satisfy the mineral requirements in grazing cattle .

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The effect of vegetative cover in the erosion prevention of a cattle trodden slope pasture

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Key words: vegetation cover, tiller density, soil loss, slope pasture, Japan

Introduction Grazing is the effective means of harvesting energy and protein from steep pastures in mountainous country. However, there are risks associated with the practice, such as degradation of the soils that sustain pasture communities. Details of the effect of vegetative cover of a grazed pasture on soil loss with runoff water are not clearly understood.

The loss of vegetative cover caused by grazing at high stock densities (Warren et al. 1986a) allows direct impact of raindrops on soils (Lal and Elliot, 1994). Damage to vegetation and soils by hoof trampling increases when cattle are grazed on moist soils (Betteridge et al. 1999). This paper reports a field study, designed to determine the effect of vegetative cover on soil loss with runoff water, of a slope pasture in the mountain trodden by cattle, untrodden with vegetative cover and untrodden with no vegetative cover.

Materials and methods An experiment was conducted in Japanese mountain pasture to quantify the effect of vegetative cover on soil loss with runoff water. Four plots, each of 8m × 22m area, were fenced to exclude cattle from grazing. Duplicate plots of (20m × 2m) were with no vegetation cover (Bare), and with 90, 70 and 40 percent vegetation cover of 8 cm pasture height trodden by zero, three or six cows of approximately 300 kg body weight for 15 minutes on steep pasture on 14 June and 30 September, 2004. Measurements included pasture cover, tiller density and soil loss in runoff water.

Results and discussion Pastures with no vegetation cover and with 40 percent vegetation cover resulted in a greater soil loss with runoff water. Increased soil sediment loss with runoff water mainly resulted from the area with no vegetation cover and with low vegetation cover (Figure 1a). Runoff ratios for the low and high trodden plots and bare plot were higher than vegetative plot. Nevertheless sediment loss from the low trodden plot was low compared to the high trodden plot (Figure 1b) showing a similar runoff ratio. Results indicate that vegetation cover negatively act to soil surface by reducing the raindrop impacts and the runoff water entrainment.

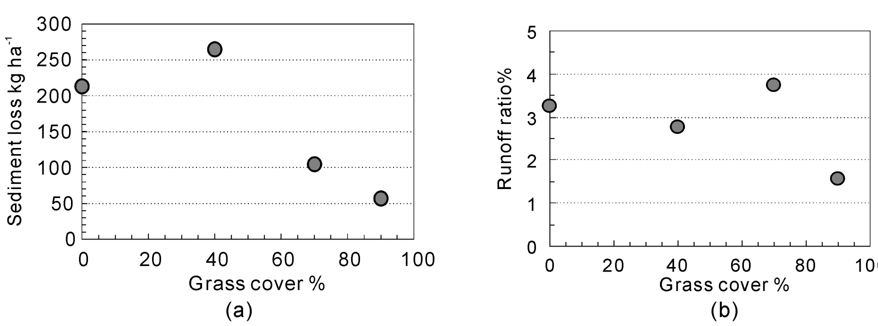

Figure 1 *Relationship between grass cover and soil sediment loss (a) and between grass cover and runoff ratio (b) from control, lightly and heavily-trodden, and bare-ground sites of steep pasture during the months July to November (values are total of the months), 2004.*

Conclusions Pastures with high or moderate vegetation cover was less seriously affected than pastures with low vegetation cover or bare ground for soil loss, indicating that steep pastures with low vegetation cover or with bare places are more susceptible to soil erosion.

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Sward characteristics of dairy cows grazed at two stocking rates in agro-pastoral transitional zone of northern China

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Key words : dairy cow , grazing , stocking rate , sward characteristics , northern China

Introduction Studies on grazing pastures are limited and the mechanisms through which the dairy cows affect the sward characteristics associated with different stocking rates are poorly understood in North China .

Materials and methods The experimental site was located at the Guyuan Grassland Research Station of China Agriculture University , Hebei , northern China (41°46′N , 115°40′E , 1400 m a .s .l .) . The pasture was established in 2003 with a seed mixture of smooth bromegrass (SB) , western wheatgrass (WW) and Russian wild ryegrass (RW) and alfalfa (AL) . The stocking rate for lax grazing (LG) and moderate grazing (MG) was 2 .6 and 3 .8 cows ha^{-1} respectively . A simplified rotational grazing system was applied , with 3d grazing periods followed by 18d resting periods . Three quadrats were chosen at random in each plot at the end of each grazing cycle to investigate changes in vegetation cover , plant density , above-ground and root biomass , and botanical composition . Leaf and stem masses were measured on an individual plant basis .

Results and discussion Annual mean forage standing yield under LG was 7 .28% higher than that under MG . The proportion of AL and SB was consistently higher under LG than that under MG , while the percentage of WW and RW was slightly higher under MG . Mean canopy cover of all species in LG was slightly higher ($p > 0.05$) than that of MG . The change of leaf/stem ratio differed among stocking rates and growth stages . Mean leaf/stem ratio of all species was slightly higher ($p > 0.05$) in MG than those in LG . Leaf/stem ratio of all component species except alfalfa increased . The root biomass significantly decreased with the increased stocking rate (Table 1) . The total root biomass (0-30 cm) increased 2 .43and 2 .35 times for LG and MG from the initial to the end of the grazing period , but the difference between them was not significant ($p > 0.05$) . For both treatments , we found a strong vertical distribution of root biomass towards the upper 20 cm of the soil profile . This finding is in accordance with the observations of McNaughton et al . (1998) .

Table 1 *Sward characteristics by component and year for the two stocking rates .*

Year	Sward characteristics	AL		SB		WW		RW	
		MG	LG	MG	LG	MG	LG	MG	LG
2004	Botanical composition (%)	0 .13	0 .17	0 .60	0 .62	0 .07	0 .07	0 .15	0 .11
	Population density(point/m^2)	379	394	1750	1721	394	378	740	678
	Canopy cover (%)	13 .44	12 .32	49 .99	44 .96	5 .06	4 .80	11 .05	8 .09
	Leaf/stem ratio	1 .52	1 .36	2 .44	2 .62	1 .30	1 .29	2 .34	2 .59
2005	Botanical composition (%)	0 .26	0 .39	0 .55	0 .48	0 .03	0 .03	0 .14	0 .08
	Population density(point/m^2)	559	653	833	903	156	142	533	447
	Canopy cover (%)	40 .14	54 .21	51 .91	53 .68	3 .83	3 .39	12 .31	9 .85
	Leaf/stem ratio	1 .36	1 .23	4 .21	3 .71	1 .59	1 .50	5 .73	5 .58

Conclusions Obtaining and maintaining pasture productivity is a measure to sustain cow grazing systems . From a management perspective , adopting a rotational grazing system with lax stocking rate may improve the sward quality and indirectly increase the productivity of pasture in agro-pastoral transitional zone of northern China .

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Effect of stocking density of yak (*Bos grunniens*) on floral diversity and biomass of rangeland in northern Qinghai-Tibetan Plateau

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Key words: yak, stocking density, floral diversity, biomass, alpine rangeland, Qinghai-Tibetan Plateau

Introduction Degradation of alpine rangelands in Qinghai-Tibetan Plateau was reported by Song *et al*. (2006) and Li *et al*. (2006). It is considered that it has been caused by an increase in the numbers of domestic animals following the rise of human populations in addition to global warming. The purpose of this trial was to investigate the effect of stocking density of yaks in set-stock-grazing system on vegetation of rangeland in Qinghai-Tibetan Plateau for preventing the rangelands from deterioration and desertification.

Materials and methods Experiment was conducted in *Elymus nutans*-dominant alpine meadow which was utilized as cold-season-grazing paddock from 1996 to 2004 in Mengyuan Prefecture, Heibei State, Qinghai Province, China. From May in 2005, 3 one-year-old yaks were set-stocked in each of paddocks with different stocking rates of heavy (H), moderate (M), light (L) and control (C) treatments as given in Table 1. Vegetation was evaluated by 5 50 cm x 50 cm quadrats for each treatment and aboveground biomass were measured by cutting plants in quadrats which were classified into plant species and dried with electric oven in Augusts, 2005 and 2006.

Results and discussion Vegetation coverage was the highest in C among treatments followed by that in L in 2005 and 2006. Aboveground biomass was negatively correlated with stocking rate in 2005 ($r=-0.903$, $p<0.1$) and in 2006 ($r=-0.987$, $p<0.01$), and decreased significantly in M and L between 2 years ($p<0.05$). Richness index was the smallest in H among treatments but other items did not differed. It was considered that increase of intake which was caused by growth of yaks decreased dramatically aboveground biomass between 2 years especially in M and H by overgrazing.

Table 1 *Characteristics of plant communities in pasture under different stocking rates.*

Item		Treatment			
		Heavy	Moderate	Light	Control
Stocking rate, head/ha		6.25	4.11	3.23	0
Vegetation coverage, %	2005	82.5 ± 5.7^{c}	85.4 ± 3.6^{c}	90.0 ± 3.1^{b}	96.6 ± 2.3^{a}
	2006	70.0 ± 5.0^{d}	81.0 ± 4.2^{c}	94.6 ± 2.9^{b}	100.0 ± 0.0^{a}
Height of community, cm	2005	17.8 ± 4.4^{ab}	16.3 ± 3.7^{b}	19.8 ± 4.1^{ab}	24.1 ± 8.8^{a}
	2006	5.2 ± 1.3^{d}	8.9 ± 2.3^{c}	14.5 ± 4.9^{b}	25.4 ± 2.4^{a}
Aboveground biomass, gDM/m^2	2005	444.6 ± 134.6	473.9 ± 94.7	583.5 ± 167.4	601.1 ± 139.0
	2006	240.4 ± 91.2^{c}	280.0 ± 52.8^{c}	442.8 ± 84.4^{b}	626.4 ± 159.0^{a}
Richness index, No. of species/m^2		20.6 ± 9.1^{b}	26.0 ± 4.9^{ab}	28.2 ± 2.6^{a}	23.6 ± 3.2^{ab}
Shannon—Wiener diversity index		2.238 ± 0.821	2.454 ± 0.352	2.493 ± 0.213	2.550 ± 0.128
Simpson diversity index		0.825 ± 0.169	0.869 ± 0.053	0.886 ± 0.035	0.898 ± 0.012
Pielow evenness index		0.750 ± 0.146	0.754 ± 0.069	0.747 ± 0.053	0.808 ± 0.039

^{a,b,c}Mean±SD with different letters within a row differ significantly at $p<0.05$.

Conclusion From these results, proper stocking rate of mature yak older than 2 years old in set-stock-grazing system was estimated to be less than 1.8 head/ha for securing the enough intake during cold season.

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Flexibility nutrition substance dynamic of *Seriphidium transiliense* under three enclosure status

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Key words : enclosure , *Seriphidium transilienset* , soluble carbohydrate , starch , protein

Introduction *Seriphidium transiliense* , semi-shrub , mainly distributing in Xinjiang of China (Sun , et al , 2006) , had high feeding value in desert pasture of Xinjiang . Because of mainly utilized as spring-autumn pasture , degeneration of *S . transiliense* desert pasture was very serious and had became bottleneck of restricting the development of seasonal stock breading in North of Xinjiang . In order to protecting desert pasture , enclosure was applied . The dynamics changes and differences for flexibility nutrition substance of *S . transiliense* roots were compared among different enclosure status .

Materials and methods The study site located in Ashli country in changji city , Xinjiang (N43°49′～43°56′ , E87°02′～87°05′ , 700～1000 m above sea level) . Three treatments were done based on survey of *S . transiliense* desert pasture , namely perennial enclosure (no grazing at least 20 year , PE) , forbidding grazing (forbidding grazing in 2002-2004 , then began to grazing in May and June , Oct . and Nov . each year , FG) and continuous grazing (grazing in Apr . and June , Sept . and Nov . each year , CG) . Herbage root samples were collected in Apr . and Nov . 2006 . Solubility carbohydrate , Starch and crude protein concentrations of roots were respectively quantified according to the procedure of Li (2000) and Yang(1993) . Analysis of variance (ANOVA) was performed for differences through Duncan .

Results and discussion Lots of studies suggested that mowing and grazing could effect contents and distribution of plant hoarding substance , which could reflect strategy of adapting environment (Olson , et al , 1997 ; Loewe et al , 2000) . The hoarding substance of *S . transillense* under the three enclosure model was shown in Figure 1 . Soluble carbohydrate contents of roots emerged a single peak trend , and the highest contents was respectively 53 .4 , 36 .8 , 32 .6 mg/g for PE , FG , CG (Figure 1A) . Starch contents had obvious fluctuation , and appeared three inverse V type , but finished store before 17th Oct . (Figure 1B) . Crude protein contents appeared down-up-down trend , and the emerging date and duration of peak was different (Figure 1C) . Figure 1 showed that contents of soluble carbohydrate , starch and crude protein had significant difference among three enclosure status ($P < 0.05$) , and the sequence of soluble carbohydrate was PE>FG>CG , that of starch was PE>CG>FG . Crude protein contents of CG was higher than that of PE($P < 0.05$) , but FG appeared instability .

Conclusions Enclosure could accumulate contents of carbohydrate , and continuous grazing could stimulate the increase of crude protein . Reverting back to continuous grazing after short period enclosure was not benefit to the continual development of desert pasture .

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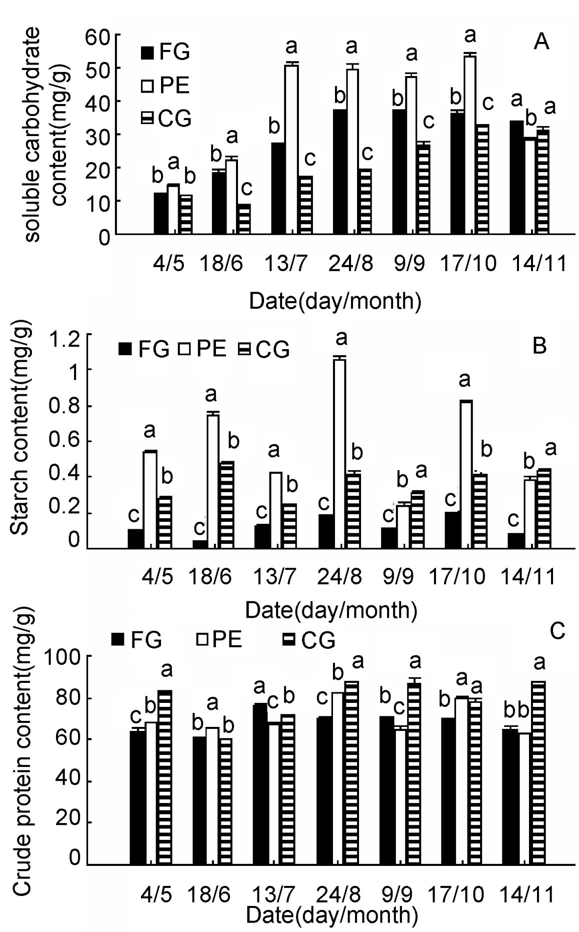

Figure 1 *Effect on flexibility nutrition substance of S .transillense roots under three enclosure status .*

Effects of cattle grazing on survival and regrowth of *Miscanthus sinensis* tillers

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Key words: cattle, defoliation, grazing intensity, *Miscanthus sinensis*, trampling

Introduction *Miscanthus sinensis* is one of the major native grass species in eastern Asia. Although it has been recognized that *Miscanthus* grasslands were maintained by moderate use (*e.g.*, cutting, burning or grazing), a long-term experiment recently indicated that the grasslands were deteriorated by cattle grazing (Hirata *et al*., 2007). This suggests that cattle grazing gives different impacts on *M. sinensis* in comparison with cutting. The aim of this study was to investigate the relationships between damages of tillers to *M. sinensis* by cattle grazing and deterioration of *Miscanthus* grasslands.

Materials and methods The study was conducted in early June (early summer), August (late summer) and September (early autumn) 2005, at a *Miscanthus* grassland (3.7 ha) in Kawatabi Field Science Center, Graduate School of Agricultural Science, Tohoku University. Nine paddocks (8 m × 8 m each) were established in the grassland. Before the grazing period in each season, *M. sinensis* tillers were categorized into either wintering tillers, first new tillers or second new tillers based on their height, and 40 tillers of each category were tagged. Two, 4 and 6 steers (mean BW was 270 kg) were grazed for 40 min in three paddocks in each season, to set grazing intensity for 14, 28 and 42 animal unit (AU) · days/ha. In mid-summer and early autumn, 56 and 84 AU · days/ha were also established by grazing again in the same paddock. After each grazing period, the degree of damage of the tillers (defoliation of leaves, defoliation of shoot apexes, or trampling of tiller) and the proportion of survival, and the heights of leaves were recorded.

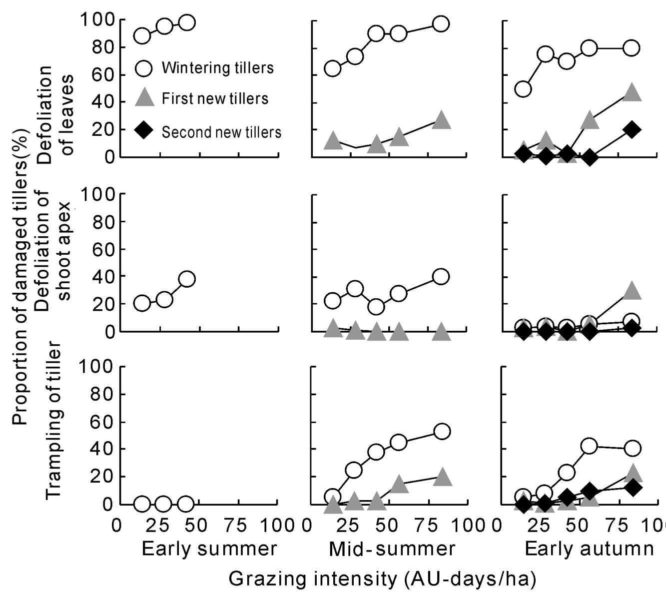

Figure 1 *The relationships of the degree of the damages (defoliation of leaves / shoot apex, and trampling of tiller) to grazing intensity.*

Results and discussion In wintering tillers, 50-98% of leaves and 20-48% of shoot apexes were defoliated over the grazing seasons (Figure 1). The percentage of trampling, which is specific to grazing condition, *increased with the increase of grazing intensity and reached* 40-53% in mid-summer to autumn in wintering tillers. The proportion of surviving tillers was lowest (15-27%) when their shoots were trampled. Mean height of leaves in the tillers, which reveals the degree of regrowth after last grazing period, decreased by both of the defoliation of shoot apex and the trampling. The relationships of total proportion of the defoliation of shoot apex and the trampling to grazing intensity (Figure 2) indicates that the damage of *M. sinensis* tillers was low when grazing intensity was less than 42 AU · days/ha.

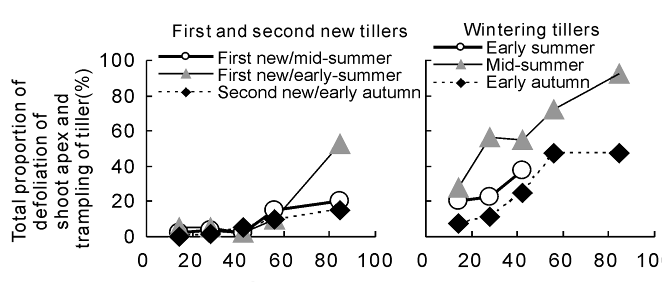

Figure 2 *The relationships of the defoliation of shoot apex and the trampling of tiller to grazing intensity.*

Conclusions The study indicates the sensitiveness of *M. sinensis* tillers to defoliation of shoot apex and the trampling by grazing cattle, and suggests that *Miscanthus* grasslands would be maintained if cattle was grazed at less than 42 AU · days/ha in autumn, by keeping down damages of plant parts which result in the deterioration of *M. sinensis*.

Reference

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Vertical distribution of plant parts and the selectivity of harvesting heights by cattle in *Miscanthus sinensis*

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Key words: availability, cattle, foraging heights, *Miscanthus sinensis*, vertical distribution

Introduction The previous study showed that survival and regrowth of *Miscanthus sinensis* tillers were sensitive to defoliation of shoot apex and the trampling by grazing cattle (Takahashi *et al.*, 2008). It is generally recognized that grazing herbivores select plant species and plant parts to maximize their intake rate (Gross *et al.*, 1993). However, there is little information on foraging response of herbivores to sward structure in the long grass, *M. sinsnsis*. The aim of this study is to understand the relationships between harvesting height of cattle and vertical distribution of plant parts in a *Miscanthus sinensis* grassland.

Materials and methods The study was conducted on June-July (summer) and September (autumn) in 2003, at a *Miscanthus* grassland (1.2 ha) in Kawatabi Field Science Center, Graduate School of Agricultural Science, Tohoku University. In the two seasons, eight steers were grazed in the grassland for 5-7 days at 29.7-37.8 animal unit (AU) · days/ha. Before grazing in each season, leaf density was estimated as frequency of occurrence measured for every layer at a 20 cm height interval from the ground in the canopy of *M. sinensis*, within 9 plots (50 cm×50 cm each). Standing crop (the mass of leaves and stems) was also measured by cutting within the plots. During each grazing period, the number of bites taken by steers was counted (3-14 hours, 3 days) by visual observation, and proportion of the bites in individual layers to the total bites was calculated.

Results and discussion Leaf mass was high in layers of 20-80 cm in summer (42-78 g DM/m^2), and nearly equal in individual layers of 0 80 cm in autumn (33-51 g DM/m^2) (Figure 1). Vertical distribution of leaf density was similar to that of leaf mass. Proportion of bites taken by steers was highest in layer of 20 80 cm (in which, leaf density was more than 84%) in both seasons. Leaf mass in individual layers was significantly related to leaf density of the layers (Figure 2; $P<0.001$), meaning that leaf density well revealed vertical distribution of leaf mass in *M. sinensis*. Proportion of bites taken by steers increased curvilinearly with increasing leaf density in individual layers (Figure 3; $P<0.001$). The result indicates that cattle strongly take bites from layers having more available leaf mass.

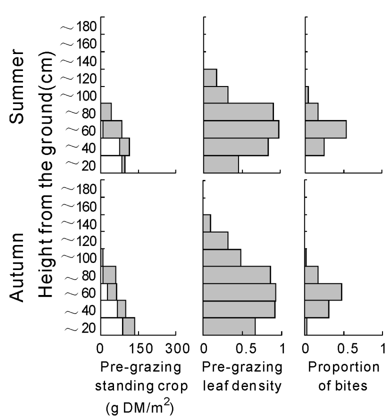

Figure 1 *Vertical distribution of leaf and stem in M. sinensis and proportion of bites taken by grazing steers.*

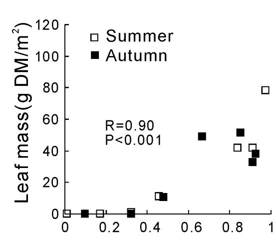

Figure 2 *The relationship of leaf mass to leaf density in the M. sinensis grassland.*

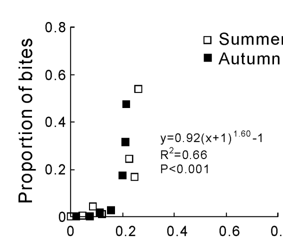

Figure 3 *The relationship of proportion of bites taken by grazing steers to proportion of leaf density in the M. sinensis grassland.*

Conclusions Grazing cattle selected the layers with high leaf mass in both seasons. This selectivity in harvesting heights probably gives severe impacts on *M. sinensis* (Takahashi *et al.*, 2008), which cause deterioration of *Miscanthus* grasslands.

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Germination response of different species to allelopathy on rangeland plants

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Key words : allelopathy , rangeland , herbage residue , aqueous leachate , germination , native species

Introduction Allelopathy is defined as any directly or indirectly beneficial or detrimental effect by one plant on another through production of chemical compounds that are released into their environment (Rice , 1984) . Allelopathy helps to elucidate the phenomena such as the composition and distribution of plants . The research in this area on rangeland is very scarce . The objective of this research was to assess the allelopathy through the germination response of different species to the aqueous leachate from residues of dominant rangeland plants .

Materials and methods Residues of *Stipa bungeana* Trin ,*Lespedeza davurica*(Laxm .) Schindl , and *Artemisa capillaris* Thunb were collected during July 2006 , air-dried and used as donor plants prepared for the aqueous leachate . Native species seeds of . *L . davurica* , *A .capillaris* , and *Potentilla bifurca* were receptor plants . All materials were from an agriculture and pasturage interlaced zone of Huanxian in the northern part of China . Three treatments were imposed with three replicates . The solutions were bioassayed at different concentrations (2 .5% , 5% , 10%) . Seeds of each species were germinated in Petri dishes and moistened with different concentrations . By using seed germination rate , germination speed and RI , we assessed their allelopathic potential . All data were analyzed with SPSS 13 .0 .

Results Aqueous leachate from residue of dominant species showed a significant inhibition of germination rate (Figure 1) and delay in germination speed (Figure 2) . When watered with each concentration of solutions , the allelopathy of Bunge Needlegrass was weaker compared with other two plants' aqueous leachate (Figure 3) .The results provide evidence for potential allelopathic inhibition by the three dominant species on their associated species by delaying or totally inhibiting germination depending on the concentration .

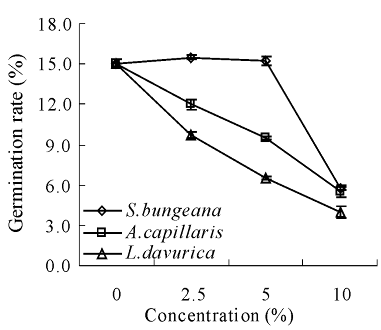

Figure 1 *The influence of aqueous leachates from three plant's residues on* P .bifurca *germination rate(P< 0 .05) .*

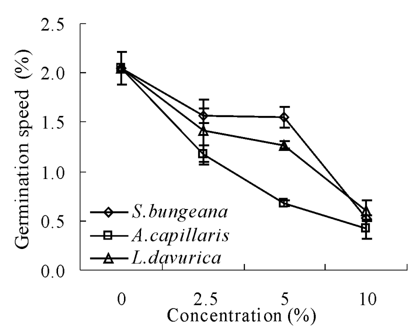

Figure 2 *The influence of aqueous leachates from three plant's residues on* P .bifurca *germination speed (P< 0 .05) .*

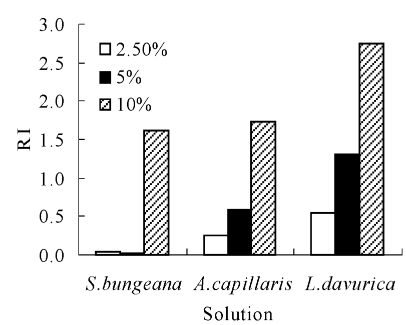

Figure 3 *The RI (response index) of three aqueous leachates to* P .bifurca .

Conclusions The population distribution structure and dynamics are not only affected by the environment but also affected by allelopathy which is the biochemical basis to aid stabilization of an ecosystem . Demonstrating the allelopathy in a natural ecosystem and exploring interconnections with other ecology processes influencing ecosystem functions will make a significant contribution to sustainable management of the natural resource .

Reference

Rice , E .L . , (1984) . Allelopathy . New York . : Academic Press . 421 .

Relation between vegetation and soil in West Azarbaijan rangelands of Iran

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Key words: Iran, classification, ordination, soil characteristics

Introduction In order to better understand and manage rangeland ecosystems, it is important to study the relationship between environmental factors and plants in these ecosystems (Jafari *et al*., 2003). The objective of this research was to study the relationships between soil characteristics and vegetation in order to find the most effective factors in the separation of the plant communities.

Material and methods Vegetation data including Abundance-Dominance were estimated within each quadrat (Table 1). Two-way indicator species analysis (TWINSPAN), was used to classification of vegetation into different groups. Soil characteristics including; PH, EC and OC (Table 1), were taken in each quadrat. Multivariate techniques including detrended correspondence analysis (DCA) was used to analyse the collected data (Torkan, 2006).

Table 1 *Ecological series for soil characteristics at Nazlochai Basin in West Azarbaijan rangelands of Iran*

No. Quadrat	7	16	1	19	6	11	4	13	17	3	15	2	9	20	10	18	8	14	12	5
OC	2.6	3.9	3.6	3.4	3.4	1.2	3.7	2.8	2.5	1.9	2	1.2	1.4	2.6	3.9	2.1	2.2	3.5	2	2.1
Ph	6	5.2	5.4	5.5	5.6	5.6	5.4	6	6.1	6.1	6.5	5.7	5.8	6	5.2	6.6	6.6	6.5	6.8	6.8
EC	2.3	1.9	2.7	2.7	1.4	1.7	2.7	3.5	1.1	1.5	3.7	2	3.3	2.2	2.1	3.7	3.7	2.4	3.2	3.4
Linum cartharticum		2	2	1	2		2	1					1							
Alopecurus pratensis	2			1		2			1	3		2		2						
Polygonum bistorta											1						1			2
Koeleria cristata			1		3		2								2			2		
Geum rivale	1			1	2			1	2			1								
Prunella vulgaris					1			2		1			3	2						
Scabiosa columbaria		2		2			1											1		
Campanula glomerata		2			1	2	2					3	2		1			1		
Festuca pratensis										2							1		3	3
Viola hirta		1		2		2	1	2					1					2		
Briza media			2	1	1			2				1			3					
Bromus tomentellus		2					1								3			3		
Festuca ovina	2			2	1	3			1	2			1	3						
Ajuga reptans						1		2	1				1	1						
Trisetum flavescens									3	1						3	2		2	
Thymus serpyllum		1	3	2			2								1			1		
Cirsium oleraceum		2							1		3					1	3		1	
Deschampsia caespitosa				2	1					2	3					2		1	1	

Results and discussion vegetation of the study area was classified into 3 groups. Each groups differs from the other in terms of its environmental needs. The results of DCA ordination (Figure 1) showed; PH is effective factors in the distribution of vegetation types.

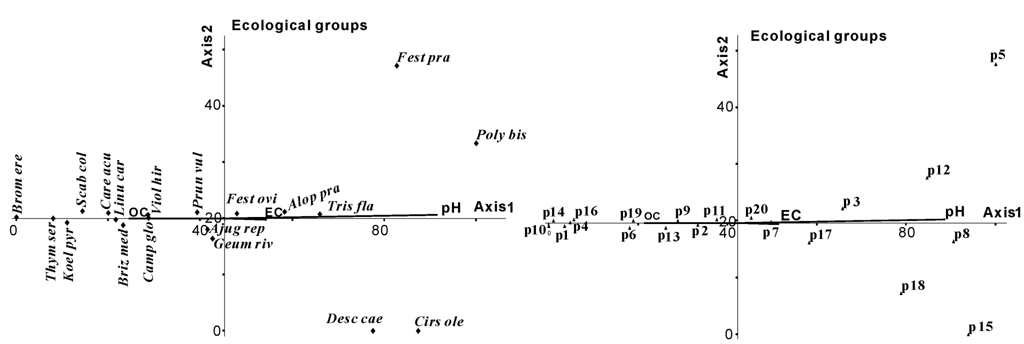

Figure 1 *DCA-ordination diagram of the vegetation types related to the soil characteristics in Table 1.*

Conclusions The results showed that the vegetation distribution pattern was mainly related to soil characteristics. Totally, considering the habitat conditions, ecological needs and tolerance range each plant species has a significant relation with soil properties. Analyzing ecological data using ordination methods (e.g. DCA) makes simpler understanding of the complex relationship between plants and environmental gradients. In addition, these methods prevent presence of ineffective factors and data complexity from affecting ecological models (Jafari et al., 2003).

Reference

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Effects of herbage species on the spatial heterogeneity of biomass in grazed pasture : Kentucky bluegrass vs . White clover

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Key words : calf , grazing pressure , *Poa pratensis* , rising plate meter , *Trifolium repens*

Introduction Recently , the spatial heterogeneity of plant biomass in grassland has been investigated from various approaches . However , those previous studies did not address the following aspect : if different plant species are grown in grassland , will the dynamics of spatial heterogeneity of the biomass differ ?' . This problem is important in evaluating the universality of the results of previous researches concerning the spatial heterogeneity of plant biomass . We investigated whether the different herbage species , for example Kentucky bluegrass (*Poa pratensis* L . , KB) and white clover (*Trifolium repens* L . , WC) , influence the spatial heterogeneity of the biomass in grazed pasture .

Materials and methods Three pastures (each 10 a in area) were established as follows : the first consisted of 30% KB-dominated pasture and 70% WC-dominated pasture , the second consisted of 50% KB and 50% WC , and the third contained 70 % KB and 30% WC by ground area . The grazing experiments were carried out in 7 successive days for periods I (from 8th to 15th May) , II (from 29th May to 5th June) and III (from 19th to 26th June) in 2006 . Three groups of two Holstein castrated calves (mean age 186±55 days and mean liveweight 154 .2±30 .7 kg) were the subjects for the study .Aboveground biomass was measured at 50 points in each area (KB or WC dominated) of the three pastures with a Filip's Folding Sward Meter (Jenquip , New Zealand) every morning (grazing period and the next day) . Behavioural observations were carried out in each test period (Fukasawa et al . , 2007) . The observers recorded which calf ate KB or WC during the morning meal and the evening meal on each observation day . In the results of the behavioural observations , the selectivity for each species area of the calf groups during each experiment period was stable . Therefore , we considered the following unit as grazing pressure : head · min · 8 h^{-1} · a^{-1} (liveweight 500 kg = 1 head) . The spatial heterogeneity of biomass was evaluated using SD (standard deviation) and CV (coefficient of variation) of the biomass (g DM 0 .25 m^{-2}) . We applied GLM (general linear model) to the SD and CV using the herbage species , average biomass , grazing pressure , paddocks , and experimental periods as autonomous variables .

Results and discussion Though the effects of herbage species on SD and CV were not significant , the effects of the interactions between herbage species , and paddocks and experimental periods were significant (GLM , $P<0.05$) . In both KB and WC areas , positive correlations were found between the average and the SD of biomass , between the CV of biomass and grazing pressure , and no significant correlations between the SD and grazing pressure (Table 1) . No significant correlations were found between the average and the CV in KB areas , while negative correlations were found in the WC areas . The results suggest that the spatial heterogeneity dynamics were apparently different between the KB and WC areas even in such a short term .

Table1 *Correlation matrix between average , SD and CV of biomass (g DM 0 .25 m^{-2}) , and grazing pressure (head · min · 8 h^{-1} · a^{-1}) on each of KB and WC areas .*

	KB			WC		
	Average	SD	CV	Average	SD	CV
SD	0 .82***			0 .52***		
CV	-0 .06	0 .51***		-0 .59***	0 .35**	
Grazing pressure	-0 .46***	-0 .18	0 .41***	-0 .52***	0 .07	0 .64***

** $P<0.01$, *** $P<0.001$.

Conclusion We should understand that the dynamics of the spatial heterogeneity of grasslands can be modified by the differences of herbage species .

Reference

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Changes in sward composition under different grazing management

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Key words: grassland, continuous grazing, cattle, Principle Response Curve, grazing intensity

Introduction Suitable grassland management and its intensity depended on present vegetation, local possibilities and our target goal. Grazing seems to be an interesting alternative to cutting in order to maintain species-rich grasslands.

Materials and methods Introducing intensive and extensive grazing on abandoned grassland was studied in years 1998-2004. Applied treatments were: intensive grazing (IG), 1st cut followed by intensive grazing (ICG), extensive grazing (EG), 1st cut followed by extensive grazing (ECG), and unmanaged grassland (U) as the control. Experimental paddocks were replicated twice. Relevés were made in permanent 1 m × 1 m plots using a continuous grid of nine 0.33 m × 0.33 m subplots in four replications in each paddock. Redunfdancy analysis (RDA) and principal response curves (PRC) in the CANOCO program was used to evaluate vegetation data.

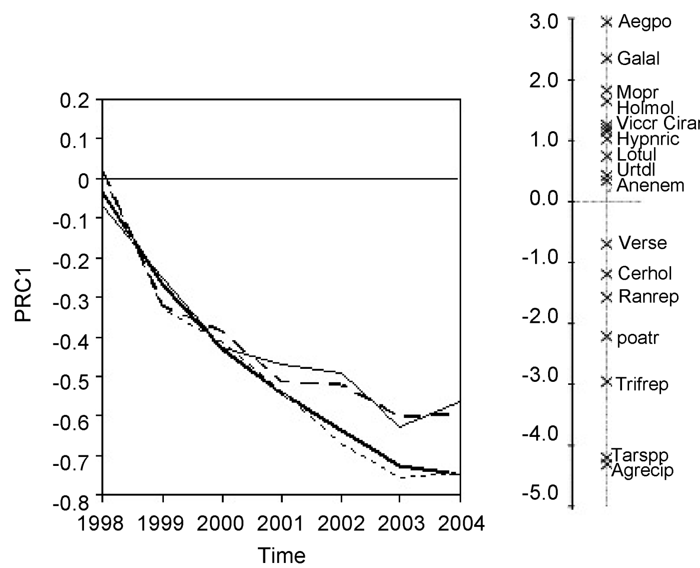

Figure 1 *PRC for different treatments ECG (_ _ _), EG (——), ICG (......), IG (——) during the experiment. The unmanaged treatment (U) was taken as a reference treatment. Abbreviation:* Aegpo-Aegopodium podagraria, Agrcap-Agrostis capillaris, Alopr-Alopecurus pratensis, Anenem-Anemone nemorosa, Cerhol-Cerastium holosteoides, Cirar-Cirsium arvense, Galal-Galium album, Holmol-Holcus mollis, Hypmac-Hypericum maculatum, Lotul-Lotus uliginosus, Poatr-Poa trivialis, Ranrep-Ranunculus repens, Tarspp-Taraxacum spp., Trifrep-Trifolium repens, Urtdi-Urtica dioica, Verse-Veronica serphylifolia, Viccr-Vicia cracca.

Results and discussion There was a shift from tall to short plant species in all managed treatments, which indicated the change in grassland community. PRC analyses based on RDA shows that diversification in plant species composition created by different defoliation occurred in the fourth year of the study (Figure 1). All management treatments with negative PRC scores have higher abundance of *Taraxacum* spp., *A. capillaris* and *T. repens*, whereas unmanaged plots become dominated by tall species *(Aegopodium podagraria, Galium album, Alopecurus pratensis, Holcus mollis, Vicia cracca, Cirsium arvense, Hypericum maculatum* and *Urtica dioica)*.

Conclusion Plant species composition of semi-natural grasslands is affected by the defoliation regime (Pavlů et al. 2007).

Ackowledgement This research was supported by MACR 0002700601 and MECR SP/2D3/179/07.

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Effect of grazing gradients on soil microbe variation in Inner Mongolia steppe

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Key words : typical steppe , livestock grazing , grazing intensity

Introduction Soil microbes are very important parts in grassland ecosystem . It forms a powerful dynamical resources store and plays a key role in plant residues decomposition , humus formation and nutrients transition and cycle . Numerous studies have suggested that grazing by livestock will influence soil physical and chemical qualities on grassland while soil microbe will promote nutrients transition under reasonable grazing density . we detected the variation of soil microbes .

Material and methods The site is located in Chifeng Dalinor National Natural Reserve of Inner Mongolia(116°38′～116°41′N , 43°25′～43°27′E) . Annual average temperature is 1～2 ℃ ,annual accumulate temperature over 10℃ is 1300～1700℃ . Vegetation type is *Leymus chinensis*＋*Stipa grandis*＋*Cleistogenes squarrosa* and dark chestnut soil . Four grazing gradients arranged from heavy grazing (HG) , moderate grazing (MG) , light grazing (LG) and no grazing (CK) . Soil samples for microbe analysis were collected to a depth of 20 cm by an auger of 8cm diameter and divided into three sections (0-5cm , 5-10 cm , 10-20 cm) . Three replicates in each grazing gradients and five points mixed . Soil microbe data in the study is the total number of three sections . Soil samples collecting for soil moisture , PH and bulk density is also divided in three sections just like the method of soil microbe . Statistical analysis was done by SPSS 15 .0 .

Results The trend of Bacillus was HG＞MG＞LG＞CK and there were no significant differences among grazing gradients(Table 1) .

Table 1 *Soil microbe variation (cfu / g dry soil)* .

Grazing gradients	Bacteria ($\times 10^6$)	Bacillus ($\times 10^6$)	Mold ($\times 10^4$)	Actinomyces ($\times 10^6$)	Bacterium of nitrogen fixation($\times 10^6$)
HG	4 .70±2 .04ba	2 .22±1 .18a	0 .83±0 .32a	3 .55±1 .23a	0 .87±0 .36ba
MG	4 .23±0 .70ba	1 .63±0 .64a	0 .66±0 .06a	3 .13±0 .43a	0 .86±0 .28ba
LG	7 .63±3 .81a	1 .56±1 .01a	1 .13±0 .44a	5 .16±0 .71a	1 .22±0 .27a
CK	2 .23±0 .32b	0 .64±0 .61a	0 .96±0 .28a	4 .77±1 .81a	0 .64±0 .08b

The same or different letters mean no significance or significant between different grazing gradients ($P < 0.05$)

Bacteria , bacillus , bacterium of nitrogen fixation are negatively correlated with soil moisture . Mold and Actinomyces are positively correlated with soil moisture . Mold and Actinomyces are positively correlated with soil pH(Table 2) .

Table 2 *Correlations between soil indicators and different microbial groups* .

Soil indicators	Bacterial	Bacillus	Mold	Actinomyces	Bacterium of nitrogen fixation
Soil moisture	-0 .352	-0 .498	0 .583*	0 .366	-0 .438
PH	0 .179	0 .044	0 .545	0 .467	-0 .243
Bulk density	-0 .081	-0 .297	0 .188	0 .051	0 .604*

Significant correlation on 0 .05 level .

Conclusions Grassland utilization will affect soil microbes . The variance of soil microbes in different grazing gradients is obviously . Soil microbe will decrease when grazing density increased . Soil microbial groups in LG are higher than that of other three gradients except Bacillus group . This result suggests that reasonable grazing density will increase microbial quantity . Soil environmental factors are positively or negatively affect soil microbial quantity . All the five microbial groups will affect by soil moisture . Mold and Becillus are mainly affected by soil pH . Bacterium of nitrogen fixation has a close relation to soil bulk density .

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Growth and P uptake of *Dactylis glomerata* L. and *Anthoxanthum odoratum* L. response to mycorrhizal inoculation in acid condition

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Key words: acid condition, *Anthoxanthum odoratum* L., mycorrhizal inoculation, *Dactylis glomerata* L., response

Introduction We found the AMF colonization of *A. odoratum* not correlated with soil pH, and coverage of *A. odoratum* strongly correlated with AMF colonization in our field study (Wu et al. 2006). In addition, we also found the mycorrhizal colonization, total spore number in rhizosphere of *A. odoratum* prominently higher than that of the *D. glomerata*, respectively. The spore density of *A. odoratum* and *D. glomerata* were of 15 and 4 spores per 10g fresh soil, respectively. Four different morphological types of spores occurred in rhizosphere of *A. odoratum* and only one morphological type of spore occurred in rhizosphere of *D. glomerata*. These results suggest that the *A. odoratum* invade and extend in severity acidic pasture origin of this specificity on arbuscular mycorrhizal symbiosis in acidic soil other than *D. glomerata*. In present study, we explored the effect of soil pH in mycorrhizal colonization, P uptake and growth of both plants by glasshouse experiment.

Materials and methods Plant materials: *D. glomerata*, is grass; *A. odoratum*, is weed. Treatment and soil modulate: all experiment include 2 (soil sterilized and non sterilized) x 4 (pH = 3, 4 (control), 5, 6) = 8 treatments. Cultivating soil collected from an acidic artificial pasture (pH = 4), soil sterilized by benomyl (Fitter and Nichols 1988), soil pH modulated by NaOH. Planting and harvest: 4 seedlings of *D. glomerata* and *A. odoratum* mixed planting to per pot respectively at 2 Jun 2003, all treatment harvested at 2 September 2003. Measures: The roots were stained with trypan blue / lactic acid and the mycorrhizal colonization (percentage of root infected by arbuscular mycorrhizal fungi) was calculated using the line-intersect method (Giovannettti and Mosse 1980). Shoot biomass and P content measured after drying at 70℃ with 48h. Experiment conducted in farm of college of Agricultural Science of Tohoku University, Osaki, Miyagi prefecture, Japan (38°45′N, 140°45′E).

Results Significantly positive correlation occurred in soil pH between Mycorrhizal colonization of *D. glomerata*, but the *A. odoratum* was not yet. A significantly positive correlation occurred in mycorrhizal colonization between shoot dry mass of both plants. Also a significantly positive correlation occurred in mycorrhizal colonization between shoot P content of both plants (Table 1).

Table 1 *Regression equations of some parameters of D. glomerata and A. odoratum.*

Plants	regression equations		
D. glomerata	$y_1 = 10.07x_1 - 24.70$, $r = 0.894$, $p < 0.0001$	$y_2 = 0.01x_2 + 0.23$, $r = 0.867$, $p = 0.0003$	$y_3 = 0.04x_2 + 2.32$, $r = 0.748$, $p = 0.005$
A. odoratum	$y_1 = 1.80x_1 + 20.05$, $r = 0.243$, $p = 0.446$	$y_2 = 0.01x_2 + 0.21$, $r = 0.778$, $p = 0.0029$	$y_3 = 0.07x_3 + 1.61$, $r = 0.797$, $p = 0.002$

y_1 Mycorrhizal colonization, x_1 soil pH, y_2 shoot dry mass, x_2 Mycorrhizal colonization, y_3 shoot P content, x_3 Mycorrhizal colonization.

Conclusions Based on these results, we concluded that the *A. odoratum* have a specific mycorrhizal symbiosis in acid soil condition. Mycorrhizal colonization of *D. glomerata* strongly affected by soil pH, but the *A. odoratum* was not yet, mycorrhizal colonization of *D. glomerata* significantly decreased by declined the soil pH, result to decrease the nutrient uptake, growth, acidity tolerance and competition ability of *D. glomerata*, conduced its declined. On the contrary, mycorrhizal colonization of *A. odoratum* not decreased by declined the soil pH, the mycorrhizal symbiosis led to a positive effect on nutrient uptake, growth, acid tolerance and competition ability of *A. odoratum*. Consider to *A. odoratum* invade and extend in severity acidic artificial pasture origin of this specificity on arbuscular mycorrhizal symbiosis in acidic soil other than *D. glomerata*. Our results have a important meaning and value reference on understand to mechanism of invade and extend in severity acidic artificial pasture by *A. odoratum* and declined of *D. glomerata* in same condition.

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Impact of grazing densities, animal types, supplemental feedings on forest-steppe pasture

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Key words: *Artemisia frigida*, grazing pressure, herbage consumption, pasture degradation, *Stipa krylovii*

Introduction The pastoral livestock production system carried on in natural open pastures in Mongolia has played a crucial role in the domestic economy. Socio-economic reform included the introduction of a market economy, which was accelerated in the early 1990s, exerted a large influence on the system: the livestock population continued to increase; it reached historical high 32.9 million in 1998; and the number of herders continued to increase in the 1990s. In the course of the changing, excessive grazing in natural pastures especially in and around centers was alarming as herders and livestock were more densely concentrated there than in other areas (Enkhamgalan, 1995). These situations, which have continued until today, may demonstrate the decreasing sustainability of the production system. Then, JIRCAS and Mongolian State University of Agriculture have been conducting a project entitled Development of a Sustainable Agro-Pastoral System in the Dry Areas of Northeast Asia (Apr 2006-Mar 2011)" to solve conflicting problems, such as pasture conservation, and increasing or maintaining the herders' income. An experiment was started in/nearby the animal and human population center. This paper introduces the experiment, and some of its first-year results are presented.

Material and methods The experiment was conducted between 31 May and 9 Oct, 2007 at *Bornuur* district (N48°41′, E106°15′), *Tuv* prefecture of Mongolia, where the vegetative type is forest-steppe. It is during this time of year that many of herders move their habitation from the winter-spring to the summer-autumn camp site. A gently sloped, but flat, land with an area of nearly 30 ha was chosen for the experiment. *Stipa krylovii*, *Artemisia frigida* were dominant uniformly at the site. Twenty-three ha of the area was fenced using cement and tree poles, and barbed wire; then the area was divided into nine paddocks using the same materials as follows: one cattle paddock (8 ha, C), one goat paddock (1.8 ha, G), six sheep paddocks (1 ha, SH; 4 ha, SL; and four paddocks of 2 ha, SE, SM, S0.5 and S1.0) and one no grazing paddock (C0). Four cattle, six goats and six sheep with an average initial bodyweight (BW) of 220.6 (standard deviation (STD), 15.3), 28.9 (1.9) and 36.6 (3.0), respectively, grazed in each of paddocks. The sheep in S0.5 and S1.0 were supplementary fed wheat bran in the amount of 0.5% and 1.0% /BW/d, respectively. The cattle were weighed every month, and the sheep and goats were weighed weekly. All animals were weighed at the end of the experiment. The SE was divided into 10 paddocks using electric fences, and the animals were rotated every week. The apparent herbage consumption by the SE sheep was determined by calculating the difference between the pre-and post-grazing herbage masses. The amount was also measured by the protect cage method in the C, G, SM and S0.5 every month and at the end of the experiment. A vegetation survey measuring plant height, coverage, etc. was performed at 10 fixed locations (100cm×100cm) in each of the fenced areas and outside of them, from 1 to 4 August, to determine the successive changing of the pastures with the different grazing treatments.

Results *Stipa spp*. and *Artemisia spp*. occupied a high proportion of the total consumption during the experiment (Table 1). The apparent herbage consumption increased during the course of the seasons (Table 2). And, *Artemisia spp*., which are considered indicative of pasture degradation, were eaten by sheep, irrespective of the season. The average final BW of the sheep in each paddock was 40.3 (SH), 42.2 (SM), 44.4 (SL), 45.8 (S0.5) and 44.1 (S1.0), respectively. No significant differences were found to result from the effect of grazing density (pooled STD=3.185; P=0.120) and supplemental feeding (2.803; 0.121), though there were differences in the magnitudes.

Table 1 *Herbage Production and consumption during the experimental period in 2007, kgDM/ha.*

	Stipa spp.	*Artemisia spp.*	Others	Total
Consumption	328.3	296.8	130.2	755.3
Remain (9 Oct)	5.7	5.4	1.8	12.8
Production	334.0	302.2	132.0	768.1

Table 2 *Herbage consumption by seasons in 2007, kgDM/100kgBW/d.*

	Stipa spp.	*Artemisia spp.*	Others	Total
Jun	1.07	0.84	0.76	2.66
Jul	2.09	1.96	1.24	5.29
Aug	0.67	2.42	1.24	4.32
Sep	4.34	2.18	0.22	6.74
Oct	3.12	2.93	0.99	7.05

We will continue this experiment until 2010, and the data in the first and following years would be presented later on. The data is expected to be a basic data to contribute to improve the pastoral livestock production system in the region.

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Water use by dominant species in grazed and intact grassland ecosystems of Inner Mongolia , China

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Key words : Inner Mongolia steppe , grazing , plant species composition , hydrogen isotope , winter moisture

Introduction Water is the most limiting factor for plant growth in arid and semi-arid grasslands . The water use of plant is sensitive to the degradation of grassland by heavy grazing . The hydrogen isotope ratios (δD) and leaf water potentials have widely been used to evaluate water sources of plants . The objectives of our study is to address if the dominant species differ in water use resulting from either winter or summer precipitation in relation to grazing among seasons and years and if the grazing-induced changes in water use of plant species explain the community structure shift .

Material and methods Community structure , plant available soil water , leaf water potential and hydrogen isotope ratios of plant water at the interface between the shoot and root systems of four dominant species were measured on long-term ungrazed and grazed plots to identify the contribution of winter moisture to water supply in May (early growing season) and August (late growing season) from 2005 (dry year) to 2006 (normal year) .

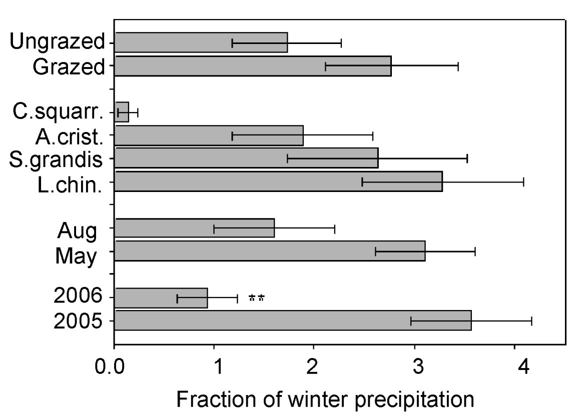

Figure 1 *Fraction of winter precipitation contributing to plant water uptake calculated from the deuterium signature of plant water in non-photosynthetic tissue . Error bars give standard error . Total sample number is 84 .*

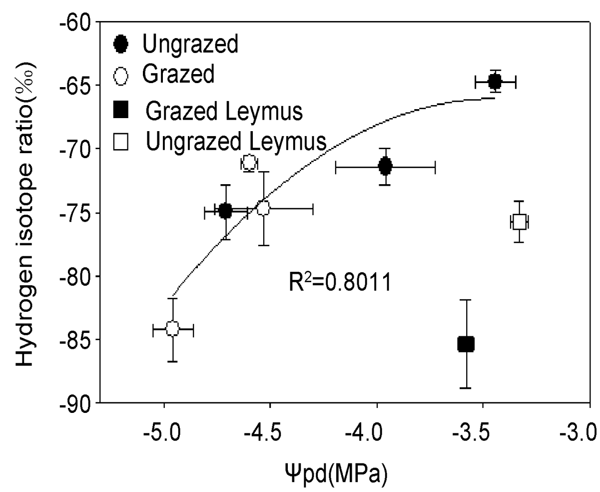

Figure 2 *Correlation of hydrogen isotope ratios of the non-photosynthesis tissues' water and predawn leaf water potential for different species in the ungrazed plot (solid circles) and the grazed plot (open circles) in August , 2005 .* (L . chinensis *denoted by solid and open squares is shown but not included into the regression)*

Results and discussion *Leymus chinensis* was able to extract winter moisture even from below 60 cm depth and maintained a lower leaf water potential than all other species , while *Cleistogenes squarrosa* due to its late development as a C4 species and its shallow root system made least use of winter moisture . Winter precipitation stored within the soil after snowmelt was an important source of water contributing about 30% in the dry year and less than 10% in the normal year to total water supply (Figure 1) . The δD value increased significantly with predawn leaf water potential ψ_{pd} and all species followed one relation except for *L . chinensis* (Figure 2) . Both the relative biomass and relative abundance of the shallow rooted *C . squarrosa* and *A . cristatum* increased ($P<0.05$) , whereas those of *L . chinensis* decreased significantly ($P<0.05$) by grazing .

Conclusions Grazing reduced the abundance of L . *chinensis* and promoted C . *squarrosa* and thus reduced the exploitation of winter moisture . This in turn will increase the severity of drought because winter moisture increases in importance for the plant water supply in years with rain below average .

Responses of vegetative propagation of *Reaumuria soongorica* to grazing and fenced non-grazing

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Key words : split propagation ,adventitious-root propagation , genet ,ramet , arid desert rangeland

Introduction Overgrazing has been resulting in serious degradation of grassland in northwest China . The present study was conducted to investigate overgrazing and fenced non-grazing treatments on vegetative propagation performances of *R . soongorica* , one of the extensively distributed , dominant xerophile species in northwest China . The shrub has two kinds of vegetative propagation : split propagation and adventitious-root propagation (Liu , *et al* , 1982 ; Zeng , *et al* . 2002) .

Research area and methods The research area locatted in Alashan region of Inner Mongolia , northwest of China (105° 34′E ; 39° 05′N) . The study was conducted on a lightly degraded and a highly degraded zone respectively in an overgrazed arid desert grassland in August , 2004 . In each zone 6 plots (25m×25m) were selected at random , of which three were grazed up to and during the trial period as used to be , whereas the other plots had been fenced since 2000 . All-together this amounted to 4 treatments : lightly degraded-grazing (T1) , lightly degraded-non-grazing (T2) ; highly degraded-grazing (T3) , highly degraded-non-grazing (T4) , and 3 replicates per treatment . In each plots 3 genets were selected at random and each gennet were dug out , ramet and adventitious root of vegetative propagation of each genet were checked and recorded by criterions as following : split ramets (SR) _ ramet split from top root ; adventitious-root ramet (ARR) _ ramet developed from adventitious-root propagation ; elder adventitious roots (EAR) _ adventitious root developed before 2004 but root belonged to ARR not included ; new adventitious-root _ adventitious root developed during 2004 , and sand cover depth (SCD) on each genet were measured . The statistical analysis of data was based on Statistica for Windows 4 .5 D (Stat Soft Inc . USA) .

Results and discussions A significant difference was observed for the amount of SR between T3 and all other treatments (Table 1) , which indicated that serious overgrazing accelerated the split process . However , these ramets were most often abnormal , with some of them close to death . No significant differences between treatments could be observed for the characteristic ARR , which can be explained by the longer time needed for the formation of this characteristic than available in this experiment . In both , the amount of EAR and the amount of NAR , significantly higher amounts were observed in T4 versus all other treatments . That no NAR was observed on genets of T3 is explained by the need for sand cover in the development of adventitious root (Liu , *et al* , 1982) . Regression analysis confirmed the positive correlation between NAR and soil cover depth on genets ($y=1.1912x^2-12.435x+5.5406$, $N=30$, $R^2=0.8254$) .There were no SCD observed on genets of T3 which may be due to over-disturbance by sheep and wind erosion . In the plots of T4 , SCD were significantly higher than all other treatments , that because the growth of damaged genet have been recovering since be fenced in 2000 and the nearby over-hoofing of sheep .

Table 1 *Responses of the amounts of split ramet (SR) , adventisous-root ramet (ARR) , elder adventisous-root (EAR) , new adventisous root (NAR) of R . soongorica genet and sand cover depth (SCD) to grazing and fenced non-grazing on different degraded zones .*

Item	Treatment			
	T1	T2	T3	T4
SR (ramet/genet)	1 .7±1 .4b	3 .2±2 .5b	7 .8±3 .9a	2 .4±0 .5b
ARR(ramet/genet)	2 .8±2 .9	4 .0±2 .1	4 .3±3 .5	3 .6±2 .9
EAR (root/genet)	5 .5±4 .0b	7 .5±4 .9b	4 .7±5 .7b	21 .0±6 .4a
NAR (root/genet)	22 .5±39 .7b	33 .4±42 .0b	0 .0b	210 .8±141 .5a
SCD (cm)	8 .5±6 .1b	10 .8±6 .1b	0 .0c	18 .2±2 .9a

For an individual item , means (± SD) which share the different letters of lower case indicate significant differences ($P<0.05$, Duncan's multiple range test) .

Conclusions Serious overgrazing was unfavorable for both split and adventitious-root propagation ; Whereas in the fenced non-grazing polts on the highly degraded zone the positive effect was observed for development of ERR and NAR .

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Effect of lambs' early weaning on their growth performance and the pasture's stocking rate

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Key words: lamb, weaning ages, stocking rate

Introduction There are many reports on lambs' early weaning (J.N.Zhang et al., 2005). In Yugur Minority Autonomous County in Zhangye Prefecture of Gansu Province, the sheep production mainly depends on grazing in a whole year, age is in September when they are sold. The study was conducted in Sunan, it focused on the local optimal lamb weaning age and improving the production efficiency of ewes, and reducing pressure on the grasslands.

Materials and methods The experiment choosed 120 hybridized lambs of Gansu alpine fine-wool sheep and Australia merino sheep, then randomly dividing into four groups with 30 sheep of each group, and the weaning ages are separatively 35d, 45d, 60d and 90d.

Results 30 days' weight and 60 days' weight, there was no significant difference in four groups ($P > 0.05$). 90 days, 35d weaning group significantly less than the other three groups, while the other three groups had no significant difference ($P > 0.05$). (Table 1). 30 to 60d, the lambs' daily-gaining-weight of 45d, 60d, and 90d weaning group was significantly higher than that of 35d's weaned group ($P < 0.05$), and there is no significant difference among them ($P > 0.05$); 60 ~ 90d, the 45d's daily-gaining-weight was significantly higher than the other three groups ($P < 0.05$), and the 60d's daily-gaining-weight was significantly higher than that of 35d and 90d (Table 2).

Table 1 *Weaned lambs' weight of different groups (Kg / sheep).*

groups	30d	60d	90d
35d weaning	$9.76^a \pm 0.85$	$14.23^a \pm 0.96$	$19.81^a \pm 1.23$
45d weaning	$9.47^a \pm 0.74$	$15.08^a \pm 1.13$	$22.16^b \pm 1.43$
60d weaning	$9.85^a \pm 0.87$	$16.21^a \pm 0.87$	$22.36^b \pm 1.21$
90d weaning	$9.63^a \pm 0.83$	$16.23^a \pm 0.92$	$22.17^b \pm 1.34$

Note: The figures in the same volume with same suffix letter is not significant ($P > 0.05$), conversely significant.

Table 2 *Weaned lambs' daily-gaining-weight of different groups (g / sheep).*

groups	$30 \sim 60^d$	$60 \sim 90^d$
35d weaning	149^a	186^a
45d weaning	187^b	236^c
60d weaning	212^b	205^b
90d weaning	220^b	198^a

Conclusions The lambs' optimal weaning age is 45d in the farming-pastoral zone, using some substituting milk and high-quality alfalfa in lambs' early weaning is the effective measure to increase sheep flock's production efficiency and reduce pressure on grasslands stocking. Early weaning can not only reduce the pressure on the pasture, but also improve the economic benefits of mountain animal husbandry, and increase the economical income of peasants and herdsmen.

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Improving land productivity and sustainability by developing lucerne and livestock production in Huanxian county, Gansu province, China

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Key words: soil erosion, Lucerne, livestock, Loess Plateau, China

Introduction Huanxian county is one of the counties in China severely affected by poverty. About 93% of the 0.33 million population lives in the rural areas. The county lies in the western part of the Loess Plateau which has a reputation for having the worst soil and water erosion on the earth. It covers the area of 106°21-107°45E～36°01-37°09N. The altitude is 1130-2089 m above sea level and the mean annual rainfall is 359.3 mm, of which about 60% falls during the period of July to September, with drought in spring being a frequent occurrence (Hou *et al*., 2002). The main crops grown in the region are: wheat (*Triticum aestivum*), potato (*Solanum tuberosum*) and buckwheat (*Fagopyrum Mill*). The main livestock include sheep, goats and donkeys. The major farming system is cereal monoculture with livestock grazing rangeland and being fed cereal straw and little forage during the winter and spring periods. There is no close link between cropping and rangeland livestock production, although rangeland covers 67.7% of the total land area in the county. The annual degradation of rangeland occurs at about the rate of 53km^2. With the technical support from ACIAR projects and other projects the county has set up an objective of establishing and developing integrated crop-pasture-livestock production systems to achieve the sustainable development of agriculture. One of the ambitious targets is increasing the area under lucerne (*Medicago sativa*) by 2 million mu (130,000 ha), which will feed about 2 million sheep by 2010.

Technical services About 833 agricultural extension officers and public servants were working fulltime on the lucerne-sheep project. A method of train the trainer was employed. The 833 technical staff were trained on lucerne, and sheep and goat production in the county. The staff that were trained then went to townships and villages to train the farmers. More than 6000 copies of technical booklets on lucerne, sheep and goat production were distributed to the farmers, and more than 20,000 farmers were trained. A County Standard of Lucerne Establishment and Management was produced as guidelines for the practices. About 15 cultivars of lucerne were selected for the local production based on the evaluation trials. A special program on lucerne was also launched on the county television station. With the efforts of the extension officers, demonstration fields were established at the township and village levels. Normally there were two to three demonstration fields with 1000 mu (about 67 ha) each for every township. One demonstration field with the area of 100 mu was developed for each village. Lucerne was grown on various landscapes to complement the local farming systems. For instance a six meter wide area of lucerne intercropped with a five meter wide area of wheat on the tableland. Lucerne was rotated with cereal on the terraces while all slope croplands were converted to lucerne where the slope was more than 30 degrees.

Ecological and economical benefits There have been 0.749 million mu of lucerne newly planted since 2005. The total number of sheep and goats has reached 0.4775 million, of which 0.262 million were slaughtered for commodity. Farmers' income increased significantly (Table 1). Soil quality has also improved. Soil organic carbon of 9-year-old lucerne was 6.27 kg/m^2, which was 19.5%, 26.6% and 40.7% higher than that of buckwheat, potato and winter wheat, respectively. Total nitrogen of 0-100 cm soil profile of 9-year-old lucerne was 0.564 kg/m^2 which was 15.8%, 22.7% and 25.0% higher than that of buckwheat, potato and winter wheat, respectively.

Table 1 *Incomes from lucerne and livestock production at Guo Yuan village, Huanxian county, China, in 2007.*

Farmer	Lucerne areas (Mu)	Livestock (numbers)	Income (RMB)
Y.F.Tang	30	Goat 15	10 000
W.C.Guo	60	Goat 20	7 800
Y.K.Du	120	Cattle 5	8000
J.Du	500	Goat 320	120 000
Village in total	2800	Goat 955	360 000

Reference

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Study on root system morphology of creeping-rooted alfalfa and related analysis of soil physical factor

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Key words: Creeping-rooted alfalfa, root system morphology, soil physical factor

Introduction Creeping-rooted character was very important for breeding and selection of the new variety of creeping-rooted and grazing alfalfa. In this paper, the author discussed the ontogenesis of creeping-rooted character and its performance in the BFU grassland experimental land. Through the research on effects of physiological and ecological factors of creeping-rooted Alfalfa, the influence of physiological and ecological effects on the performance of creeping-rooted character could be analysed.

Materials and methods The materials come from our experiment lands which is in Shunyi of Beijing, seeded on May 2004, including three grazing-type alfalfa, that is creeping-rooted material, main-rooted materical, side-rooted materical. The varieties of alfalfa includes Travois, Zhongmu No.1, Grassland No.2, Baoding alfalfa, Kazakhstan wild alfalfa. The methods mainly focus on three points: the plants modality survey, the plants root system survey, the soil condition survey. The plants modality survey includes plant height, material expansion, cluster quantity, branches quantity; and plants root system survey focus on the root expansion, the stem primordial; The soil condition datas were collected by three level: 0-10cm, 10-20cm, 20-30cm. the datas are deal with the multianalysis, including square error analysis, simple factor analysis variance four group datas, correlative coefficient matrix and so on.

Results The results of these studies were as follows: the underground horizontal root of creeping-rooted alfalfa could form root expansion part and stem primordia on the root through whole growth season. The appearance of creeping-rooted plant was better during the second and third years than during the first and later of the fourth year in the creeping-rooted varieties. The development of creeping-rooted seedlings and the range of expansion of root turion node were influenced by marginal effect. The percentage of creeping-rooted plant was a little higher in marginal rows than in inner rows, and the range of expansion of creeping-rooted seedlings was obviously larger in marginal rows than that in inner rows. Compared with the other materials, the expansion of horizontal roots of the creeping-rooted alfalfa are 30% farther than the side-rooter material, but not better on the index of plant height and branches quantity which are compared with the side-rooted material and the main-rooted material. Compared with the 10-20cm level, under the 0-10cm level the root diameter are bigger both the horizontal roots and the vertical roots. Under the 0-10cm level, the vertical root diameter of main-rooted material > the vertical root diameter of side-rooted material > the vertical root diameter of creeping-rooted materical. Soil condition has a great influence on the development of creeping-rooted alfalfa, especially on the index of soil moisture. The weight content of CR and NCR are similar, the creeping-rooted alfalfa has a strong tolerance to the stiff environment.

Reference

Gao Zhensheng, Wang Pei, Hong Fuzeng. Studies on Ontogonesis and Ecological Adaptability of Creeping-rooted Character of Alfalfa (Medicago media Pers.), Acta Agrestia Sinica.

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MOE: 20060022011

Grasslands/Rangelands Resources and Ecology

—Indicators for Sustainable Use and Conservation of Grasslands/ Rangelands Resources

Indicators of sustainability for production and biodiversity conservation in Australian rangelands

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Key points: Australian rangelands provide a diversity of ecosystem services and there is a growing demand for monitoring that is based on biophysical, economic and social values. Federal and state government agencies are collaborating to report on change in rangelands, at scales relevant to federal, state and regional needs. The Australian Collaborative Rangeland Information System (ACRIS) takes the pragmatic approach of reporting against themes using available data. The ACRIS collates the data from diverse sources, conducts meta-analyses using derived indices as appropriate and provides a national synthesis at regional resolution to enable comparisons amongst regions. A number of indicators need testing, as does the validity of up-scaling point-based data. Aspirational targets for reporting are avoided, recognising that institutional capacity is declining and short-term funding cycles hinder the implementation and maintenance of long-term monitoring.

Key words: monitoring, collaborative information system, institutional capacity

Introduction

Rangelands occupy 81% of Australia's land area (Figure 1), popularly known as 'the outback'. While they generally include hot climate deserts, the land area is large enough to encompass summer-dominant (monsoonal) and winter-dominant rainfall patterns from north to south (Bastin *et al*., in press). Tropical woodlands and savannas prevail in the far north, *Acacia* woodlands and shrublands occupy the arid central regions and chenopod shrublands predominate in the south. Soils are characteristically low in fertility, rainfall is highly variable and growing seasons are short.

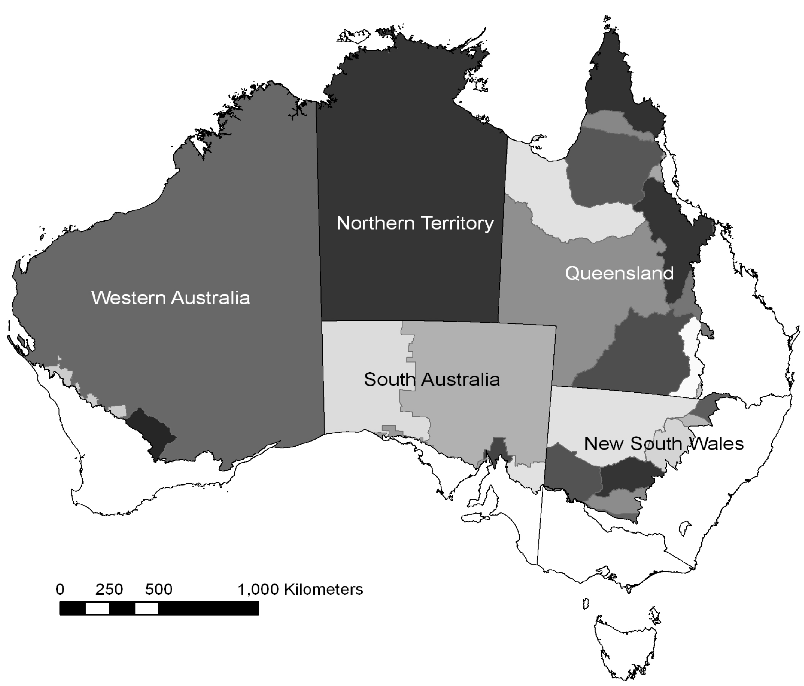

Figure 1 *Natural Resource Management regions wholly or partly within the Australian rangelands (shaded area). The Northern Territory is one NRM region as is most of Western Australia. Elsewhere, NRM regions are much smaller.*

Commercial livestock grazing is by far the most widespread use of rangelands in terms of area (3.67m km^2, 59% of the rangelands in 2001), but mining and tourism bring greater economic returns. Through the Aboriginal Land Rights (Northern Territory) Act 1976 and other legislation indigenous people have regained primary responsibility for 27% of the rangelands, while conservation lands occupy under 10%.

Rangeland monitoring in Australia evolved from the late 1960s as a means of understanding the impact of grazing on pastoral rangelands. Most of the pastoral lands are publicly owned. Administration of land management is a state rather than a federal responsibility and so monitoring has been a state-based activity. The type and quality of data gathered is variable because each of the states collects data for different reasons, with varying degrees of regulatory backing.

While monitoring for pastoral production has been established for some time, albeit with a history of false starts and irregular reporting, the capacity to monitor biodiversity outcomes is in its infancy. Baseline data have been gathered in many areas by state agencies but coverage is incomplete for the rangelands and re-sampling (to report change) is limited to local or regional scales (Bastin *et al*., in press). Various indicators have been proposed for monitoring biodiversity (Smyth *et al*. 2003) but the choice of indicator is often dependent on ease of use or the professional interest of the individual rather than the validity of its connection to biodiversity.

With growing recognition of the capacity of Australian rangelands to provide diverse ecosystem services, demand has increased for monitoring that is based not only on biophysical values but economic and social values as well. Information about the current status and trend of rangelands is essential for a number of purposes. Federal and state governments need information to support legislative and policy initiatives, to meet international reporting requirements and for periodic state of the environment' reporting. Regional bodies (Figure 1) now have increasing responsibility for setting and meeting targets for natural resource management, which includes both production and conservation outcomes (http://www.nrm.gov.au/nrm/region.html, accessed 17/11/2007). In addition, comprehensive reporting will contribute to Australia's capacity to predict the outcomes of, and respond to, climate change.

Monitoring activities

Some form of pastoral monitoring has been in place in state jurisdictions for several decades. What is monitored is dependent on each state's objectives and is intimately linked to spatial and temporal scale (Friedel *et al*., 2000). Most monitoring systems are ground-based and hence data collection is focussed at a very local scale, so that the point-based assessments provide only a sample of the national context. A summary of commonly used indicators and methodologies is provided by Friedel *et al*. (2000).

Point-based data are particularly relevant for enterprise-level management but there is an inherent danger in extrapolating to regional level or higher. How many points are enough to represent variability within or between land types? Are there sufficient to represent regional status? Remotely sensed data can provide a regional perspective and are collected by some jurisdictions, but they are rarely an integral part of institutional monitoring. Queensland uses Landsat TM imagery to routinely monitor the extent of woody vegetation, clearing for agriculture, regrowth and ground cover over the entire state (http://www.nrw.qld.gov.au/slats/, accessed 20/11/2007; DNRM, 2005). Elsewhere remote sensing is used to support ground-based monitoring but is not embedded as a key component of pastoral monitoring systems.

The development of a framework for biodiversity monitoring in Australia has been relatively recent (Smyth *et al*., 2003; Hunt *et al*., 2006). Smyth and James (2004) outlined the multiplicity of purposes for monitoring biodiversity, not all mutually exclusive: policy-making, regulation, early warning of change, detecting effects of management, assessing niche markets for rangeland products, improving public knowledge and improving communication and education. As with pastoral monitoring, a single system cannot meet all needs. Attributes that could be used as indicators were categorised into four types: biotic, ecophysical, pressure and management. Until now data have been collected using ground-based plots on a local to regional scale but there has been very little resurveying from which to report change.

Recently Smyth *et al*. (in press) developed an approach to biodiversity monitoring based on ecological risk assessment. The first step was to identify the desired outcomes or endpoints for assessing biodiversity condition. In their case study region of some 130,000 km^2, these were:

- Native vegetation typical of the study region's communities maintained or restored
- Reduction in the loss of the existing complement of rare and regionally significant native species, populations and ecological communities
- Natural surface water flows maintained or restored
- A mosaic of water-remote areas maintained. (Research in other parts of the Australian rangelands has shown that some biota are adversely affected by grazing disturbance (James *et al*., 1999) and maintaining areas remote from stock water is recommended to assist in conserving these species.)

Having identified for each outcome the biodiversity values and how these helped to maintain condition, they selected a number of candidate indicators, such as average percent vegetation cover after long dry periods, presence of non-native invasive weeds, presence of terrestrial endemic and threatened fauna, and percent area remote from stock water by length of time, using an integrated set of attributes such as availability of historical records, quality of measurements and feasibility of implementation. They were not successful in identifying derived indicators such as persistent grazing gradients and modelled floristics for the case study area. The notion of a single biodiversity condition metric was rejected in favour of presenting the values for a suite of selected indicators for each desired outcome. They concluded that a problem formulation framework as outlined was fundamental to devising a candidate set of indicators for assessing biodiversity condition. However there is no evidence yet that this approach will be implemented as part of routine monitoring.

While there may be general acceptance at state and federal level of what needs to be done, implementation is constrained by institutional capacity (Watson and Novelly, 2004). Resources are limited, with the consequence that the proposed indicators remain largely aspirational. Without the potential for commitments from state agencies to fund and maintain dedicated and extensive biodiversity monitoring systems across their jurisdiction for the long term, a comprehensive system will remain aspirational. Recognising the competing demands placed on agencies, it is important to find pragmatic ways of obtaining useful information on biodiversity status and trends. The following section explains what is being done by a partnership between federal and state agencies to report on change in a number of rangeland-relevant themes, including biodiversity.

ACRIS

The Australian Collaborative Rangeland Information System (ACRIS) (http://www.environment.gov.au/land/management/rangelands/acris/index.html, accessed 17/11/2007) was established in 2003 to facilitate data collection and documentation for reporting on regional and national changes in the rangelands. It is a partnership between the federal and state agencies that are responsible for resource management and biodiversity conservation. The main activity to date has been collation and synthesis of available datasets (including jurisdictional monitoring data) to provide more complete understanding of change in the rangelands (Bastin *et al*., in press).

The initial motivation for creating the ACRIS came from the states involved in rangeland monitoring. They recognised in the 1990s that it should be possible to build a broader collective view of change in the rangelands by combining their various data. This desire was strengthened when the earliest attempts at national 'state of the environment' reporting, built largely on expert opinion, were published. However individual jurisdictions lacked the required resources to report beyond their borders until the National Land and Water Resources Audit provided the means in the late 1990s (http://audit.ea.gov.au/ANRA/rangelands/rangelands_frame.cfm?region_type=AUS&region_code=AUS&info=description, accessed 23/11/2007). The resultant report described 16 information products for reporting change and proposed the ACRIS as the coordinating mechanism to collate and continually update a wide diversity of rangeland information.

In addition, over the last 20 years, land uses other than pastoralism have been growing in importance. There has been a transfer in ownership of pastoral properties, often of marginal pastoral value, to conservation, indigenous and in some cases tourism interests (Bastin *et al*., in press). With the increase in indigenous land ownership, there are growing expectations amongst both government and community sectors that indigenous people will engage more fully in livelihood activities such as tourism, harvesting of bush foods for generating income and natural resource management (e.g. http://www.desertknowledgecrc.com.au/research/livelihoods.html, accessed 18/11/2007). The consequences are that there are additional data requirements and a need to provide results in culturally appropriate ways.

ACRIS reporting occurs within a framework of themes: climate variability, landscape function (Ludwig *et al*., 1997), sustainable management, total grazing pressure, water use and management, biodiversity and socio-economic change (Table 1). The ACRIS does not have an independent capacity to gather data. Instead it depends on state and territory agency partners willingly contributing their data for these themes, assisted by national datasets where available and relevant. The state agencies have collected their data for a diversity of purposes, and the methods used are often specific to particular environments, for example pastoral monitoring in grasslands or shrublands. Thus, the data are not directly comparable. The ACRIS Management Unit (Bastin *et al*., in press) assists by collating these disparate data, conducting meta-analyses using derived indices (e.g. of landscape function) as appropriate and providing the national synthesis, but at regional resolution so that inter-regional comparisons are possible. In 2008, the ACRIS will publish its national report of change in the rangelands between 1992 and 2005 for the themes shown in Table 1 (Bastin *et al*., in press).

Table 1 *Information products grouped by theme used by the ACRIS to report change in the Australian rangelands between 1992 and 2005.*

Theme	Information product
Climate variability	• seasonal quality as context for interpreting change
Landscape function	• change in landscape function (the capacity of landscapes to capture and retain rainwater and soil-borne nutrients for plant growth)
Sustainable management	• change in critical stock forage • change in pastoral plant species richness • distance from stock water • invasive weeds
Total grazing pressure	• change in domestic stocking density • change in kangaroo density • feral herbivores

Products that support landscape function and sustainable management	• change in fire regime • change in atmospheric dust (dust storm index)
Water resources	• information sources for water availability and sustainability
Biodiversity	• change in protected areas • change in number & status of threatened species / communities • habitat loss by clearing • effects of stock watering points on biota • fauna records and surveys • flora records and surveys • transformer weeds • wetlands : condition and change • habitat condition derived from remotely sensed ground cover • bird composition
Socio-economics	• socio-economic profiles • value of non-pastoral products in the rangelands • change in land use • change in pastoral land values

Having demonstrated that national reporting is feasible , the ACRIS now needs to increase its ability to meet regional needs . As part of devolved federal government responsibility for natural resource management , regional groups (Figure 1) are required to report progress towards specified resource condition targets . To assist them with their reporting obligations under the National Natural Resource Management Monitoring and Evaluation Framework (http ://www .nht .gov .au/publications/annual-reports/2004-05/index .html , accessed 18/11/2007) , the ACRIS could provide broader context against which progress towards agreed condition targets is judged .

Table 2 *Method used by ACRIS to assign causality to change detected at monitoring locations (left) and the associated probable response by state agencies or regional boards to such change (right) (adapted from Bastin* et al *., in press) .*

Prior seasonal quality	Change in Landscape Function or Sustainable Management					
	Biophysical change at monitoring sites			Probable institutional response when most of the region is showing		
	Decline	No change	Increase	Decline	No change	Increase
Above average	XX	X	～	Management has suppressed the expected response *Further investigation required*	Management has not allowed the landscape to respond to favourable seasons *Further investigation required*	Management has delivered a response consistent with expectations
Average	X	～	√	Management has not delivered the expected response *Further investigation required*	Management has delivered a response consistent with expectations	Management has delivered a better than expected response *Investigate , acknowledge and promote*
Below average	～	√	√√	Management has delivered a response consistent with expectations	Management has delivered a better than expected response *Investigate , acknowledge and promote*	Management has had a significantly beneficial impact on the outcome *Investigate , acknowledge and promote*

√√ *indicates an increase although seasonal conditions were below average (decline in the measure expected at this time)*
XX *indicates a decrease although seasonal conditions were above average (increase expected at this time)*
～ *indicates no change*

The Australian rangelands are characterised by considerable climate variability (e .g . Friedel *et al* ., 1990) and prior rainfall , in particular , is the major driver of biophysical change (e .g . vegetation amount , composition and demography) . In order to report at the regional scale in a way which assigned causality between seasonal variation and management impacts , the point-based data for landscape function and sustainable management were expressed in terms of change relative to values expected for prevailing seasonal conditions (Table 2 , left) . This approach has been adapted from that used by at least one state agency monitoring system (Watson *et al* ., 2007) . The matrix structure is expanded to show the effectiveness of management and probable institutional responses by land management agencies (Table 2 , right) .

Indicator value

The pragmatic approach by the ACRIS to thematically reporting change based on available data has highlighted several issues related to indicator value. These include the suitability of an indicator for reporting change against a particular theme, and the appropriateness of available data for use with some indicators.

A number of the ACRIS indicators are yet to be fully tested for their accuracy. For example, there is a recommended methodology for assessing landscape function (Tongway and Hindley, 2004) but it is only in Western Australia that these procedures have been implemented as part of routine monitoring. The ACRIS Management Unit constructed a number of indices to estimate landscape function from available jurisdictional datasets but the effectiveness of these indices has not yet been tested. Landscape function is a potential surrogate for several ecosystem services such as maintenance and regeneration of habitat, prevention of soil erosion, maintenance of soil fertility, maintenance of soil health and water infiltration (Ludwig *et al*., 1997), but both the proposition and the capacity of available data to quantify ecosystem services need testing. A further requirement is testing of the ability to up-scale point-based monitoring of landscape function using remote sensing-based methods such as the leakiness index (Ludwig *et al*. 2007).

Reasonably reliable data reporting change in livestock and kangaroo densities are available for parts of the rangelands but good data are lacking for feral herbivores such as goats, camels, donkeys and horses. Thus it is not possible to confidently report trends in total grazing pressure as one of the key components affecting sustainable use of the rangelands. Feral animal distributions are known with some confidence but there is a need for regular semi-quantitative estimates of density by species. The large area and remoteness of much of the rangelands means that systematic surveys to estimate feral animal numbers will remain infrequent and so indices that can reliably indicate changes in their relative density would be valuable.

The ability to report on indicators of sustainability for biodiversity conservation is limited. The 10 indicators in Table 1 were selected from over 50 previously evaluated (Smyth *et al*., 2003; Hunt *et al*., 2006). The choice of indicators was based on their potential to provide a national view, whether sufficient monitoring data were available and whether they could provide reliable and consistent information. Of these, data on protected areas, number and status of threatened species / communities, rangeland avifauna and habitat loss by clearing contributed to the national perspective of change in components of biodiversity. It is unlikely that a more comprehensive assessment will be available until systematic regional monitoring of flora and fauna is in place, complemented by information on habitat and wetland condition, and broader contextual information about transformer weeds, fire, grazing (including changes in stock watering points) and other threats to biodiversity. It is interesting that one of the most valuable datasets for indicating change in rangelands avifauna is that contributed by Birds Australia, a volunteer community-based reporting scheme. The Birds Australia Atlas provides Australia-wide coverage but there are limitations in the more remote parts of the rangelands due to scarce data and high seasonal variability.

Socio-economic indicators are also an important aspect of sustainability for pastoral production and biodiversity conservation but they are not easy to report on meaningfully. One of the main requirements is improved understanding of the capacity of pastoralists and other land managers to adapt to, at times, rapidly changing environmental, economic and social circumstances. Indicators such as the median age of pastoralists, net emigration of young people from regions and age dependency ratio (the proportion of regional population younger than 15 and older than 65) have been proposed but subsequent testing with data from five-yearly national population censuses and targeted surveys have shown them to be poor indicators of actual change in rangeland management practices (Hanslip and Kelson, 2007). Other methods for understanding socio-economic differences amongst regions are being investigated (e.g. Maru and Chewings, in press).

In the absence of suitable indicators of pastoralists' capacity to adapt and change their management practices, the ACRIS has reported on changing land use, pastoral land values and the importance of non-pastoral agricultural production in the rangelands (Bastin *et al*., in press). Pastoral land values have increased by as much as 150 to 300 percent in different regions between 1992 and 2005. These increases are well beyond real increases in productivity and while they represent a substantial increase in asset wealth, they raise concerns about the ability of recent purchasers to cope with debt in the face of climate variability and any downturn in commodity prices.

Improving future reporting

ACRIS reporting faces several challenges. As already discussed, extrapolating point-based data to broader spatial scales is problematic. Furthermore, the current report (Bastin *et al*., in press) focuses on reporting change with little recognition of the baseline from which change is occurring. The value of future reporting will be enhanced where the direction and magnitude of change takes account of initial condition state. For example, a no change' result in critical stock forage after rain on degraded land will require a different institutional response to no change on the same kind of country at maximum productive capacity. Although objectively assigning condition in the Australian rangelands can be complex (Friedel *et al*., 2000), suitable statements of baseline condition for the various information products (Table 1) are required to provide improved context for understanding the meaning of change.

The ACRIS partnership has avoided developing aspirational targets for which data do not exist. A key component is its collaborative nature which avoids imposing a grand plan' on its partner jurisdictions. Declining institutional support, including staff, is a reality in the Australian rangelands. Short term funding timeframes as a consequence of a government's term in office, agency restructuring and staff turnover make long term monitoring programs difficult to implement and even harder to sustain (Watson and Novelly, 2004). Moreover the scientific basis for monitoring is contested from time to time and very few established monitoring systems have persisted past an initial iteration. The goal is not to start yet again, but to derive whatever benefit is possible from existing data. The pragmatic approach is to support gradual improvement in line with institutional capacity.

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Monitoring of Inner Mongolian grassland using sustainable roundtable indictors

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Key points :

1. Four distinct seral stages (early to late) were identified in Meadow steppe , typical steppe and desert steppe of Inner Mongolia .
2. The key plants in each grassland site are different . These key plant species as variables can be used to indicate the grassland trend and they played different roles at individual seral or successional stages .
3. Knowledge of the seral stages can be used to guide rangeland management in Inner Mongolia .

Key words : series stage , indicators

Introduction

The world's rangelands occupy about 70% of the total land area (Holechek et al ., 2003) . Monitoring is one of the important necessary steps for better management of natural resources (Ludqig et al ., 2000) . For grassland , we have to understand the condition of the resource base , and how and when the grasslands change and the grassland trends . In northern China , rangelands are being monitored as a means of managing livestock production (Li ,1997) . However , grassland monitoring is conducted only within exclosures and not on grazed lands for which we lack suitable methods . Traditionally , Chinese scientists used quadrats to estimate species composition and bare soil to predict degradation . This paper uses multivariate analysis to monitor the rangeland dynamics and to classify the seral stages under grazing in the Meadow Steppe , Typical Steppe and Desert Steppe vegetation types of Inner Mongolia . The study evaluated indicators that could be used to monitor the changes in seral states to determine sustainable rangeland management for these grassland types .

Materials and methods

Site description

Grassland monitoring measurements were conducted at three sites : Meadow Steppe , Typical Steppe and Desert Steppe , located in Xiwu Banner , Keshiketeng Banner , and Siziwang Banner , respectively , in Inner Mongolia (Figure 1) . These sites are the main zonal grassland types in Northern China .

The Meadow Steppe site is in the northeastern Xiginguole grassland with average annual air temperature of 1 .2℃ (average lowest temperature of-7 .8℃ in March and highest temperature of 17 .7℃ in August) and average annual accumulated heat units (base temperature of 0℃) of 2556 growing degree days (GDD) . Average annual precipitation was 342 mm with 99 days rain and 37 days snow . The seasonal precipitation allocation was 38 , 236 , 49 , and 19 mm in spring , summer , autumn , and winter , respectively . The average annual evaporation is about 1768 mm . The soil is black chestnut soil with 35 .6 g kg^{-1} of organic matter and 1 .85 g kg^{-1} of nitrogen . This soil is one of the richest soil types in China's northern grasslands . The vegetation is dominated by *Leymus chinensis* (Trin .) Tzvel ., *Stipa baicalensis* Roshev ., and *Filifolium sibiricum* (L .) Kitam . with other species , such as *Achnatherum sibiricum* (L .) Keng , *Thymus serphyllum* L ., *Allium tenuissimum* L ., *Leontopodium leontopodioides* (Willd .) Beauv ., *Stellera chamaejasme* L ., *Artemisia pubescens* Ledeb ., and *Melilotoides ruthenica* (L .) Sojak . The average aerial coverage ranged from 59 to 77% in the Meadow Steppe with high plant biodiversity and forage production .

The Typical Steppe site is in the Keshiketeng Banner located northwest of Chifeng City Prefecture in central Inner Mongolia , China . The climate is continental with significant diurnal temperature variability , cold winters , and frequent windy periods . The following attributes apply throughout the area : Mean annual temperature of about 2℃ , annual accumulated heat units (base temperature of 10℃) ranging from 1 ,300 to1 ,700℃ , mean annual total sunshine ranging from 2 ,700 to 2 ,900 ,hours , annual radiation of 57-58 J cm^{-2} , annual precipitation ranging from 310 to 350 mm with the growing season ranging from 60 to 80 days (April-September) . The soil is a Kastanozem (Mollisols in World References Base for Soil Resources) . The surface soil (0-20 cm) throughout the study area was classified as loamy texture with sand content at 59 .6±0 .6% , silt at 23 .8±0 . 4% and clay at 16 .7±0 .4% (based on 45 soil samples) . The typical pH in the 0 to 5 cm profile varied from 7 .32 to 7 .79 and soil bulk density was 1 .16±0 .07 g m^{-3} . Soils freeze to a maximum depth of about 1 ,9 m during winter . The vegetation is dominated by *Leymus chinensis* (Trin .) Tzvel ., *Stipa grandis* P . Smirn . and *Cleistogenes squarrosa* (Trin .) Keng . The primary associate species are *Artemisia frigida* Willd ., *Potentilla acaulis* L . and *Carex duriuscula* C . A . Mey . *A . frigidia* is a sub-shrub while the other plant species are all herbaceous plants .

The Desert Steppe site is in Siziwang Banner in the mid-west of Inner Mongolia . This site is dry and windy in spring and hot in summer . The weather is characterized by a colder winter and a warmer summer with an annual mean temperature of 2 .8℃ and growing season temperature (May to October) of 17.3 ℃. The soil is Kastanozem (FAO soil classification) or Brown Chermozem (Canadian Soil Classification) and soil texture is loamy sand. Vegetation is very short (average to about 8 cm in height) with canopy cover varying from 17 to 20% with relatively few species (about 20). The dominant species are *Stipa breviflora* Griseb., *Artemisia frigida* Willd. and *Cleistogenes songarica* (J. F. Gmel.) while associated species were *Convolvulus ammannii* Desr, *Heteropappus altaicus* (willd.) Novopokr, *Neopallasia petinata* (Pall.) Poljok., *Kochia prostriata* (L.)Schrad., *Caragana stenophylla* Pojark and *Leymus chinensis* (Trin.) Tzvel.

Experimental design and measurements

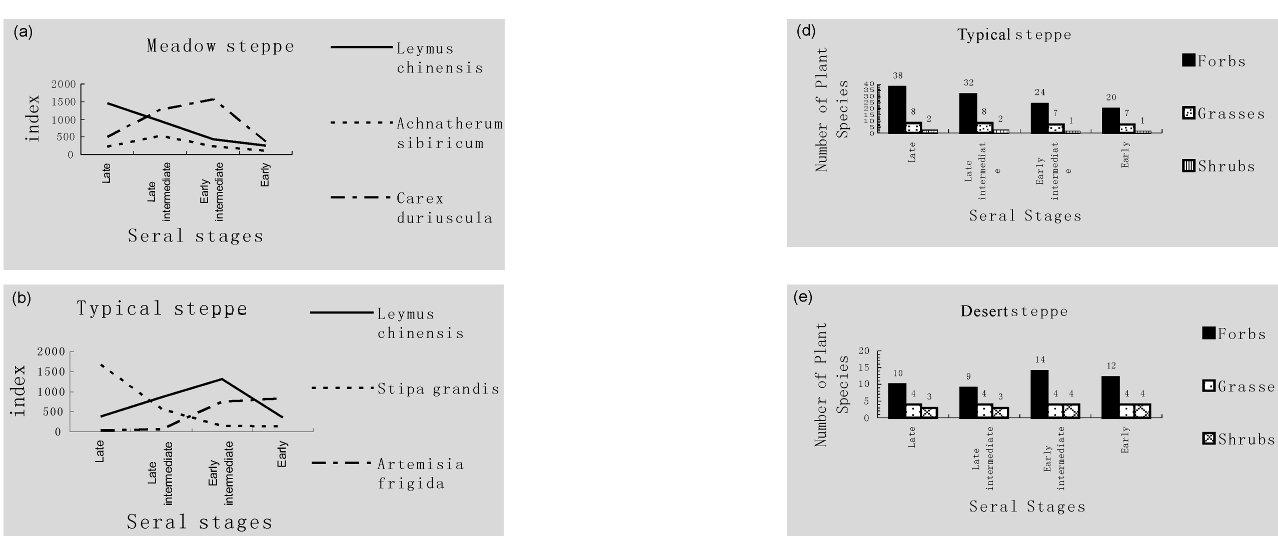
At three different locations within each grassland site, we monitored range condition from 2005 to 2007 along three transects that followed a gradient of decreasing grazing pressure from a focal source (water/corral). The transects were partitioned into three grazing intensity classes while an ungrazed exclosure at each location represented the control. Plant cover by species were measured in each grazing intensity class on single 50 m subtransects that were arranged perpendicular to the transect or randomly distributed within the exclosure. This resulted in 3, 50-m subtransects for each grazing intensity class on each ranch for a total of 12. Plant cover was estimated every 2-m along the subtransects and the biomass of functional groups, such as grass, forbs, shrub and litter, every 5 m. All measurements were made in 20×50 cm quadrats. The measuring points were recorded with GPS and repeated every year.

Data analysis

Data analyses followed Uresk (1990) at each grassland site. Average canopy cover (%) was multiplied by frequency of occurrence (%) of all plant species to produce an index value for the final analyses (Uresk 1990). A non-hierarchical clustering procedure, ISODATA (Ball and Hall 1967), grouped the gazing gradients into 4 distinct clusters (seral stages). Then stepwise discriminant analysis at the 0.05 entry level selected 3 plant species as the best predictive variables to be used for seral stage classification and monitoring in each grassland site.

Results

Four distinct seral stages (early to late) were identified along the gradient, which included the exclosure, in each steppe. The Stepwise Discriminant Analysis showed significantly differences among all the seral stages ($P<0.05$). The model is of 3 plant species (variables) and 4 Fishers discriminant functions that define the seral stages in all grassland sites (Table 2) The key plants in each grassland site are different. The key plants are *Leymus chinensis*, *Achnatherum sibiricum*, and *Carex duriscula* in Meadow Steppe, *Leymus chinensis*, *Stipa grandis*, and *Artemisia frigida* in Typical Steppe and *Stipa breviflora*, *Artemisia frigida* and *Cleistogenes songorica* in Desert Steppe. These key plant species as variables can be used to indicate the grassland trend and they played different roles at individual seral or successional stages. For example, the index value of *Leymus chinensis* is the highest in the late seral stage and lowest in the early stage of the Meadow Steppe but the highest in the early intermediate stage in the Typical Steppe. Also, the index value of *Artemisia frigida* is the highest in the early stage in the Typical Steppe and in the early intermediate stage of the Desert Steppe (Figure 2). These seral-stage dynamics are related to the cover and frequency of the selected plant species (Table 3) and define grassland condition. The percentage of total transects in late, late intermediate, early intermediate and early was 16.1%, 12.1%, 24.2%, and 47.6%, respectively in the Meadow Steppe site. The percentage of total transects by class was 54.4%. 24.2%, 10.3%, and 11.1%, respectively in the Typical Steppe site, and 53.2%, 17.1%, 9.9%, and 11.2%, respectively, in the Desert Steppe site.



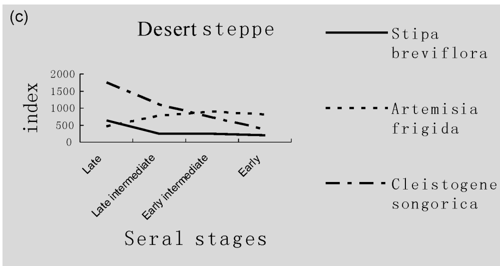


Figure 2 *Key plant species with index values [canopy cover(%)×frequency of occurrence (%)] distributed throughout all seral stages in Inner Mongolia grasslands.*

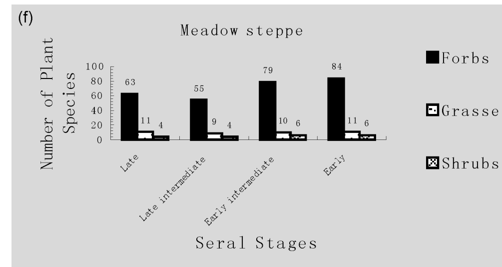


Figure 3 *Number of plant species by category throughout all seral stage in Inner Mongolia grasslands.*

Discussion

The classification of grassland seral stage was based on the ecological concept of plant community succession (Clement 1916; Dysterhuis 1949; Daubenmire 1968). Cluster analysis and discriminant analysis with cover-frequency index was used to examined all the plant species and ISODATA (Ball and Hall 1967) was used to group the transects efficiently into seral stages similar to that of Uresk study (Uresk 1990). This is a practical way to classify the seral stages quantitatively when monitoring grassland.

Three key plant species were selected with discriminant analysis as the indicators for grassland trend in each monitoring site, we can continue to use them when monitoring every year reducing the monitoring time and cost. In general, the Typical Steppe and Desert Steppe are in good condition because of the high percentage of the late and late intermediate stages, and the Meadow Steppe is in poor condition because of the higher percentage of the early and early intermediate stages (Table 2). Therefore, the low stocking rate of grazing management will be applied to the Meadow Steppe site, and improved livestock distribution will be applied to the Typical and Desert Steppe sites.

Table 1 *Fisher's discriminant coefficiencts for classification of seral stages in Inner Mongolia grasslands.*

Meadow Steppe site				
Species	Seral stages			
	Late	Late Int.	Early Int.	Early
Leymus chinensis	0.023	0.015	0.006	0.004
Achnatherum sibiricum	0.009	0.013	0.006	0.004
Carex duriuscula	0.003	0.015	0.015	0.003
Constant	-19.656	-24.860	-15.216	-2.801
Typical Steppe site				
Species	Seral stages			
	Late	Late Int.	Early Int.	Early
Leymus chinensis	0.008	0.004	0.005	0.008
Stipa grandis	0.017	0.016	0.005	0.017
Artemisia frigida	0.010	0.027	0.042	0.010
Constant	-21.111	-29.353	-27.900	-21.111
Desert Steppe site				
Species	Seral stages			
	Late	Late Int.	Early Int.	Early
Stipa breviflora	0.012	0.003	0.027	-0.008
Artemisia frigida	0.008	0.024	0.001	0.039
Cleistogenes songorica	0.008	0.008	0.032	0.011
Constant	-9.104	-23.830	-36.014	-55.450

Table 2 *Canopy cover and frequency of occurrence for key plants throughout the defined seral stages in Inner Mongolia grasslands.*

Meadow steppe site				
Seral stages		*Leymus chinensis*	*Achnatherum sibiricum*	*Carex duriuscula*
	n	Canopy cover (%)		
Late	5	15.33±3.99A	3.05±2.40A	10.03±12.60A
Late intermediate	4	10.75±3.27A	6.15±4.11A	15.99±7.68A
Early intermediate	8	4.69±2.62B	2.78±1.77B	20.61±13.92A
Early	16	3.18±1.86B	1.72±1.60B	12.89±13.97A
	n	Frequency of occurrence (%)		
Late	5	94.31±6.60A	50.92±29.98B	53.65±42.22AB
Late intermediate	4	87.64±6.89A	75.34±23.28A	60.95±3.60B
Early intermediate	8	82.40±16.41A	76.23±23.72A	90.39±14.53A
Early	16	70.35±26.81A	43.26±31.94B	56.97±30.41A
Typical steppe				
Seral stages		*Lymus chinenses*	*Stipa grandis*	*Artemisia frigida*
	n	Canopy cover (%)		
Late	20	11.69±3.13A	7.15±2.05A	1.65±0.68B
Late intermediate	9	6.46±2.00B	7.32±2.94A	2.00±1.20B
Early intermediate	4	4.54±1.06B	7.56±1.47A	3.57±1.31A
Early	4	2.52±0.29C	6.31±1.39B	2.93±0.46A
	n	Frequency of occurrence (%)		
Late	20	46.92±7.69C	47.49±8.62B	17.30±2.71C
Late intermediate	9	71.13±6.77A	70.48±17.85A	22.73±7.39A
Early intermediate	4	62.39±9.30B	73.42±5.14A	26.64±8.37A
Early	4	78.16±3.60A	80.19±8.99A	20.31±0.67B
Desert steppe				
Seral stages		*Stipa breviflora*	*Artemisia frigida*	*Cleistogenes songorica*
	n	Canopy cover (%)		
Late	12	6.23±2.49B	15.45±2.88A	8.47±3.14B
Late intermediate	10	3.28±1.99C	25.24±7.19A	12.90±3.92B
Early intermediate	5	4.92±2.35B	6.96±4.23B	13.97±1.61A
Early	9	5.60±3.47B	6.08±3.21B	8.52±1.82A
	n	Frequency of occurrence (%)		
Late	12	68.40±15.83B	86.80±8.85A	91.20±7.50A
Late intermediate	10	40.80±7.69B	85.60±10.04A	92.00±7.48A
Early intermediate	5	56.00±9.38B	60.44±15.55B	97.33±3.46A
Early	9	63.00±14.28B	72.67±12.40B	87.00±8.38A

Multivariate vegetation analysis provided an accurate method for assessing ecological seral stages (Uresk 1990), and can be used for rangeland monitoring purposes. However, more continuous monitoring sites need to be established to provide data for the development of grassland models for Inner Mongolia.

Conclusions

A monitoring tool was developed from gradients of grazing intensity in Inner Mongolia using the plant succession approach and three key plant species indicators. The species were identified using multivariate statistical methods. The index value of cover and frequency measurements can be used in Inner Mongolia grasslands for the range condition assessment at management unit scale. Knowledge of the seral stages can be used to guide rangeland management in Inner Mongolia.

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Indicators of sustainability in African ranglands

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Key points : Survival of pastoral people who derive their entire livelihoods from rangelands is the most critical indicator of sustainability of African rangelands . But that survival is under threat through rangeland ecosystem fragmentation , human and livestock population pressures , unsustainable land use changes , weak policy and soci-economic environments , available technology and natural disasters . Essential monitoring of these factors which is essential for their management by stakeholders is constrained by weak institutional capacity . This can be alleviated through regional and global , scientific and economic collaboration .

Key words : Rangeland , Indicators , Ecosystem , Human Survival

Introduction Rangelands around the world have common characteristics which include - relatively low rainfall , typically less than 800 mm unevenly distributed through the year and often unreliable , variable from year to year usually with a longer term cyclical variation ; low productive potential per unit area ; low levels of output and of population density . Thus the areas have generally become economically marginal , with poorly developed or limited physical and economic infrastructure .

African rangelands share the above characteristics but in addition have certain unique features which require adjustments in conventional approaches to rangeland management . First African rangelands are home to pastoral people of different ethnic backgrounds who traditionally derive their whole livelihood from rangeland resources . Survival of pastoral people with their cultures which have long evolved around rangeland resources is a priority consideration in assessment , monitoring and management . Secondly , poverty at both local and state levels limits the adoption of a broad range of available alternative approaches to rangeland management .

Assessment of rangeland condition and monitoring of trends in Africa has been inconsistent and constrained by lack of financial resources , enabling policy environment and institutional capacity . But individual countries , supported by international partners , have established rangeland management training and research institutions , which have made good initial inventories and surveys including mapping , but there has been lack of coordination between countries and continuity in data collection and monitoring , which has limited their use . Because of this I would like in this presentation to use , as an example , my country of Kenya with which I am most familiar .

In African terms , Kenya has had a considerably long history in rangeland management which has seen the application of various approaches to resolve the issue of land degradation in the arid and semi arid zones of the country . These have included introduction of various land tenure systems in rangelands and establishment of rangeland research , training and management institutions . In discussing indicators of sustainability of African rangelands , it is important to focus on how these developments have impacted on the stability of rangeland ecosystems and how improvements could be made . Although not supported by hard and consistent scientific data , it is generally acknowledged from field observations that African rangelands are undergoing severe degradation and pastoral people are becoming poorer .

Indicators of sustainability The causes of and impacts of land degradation are often multiple and complex and usually involve a combination of human and natural factors . There are direct and indirect relationships between the state of natural resources (soil , vegetation , water , ecosystem) , and biological diversity at species level (animal , plant and microbial species) and ecosystem level (habitats , interactions , functions) and the management of those resources (Bunning 2003) . Management practices directly or indirectly affect the capacity of land users to conserve and sustain resources and provide goods and ecological services . The assessment and monitoring of range condition and associated ecosystem processes , therefore , requires an integrated set of biophysical and socio-economic indicators , which will provide a basis for informed management decisions by a range of stakeholders from resource users and managers to technical advisers , planners and policy makers .

Territorial integrity of pastoral lands

The long term survival of pastoral people who are wholly dependent on resources of the rangelands is perhaps the best indicator of the sustainability of African rangelands . That assurance pre-supposes that the pastoral people have adequate rangeland to cater for their year round survival including times of prolonged droughts or floods or outbreaks of disease . Conversion of African rangelands to non viable grazing units is perhaps the biggest threat to their sustainability .

Pastoral nomadism is a necessity for survival on African rangelands and has been traditionally practiced for many years . Pastoral people moved over large territories in search of suitable grazing for their livestock and sections of rangeland were reserved for dry season grazing and periods of drought . The movements were orderly and the decision making processes that initiated such moves were well established within the pastoral cultures . Territorial integrity was assured through tribal councils of elders who regularly met to discuss issues of mutual interest across tribal boundaries . Grazing reserves were protected for the use of all . In order to regain the integrity of the rangeland , it is important to restore some of the original rangeland territory through trans-boundary agreements that guarantee access to grazing rangelands across modern state boundaries .

In Kenya , for example the Kenya/Uganda boundary divides the tribal territories of the Pokot and Turkana pastoralists ; the Kenya/Ethiopia border divides Borana , Gabbra and Somali pastoralists ; the Kenya/Somalia border divides Somali , Pokomo and Oromo pastoralists ; while the Kenya/Tanzania border divides the Masai and Kalenjin tribal territories . Tribal disputes due to cross border grazing have been on the increase in the recent past sometimes resulting in clashes that have cost human lives . In order to resolve these problems it will be important for the modern nation states to draw standing trans-boundary agreements that would assure orderly access to these rangelands for the pastoral populations affected .

Security of tenure of African rangelands

Security of tenure is an important indicator of the sustainability of rangelands for without security of tenure of the residents of African rangelands , long term rangeland management measures and investments cannot be assured . Tenure under the traditional systems was assured through the tribal custodianship of rangelands vested with tribal elders . Tribal territories had been established after long term negotiations between the tribes , sometimes occurred after bitter tribal wars . Rangelands were owned as tribal entities and their use was regulated by tribal rules , which had evolved over time and whose basic foundation was to maintain the integrity of rangelands for the long-term survival of the tribe .

The establishment of modern nation states which brought together many different tribes necessitated the introduction of new land tenure systems , some of which would be based on individual land ownership . Although this was easier to establish in agricultural communities and tribes , it was not very easy to prescribe specific land tenure systems for pastoral rangelands . The experience in Kenya , is a good example .

In the early 1900 s Kenya s high potential rangelands were converted into fenced off commercial ranches to raise beef largely for the export market . In addition group ranches with group title deeds were established for certain select semi-settled agro-pastoral communities . The pastoral nomadic groups were left with low potential rangelands without any specific tenure status but put under the custody of country councils , which had never been involved in rangeland management . The individual and group ranches were originally part of the pastoral nomadic seasonal grazing cycle , which consisted of both wet and dry season grazing areas in order to use rangelands in a sustainable way . The removal of these rangelands from the established nomadic grazing cycle was a factor which led to rangeland degradation . The communal ownership of rangelands left for pastoral nomadic groups did not qualify for investment credit from financial institutions . In order to assure sustainability of the African Rangelands pastoral communities must be assured of the tenure of their lands in order to take responsibility for their sustainable development and management .

Land use change and sustainability of African rangelands

Large portions of African rangelands occupied by pastoral people are ecologically fragile and nomadic pastoral grazing rangeland is the ecologically most suitable land use . Politically and economically , however , these areas have had a history opportunistic exploitation that has resulted in increasing degrees of human hardship and ecological damage .

In Kenya , for example (Table 1) , due to increasing human population pressure in arid and semi arid rangelands , rangelands are increasingly being converted into cropland . The general result of this type of agriculture , in these ecologically delicately balanced areas , is to convert potentially good quality grazing land into ecologically unstable areas of lowered fertility , liable to water and wind erosion .

Table 1 *Changes in Area of Major Land Use Categories-Kajindo District*

		Area in Hectares (Ha)			
ID	Land use	1973	1984	1994	2000
1	Forest	646 .34	595 .88	416 .69	416 .69
2	Irrigated Agriculture	245 .17	3 ,512 .48	4 ,043 .39	4 ,766 .18
3	Rainfed Agriculture	7 ,211 .47	17 ,762 .31	22 ,032 .66	24 ,911 .04
4	Rangeland	160 ,846 .76	147 ,094 .63	142 ,473 .97	138 ,871 .08

From : David J . Campbell et al , *Human Ecology* , Vol 33 , No . 6 December 2005 .

In order to further ensure food security for increasing human populations , critical areas of rangelands that were retained for dry season grazing , have been converted into irrigated farmland . Many of those irrigation schemes have been abandoned after the rangeland has been destroyed and thus increasing the instability of the rangeland ecosystem . Where such schemes have survived , they have served to displace pastoral livestock to more marginal rangelands which can least support them and hence contributing to continued rangeland degradation through overgrazing . Although it may not be economically possible to restore some of the rangelands , efforts to stabilize the already degraded areas should increase their sustainability .

Rangeland fragmentation through the sale of already securely adjudicated individual and group ranches is another factor contributing to the instability of African rangelands . Although security of tenure was seen as a way of keeping rangeland for grazing use , many of the individual and group ranch owners are increasingly leasing or selling these lands to absentee landlords for commercial wheat farming and production of other crops (Figure 1) . Valuable dry season grazing rangelands are being turned into flower farms for export . Although these exports may be beneficial to the national economy , such lands should have been guaranteed to remain rangelands through a still current zoning policy . These land use changes are leading to irreversible damage to the rangelands and serious consequences for the pastoral people who live there .

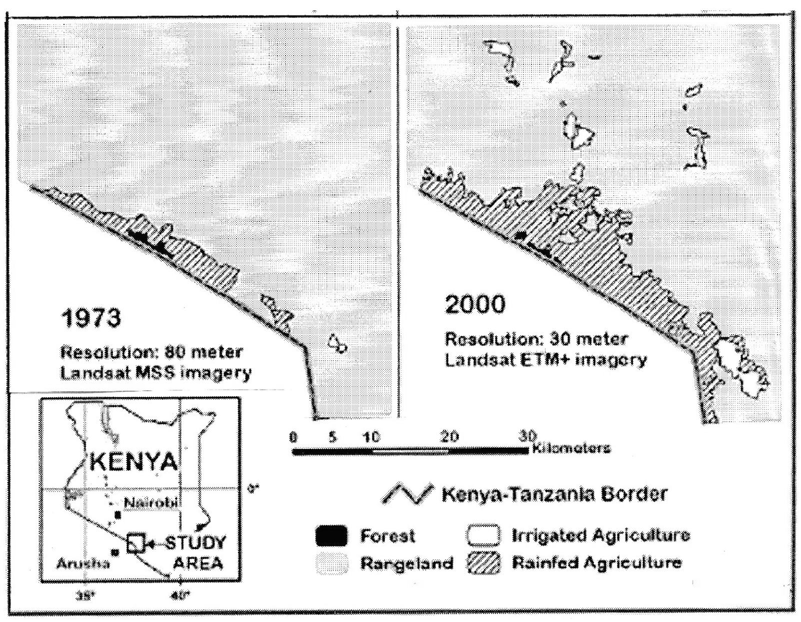

Figure 1 *Patterns of land use change in southeast Kajiado District , Kenya 1973-2000*
From David J . Campbell et al , Human Ecology , Vol 33 , No 6 December 2005 .

Demographic change and sustainability of African rangeland

Since sustainability of African rangelands is directly linked to the livelihoods of the pastoral people who live there , demographic change in rangelands and the living conditions of the pastoral people is perhaps the most important indicator of sustainability of rangelands . Apart from the reduction in pastoral territory , changing land tenure and land use ; population of the people who live in rangelands has increased by 2 .2 percent annually . This has far reaching consequences . Since the pastoral people are directly dependent on their livestock , an increase in their population traditionally requires an increase in livestock numbers . Increase in livestock populations increases pressure on already reduced rangelands . The result is unprecedented rangeland degradation accompanied by human suffering . During relatively frequent times of drought there are usually not only environmental refugees who flee to famine relief camps but loss of livestock and human life . This is the scenario across most of Africa s rangelands which has not been adequately addressed through national policies and development plans .

Another demographic trend of far reaching impact on the sustainability of African rangelands is the official government encouragement of sedentarization of pastoral nomadic people . In Kenya , this was done through the establishment of grazing schemes and group ranches as good models of proper land use and livestock management . Once settled , the pastoral populations would receive medical treatment , the children would go to school , and the people would pay taxes to the government . Other forms of settlements are outgrowths from famine relief centers created to provide food for people following droughts after they have lost their livestock . It is understandable that the government , anxious to safeguard the welfare of these people might have encouraged these types of activities without realizing their ecological consequences . But in the long term interest of the survival of the pastoral people of the rangelands , African governments must promote land use approaches and socio-economic systems that must restore the integrity of pastoral rangelands and assure sustainable human livelihoods .

Changes in livestock populations
Livestock is the primary link between the pastoral people and their environment . Pastoralists determine the condition of their rangelands through the performance of their livestock . Milk production is an important indicator of the condition of the rangeland and plays an important role in determining their movement over their rangelands . When milk production continues to decrease , it usually means that the availability of grazing and water is low and hence time to move to the next grazing unit . Assurance of survival was also further achieved through the keeping of mixed herds of livestock-cattle , camels , sheep , goats and donkeys-which utilized different parts of the available forage and had compatible water needs . Wildlife was part of the range and diversified their food security during times of drought .

The situation in Kenya with regard to livestock populations could be representative of Africa s rangelands . Control of livestock diseases and provision of adequate watering points for people and their livestock are some of the most compelling human urges on African rangelands , but this has led to livestock populations exceeding rangeland grazing capacity . This becomes self defeating when carried out on a narrow front , without any surrounding strategic design for controlling livestock numbers or diluting modern human greed for exploitation .

Vegetation and sustainability of African rangeland
In range science , condition of the vegetation - its composition and diversity , its type and vigor , and its cover of the soil surface - is one of the most important indicators of rangeland sustainability . Vegetation on African rangelands occupied by pastoral people has continued to deteriorate due to a combination of the above factors .

Human population pressures have put direct pressure on the vegetation through their demand for fuel wood and building material and for building night enclosures to protect livestock from predators . This has reduced woody vegetation which is forage to livestock and wildlife populations .

Because of weak grazing controls and livestock marketing structures on these communal lands , there is increased overgrazing over large areas of the rangelands . Information on vegetation change on African Rangelands has been fragmented but satellite imagery is now providing some hope for a broad assessment of the situation . When this information is available , new policies will need to be put in place by individual countries . But those policies need to be enforced and alternative livelihoods offered to the rangeland people .

The effects of soil degradation
Soil stability and fertility are important indicators of rangeland sustainability . The condition of rangeland soils in Africa is being increasingly reduced due land use malpractices .

After periods of rain in Kenya , for example , it is possible to see rivers changing color , as valuable soil is washed from land and swept away . This is an irretrievable loss to African nations and in many cases has already undermined the development processes and food security on which the welfare of the people depend .

Wildlife conservation and rangeland sustainability
Wildlife is an indispensable part of the African landscape , especially its rangelands . Wildlife utilizes different vegetation components from those used by livestock and is more resilient in use of available water . Pastoral people have always considered wildlife to be part of their landscape which does not only provide survival during times of drought , but also offers alternative livelihoods in terms of wildlife based tourism . Its presence or absence is an important indicator of the sustainability of rangelands .

Conclusion It is difficult to make a general evaluation of the status of African rangelands because of the vast differences in their physical location and socio-economic conditions of the countries where they are found . Socio economic conditions of the people and their welfare will continue to be the most important indicator of the sustainability of rangelands in both the short and long term . Because of poverty and differences in the socio-economic status of the individual countries , it is difficult to implement a uniform monitoring program that would yield reliable continent-wide data for development planning and management . But since most rangelands are trans-boundary , such information will be needed at the regional scale if it is to be useful . There are currently many well established centers for rangeland research and development which have been operating below their full potential due to lack of funds and enabling environments for extensive field surveys . These must for the time being remain the nucleus for rangeland development and collaboration between African states and indeed the rest of the world . It is quite possible that the recognition of these centers as regional centers of excellence could remove them from the national constraints . The most important objective for such centers would be to provide the urgently needed information to arrest and reverse the current accelerated degradation of African rangelands .

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Applicability of criteria and indicators for sustainable grassland management to rangelands of Patagonia (Argentina)

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Key points: One hundred years of pastoral use of Patagonia s rangelands have resulted in severe land degradation. Widespread application of range survey methods to determine grazing capacity of commercial ranches did not begin until the late 1980s. Public awareness about desertification problems and efforts of the science community led to the passing of an important congressional act in 2002 which has created the conditions for the implementation of a region-wide rangeland monitoring system (MARAS). Although most of the criteria and indicators for sustainable rangeland management proposed by the Sustainable Rangelands Roundtable are relevant to conditions in Patagonia (Argentina), less than half the indicators are applicable due to the relative paucity of data and validated models. Current monitoring frameworks allow broad spatial scale assessments but are somewhat lacking in fine-scale evaluation of indicators.

Key words: rangeland monitoring, biophysical indicators, socioeconomic indicators, MARAS

Introduction Most of Patagonia s rangelands (approximately 750 000 km^2) lie in the rain shadow of the Andes mountain range and are primarily treeless shrub and grass steppes that give way to dwarf-shrub semi-deserts in the drier areas of the central plateaus (Roig 1998). Blended in the steppe landscapes are riparian areas (*vegas* or *mallines*) associated with rivers and other permanent water sources. Although *mallines* are a very small proportion of the total land area of Patagonia, they frequently play a key role in livestock production and, in many instances, are the ecosystems most severely affected by improper land management decisions (Golluscio and others 1998). Approximately 90 percent of soils in the region exhibit some degree of degradation, mostly as a consequence of improper land use. Severe desertification affects about a third of Patagonia (Del Valle et al. 1998); some of its most dramatic expressions are the *lenguas medanosas* (sand dunes) that covered an area of approximately 85 000 km^2 in the early 1970s.

Commercial sheep grazing enterprises are a fundamental element of rangeland livelihood of most of Patagonia. Almost all of Patagonian rangelands are privately owned and, therefore, grazing use is virtually unregulated. Rangeland science and management tradition is fairly young in most of Patagonia; widespread application of range survey methods to determine grazing capacity of commercial ranches did not begin until the late 1980s. Surprisingly, invasive noxious weeds are not a widespread problem on Patagonia s rangelands. We report past, present and future of rangeland monitoring in Patagonia and the applicability of a suite of criteria and indicators for sustainable grassland management to conditions in Patagonia.

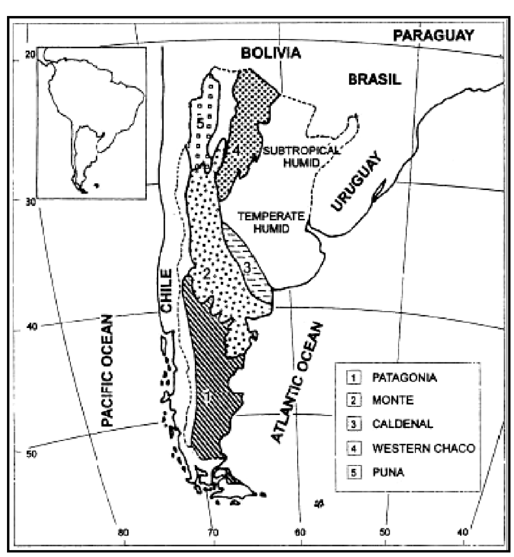

Figure 1: *Map of rangeland types of Argentina according to Fernandez and Busso (1999).*

History of Patagonian land use Pastoral use history of rangelands in Patagonia is relatively recent. Colonization took place in the late 1880's , after military desert" campaigns subjugated native peoples and offered land for settlement , mainly to Argentine and Chilean *criollos*" but also to settlers of European or Middle-Eastern descent , including Spaniards , English , Scottish , Italians , Syrian-Lebanese and Yugoslavians . Native peoples were mainly hunters and gatherers : the Tehuelche in the south did not endure the cultural impact of colonization and are now severely reduced in number , while the Mapuche people , in the north , recovered after an initial decrease in number . Both groups add up to 23 to 50 thousand people , about 1 .4 - 3 .5% of current residents of the region . Early (1880-1900) colonization was actively encouraged by the government and settlers were given access to pastoral leases in large areas of the most productive or readily accessible land . At the turn of the 19th century , poorer settlers took part in the colonization of more arid or less accessible areas . The land was divided geometrically into allotments of about 10 to 20 thousand hectares without considering environmental factors or the balance of range types , water points or wintering areas within the properties (Barbería 1995) . Native Americans remained on the land in small subsistence allotments of about 500 to 2500 hectares or in a few reservations . Freehold rights consolidated land tenure of most of the big *estancias*" at the turn of the 20th century , but small allotments remain mostly with informal or traditional occupation , a great number of them unfenced .

History of Patagonian sheep industry The sheep industry flourished until 1920 , while prices of wool were high and undisturbed grasslands could take heavy grazing pressures . Sheep numbers peaked in 1937 (approx . 20 million) and remained stable for the following 50 years (Escobar 1997 ; Mendez Casariego 2000) . In the 1980 s , a generalized stock reduction process (approx 8 million) was triggered by a combination of lower international wool and meat prices , loss of productivity due to rangeland degradation , and macroeconomic policies that inflated the value of local currency (Borrelli and others 1997 ; Mendez Casariego 2000) .

These factors put most sheep ranching enterprises in a difficult financial position ; by the end of the 20th century most ranchers had become heavily indebted and had drastically reduced their work force . This crisis primarily affected mid-sized (20 .000 hectares) family-owned ranches in the Central Plateau of Santa Cruz , where about 440 (40% of the total) *estancias* were abandoned or remained occupied by caretakers with no pastoral activities . Rural population in Santa Cruz fell from 24 .500 in 1960 to 13 .700 in 1991 (Mendez Casariego 2000) . Changes in macroeconomic policies implemented in 2002 have increased the profits of the sheep ranching industry (Teran and Claps 2002) , and there is currently a strong predisposition to re-colonize vacant lands .

Environmental degradation and the role of central government Grazing-induced degradation processes were described early on by Bailey Willis (1914 , as cited in Castro (1983) , Morrison (1917) , Auer (1951) , and Soriano (1953) . Soil erosion was treated using dune control techniques as early as 1950 (Castro 1983) . Nonetheless , the underlying causes of degradation were not addressed , and heavy stocking rates remained in place until the 1980 s . Regional evaluation of desertification using satellite imagery which began in the early 1990 s , showed that severe or very severe desertification had affected approximately 34% of Patagonia (Del Valle et al . 1998) .

According to the Argentine constitution , natural resources , including rangelands , are under the jurisdiction of provincial governments . Sadly , environmental consequences of improper grazing have rarely been addressed by provincial or national government policies due to the fact that most of the land is under freehold tenure and there is no constitutional mandate to monitor the state and management of rangelands . Grazing has , therefore , gone unregulated and conservative management has depended mostly on the perceptions and goodwill of landowners . Due to social and political influence of traditional rancher associations , significant amounts of public funds have frequently been directed towards the maintenance and expansion of the sheep industry through subsidies and financial support regardless of the grazing capacity of rangelands .

Joint desertification projects sponsored by the Instituto Nacional de Tecnología Agropecuaria (INTA , Argentina) and the Deustche Gesellschaft fur Technische Zusammenarbeit (GTZ , Germany) from 1989 to 2002 helped increase public awareness regarding the threat that desertification posed to the region , and stimulated the design and fairly extensive application of rangeland survey and monitoring techniques . The trend in public fund allocation has changed in recent years since the passing of a Sheep Act in 2002 (Poder Legislativo Nacional 2004) that assigns about u $ 7 M yearly to projects that can demonstrate ecological sustainability through certified range evaluation . Rancher associations participate in the distribution of these funds that support the development of a regional-scale monitoring system . A project with funding currently under consideration by the Global Environment Facility Program of the World Bank (GEF) will address three aspects that the Sheep Act of 2002 does not include , namely : 1) rangeland monitoring ; 2) education ; and 3) diversity conservation through public and private protected areas . Such recent developments allow moderate optimism regarding a change in long-term government rangeland conservation policies .

Past , present , and future of rangeland monitoring in Patagonia The use of rangeland science to address management problems in Patagonia is fairly recent . It was not until the early1980s that researchers began using traditional range condition analysis to develop utilization guides for a few selected range sites in the region (Borrelli *et al* . 1984 ; Borrelli *et al* . 1988) . Because no vegetation-based rangeland assessment techniques had been calibrated for extensive use across Patagonia, concurrent eforts were also made during the 1980s to develop range assessment methods that would provide region-wide stocking rate guidelines for sheep ranchers (Borrelli and Oliva 1999). Starting in 1992, range scientists began working on transforming old" range condition guides into state and transition models (Paruelo *et al*. 1993). Unfortunately, ecological site description work associated with this effort was soon put on hold; all efforts were progressively directed to train extension personnel and private consultants to use the newly developed range assessment methods in the field. Region-wide programs funded by the federal government were basically aimed at mitigating the effects of desertification. Their basic assumption was that desertification processes were being driven by sheep-grazing; consequently, development and application of tools to adjust stocking rates were given highest priority.

Although some range assessment data were compiled into regional databases, their detail was insufficient to make reliable inferences about regional vegetation trend. These shortcomings were somewhat offset by the development of a regional GIS that used 1986 Landsat 7 satellite images to generate an inventory of land degradation status in selected areas of Patagonia. This effort, allowed a first approximation to quantifying the problem of desertification. The last stage of this project involved a socio-economic survey of ranchers across some key areas of Patagonia that was completed recently. This was possibly the first survey in Patagonia, documenting individual rancher s perceptions of land management issues. Detailed long term plant cover and soils data exist for a handful of sites across Patagonia, mostly on federal government experimental ranges.

The need for an independent method to determine rangeland state and trend at the scale of range types (from 0.4 to 14.3 M ha) and at relevant time scales (decades) has been acknowledged recently. Range scientists from across Patagonia have developed the MARAS" monitoring system (*Monitoreo Ambiental de la Reg*ión *Arida y Semiárida de Patagonia*, (Oliva and others 2004) based on Australia's WARMS method (Western Australia Monitoring System), that includes point intercept transects or frequency samples to evaluate herbaceous vegetation and Canfield transects to monitor shrubs. Soil surface stability sampling is also performed to monitor topsoil integrity. Monitoring stations will be set up at a rate of 1 : 20.000 hectares and will be measured every five years. MARAS has received funding from a federal Sheep Act of 2002 to train field personnel, install the first monitoring sites, and design a web-based data bank that will be accessed by government agencies and NGO's. In the future, MARAS could supply information to monitor vegetation cover, species composition, forage biomass and soil condition of rangelands in Patagonia. To date, there are no plans in place to incorporate social or economic variables into this monitoring system.

Rangeland monitoring and issues of scale Ecological problems, such as rangeland sustainability, occur at temporal scales of several decades and at spatial scales of entire ecosystems. However, many indicators of sustainability can only be measured directly in small areas over relatively short periods of time. Because patterns and processes that occur at fine spatial scales do not necessarily prevail at broader scales (Allen and Starr, 1982), it is not possible to simply aggregate across scales from local to regional or national levels to make inferences about sustainability of rangelands (Mitchell, 2002). The suite of criteria and indicators such as those developed by the Sustainable Rangeland Roundtable (SRR) were intended to … guide monitoring efforts to measure rangeland sustainability .. at multiple scales [and to] ensure that .... appropriate temporal and spatial scales for assessing the criteria [were used] …" (SRR 2005).

Catastrophic events that have long-lasting effects on rangeland ecosystems (e.g. desertification, wildfires) exhibit non-linear behaviors that are thought to be driven by cross-scale interactions and complex feedbacks among ecosystem components (Peters *et al*., 2004). Although significant progress has been made in describing thresholds of vegetation change (Bestelmeyer *et al*. 2003, and references therein), the ability to predict the point at which ecosystems are likely to cross a threshold is still in its infancy. Peters *et al*. (2004) proposed that threshold behavior is the result of cross-scale interactions in which broad-scale processes, such as drought or wildfires, eventually overwhelm fine-scale processes and control the dynamics of the system. For example, in a highly degraded rangeland ecosystem, landscape-level transport of materials by wind and water may override micro-patch conditions that control plant recruitment and determine overall vegetation trend. Peters *et al*. (2004) argue that in such conditions, grazing may be irrelevant to overall system dynamics. Monitoring indicators of rangeland sustainability should, therefore, be based on a basic understanding of the processes currently driving the system and the spatial and temporal scales at which they operate. Data from plots or transects should be interpreted in the context of landscape dynamics to meet these challenges (Peters and Havstad 2006). Although rangeland scientists in Patagonia have recognized the non-linear nature of rangeland plant community dynamics (Oliva *et al*. 1998; Parizek *et al*. 2002), current monitoring efforts do not explicitly address issues of scale.

Scale issues may be of a somewhat more complex nature when social and economic variables are considered. Scaling up in time and level of organization (from individuals to institutions) by simple aggregation is, conceivably, also an inadequate means of predicting behavior of social systems. Complex social and economic behavior interactions may also exhibit non-linear dynamics with critical thresholds and transitions that may be irreversible for time frames relevant to rangeland managers.

Table 1 *Qualitative analysis of scales at which applicable SRR indicators can currently be monitored in Patagonia (Argentina)*

Short list of criteria and indicators that could be monitored in Patagonia		**Spatial scale**		**Temporal scale**	**Methods**
		Extent (*)	**Grain (**)**		
I	**4.** Area …with significant change in …bare ground	Pasture to landscape	Pixel size	Every 5-10 years	Satellite image analysis
	5. Area …with accelerated soil erosion by water or wind				
II	**12.** Rangeland area by plant community				
	15. Density of roads and human structures				
	17. Extent and condition of riparian systems	Floodplain to watershed			
	18. Area of infestation…of invasive plant…species….	Plant communities	0.1 m^2 quadrats to pixels		Satellite image analysis- plot or transect monitors
III	**21.** Rangeland aboveground biomass	Pastures		Yearly	
	22. Rangeland annual productivity	Plots to landscapes			
	23. Percent available rangeland grazed by livestock	Ranches to landscapes	Ranch	Every 5 years	National or Provincial population surveys
	24. Number of domestic livestock on rangelands	Counties	Counties	Every 4 - 6 years	
IV	**29.** Number of visitor days by activity and recreational…	National Parks	Nat. Parks	Yearly	
	32. Rate of return on investment for range livestock…	Ranch to regional	Ranch	Occasional	
	36. Poverty rate (general)	Province	Province	Every 4 – 6 years	
	37. Poverty rate (children)			Every 4 - 6 years	
	38. Income inequality			Yearly	
	41. Federal transfers by categories…..			Yearly	
	45. Agriculture (ranch/farm) structure	County	County	Every 4 - 6 years	
	46. Years of education	Province	Province	Every 4 - 6 years	
	47. Value produced by agriculture and recreation…			Occasional	
	48. Employment, unemployment, underemployment…			Every 6 months	
	49. Land tenure, land use, and ownership patterns…	County	County	Every 4 years	
	50. Population pyramid and population change	Province	Province	Every 4 - 6 years	
V	**56.** Institutions and Organizations	Region	Region	Occasional	
	59. Professional Education and Technical assistance				
	63. Measuring and Monitoring				
	64. Research and Development				

* Extent is the largest area monitored

* * Grain is the smallest unit that can be monitored and is therefore indicates the level of resolution of the data

Applicability of criteria and indicators (C&I) for sustainable grassland management in Patagonia Cibils and Oliva (2006) assessed the relevance of the Sustainable Rangelands Roundtable (SRR) C&I to conditions in Patagonia and found that : **a)** Most C&I were relevant to conditions in Patagonia and that only a few indicators , mostly within the criterion dealing with conservation and maintenance of plant and animal resources on rangelands (SRR s criterion 2) , were classified as not being applicable to Patagonian rangelands ; **b)** available data or models could only assess 26 of the 53 relevant indicators for sustainable rangeland management proposed by the SRR ; and **c)** relative lack of quality data and scarcity of validated models were the factors that limited the applicability of SRR C&I to Patagonian rangelands the most .

Cibils and Oliva (2006) suggested that their assessment exercise could be indicative of the kinds of challenges associated with applying the SRR C&I to rangelands in developing countries. They further suggested that the application of rangeland monitoring assessments in such countries following the framework proposed by SRR may require a shorter bare-bone list of essential criteria and indicators (Table1). The development of a condensed list of essential indicators could serve as a guide to help land managers and local enforcement authorities in developing countries prioritize the use of scarce funds allocated to monitoring efforts.

Can applicable criteria and indicators be measured at appropriate scales in Patagonia? Because not all indicators can be monitored in Patagonia, a second qualitative assessment was conducted to determine whether monitoring the reduced subset of indicators mentioned above would provide reliable information at multiple scales.

This assessment showed that most biophysical indicators on the short list (Table 1) could only be currently monitored at broad spatial scales ranging from pastures to watersheds and landscapes. The grain of the scale at which most indicators could be monitored ranged from $30m^2$ to1 km depending on pixel size of the satellite image used. For indicators related with area of infestation of noxious or invasive plants, rangeland aboveground biomass, and annual aboveground productivity transect or plot data were available for a reduced number of sites across the region. Prior analysis of satellite images that provide baseline data to determine several soil and plant indicators was also circumscribed to 4 pilot areas that cross most of the Patagonian steppe from W to E at different latitudes.

Limitations associated with the spatial grain of the data are greater when socio-economic indicators are considered (Table 1). Although most surveys are conducted at the level of individual households or ranches, the data made available to the general public (including researchers) cannot be disaggregated beyond the level of provinces and, sometimes, counties. In addition, regional and national censuses are subject to sporadic federal funding pulses and are, therefore, conducted at irregular intervals. Hence, it is difficult to overlay watershed or landscape scale trends with corresponding socio-economic changes.

Conclusions Most of the C&I for sustainable rangeland management proposed by the SRR are relevant to conditions in Patagonia (Argentina). Less than half the indicators are applicable, however, due to the relative paucity of data and validated models. A shorter list of essential indicators may be necessary to realistically conduct regional long-term assessments of overall sustainability of rangeland ecosystems in developing countries.

Current monitoring frameworks of bio-physical indicators of rangeland sustainability in Patagonia allow broad spatial scale assessments but are somewhat lacking in fine-scale evaluation of indicators. Broad-scale bias is even more accentuated if socio-economic indicators are considered. A new monitoring framework developed by scientists in Patagonia (MARAS) will tend to increase fine-scale assessment of bio-physical indicators. This monitoring framework could be enhanced by explicitly addressing cross-scale interactions following a novel conceptual model developed for arid rangeland ecosystems of North America (Peters and Havstad 2006).

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The use of criteria and indicator monitoring of ecosystem sustainability to assess ecosystem services on grasslands/rangelands

R. Dennis Child, Janette Kaiser, and Ralph Crawford

Introduction Ecosystem services are benefits people obtain from ecosystems. An international work program and the largest assessment of the world=s ecosystems was launched by UN Secretary, General Kofi Annan, June 2001; completed March 2005. The Millennium Ecosystem Assessment (MA), as it was known, was prepared by over 1300 authors in 95 countries. The findings are contained in 15 reports. One of the main findings indicates that over 60 percent of the world=s ecosystem services are in decline. Further, the report describes the critical link between ecosystem services and human well-being. The MA assessed 24 services and predicted their status; 15 of these were found to be declining. The MA highlighted that ecosystem services are natural assets for countries around the world, but without formal valuing mechanisms, they are not taken into account in measures of a country's economic progress or wealth.

Part of the problem is that these services are often considered to be public goods" that are free and limitless. Lacking a formal market, these natural assets are traditionally absent from society's balance sheet; their critical contributions are often overlooked in public, corporate, and individual decision-making. There isn't an incentive to protect or conserve these public benefits. Recognizing rangeland ecosystems as natural assets with environmental, economic and social value can promote conservation and lead to more responsible decision-making on both public and private rangelands in the United States and the world.

Walter Reid, Institute for the Environment, Stanford University professor and the leader of the MA, identified four ways in which we might be able to prevent the degradation of ecosystem services: new business models, new technologies, new incentives and new markets. All of these changes result in changing human behavior. So what does this mean for public or federal rangelands in the US, and for rangelands around the globe?

Rangelands of the United States Rangelands, grasslands, improved grasslands and shrublands comprise approximately 70% of the earths land surface including approximately 400 million hectares of the United States land base.

These lands are ecosystems which serve important ecological, cultural and economic roles that go well beyond the traditional multiple uses" that usually come to mind. Healthy rangeland ecosystems provide a full suite of goods and services that are vital to human health and livelihoods, also known as ecosystem services. Many of these goods and services are traditionally viewed as free benefits to society, or public goods. These lands provide commodity, amenity, and spiritual values that are vital to the well-being of Nations, regions, and local areas. These goods and services include: food and fiber, forage for grazing animals, critical species and wildlife habitat, water storage and filtration, carbon sequestration to mitigate climate change, consumptive and non-consumptive recreation opportunities, erosion and pollution control, biofuels, cultural heritage and a way of life for grassland/rangeland dependent human communities, to name a few. Intact grassland ecosystems provide integral processes critical to functions such as pollination control, nutrient storage, climate moderation, primary productivity, and maintenance of genetic reservoirs and seed sources.

Even so, rangelands suffer from an identity crisis. A clear mental picture exists for forests, but for rangelands it's not so clear. Common characterizations of landscapes do not identify rangelands as a type of land, and often fragment rangelands into more recognizable descriptors such as forests, crop and agricultural lands which often omit those lands that are relatively undeveloped. This can be challenging, especially for management of federal rangelands. In fact, a national survey exists for all forested lands, as well as private agricultural lands. There is also a global effort to characterize forests and assess their sustainability to nations and the world which utilizes criteria and indicator monitoring protocol. Sadly, there is no national survey for rangelands in the US that includes federal rangelands, and there is no use of criteria and indicator monitoring for sustainability of rangeland resources on a global scale.

In the US, there is no data collected using the same methodology over time that allows for aggregation at the national level. That leaves interpretation to professional opinion and personal judgment. When rangelands are undervalued, as they currently are, they are increasingly susceptible to degradation, development pressures, and conversion. The highest value for rangelands in America today is development; and I suspect that is not untrue for other countries as well.

There is a need for increased recognition of the full range of ecosystem services, especially in light of increased consumption, increased demand for development, the continued need for spiritual and aesthetic values, and commitment to local community stability. The ability to identify, characterize and provide a value for these services can inform decision making and policy development on public and private rangelands.

Valuing ecosystem services on both public and private lands can make good stewardship profitable. In the US, the Forest

Service , along with other federal agencies , is exploring ways to value ecosystem services opportunities to advance markets and payments for ecosystem services on rangelands , and any application this concept may have to stimulate market-based conservation and stewardship for future sustainable use of rangeland renewable resources for current and future generations . In doing so , we can

- Provide new revenue streams for renewable resource industries
- promote conservation and sustainable land management
- support ecological restoration
- Increase appreciation and support of public lands .
- Better inform decision makers on the value and sustainable use of rangelands

Scientists predict that to stabilize carbon dioxide in the atmosphere , we need to reduce global emissions by 70 percent . Adopting certain agricultural and land management practices can reduce greenhouse gas emissions to the atmosphere and sequester additional carbon . Market based approaches to carbon sequestration , biomass utilization , and water quality exist . And other potential markets are in place or emerging . Market-based mechanisms include public payment or incentives ; self-organized private payments , trading schemes , mitigation (mitigation banking ; conservation banking) and investments and offsets . Market based approaches are part of the solution to the need to value and conserve important public benefits that rangeland landscapes provide .

The Sustainable Rangeland Roundtable (SRR)
There are 4 Sustainable Roundtables functioning within the US . They include :

- Sustainable Forest Roundtable
- Sustainable Rangeland Roundtable
- Sustainable Minerals Roundtable
- Sustainable Water Roundtable

The Sustainable Rangelands Roundtable is a grass-roots effort that has promoted social , ecological , and economic sustainability of U .S . rangelands . It urges associated resource assessments based upon periodic inventory and monitoring of SRR criteria and indicators . Criteria are explicit goals of sustainable management , but are too general to monitor directly . Each criterion is characterized by measurable indicators to demonstrate trends over time .

SRR= s standardized monitoring and reporting framework provides a model for comprehensive national rangeland data collection . Consistent inventory and monitoring information may enable governments , agencies , and people on the land to more accurately assess effects of conservation programs , uses , and management actions which ultimately can inform decision makers on the sustainable use of rangelands . Better information can improve the delivery of effective , efficient land management actions , allocations , and conservation programs that advise and assist landowners . Comprehensive rangeland information consistently collected coast to coast and border to border , will benefit everyone . Potential outcomes include improved coordination and cooperation among agencies and organizations , improved use of scarce resources , and enhanced resource allocations for rangeland management and science . However , to be effective , SRR indicators must first be universally adopted and used to track trends in rangeland resources , economics and communities on a global scale to realize their full utility .

SRR s *First Approximation Report on Criteria and Indicators for Sustainable Rangelands* described a method for assessing rangeland sustainability and represents a milestone in collaborative development of significant rangeland metrics . While data currently is gathered for many of the indicators , it is not consistently collected , analyzed , and reported across organizations or efforts . This first approximation report offers a discussion of sustainable development in relation to rangelands and the SRR process . A subsequent Progress Report identifies 27 core indicators , and discusses data status and needs . Additional information about the Sustainable Rangelands Roundtable is available at http ://SustainableRangelands .cnr .colostate .edu .

Core indicators
I . Conservation and maintenance of soil and water resources

Soil-based
- Area and percent of range-land soils with significantly diminished organic matter and/or high Carbon :Nitrogen (C :N) ratio .
- Area and percent of rangeland with a significant change in extent of bare ground .
- Area and percent of rangeland with accelerated soil erosion by water or wind .

Water-based
- Percent of water bodies in rangeland areas with significant changes in natural biotic assemblage composition .
- Percent of surface water on rangeland areas with significant deterioration of their chemical , physical , and biological

properties from acceptable levels .
- Changes in the frequency and duration of surface no flow periods in rangeland streams .

II . Maintenance and conservation of plant and animal resources on rangelands

- Rangeland area by plant community .
- Fragmentation of rangeland and rangeland plant communities .
- Extent and condition of riparian systems .
- Area of infestation and presence/absence of invasive and other non-native plant species of concern .
- Population status and geographic range of rangeland dependent species .

III . Maintenance of productive capacity on rangelands

- Rangeland aboveground phytomass .
- Number of domestic livestock on rangeland .

IV . Maintenance and Enhancement of Multiple Economic and Social Benefits to Current and Future Generations

- Value of forage harvested from rangeland by livestock .
- Rate of return on investment for range livestock enterprises .
- Number of conservation easements purchased .
- Index of social structure quality .
- Sources of income and level of dependence on livestock production for household income .
- Employment diversity .
- Value produced by agriculture and recreation industries as percent of total .
- Employment , unemployment , underemployment , and discouraged workers by industrial sector .
- Land tenure , land use , and ownership patterns by size classes .
- Population pyramid and population change .

V . Legal , institutional and economic framework for rangeland conservation and sustainable management

- Professional Education and Technical Assistance . Extent to which laws , regulations , and guidelines , institutions , and organizations provide for professional education and the distribution of technical information and financial .
- Land Management . Extent to which land management programs and practices support the conservation and sustainable management of rangelands .
- Measuring and Monitoring . Extent to which agencies , institutions and organizations devote resources to measuring and monitoring changes in the condition of rangelands .
- Research and Development . Nature and extent of research and development programs that affect the conservation and sustainable management of rangelands .

Sustainability-the SRR conceptual model for Ecological , Economic and Social Components Proposal for integrated Rangeland Sustainability Modeling

Integrated research and resource management offers rich opportunities for additional exploration and elucidation . The Sustainable Rangelands Roundtable (SRR) has developed a conceptual model showing information flows through the model=s multiple tiers . Ecological systems and processes , including reproduction , growth , death , decomposition , succession , migration , adaptation , water cycles , nutrient cycles , carbon cycles , stage the biological interactions underlying forest and rangeland ecosystem viability . Social and economic infrastructures and processes , including demand , investment , depreciation , management , social regulation , production , consumption , social interaction , institutional processes , characterize rangeland use and management , as well as the context in which rangelands improve or decline . These systems and processes intertwine and feedback , altering natural and human capital and conditions over time . The Sustainable Rangelands Roundtable (SRR) has developed an integrated conceptual framework to capture complex relationships among ecological and natural resource processes , and intricate interactions with social and economic processes , capacities , and capitals .

Criteria and Indicator monitoring in the US (Pilot Project) The Forest Service , along with other federal agencies such as the Bureau of Land Management and the Natural Resource Conservation Service , informed by the Sustainable Rangelands Roundtable , have begun a prototype for a national survey of rangelands utilizing the SRR criteria and indicator model for assessing and monitoring sustainability of US rangelands . The Sustainable Rangeland Roundtable , a broad consortium of interests working at the grass roots level , has identified 5 criteria and 23 indicators applicable to monitor the ecological , social and economic sustainability of rangelands . Indicators are intended to provide measures of key variables that will inform and facilitate monitoring and periodic assessment of the condition and functioning of rangeland ecosystems over time . Because human actions and influences can affect the extent and condition of rangelands, it is important to monitor human use of rangelands and the human influences on rangeland condition. Such uses and influences are, in turn, driven by underlying social and economic conditions and processes. Monitoring those driving conditions and processes will allow decision makers insight into how and why impacts on rangelands occur, and allow the possibility of proactive management to prevent or mitigate rangeland degradation or to enhance rangeland health and sustainability. It is also important to understand how changes in rangeland ecosystems affect the well being of communities that depend on them.

To date we have utilized several ecological and social economic indicators in a pilot project in Eastern Oregon in a proof of concept exercise and a prototype of future surveys. The pilot project is an important first step characterized by the following:

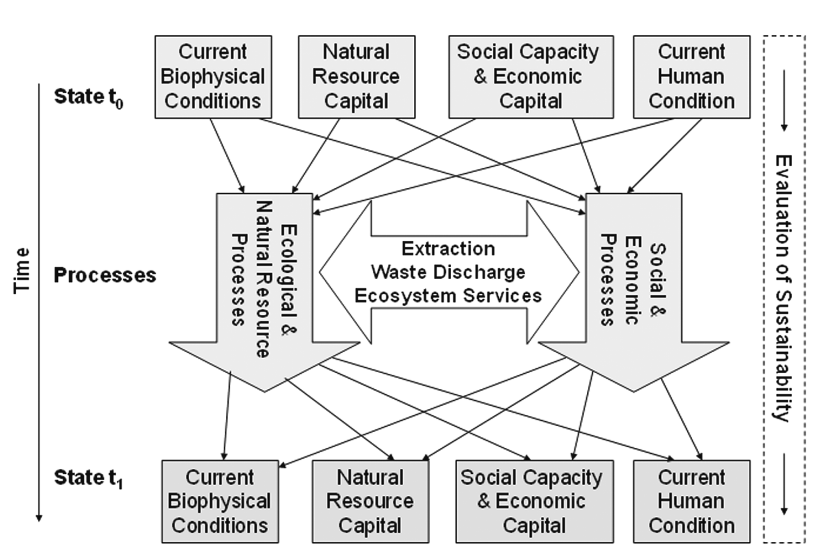

Figure 1 *Tier 1 Rangeland Sustainability Evaluation Framework.*

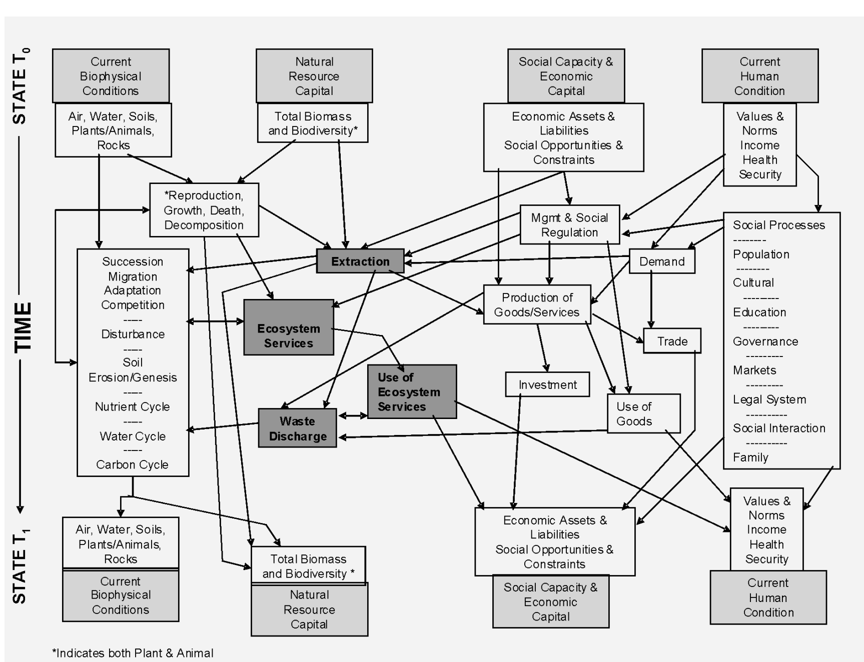

Figure 2 *Tier 2 Framework-Rangeland Example.*

Three federal agencies (FS, NRCS, and BLM) are collaborating to expand the FS FIA grid and the NRCS NRI grid into all rangelands utilizing criteria and indicator monitoring.

C&I from SRR informed the selection of 5 indicators: invasive spp.; bare ground; vegetation composition; change in use/condition; and fragmentation.

Simultaneously, a Land Grant University group is evaluating social and economic indicators from SRR in same area.
If successful, the characterization of rangelands could be done on a national scale; providing the ability to monitor indicators of sustainability and change; putting science in a position with professional opinion and personal judgment.

Proposed Project We believe there is a critical need to establish C&I monitoring system at national and global scale. Our experience with SRR could provide a model to launch an international dialogue and the eventual development of C&I monitoring at the global scale. Some basic questions for consideration include: How to quantify, measure, and monitor ecosystem services; what is the responsiveness of indicators to track long-term changes in grassland ecosystem sustainability, and can we design a cooperative to compare the values of ecosystem services on grasslands across the globe?

This symposium, associated with the combined IRC/IGC, could lead to the adoption of a set of indicators that monitor grasslands on a global basis. This would be similar to the Montreal Protocol developed for temperate forests. It would provide a basis for stakeholder dialogue at local, regional, and national scales and expanded understanding of grassland resources and their contribution to social, economic, and ecological sustainability.

The development of international C&I monitoring would help answer some important questions about the appropriate use and potential success of sustainability monitoring linked to sustainable market based approaches in achieving our conservation goals. We anticipate that the set of key indicators of grassland ecosystem sustainability will be the same for similar grassland ecosystems in countries across the globe.

We propose a cooperative project to leverage support for grassland monitoring. Along with the modeling, assessment and valuation of indicators to determine trends in resource condition, management, and the economic and social values derived from grasslands and associated ecosystem services. What will come from the proposed project includes:

- An agreed upon framework for data collection and periodic standardized reporting to more clearly depict resource management performance and to minimize duplication in reporting standards.
- Common assessment capabilities at multiple scales among a wide range of users, permitting local, regional, and national comparisons, as well as use by the international community.
- Increased likelihood of obtaining complete coverage of key attributes to monitor due to the collaborative nature of this endeavor.
- Future research by agencies, universities, and organizations can be focused on developing methods to address data gaps and research needs associated with criteria and indicators to improve grassland management.
- Enhanced agency performance planning and prioritization of funding for at-risk grasslands and those associated with the land.
- Monitoring efforts directed to sites identified by indicators as being important.
- Identification and valuation of unique grassland goods and services for improved management and decision-making.

Conclusion Rangelands/grasslands are the largest single land type in the U.S. and on a global basis. Yet we don't have a common way to evaluate the sustainability of this important resource. We have the opportunity to change this. But, we will only find success when it is recognized that:
Social, Economic and Environmental indicators are all necessary to assess grassland sustainability.

- Ecosystem Services are central when linking environmental, social, and economic indicators.
- Common indicators exist for grassland sustainability at a global level.
- Indicators of grassland ecosystem sustainability will be responsive to long-term differences in natural resource capital, social capacity and economic capital.

Assessing the affect of distance from settlements on landscape function analysis indices in central Mongolia

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Key words: grazing, landscape function analysis, Mongolia, distance to settlement, rangeland

Introduction Changes in grazing pressure in many rangeland areas of Mongolia has resulted in increased stocking rates around settlements and the decreased number of functional water points (Fernandez-Gimenez, 1999). Despite these changes, there is very little published research regarding the impact of such shifts in grazing pressure on rangeland functionality. This paper describes the use of the Landscape Function Analysis (LFA) (Tongway & Hindley, 2004) rangeland monitoring method to assess landscape health in reference to distance from settlements.

Materials and methods In September, 2007, six rangeland sites were selected and georeferenced along a 200km transect between two glacial-derived valleys and an associated saddle connecting Bayonkhongor and Tsetserleg. These towns have an annual average rainfall of 199.4 and 313.2mm respectively. Sites were mid-slope, native perennial grasslands (steppe to mountain steppe) 100-200m from available livestock water. At each site, two transects of 5m were positioned upslope and assessed using LFA, a method measuring soil and vegetation parameters that sum to give indices of nutrient cycling, infiltration and soil stability. These indices can then be tracked over time, or compared to an associated analogue, to identify trends in rangeland functionality' (Tongway & Hindley, 2004). LFA indices, including basal cover, soil texture, litter cover and the presence of cryptogams, were entered into a LFA pro forma spreadsheet then correlated with distance from the nearest settlement using regression analysis.

Results and discussion None of the three LFA indices were significantly correlated with distance from settlement (Table 1), suggesting that distance from settlement does not have a significant affect on LFA measures of rangeland functionality. Other indicators that relied more heavily on patch size/length were significantly correlated, however. This suggests that either soil stability, infiltration and nutrient cycling may not be as dependent on patch size in this area of Mongolia or that this landscape may be more resilient to high levels of grazing pressure, as reflected in patch size, than assumed by LFA. Increasing sample size and grazing utilization assessment at the sites would benefit future research.

Table 1 *Regression analysis on correlations between distance from nearest town and the following LFA variables.*

Patch/interpatch measures of rangeland health	Interpatch Length	NS
	Maximum Interpatch Length	NS
	Patch Area Index	**
	Landscape Organisation Index	**
	Total Patch Area	*
LFA indices	Stability	NS
	Nutrient Cycling	NS
	Infiltration	NS

NS = not significant. * = significant at 0.10. ** = significant at 0.05. See Tongway & Hindley (2004) for further explanation of LFA variables.

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A monitoring system to aid decision making in grassland management in arid areas of China

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Key words: dynamic grassland, rangeland monitoring techniques

Introduction In 2004 a grassland monitoring system was devised and established in sub-project areas of the Alxa League Environmental Rehabilitation and Management Project (ALERMP), Inner Mongolia-a project funded by AusAID, and managed by Cardno Acil. The aim of the system was to better inform managers of the effects of grazing management decisions. The objectives of the monitoring system were to provide: (1) precision in biomass and soil cover estimates, (2) an assessment of the dynamic changes occurring within grassland and their causes, and (3) an assessment of soil changes.

Materials and methods Site selection in September 2004 followed the usual search for representativeness' within the chosen grassland type. Two 50m tapes were laid out on the chosen site such that they crossed at right angles at their centres. One was laid across the slope while the other lay up and down slope. Vegetation patch types (shrub, grass, bare soil) were measured and recorded along each 50m transect, from which cover% was calculated. The transects were utilised for Landscape Function Analysis after the method of Tongway (2003). The second part of the site layout was a 10m x 10m square whose right top (north east) corner coincides with the intersection of the 50m transects. Two parallel transects 10m x 2m were located within the 10m square. A measuring tape was laid along the 10m midline of each of these transect. Using the beginning of the tape (0.00m) as a reference, the location of every shrub within each 10m transect was recorded, along with its species name, plant height and two plant widths taken at right angles. Plant location was recorded as distance along the tape and distance offset from the tape right or left. Grass plants were recorded where they fell immediately under the measuring tape. The ends of all transects were permanently marked. At subsequent annual monitoring, the transects and individual plants were exactly relocated. The Alxa sites included 11 pairs of fenced and unfenced (grazed) sites. Biomass was measured by destructive sampling (quadrats for grasses or representative plants for shrub species), and related to the plant densities on the central 10m x 10m site. Exact relocation of sites allowed measurements of individual plant growth, deaths and recruitment. Sites were recorded in September in 2004, 2005 and 2006.

Results and discussion Concentrating on the 5 pairs of fenced and unfenced sites in Right Banner, seasonal conditions 2004-2006 were found to affect the rate of overall plant recruitment ($p<0.01$), plant deaths ($p<0.05$), and edible biomass changes ($p<0.05$). Within the monitoring period, plant recruitment, plant deaths, biomass changes 2004-2005 and soil cover in 2006 were not significantly affected by grazing. Grazing 2004-2005 was noted to affect the sum of the volumes (Height x Width x Width) of certain plant species within transects, particularly *Reaumuria soongorica*, *Potaninia mongolica* and *Caragana stenophylla*, but did not appear to affect the sum of the plant volumes of the grasses *Stipa glareosa* or *Cleistogenes soongorica*. Grazing had a marginally significant effect on biomass changes 2005-2006 ($p=0.08$).

Conclusions The system described makes possible an understanding of grassland dynamics and the causes of change. Such a system would be a useful tool in assessing and promoting wise and sustainable grassland use. It would be an aid to studying grassland rehabilitation, and assessing when and at what intensity grassland could be re-opened following a grazing ban.

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Trigger points —decision tools to mitigate seasonal climate risk in western New South Wales , Australia

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Key words : stocking rate , risk assessment , pasture growth , SOI

Introduction Making management decisions that involve taking a chance on future climatic conditions is always difficult especially when rainfall is not strongly seasonal , as in western NSW . Assessment of the relationship between seasonal climate indicators (SOI and SST) and pasture growth strongly suggested that the SOI phase system can provide useful pasture growth outlooks in the winter-spring period (Hacker *et al* . 2006) . However , this capacity does not exist during the critical summer-autumn season . During this period , having a rule of thumb about how long de-stocking decisions can reasonably be delayed in the hope that the season may improve should assist with these difficult decisions . This paper encapsulates the idea of rules of thumb' in the form of trigger points' for stocking decisions . Trigger points are times of the year-calendar dates-when the prospects for future pasture growth , based on the long-term record , are high or low and beyond which decisions that depend on future pasture growth should not be delayed .

Materials and methods A pasture growth model , WinGRASP , based on Littleboy and McKeon (1997) , was used to calculate daily pasture growth from long-term (>100 years) daily environmental and meteorological data for several locations . Daily growth data were then summarised to produce a growth potential index , derived from the area under the cumulative probability distribution , and critical percentiles -20th , 50th and 80th percentile values for the historical data set-for three-monthly periods commencing at fortnightly interval throughout the year .

Results Their interpretation for one of the 27 locations analysed are shown in Figure 1 . Defining trigger points from the growth potential index is straight forward as the highest and lowest values are easily identified . Defining trigger points using critical percentiles includes information on the historical variability of pasture growth at each starting date which may lead to some adjustment of the trigger points that would otherwise be identified from the 50th percentile or growth index values alone . Significantly , the time of peak pasture growth coincides with the time when the skill of seasonal climate outlooks also reaches a maximum (winter/spring) in the region . At these times , it should be possible to use both the trigger point date and the seasonal growth outlook based on the SOI phase to help with stocking decisions .

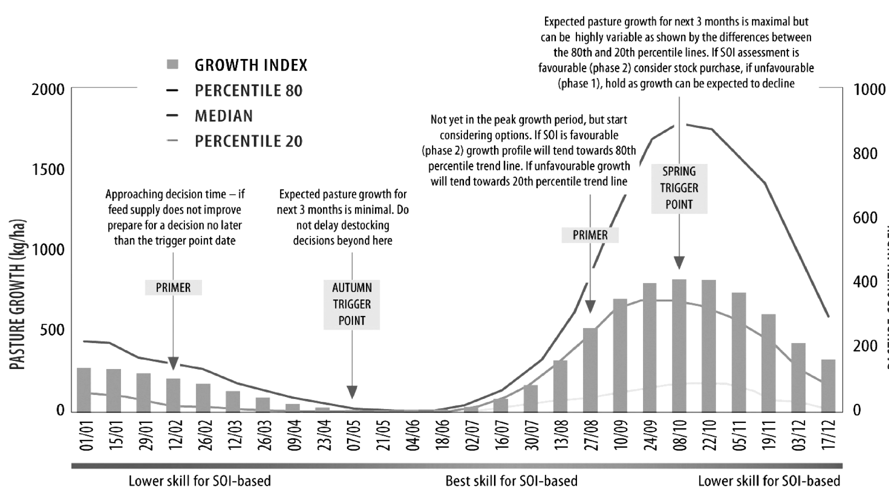

Figure 1 *Results and interpretation of trigger point analysis for a location in western NSW* .

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Case studies in developing rangeland sustainability indicators : scale matters

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Key words : sustainability indicators , scale , integrity , health

Introduction Several new monitoring systems that rely on ecosystem sustainability indicators" are being developed and used in California . Indicators ideally are ecosystem attributes that can be measured over time to determine whether specific management goals and objectives are being achieved . We argue that attempting to apply one set of indicators to all cases repeats a long history of inappropriate generalization of ecological science . Instead , a tool box of broadly accepted indicators from which managers can select to meet specific needs better recognizes diverse ecological , social , and political contexts (Harris and Hobbs 2001) . To be practical , indicators must fit the situation--in particular local capacity for consistent application , address the important questions (Ford and Huntsinger 2007) , and provide meaningful data . Indicators should be based on what we know about how systems work , and should be dynamic as more data is collected and interpreted and understanding of system structure and function increases . One of the primary purposes of indicators is to challenge assumptions and identify knowledge gaps , replacing them with more reliable , data-driven information .

Goals for indicator monitoring systems often include terms such as sustainability , productivity , integrity , and health . These inter-related terms should be defined (sensu Battles (pers .comm) and Harris and Hobbs 2001) as demonstrations or tests of rangeland ecosystem :
- productive capacity
- desired biological community composition and structure
- ability to recover from stress (chronic and cumulative in its effect , e .g . heavy grazing) and from disturbance (sudden and often severe effect)
- production of economic , social , and aesthetic benefits to the owner , manager , and local communities , in order to maintain economic and social viability .

Methods We use case study analysis of three indicator development projects to discuss how indicators , to be effective , need to be scale-sensitive , temporally as well as spatially .

Results and discussion The first case study is a grassroots effort by ranchers on California's central coast to develop an indicator system with currency among the ranching community , ecological scientists , agency managers , and the public . A second case is California's statewide assessment of rangeland conditions and sustainability , conducted at the level of the state government and for the state legislature . A final case is the well-known Montreal Process , and the five criteria and 28 indicators developed as part of that process . For each of these initiatives , we examine the indicators in the light of their applicability at particular scales , their commonalities and differences , and issues of application and implementation . We will discuss criteria for appropriate selection of indicators for particular situations , and issues of application and relevance .

Conclusions We return to the underlying foundation of our understanding of basic factors driving rangeland ecosystems , and the link to sustainability indicators . Models of ecosystem function , for example , should be evaluated for their repeatability over time and space to determine whether they are generalizable or idiosyncratic , and based on experimentation should be explicitly linked to spatial and temporal scales and the identification and potential revision of indicators . Indicators , therefore , to be useful , must be explicitly tied to a spatial scale . A critical consideration is that processes that occur at one level of a system may not be indicative of dynamics at higher or lower levels (Allen and Starr 1982) .

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Forage production estimate of incienso (*Flourensia thurifera* (Mol .) DC .) , repanda (*Atriplex repanda* Phil .) and numularia (*Atriplex nummularia* Lindl .) according to shrub size and annual rainfall

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Key words : *Flourensia* , *Atriplex* , forage production estimate , regression , shrub size

Introduction The range lands of central-north semiarid zone of Chile is dominated by shrubs which contribute with fresh forage during critical times of the year when herbaceous species become dry due to seasonality . Shrubs also ensure soil and water conservation and give animals shelter and shadow , so it should be strategically used promoting its conservation . In order to program range managements , it is fundamental to estimate the dry matter production . Direct cutting measurements , although precise , are low effective , time consuming and expensive and therefore indirect methods , using multiple variables regressions , might be more useful (Azócar *et al .* , 2004) . The objective of this study was to estimate forage production of three shrubs species , using plant size parameters and annual rainfall .

Materials and methods Data was obtained from experimental field Las Cardas" , located 30°14' south and 71°19' west . Climate is Mediterranean arid , varying with a maximum and minimum monthly mean temperature of 26℃ and 5℃ in January and July , respectively . Average annual rainfall is 144 mm concentrated between June and August . Vegetation is dominated by scrubland species as *Gutierrezia resinosa* , *Flourensia thurifera* and planted *Atriplex* spp . , coexisting with *Acacia caven* and *Lithraea caustica* trees and with an herbaceous stratum dominated by therophytes .

In August or September , available forage dry matter (g DM shrub^{-1}) of *Flourensia thurifera* , *Atriplex repanda* and *Atriplex nummularia* was measured , along 1978 to 2004 , registering annual rainfall the year of cutting (R , in mm) and of the previous year (R_p , in mm) . Height (h , in cm) , major diameter (M , in cm) , minor diameter (m , in cm) and plant density (D , plants ha^{-1}) of at least 250 shrubs of each species was measured , to calculate volume (V) as $V = (M\ m\ \pi\ h) / 12$ and area (A) as $A = (M\ m\ \pi) / 4$, grouping the plants as small , intermediate or large . A multiple stepwise regression analysis was applied to fit the best curve between real DM , shrub size and annual rainfall .

Results and discussion The shrub size measurements and the annual rainfall gave a good estimate of the real DM production for the three shrubs species , adjusting regressions with high coefficients of determination (Table 1) . Precision of models decreased under higher rainfall conditions and larger shrub size , especially in *A . nummularia* .

Table 1 *Real and estimated (Est .) dry matter production (g DM shrub^{-1}) of* F . thurifera , A . repanda *and* A . nummularia *according to median annual rainfall (R) and shrub size , showing the best regression adjusted .*

	F . thurifera				*A . repanda*				*A . nummularia*			
Median R	< 120 mm		> 120 mm		< 120 mm		> 120 mm		< 120 mm		> 120 mm	
	Dry matter production (g DM shrub^{-1})											
	Real	Est .	Real	Est .	Real	Est .	Real	Est .	Real	Est .	Real	Est .
Shrub size												
Small	4.2	3.5	10.3	9.2	183.7	135.9	148.0	165.8	71.2	60.6	105.2	92.8
Intermediate	24.7	29.9	49.8	46.1	540.3	646.1	897.4	1,032.3	312.9	326.8	485.5	458.4
Large	126.5	133.2	155.3	137.9	655.0	682.7	1,564.3	1,483.6	474.8	581.4	1,676.0	1,565.0
Regression	$\ln(DM) = -4.68 + 1.82 \ln(R_p) - 0.268 (\ln(R_p))^2 + 0.277 \ln(V) + 0.055 \ln(V) \ln(R_p)$ ($R^2 = 86\%$)				$DM = 942.128 A - 0.138 D A + 0.0098 R_p^2 - 2.122 R_p - 0.572 R_p A$ ($R^2 = 96\%$)				$\ln(DM) = 25.6 + 0.619 \ln(V) - 11.83 \ln(R) + 1.64 \ln(R)^2 + 3.75 \ln(R_p) - 0.846 \ln(R) \ln(R_p)$ ($R^2 = 84\%$)			

Conclusions The proposed models to estimate available forage from *F . thurifera* , *A . repanda* and *A . nummularia* by shrub size and previous year annual rainfall , are reliable and easy to apply , simplifying the need of direct cut measurements for forage budgeting . Further research on this technique should be carried out in other shrub species .

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Natural and cultural resources, qualities of the products and local development in rangeland and grassland areas in France: animal products in the "PDO system"

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Key words: Protected Designation of Origin (PDO), *terroir*, livestock farming, food quality, France

The development of livestock farming in mountain, rangeland or less-favoured grassland areas of France is often related to acknowledged signs of quality, especially "Origin Labelled Products" (OLP) that have proved to be powerful vehicles for the creation of local added value for livestock products. The best known of these signs is the *Appellation d'Origine Contrôlée* (AOC), a French creation from the early 20th century which was subsequently extended Europe-wide in 1992 (EC Regulation 2081/92) under the name "Protected Designation of Origin" (PDO). PDOs guarantee the typicality of products the specific qualities of which is due to the *terroir*. According to INRA-INAO, "Terroirs et Cultures" and UNESCO (2005), "a *terroir* is a delimited geographic area defined by a human community which develops all along its history a set of distinctive traits, know-how and practices based on a system of interactions between the natural environment and human factors. The skills and knowledges express originality, confer typicality and allow the recognition of the products or services originating from this particular area and therefore of the people who inhabit it. *Terroirs* are living and innovative spaces that cannot be associated solely with tradition". At present, nearly 40 French PDO dairy products (mainly cheeses) involve 40,000 cattle, ewe and goat dairy farms representing 15% of the national dairy production of which 80% comes from moutain areas. There are only 3 PDO beef meats, 1 PDO lamb meat and 2 PDO poultry types in France (Casabianca et al.). Several other PDO projects are in progress. There is a second type of OLP in the context of EC Regulation 2081/92: the "Protected Geographic Indication" (PGI), that means less specification constraints than with PDO; about 70 PGI products are registered in France.

Since 1994, in partnership with INAO (National Institute for PDOs), interdisciplinary research actions have been engaged on the technological and cultural foundations of elaboration of these origin labelled products, and to highlight the links between food products and territories in order to better differentiate and qualify them (Montel et al., 2005). The aim is to promote and consolidate agro-food systems that are based on quality products linked to a locality and which can therefore not be delocalized since they are tied to the valorisation of bio-ecological resources (local breeds, grasslands) and immaterial resources (history, skills and know-how, cultural aspects) localized into a given environment on the basis of a quality recognizable by its ties to a geographic origin. Raw matter can be imported; a cattle breed can be imported; a technique can be reproduced; but a *terroir* cannot be copied! The objective is to promote activity locally, added value and diversification of products which will maintain the economic and cultural development of the identified areas. This added value and benefit is shared among the stakeholders that participate in the elaboration of this product. Public acknowledgement, protection of the name and characteristics of these products are ensured by the State through INAO in order to avoid imitations and misuse of the notoriety of the name of origin of the product.

These studies have shown the real influence of physical environments and production systems combined with processing technologies embedded in local culture on a range of specificities of the animal products (sensorial and nutritional qualities, image...) (Montel et al, 2005; Béranger et al., 2005). Thus cheese and meat qualities have been linked to grassland flora, to animal breed, its age and its growth curve, to feeding and herd management, to processes, to the diversity of microbial ecosystems of environment,... New links were found between some components of grass, or milk, or microbial ecosystems and the sensorial characteristics of the finished cheese or meat product. Analyses of skills and knowledges thus contribute to the tracing of original characteristics all along the production-processing chain. In 2007, UNESCO has acknowledged this *terroir* approach and plans to set up an international action-research network for the compared analysis of different "development itineraries" of *terroirs*, in order to better promote this approach that is able to make, in a sense, livestock breeders become artists like merchants selling dreams.

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Development of resilience-based state-and-transition models

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Key words: alternative stable states, ecological resilience, rangeland monitoring, thresholds

Introduction The objective of this paper is to recommend the incorporation of additional resilience concepts into the state-and-transition model (STM) framework. Ecological resilience describes the amount of change or disruption that is required to transform a system from being maintained by one set of mutually reinforcing processes and structures to a different set of processes and structures (e.g., an alternative stable state). In the light of this concept, effective ecosystem management must focus on the adoption of management practices and policies that maintain or enhance ecological resilience to prevent stable states from exceeding thresholds. Therefore, resilience-based management does not exclusively focus on identifying thresholds *per se*, but rather on within-state dynamics that influence state vulnerability or proximity to thresholds.

Methods and materials The concepts reported in this paper were partially developed at a State-and-Transition Ecological Theory workshop sponsored by USDA-NRCS on the campus of Oregon State University, August 2006. Academics and managers convened to identify and summarize the most important advances and necessary requirements for STM to more effectively describe ecosystem dynamics.

Results and discussion The assessment of state resilience requires the development of recognizable indicators to identify when states are approaching thresholds as well as how far states have moved beyond thresholds when they have been crossed (Stringham et al. 2003). In an effort to incorporate resilience-based concepts in the STM framework, we recommend that triggers, at-risk community phases, feedback mechanisms, and restoration pathways be incorporated for each threshold separating individual states, including process-specific indicators to identify at-risk plant communities and potential restoration pathways. Triggers describe biotic or abiotic variables or events that initiate threshold-related processes by contributing to the immediate loss of ecosystem resilience. Selection of at-risk communities requires identification of community phases known or assumed to have the least ecological resilience within a state and that immediately precede shifts to alternative states. Indicators of positive and negative feedbacks, contributing to either decreasing or increasing state resilience, respectively, can be inferred from altered patterns and processes within individual states. Patterns and processes associated with negative feedbacks in alternative states can be used to develop indicators of the resilience attained by these states after thresholds have been surpassed. Restoration pathways can be assessed with indicators that identify the residual properties of former states that continue to exist within alternative states after thresholds have been crossed. Community phases within alternative states that have developed the least resilience (e.g., fewest negative feedbacks) and possess the greatest proportion of residual properties of the former state are the most likely candidates from which to initiate restoration pathways (Bestelmeyer 2006; Briske et al. 2006).

Conclusions The incorporation of resilience-based concepts into the STM framework will promote adaptive management by emphasizing indicators of state resilience in addition to indicators of pending thresholds and it will identify additional variables to better inform ecosystem managers of risk and restoration options.

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New approaches to measuring the functional value of biodiversity in plant communities

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Key words : diversity-function , biodiversity , methodology

Introduction The weight of evidence across a wide range of organisms points to a positive relationship between diversity and ecosystem function . The methods used to analyse biodiversity experiments have been largely based on ANOVA or graphical representation (e .g . Figure 1) . We propose a framework based on biologically meaningful coefficients that quantify the separate contribution of each species and various interactions among species to the functional response . Recent work (Kirwan et al , 2007) and preliminary analysis suggest that diversity-function (DF) relationships can largely be described in terms of the identity of species and low order species interactions . The difficulties attending DF research are further compounded as the size of the species pool from which communities can be assembled increases . We propose a quantitative approach based on a small number of biologically meaningful coefficients .

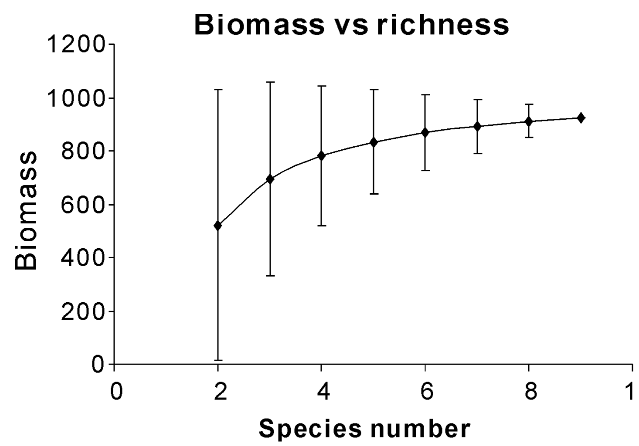

Figure 1 *Idealized relationship between diversity effect (D) and species richness . The solid line shows the average diversity effect over all species selections and the bars the range of deviations for particular species selections .*

Materials and methods In general the functional response (y) for a community of t species selected from a pool of s species can be characterised as the sum of five terms , $y = ID_{av} + ID_p + D_{av} + D_p + \varepsilon$, where Average Identity effect (ID_{av}) = mean average monoculture effect over all s species and Particular identity effect (ID_p) for the t species selected , Average diversity effect (D_{av}) = Mean difference between response and ID (= $ID_{av} + ID_p$) , averaged over all t-species selections (solid line Figure 1) , Particular diversity effect (D_p) = extra diversity effect due to the particular species selected (Range bars Figure 1) and Random error . The diversity effect is $D = D_{av} + D_p$. We used data of 206 experimental plots and 100 different plant assemblages of grassland species that varied in species richness (1 , 2 , 3 , 4 , 6 and 9 species , Roscher et al , (2004) , data supplied courtesy of Dr Christiane Roscher , Max-Planck-Insitute for Biogeochemistry in Jena , Germany) to test our models .

Results and discussion We propose a range of models to quantify the terms in [1] to provide a description of the functional response . We fitted several of these models to the data . We estimated 5 coefficients for a simple version of the model (all estimates in g m^{-2}) : ID_{av} (estimate of coefficient 312) , the standard deviation among monoculture yields (212) , D_{av} (926) , the standard deviation of pairwise interaction coefficients (385) and the residual standard deviation (123) . ID_p and D_p are related to the first two standard deviations estimated . The model describes the data as well as the 99 degrees of freedom between all assemblages .

The model can be used to address a wide range of theoretical questions about diversity-function relationships including :
- Does the diversity effect saturate with increasing richness and is there a simple characterisation/explanation of this effect ?
- What is the relative importance of the average diversity effect , the sampling and selection effects in contributing to the DF relationship ?
- What is the relative importance of the identity and diversity effects ?
- Is there evidence for transgressive overyielding (do mixtures perform better than the best monoculture) ?

In addition , the model is flexible enough to explore changes in DF relations through time and the effect of functional types and species traits .

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Fluorometry—an evolving methodology for range animal ecologists

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Key words : botanical composition , luminescence spectroscopy , laser-induced fluorescence

Introduction Fluorometry is an optically based tool for identifying pre and post-digest plant material (Anderson et al ., 1998) . Though similar to near-infrared reflectance spectroscopy (NIRS) , fluorometry offers a potentially superior capability for discriminating differences among plant materials because of its multidimensional characteristics . Research suggests that emission data from the blue and green regions of the visible spectrum are rich in information necessary for determining chemical differences among plant species . To date a neodymium : yttrium aluminum garnet (Nd :YAG) laser , a Xenon-arc lamp , and most recently high intensity light emitting diodes (LED's) have successfully been used as the excitation light sources . Manipulating the solvent used to extract fluorophores can enhance the methodologies utility . Though organic solvents (chloroform in particular) extract plant fluorophores they also extract chlorophyll that emits in the red portion of the spectrum . The red fluorescence tends to mask fluorophores that appear most important in identifying plants , those in the blue and green regions of the spectrum . Physiologically buffered saline (PBS) is currently the solvent of choice . It does not remove the chlorophyll and is environmentally benign . Furthermore by altering the pH of PBS different blue and green fluorophores can be extracted (Danielson , 2006) . To date the exact fluorophores giving the spectral finger prints are unknown . However , this does not detract from the methodologies ability to discriminate among species , especially , when multi-way principal component analysis (MPCA) is used to tease apart the various spectra (Obeidat et al ., 2007) .

Material and methods Figures and tables will outline the development (1996 through 2007) of fluorometry as a range animal ecology tool .

Results and discussion Emission spectra from peak count (intensity) ratios , the entire fluorescence data set using polynomial regression models , confidence interval plots , discriminate analysis , and 3-dimensional plots of the entire fluorescence data set using several solvents and multi-way principal component analysis (MPCA) have been successful in differentiating among species . A lightweight laptop activated multi-source portable LED spectrofluorometer exhibits potential to acquire data in the field .

Conclusions Fluorometery is an evolving rapid non-invasive method range animal ecologists can use to determine botanical composition of pre-and post-digested plant material for managing nutrition and health of free-ranging animals .

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New approaches for coping with pastoral risk

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Key words : collective action , livestock early warning system , livestock marketing , East Africa

Introduction Pastoralists in East Africa face high and increasing exposure to risks , including limited access to grazing and water due to population pressure , insecurity , resource degradation , increasing climate variability , and lack of information about markets . In recognition that the traditional means of risk management--mobility--is much less available to pastoralists today , the Global Livestock Collaborative Research Support Program (GL-CRSP) has focuses on developing strategies to assist pastoralists in coping with risk . The approach is a three-part strategy to : 1) predict risk ; 2) better connect pastoralists to markets ; and 3) develop new capabilities to manage risk at the local level .

Materials and methods To predict risk the GL-CRSP developed the Livestock Early Warning Systems (LEWS ;http ://glews . tamu .edu/africa) that provides spatial predictions of forage availability 60-90 days out for most of Eastern Africa and is part of the FEWS network (Kaitho et al . , 2007) . To better connect pastoralists to markets the Livestock Information Network and Knowledge System (LINKS ;http ://links .tamu .edu) project has developed a cell-phone based market information system that provides public data on markets and collated data for national integrated market reporting . These projects created a suite of technologies that combine real-time , spatial-based forage and climate conditions with market information enabling pastoralists and managers/policy makers to make informed management and marketing decisions . In Ethiopia this has been augmented with outreach programs that have built market networks involving producers , trading associations , and livestock exporters (Desta et al . , 2006) . To gain understanding of risk factors and how they are perceived , the Pastoral Risk Management on East African Rangelands project surveyed hundreds of pastoral households in northern Kenya and southern Ethiopia to document the sources and perceptions of risk through periods of boom and bust in the livestock cycle .

Results and discussion The LEWS team has developed a robust forage monitoring and livestock market information systems covering all pastoral areas in Ethiopia , Kenya , Tanzania , Uganda , Djibouti and Somaliland . The two systems systematically and continuously collect and deliver timely information on forage supply and forecasts (60-90 days) , and livestock market prices and volume trends to stakeholders . This information is updated every 10 days with situation reports and maps distributed via WorldSpace radios , email , internet and newsletters , impacting over 400 organizations and 600 decision makers in the region . Working closely with pastoral community groups dominated by women , the PARIMA team is assisting groups in problem solving and approaches to livelihood diversification . In southern Ethiopia , 59 collective action groups have been trained , involving over 2 ,000 members . These legally recognized savings and credit cooperatives have sustained themselves and created assets . Over 4 ,500 micro-credit loans exceeding ＄559 ,000 have been extended based on an accumulated pastoral savings of US ＄93 ,000 , in part generated by animal trading . In associated efforts , PARIMA has organized 12 cross-border (Ethiopia/ Kenya) meetings to address livestock production problems , trade , and conflict mitigation . Opening of export markets from Ethiopia to the Gulf States starting in 2003 has resulted in a large outflow of marketed stock from northern Kenya and southern Ethiopia ; over 25 ,000 head of sheep and goats were traded by 11 collective-action groups assisted by PARIMA during 2004-05 alone (Desta et al , 2006) .

Conclusions Only by investing in interdisciplinary field studies and bringing new technologies to bear on the problem can we provide new tools to mitigate risk in the contemporary pastoral environment . In order to understand new" risks and how they operate and are perceived , it is important to invest in long-term survey work . Participatory research has shown remarkable results , as it integrates implementation and project design with community participation in a dynamic system of project monitoring , adjustment , and evolution . Projects , communities and development professionals learn by monitoring , rethinking , and adjusting their efforts .

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Estimating pastoral pressure on arid rangelands taking into account herd management practices

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Key words : pastoral pressure , arid rangelands , herd management , Tunisia

Introduction One of the main critics formulated against the grazing pressure concept , is that proposed indexes usually do not include elements of livestock management (i .e . forage schedules , temporality of herd movements , supplemental feeding) . However , these elements largely modulate the actual level of pressure livestock can exercise on rangeland integrity .

Materials and methods Study area was located in the arid region of Jeffara (South East Tunisia) , with mean annual rainfalls of about 170 mm . One hundred parcels of *Rhanterium suaveolens* and *Stipa tenacissima* steppes were surveyed (plant cover measurements , floristic diversity , plant types) in order to characterise range conditions . At the same time , qualitative surveys were performed on each parcel with pastoralists regarding their herd and pastoral management (type of livestock grazing management (transhumant or sedentary) , types and temporality of uses , tenure system , livestock feeding system , seasonal and daily grazing patterns , types and levels of complementation , etc .) . Collected data were processed by means of Multiple Factorial correspondences analyses , and constituted the basis for the formulation of a Pastoral Use Intensity Index (IIUP) , as follow :

$$IIUP = \frac{NA . NMU . TU . PPA . PRP}{SP . 12}$$

Where : NA : number of small stock (in Ovine Units) ; NMU : Numbers of months where rangeland is grazed during the year ; TU : qualitative variable related to the intensity of use during grazing period (continuous grazing = 1 , diffuse grazing on rangeland integrated in larger grazing patterns = 0 .5) ; PPA : proportion of grazed forages in the diet of small stock (0% = 0 ; 0-20% = 0. 1 ; 20-50% = 0. 3 ; 50-90% = 0. 7 ; > 90% = 1) ; PRP : eventual period of resting of the parcel during spring (If rangeland is not grazed during spring then PRP = 0 .5 , if not PRP = 1) ; SUP : surface of rangeland in hectares ; 12 corresponds to the twelve months of the year .

This index was related to the classical calculation of stocking rate and to the range conditions of the 100 studied parcels .

Results and discussion IIUP ranged from 0 to 65 , while instantaneous stocking rate varied from 0 to 132 . The latter index led to an over-estimated evaluation of grazing pressure because it did not integrate eventual adjustments made by herders in order to balance herd requirements and forage resources of rangelands . We found a clear relationship between IIUP value and range condition . In *R . suaveolens* steppes about 50% of rangelands with a low or moderate IIUP were classified in good condition , while only 26% of them with high IIUP was found in good condition . This relationship was still stronger in *S . tenacissima* steppes . Relationships between stocking rate and IIUP values indicate the magnitude of the risk of overestimating grazing pressure (slopes of the regression curves between 0 .35 and 0 .45) .

Conclusions The IIUP index , potentially , appears to be a useful tool for evaluating livestock management impacts on rangelands , thanks to its capacity to take into account several aspects of herds management practices which fully influence grazing pressure level . However , it needs to be refined in order to simplify it , and be tested within different rangeland situations in order to evaluate its heuristic character .

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Soil nutrients as indicators of desertification in Northern Kenya

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Key words: degradation gradients, desertification, Northern Kenya, pastoralists, settlements

Introduction Monitoring processes of desertification using nutrient indicators has not been widely reported. Research on desertification is usually concerned with the impacts of agricultural and pastoral production but less on the ecosystem processes (Tongway & Whitford, 2002). A common assumption is that desertification results in loss of soil fertility in the grazing lands. Assumed linkages between desertification processes and soil nutrient loss around settlements in the arid zones of Africa (Lusigi, 1981) has however not been confirmed by research. We investigated if there is a gradient of nutrient loss from two pastoral settlements in Northern Kenya.

Materials and methods We selected the settlements of Kargi (N 02 31°275′ E 037°34′) and Korr (N 02 00°200′ E 037°30′) that were associated with *in situ* desertification from overexploitation of the vegetation by sedentary Rendille pastoralists earlier in the 1980s (Lusigi, 1981). We established 4 km transects set in four compass directions from the centres of the two settlements. The settlements showed different patterns of pastoral camps. In Kargi, the pastoral camps formed a central cluster within 0-1 km radius of the settlement, while for the Korr site, the pastoral camps were located >4 km from the settlement. In Kargi settlement there was evidence of sand dune movements in the areas of pastoral camps, while in Korr soil movements were evident 4 km from the settlement. Along the transects, soils were sampled at 200 m intervals from 0-20 cm depth (n=80 samples for each site). Soils were mixed and about 250 g analyzed for total nitrogen (% N), total organic carbon (% C), extractable phosphorus (% P) and electro-conductivity (Ec) using the standard laboratory methods. Woody cover was also estimated. Soil nutrient gradients and woody cover were analysed using linear constrained ordination in CANOCO. Redundancy Analysis (RDA) was used with soil nutrients and woody cover as response variables and distance as explanatory variable.

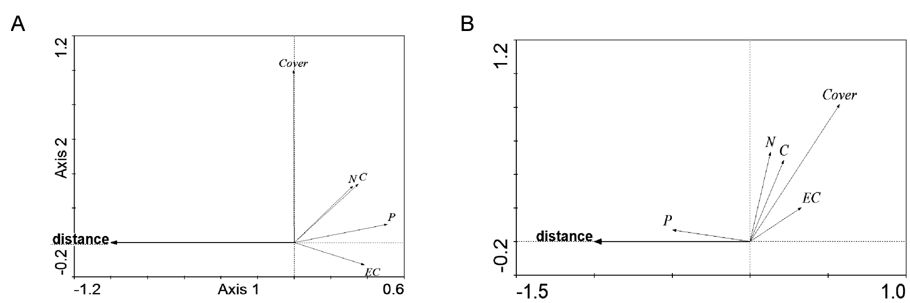

Figure 1 *Soil nutrients and woody cover ordination from the settlements: (A) Kargi and (B) Korr in Northern Kenya.*

Results Total nitrogen, total organic carbon and Ec were negatively correlated with distances from the settlements, but the correlations were not significant ($p>0.05$) (Figure 1A-B). Extractable phosphorous was negatively correlated for the Kargi but positively for the Korr settlement ($p<0.05$). In Kargi woody cover showed no spatial patterns, while for Korr, woody cover decreased with increasing distance from the settlement. Woody cover showed no correlation with soil nutrients except for Ec for the Korr site ($r=0.20$, $p<0.05$).

Conclusions In both settlements, the patterns of extractable Phosphorus varied according to the locations of the pastoral camps suggesting that the changes were related more to livestock activities than to losses attributable to degradation. The distributions of total nitrogen and total organic matter were also greater around the settlements (albeit being insignificant). The results showed that soil nutrients in the settlements did not directly reflect the losses often linked to the processes of desertification. The responses of different nutrients along degradation gradients appeared to reflect the positive roles played by livestock in nutrient transport into the pastoral camps. The study concluded that settlements in the arid zones of Northern Kenya accumulated nutrients contrary to the common expectations.

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A test of the key resource hypothesis in the Richtersveld, South Africa

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Key words: key resource model, herbivory, density-dependence, Succulent Karoo biome

Introduction The key resource model predicts that herbivore numbers in seasonally-variable grazing systems are determined by access to a critical subset of forage resources, and that herbivore population dynamics are essentially uncoupled from resources accessible during the growing season (Illius & O'Connor 2000). This contrasts with the view that nonequilibrial dynamics are ubiquitous in variable environments, with weak or no coupling between herbivore and resource dynamics (Ellis & Swift 1988). We tested predictions of the key resource model in the Richtersveld National Park (RNP), South Africa, where herders move their herds in response to local resource availability (Hendricks et al. 2005). Herd dynamics, local densities and habitat use were examined to test whether herbivores are: (1) limited by density-dependent competition for the dry season forage resource; and (2) coupled to their forage resource in the dry season, but not in the wet season.

Materials and methods Regular censuses of the mixed goat and sheep herds in the RNP were initiated in July 1995. These were used to determine goat population growth rate, calculated as $\ln(N_{t+1}/N_t)$, during the period November 1999—October 2001, for which weekly records of herd positions were also kept. Local animal densities were calculated for 15 regions within which the daily foraging paths from individual stockposts were likely to overlap. These regions were classified into three habitat types: riparian, plains and mountains. The climate is arid and erratic, but three-month summed rainfall over the study period were twice as high on average for a wet season month (20.4± 22.9 mm; April-October) as for a dry season month (11.7± 19.2 mm; October-April). The effects of season and local animal density on goat population growth rates were examined, as were seasonal habitat preferences.

Results and discussion Goat herd growth rate and local animal density were not correlated in the wet season (Figure 1; n=14, $R^2=0.05$, $p=0.419$), but were negatively correlated in the dry season (n=13, $R^2=0.25$, $p=0.085$). Mean goat population growth was positive in the wet season [0.165± 0.23 (s.e.)] and negative in the dry season (-0.062± 0.18). During the wet season, animal numbers were split fairly evenly between riparian (55%) and non-riparian (45%; plains=35%, mountains=10%) habitats. However, the riparian zone was preferred (79%) to non-riparian habitats (21%; plains=17%, mountains=3%) in the dry season.

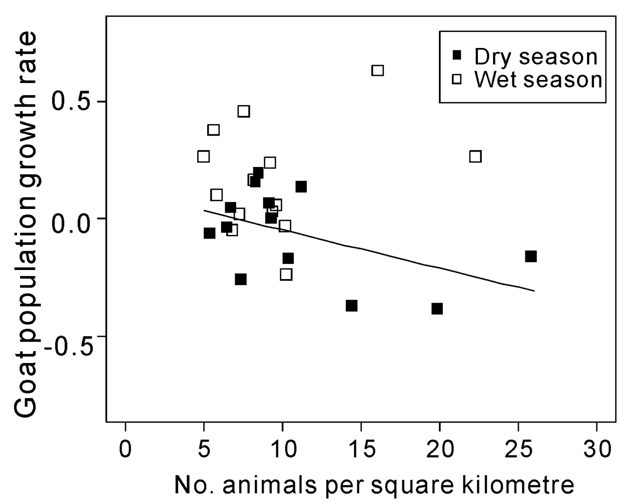

Figure 1 *Goat population growth rate versus local animal density for the dry and wet season. The solid line represents the best fit for the dry season ($y=-0.016x+0.116$, $R^2=0.25$, $p=0.085$).*

Conclusions The density-dependent decline of herd growth rate in the dry season suggests resource limitation at this time. This is not apparent in the wet season. Hendricks et al. (2005) and our discussions with the herders indicate that movements away from the riparian zone are in order to access the flush of annual forage species on the plains after rain events. In contrast, movements back to the riparian zone are due to the need for daily access to drinking water, rather than forage resource limitation. The riparian zone thus appears to form a key resource in the RNP, and there is some degree of support for the first two predictions of the key resource model: (1) density-dependent limitation may occur in the dry season, likely due to coupling with the forage resource, while (2) the population appears to be relatively uncoupled from the wet season resource.

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Infrared heater arrays for warming grazingland field plots

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Key words : temperature , global change , climate change , infrared heater , warming

In order to study the likely effects of global warming on rangeland and other ecosystems in the future , we developed arrays of infrared heaters that can produce uniform warming across 3-m-diameter field plots (Figure 1 ; Kimball *et al* . , 2008) . The efficiency of the heaters was higher than that of the heaters used in most previous infrared heater experiments . Operating costs can be predicted from knowing this efficiency , desired degrees of warming , type of plant canopy , and site weather data , especially windiness . Four such arrays were deployed over plots of grass at Haibei , Qinghai , China and another at Cheyenne , Wyoming , USA , along with corresponding reference plots with dummy heaters . PID (proportional-integral-derivative) systems with infrared thermometers to sense canopy temperatures of the heated and reference plots were used to control the heater outputs . Over month-long periods at both sites , about 75% of canopy temperature observations were within 0 .5℃ of the setpoint temperature differences between heated and reference plots . Electrical power consumption per 3-m-diameter plot averaged 58 and 80 kW-hr per day for Haibei and Cheyenne , respectively . However , the desired temperature differences were set lower at Haibei (1 .2℃ daytime , 1 .7℃ night) than Cheyenne (1 .5℃ daytime , 3 .0℃ night) , and Cheyenne is a windier site . Thus , we conclude that these hexagonal arrays of ceramic infrared heaters can be a successful T-FACE (temperature free-air controlled enhancement) system for warming field plots of grazingland and other ecosystems .

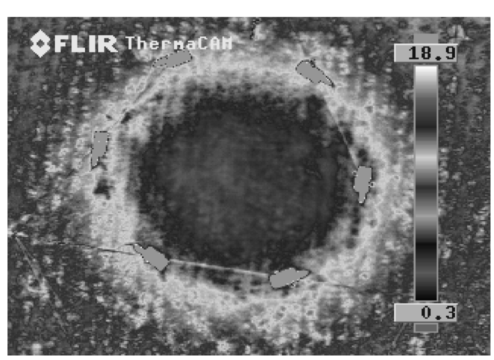

Figure 1 *(Left) Hexagonal array of infrared heaters over grazingland at Haibei , Qinghai , China on 3 April 2007 . (Right) Thermal image of 25-cm-tall wheat under a similar heater array at Maricopa , Arizona , USA before dawn on 7 November 2007 .*

Reference

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Biotools : indicators for biodiversity outcomes of grazing practices in the Australian rangelands

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Key words : grazing , biodiversity , condition , metrics , sustainable , management , Queensland

Introduction Australia's tropical savanna rangelands are one of the most intact and best condition savannas in the world , and have significant biodiversity values (e .g . habitat for 50% of Australia's bird fauna) (Woinarski *et al* . 2007) . Livestock grazing is the dominant land use ; therefore grazing land management will have a major influence on the ability of rangelands to maintain biodiversity . For graziers , maintaining rangeland condition (perennial grass cover and capacity to produce forage) is a goal for sustainable management . Historically , rangeland condition was presumed a surrogate for biodiversity condition , but it is now recognised that this is not entirely true (Fisher and Kutt , 2007) . The Biotools project is investigating the relationship between biodiversity pattern and a range of condition metrics , and is developing a framework for land managers to learn about biodiversity on their land , and gain new perspectives about their role as land stewards .

Materials and methods Twenty case study properties , throughout northern Queensland in the Northern Gulf , Southern Gulf , Burdekin Dry Tropics , Desert Channels and Far North Queensland regions , form the basis for this study . At each property 10-50 1-hectare sites were selected to represent a range of typical condition states (variation in ground cover , fire pattern , tree density , vegetation diversity) . At each site vertebrate fauna was sampled using trap and release , observation and active searching methods . The relationship between biodiversity , habitat variables and condition metrics was investigated to assess universal and idiosyncratic relationships across taxa , land types , management and region .

Results The relationship between bird , reptile and mammal richness , abundance and diversity indicated varying and inconsistent relationship between typical measures of land condition (e .g . dry matter yield , perennial ground cover , tree basal area , stem counts) . For example , bird species richness showed a quadratic relationship with dry matter yield , whereas mammal and reptile species richness was positive and linear (Figure 1) . A test of four typical condition metrics (Stocktake = rangeland condition , Patchkey = soil and hydrological function , BioCondition = habitat values , Landsat = temporal ground cover trends) , indicated that only the metric specifically designed to assess biodiversity condition , was able to account for variation in species composition across a range of site condition states (Table 1) .

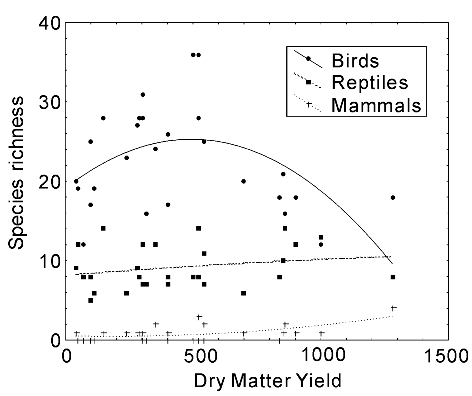

Figure 1 *Relationship between ground cover (as dry matter yield) and fauna species richness at 50 sites in the Northern Gulf region .*

Table 1 *Analysis of similarly between four land condition classifications , each with four categorisations (A to D , with A indicating good" , and D poor") and bird , reptile , mammal and plants species composition at 60 sites in the Desert Uplands region . The general relationship and the comparison between the most contrasting condition states (A vs D) are presented .*

Classification	n	Birds	Rept	Mamm	Plants
Stocktake	4	ns	0.12^{*}	ns	ns
(A vs D)		*ns*	*ns*	*ns*	*ns*
Patchkey	4	ns	ns	ns	ns
(A vs D)		*0.64^{**}*	*ns*	*ns*	*ns*
BioCondition	4	0.16^{**}	0.10^{*}	0.08^{**}	0.13^{**}
(A vs D)		*0.78^{***}*	*ns*	*0.35^{**}*	*0.75^{**}*
Landsat trend	4	ns	ns	ns	ns
(A vs D)		*ns*	*ns*	*ns*	*ns*

(* = $P<0.05$, ** = $P<0.01$, *** = $P<0.001$)

Conclusions Traditional measures of rangeland condition were not directly related to biodiversity condition . We argue , therefore , that their use is not equated with sustainable environmental management . The Biotools project provides more accurate information on land condition and biodiversity , thereby providing a tool to help land stewards manage and monitor biodiversity values . Going forward , one key challenge for the Biotools project is to find the balance between information that is simple enough for all land managers to use , but is able to capture ecological complexity .

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Combining agroecological knowledge and empirical knowing to build pastoral management guidelines within multipurpose land use

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Key words : pastoral resources , rangelands , agropastoral diagnosis , agroecological knowledge , knowing

Introduction Whereas many technical references on grazing management of permanent grasslands exist , operational knowledge for rangeland management is scarce . For this reason , rangeland extension agents take available knowledge and transpose it to more complex rangeland vegetation , for which it is no longer valid . The objective of this paper is to investigate how these practitioners face this lack of specific knowledge for rangeland management and adapt existing knowledge to their own knowing (Cook and Brown , 1999) .

Materials and methods We took a knowledge engineering approach (McGraw and Harbison-Briggs , 1989) , that is , an activity consisting of eliciting and modelling knowledge currently in use , which is mainly tacit (Nonaka , 1991) , i .e . , *highly personal [. . .] hard to formalize and , therefore , difficult to communicate to others*" . We analysed the reasoning process of pastoral diagnosis in a case study of a land-use project in the Western Pyrenees . For that purpose , we conducted semi-structured interviews with the practitioner and analysed methodological documents (technical and scientific literature) as well as documents produced by the practitioner related to his own diagnosis of several pastoral areas .

Results Our results show that the pastoral extensionist combines scientific agroecological knowledge (agronomy and phytosociology) and empirical knowing (from himself , other extensionists and from livestock farmers using these areas) . This combination appears at different stages in his approach (Figure 1) , from the zoning of physiognomic types to the building of a map of resource potentialities for livestock feeding .

Pastoral Value (PV) (Daget and Poissonet , 1972) is used as a key concept in his approach , but after being assessed from generic tables , it is twice re-evaluated with : (i) his experience of other similar ecofacies , integrating their accessibility into their PV ; (ii) interactions with livestock farmers and their own categorisations of these areas regarding their use to feed their flocks (agronomic value") .

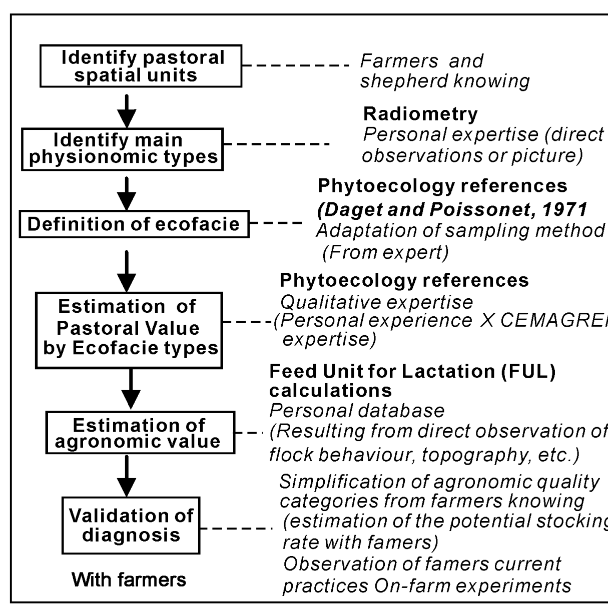

Figure 1 *Reasoning process for pastoral diagnosis . On the left , the main diagnosis step ; on the right , the agroecological knowledge (in bold type) and knowing (in italics) used .*

Conclusions This type of cognitive approach to the synergy between empirical and scientific knowledge should be completed by an analysis of the socio-organisational settings in which this knowledge finds its sense meaning (see poster of Girard et al .) . These results also point out the necessity to develop new qualifications of complex vegetation in rangelands (see two posters of Agreil et al .) and even to design new approaches to build agroecological knowledge that could be both shared and actionable" . In keeping with Russel and Ison (2000) , it may be seen as an opportunity to develop contextual science" , and a first step in imagining new relationships between research , agricultural extension and rural development .

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Sustainability assessment of animal production systems in the (sub) tropics : review and prospects on combining Life Cycle Assessment (LCA) with other environmental impact assessment methods

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Key words : animal nutrition , grazing , intensification , silvopastoral systems

Introduction In developing countries , the demand for animal products is increasing . However , intensified animal production can cause serious environmental problems , especially in sensitive areas , e .g . mountain ecosystems and (sub) tropical forests . Research concerning tropical and subtropical animal nutrition has focussed so far mainly on the optimisation of the nutritional properties of animal diets . However , especially in tropical and subtropical regions , where many developing countries are located , sustainability issues , such as soil , water and biodiversity conservation , should be considered thoroughly in order to maintain both the alimentary basis of the local population and the possibility to produce for the market . Life Cycle Assessment (LCA) is the internationally most accepted method to assess potential impacts to human health and the environment associated with a product , process or activity by evaluating resource consumption and emissions . In temperate zones , LCA has been applied for the assessment of the sustainability of different animal agriculture systems in several case studies , e .g . comparisons of conventional and organic dairy systems . In many cases , in order to achieve an increase of milk and meat production , specialists recommend to shift from (extensive) grazing systems to intensified animal production systems , which implies among others reduction of forest area in order to increase the percentage of open pastures and thus the productivity of herbaceous plant species , conversion of native pasture to improved' pasture , introduction of artificial fertiliser in order to enhance biomass production , supplementation with crop-residues and agro-industrial by-products , zero-grazing systems , etc . With the help of LCA , environmental implications of intensified production systems (including the above mentioned measures) can be compared with traditional grazing systems .

Material and methods In order to be able to differentiate between extensive grazing systems and intensified animal production systems , consensus on how to include biodiversity and other additional impact categories in LCA is essential . This paper i) describes the steps involved in a LCA , ii) gives an overview on existing publications concerning the use of LCA in tropical and subtropical countries , iii) points out which factors have to be specifically taken into account when applying LCA in tropical and subtropical animal nutrition , iv) and highlights the importance of including additional impact categories in LCA studies .

Results In tropical and subtropical countries , so far , only few LCA studies concerning the sustainability of different animal feeding alternatives have been conducted . However , LCA studies in temperate regions and related LCA studies in subtropical and tropical areas provide a good basis for the application of LCA in subtropical and tropical livestock nutrition . For example , LCA studies on bioethanol production in Mediterranean and tropical regions can provide useful data concerning the environmental burdens of crop cultivation , e .g . wheat and corn , which are important supplements for livestock in subtropical and tropical areas . Furthermore , LCA studies concerning irrigation-based fruit production and toxicological impacts of greenhouse farming include recommendations concerning the application of LCA in (sub) tropical environments . In several (sub) tropical countries , LCA is gaining importance both in industry and in research , and several groups started to adapt the methodology to (sub) tropical environments and to collect additional region-specific data .

Conclusions For some environmental impact categories , the LCA databases developed in Europe can be used directly , e .g . energy use . However , for other impact categories , data , models and methodology developed for the temperate zone need to be adapted to (sub) tropical environments . LCAs on (sub) tropical agriculture should specifically include soil erosion and fertility , water consumption and biodiversity , in addition to the impact categories usually included in LCA studies . Concerning the integration of biodiversity , there are already feasible existing methods at least for European conditions , while more efforts are needed to develop simpler models or indicator sets to include soil erosion and water consumption in (sub) tropical LCA . In this context , the combination of LCA with other environmental impact assessment methods and conventional field study techniques and experiments might be useful . Pilot studies are necessary to investigate how LCAs of (sub) tropical animal production systems can be implemented and to what extent new developments in terms of methodology and data collection is needed . Life Cycle Assessment of different resource use alternatives can help to improve the ecological sustainability of agricultural production in the tropics and subtropics , both by improving the marketability of more sustainably produced goods and by guiding research , consultancy and policy .

Assessing resource condition in grazing lands : how do different indicators compare ?

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Key words : ecosystem function , biodiversity , grazing , catchment

Introduction A widespread concern over declining resource condition of grazing lands throughout the world is leading to the need to be able to assess resource condition to both aid management decision-making , and allow producers to demonstrate the effectiveness of their land management . There are many possible indicators that can be used and many ways they can be applied . This paper illustrates the application of a number of indicators to small , commercially grazed catchments .

Methods Thirty catchments (~ 400-500 ha) were selected in the Crows Nest region (27° 15'S , 152° 05'E) of south-east Queensland . Grazing was the major land use in all catchments , although they had a variety of soils , native vegetation , pastures and extent of tree clearing . Assessments were made of 12 indicators (Table 1) representing two components of resource condition (ecosystem function and biodiversity conservation) . Each indicator was expressed on a 0-100 scale , where 0=poor and 100=good condition . The methods are described in detail in MacLeod *et al* . (2004) .

Results The means and ranges of values of the 12 indicators over the 30 catchments are shown in Table 1 . For any one catchment , there were often large differences in the values of the individual indicators (sometimes from 0 for one indicator to 100 for another) showing that some aspects of condition were poor while other aspects were good . Levels of some indicators were good for all catchments (e.g . salinity , soil surface , soil erosion) , while others were poor in many catchments (e.g . wildlife habitat , remnant vegetation) . When the values of the 12 individual indicators were averaged to provide a single value for a catchment , there was much less variation in the values between catchments than there were for some individual indicators . Some catchments had similar overall values despite large differences for individual indicators as shown in Figure 1 for two catchments—both these catchments have the same overall value (76) , the same value for some indicators (1 ,3) , similar values for some (5 ,11) and widely different values for others (7 ,12) .

Table 1 *Range and mean values of 12 indicators of resource condition for 30 grazed catchments*

Indicator/component	Min	Max	Mean
1 . Soil surface	78	100	90
2 . Soil erosion	79	99	91
3 . Salinity	100	100	100
4 . Pasture health	56	100	87
5 . Tree health (upland)	54	95	76
6 . Tree health (riparian)	56	97	89
7 . Weeds (upland)	40	96	76
8 . Weeds (riparian)	78	100	92
9 . Stream bank stability	63	95	84
10 . Stream bed stability	18	71	49
11 . Wildlife habitat	20	53	36
12 . Remnant vegetation	0	100	37
All	69	83	75

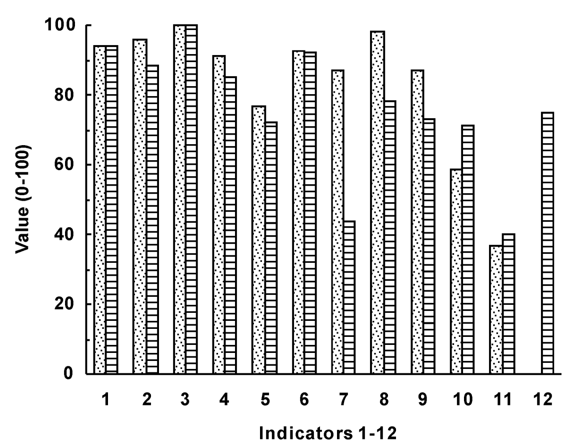

Figure 1 *Values of 12 individual indicators for two catchments .*

Discussion The concept of a single aggregated indicator score to represent the overall resource condition of a catchment is attractive for making comparisons of catchments . However , such values may not reflect real differences between catchments . Combining values of indicators which vary independently results in overall values that vary little between catchments , and similar combined values may disguise large differences between catchments for individual indicators . Indicators are often used to meet multiple goals and a combination of an overall index (for simple comparisons) and individual indicator values (for details of differences) is more likely to be useful than either approach on its own .

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Ecological pratacultural construction and sustainable development strategies in Guizhou

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Key words : zoology , prataculture , sustainable development , Guizhou

The pratacultural resource in Guizhou Guizhou Province is located in the upper reaches of the Yangtze and Pearl rivers , and governed by a sub-tropical monsoon climate . Soils of the 176 ,100 square kilometer region are typical of the mountains and hills that make up 97% of the area , Karst physiognomy accounts for 73% of the total land area .with more than 1 ,800 species of forage plants in Guizhou province . Among them , are more than 1 ,400 species of shrubs and herbage plants . Natural grasslands comprise 24 .3% of the total land area . The rich forage resources and good climatic conditions make excellent conditions for grassland-animal husbandry .

Current grassland status Because of previous agricultural practices , including slash and burn agriculture and excessive grazing large areas of once natural grasslands are damaged . The result is bare ground and serious soil erosion leading to desertification .

The necessity of development ecological prataculture in Guizhou

Decrease grain production pressure Traditional animal agriculture in Guizhou has long been an important economic activity , through praised science and technology content , returned the tradition animal agriculture production way , Changed consume type animal agriculture to eating grasses type animal agriculture ,through developed and utilized natural grassland , built high yield and good quality artificial-pasture , processed good quality the grass product , and reduced the forage grains ,lighten grain production pressure , Avoid the natural grassland of destroy for grain supplies question , Being into healthy animal agriculture production .

Fathering the water loss and soil erosion , and protecting environment Guizhou is the ecological barrier in the upper reaches of the Yangtze and Pearl river basins . The water loss and soil erosion areas arrived to more than 7×10^4 square kilometer ,accounting for 40% of the total land . The water and soil erosion modulus arrived to 2800-5000t/km .h , Scarification and denudation waste land in the steep slope etc phenomena still existed .Stony desertification seed was quicken . It caused serious water and soil erosion , strengthen environmental conservation and fathered no time to delay . Strengthen scientific utilization to the grassland vegetation . Preserved ecological environment . Coming true continuable prataculture production and development .

The strategies of Guizhou ecological prataculture development For effectively utilization the grassland resource , Developed pratacultural economy and preserved the ecological environment , must carry out three breakthrough" , Namely planted the grass should have large breakthrough , Developed and strengthened pratacultural industry , The mode of production should have large breakthrough , tracked the road of planting grass to raising animal , Assuredly changed tradition stock breeding production mode , Scientific stock keeping should have large breakthrough , Quicken pratacultural and forage project . The emphases were done well three aspect works : First , built good strains breeding system ,spread excellent varieties . Second , developed manual planting grass , Spreading ecological breeding .Third , developed technology innovation , improved technological level .

Using microhistlogical techiques to predict botanical composition of horse diets on cool-season grass pasture

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Key words: horse, diet, pasture, grazing, microhistological

Introduction The horse industry is Kentucky's top agricultural cash crop at over 1 billion dollars annually (USDA, 2007); therefore, high quality pasture and efficient utilization is essential for animals to remain healthy and producers to remain economically viable. This research employed the use of microhistological analysis to analyze diet composition of Thoroughbred horses grazing cool-season grass pasture. Microhistological analysis is a popular method of diet determination based on microscopic recognition of generally unique and identifiable undigested cellular structures from the cuticle layer of plant leaves. These identifiable structures include: stomata and their density patterns, size of bulliform cells, shape and frequency of prickle hairs, cell wall construction, shape and thickness, and cuticle size. The objective of this research was to determine if the microhistological technique as described by Sparks and Malechek (1968) can accurately predict the diets of domesticated horses grazing cool-season pasture.

Materials and methods Extensive microscope training was required to become proficient at recognizing unique microscopic cellular characteristics and discerning individual species. Samples of tall fescue [*Lolium arundinaceum* (Schreb.) S.J. Darbyshire], bluegrass (*Poa pratensis* L.) and orchardgrass (*Dactylis glomerata* L.) were evaluated. After training and validation of the procedure, experiments were designed to test the accuracy of microhistological analysis for determining diet composition of horses grazing cool-season grasses.

Cool-season pasture grazing studies were conducted in October, 2006 and May, 2007 in Lexington, KY. Eight 0.25 ha paddocks with varying amounts of tall fescue were evaluated for percent botanical composition by using a 0.6 m^2 quadrat. Visual estimation, point quadrat analysis, and hand separation were used to determine botanical composition and dry matter availability. One Thoroughbred mare was placed in each paddock and allowed to graze freely for 6 days, and fecal samples were taken from paddocks on days 4-6. Fecal samples from day 5 were used for analysis to insure against contamination from pre-study herbage intake.

Results and discussion There was strong correlation ($r = 0.90$) between botanical composition in the paddock and diet composition of tall fescue component in grazing experiments; the same was true for orchardgrass measurements ($r=0.80$). Intake of bluegrass as a proportion of available dry matter was higher in the fall than the spring. Figure 1 shows the regression of percent tall fescue available in paddocks against percent tall fescue present in feces. These data show that when tall fescue percentage in a paddock was higher, less tall fescue was consumed as a percent of what was available. Conversely, when tall fescue percentage in a paddock is low, it is consumed in a higher proportion. As tall fescue availability increased, the amount in the diet increased, only at a decreasing rate. The same trend occurred for orchardgrass.

Conclusions Microhistological analysis is a useful tool for determining diet composition of horses grazing cool-season grass pastures.

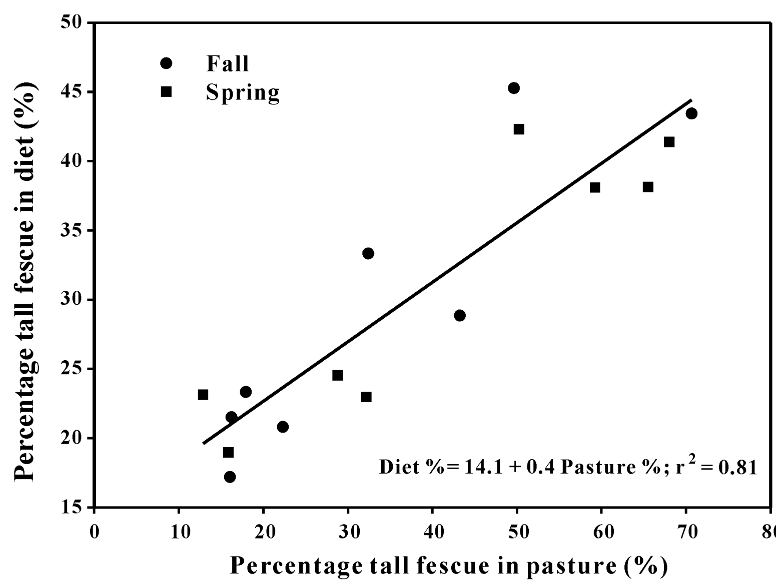

Figure 1 *Regression plot of fecal tall fescue percentage and percent tall fescue available in paddocks from grazing experiments.*

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Dealing with transitions in climate, economic, and political conditions in Eurasia

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Key words: adaptation strategies, climate change, land use change

Introduction Dramatic changes occurred in pastoral systems of Mongolia, China and Russia for past decades. Integrated assessment of these changes on environment and quality of life is essential for sustainability of the region. Integrated assessment entails determining the interactions and impacts of various management strategies on the environment and human systems. Recently, evaluation of the pastoral systems has been conducted in the region. Overview of these research project findings, integration of knowledge and delivery of this knowledge to scientists, policy makers and land users is critical for regional sustainable development.

Pastoral systems, where humans depend on livestock, exist largely in arid or semi-arid ecosystems where climate is highly variable. Thus, in many ways pastoral systems are adapted to climatic variability. It is plausible to assume direct connection between climate variability, ecosystem dynamics and nomadic land use system in Mongolia. Interaction between ecosystems and nomadic land use systems co-shaped them in mutual adaptive ways for hundreds of years, thus making both the Mongolian rangeland ecosystem and nomadic pastoral system resilient and sustainable.

We also recognize the pervasive role of demographic, political and economic driving forces on pastoral exploitation. The general trend involves greater intensification of resource exploitation at the expense of traditional patterns of extensive range utilization. This set of drivers is orthogonal to the above described climate drivers. Thus we expect climate-land use-land cover relationships to be crucially modified by the socio-economic forces mentioned above. Nevertheless, the complex relationship between climate variability and pastoral exploitation patterns will still form the environmental framework for overall patterns of land use change.

Key findings We have analyzed climate data and land cover changes to evaluate factors affecting land use changes. Developing linkages between current trends in policy decisions and economic forces will be developed in the analysis of environment and ecosystem dynamics. During last 60 years the annual mean air temperature increased by 1.56℃ in Mongolia (Mongolia National Action Program on Climate Change 2000). Winter and spring-fall temperatures increased by 3.61℃ and 1.4-1.5℃ respectively. However, the summer temperature decreased by 0.3℃. Change in warming has spatial character: winter warming is more pronounced in the high mountains and mountain valley, and less in the Gov' desert and the steppe. There is a slightly increasing trend in the annual precipitation in the last 60 years (Natsagdorj, 2000). During 1940-1998, the annual precipitation increased by 6%, while summer precipitation increased by 11% (mostly in August) and spring precipitation decreased by 17%, mostly in May.

Remote sensing data analysis showed that large portion of the desert steppe and dry part of the steppe region in Mongolia and Inner Mongolia has delayed green-up trend during 1982-1992 and up to 1999 as well. Field trip-2001 conducted in Mongolia mainly climate change effects in Mongolia. The goal of the field survey-2002 in Inner Mongolia was to understand further climate and land use change effects on plant phenology dynamics.

Sustainability of pastureland may be more attainable through adaptation of the concept of landscape management so that improvements can be seen in the adaptability of pastoral nomadism, herd quality, and herder's living standards. Herders may then have the opportunity to utilize seasonal resources and enhance their ability to process and manufacture products from their pastoral systems.

Plant species diversity as an indicator of sustainable use of *Astrebla* grasslands in Australia

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Key words: *Astrebla* grassland, plant species diversity, sustainable use

Introduction A preliminary study of plant species diversity in a long term grazing study indicated that diversity was impacted by grazing pressure: species diversity was highest at the lowest grazing pressure and lowest at both the highest grazing pressure and in exclosure (Orr and Phelps 2003). This paper presents further results from the continuing diversity study and discusses these results in terms of sustainable use in *Astrebla* grasslands.

Materials and methods A grazing study incorporating 6 grazing treatments was established in *Astrebla* grassland near Julia Creek, Australia in 1984 and remains current in 2007. The climate is semi arid with mean annual rainfall of 458 mm with 85% falling in summer (October-March). Treatments are unreplicated paddocks with sheep numbers adjusted annually in autumn to consume 0, 10, 20, 30, 50 and 80% of the end of summer available forage. Plant species was determined in 2001 and 2004 by germinating seed within soil samples collected within a 60 x 60 metre grid using a Geographic Positioning System. Each sample comprised 4 individual cores of 5 cm diameter to 5 cm depth (Orr and Phelps 2003). A total of 16, 162, 69, 49, 36 and 20 soil samples were collected from the 0, 10, 20, 30, 50 and 80% treatments respectively.

Results and discussion The 2001 sampling occurred after 3 consecutive summers of above average whilst the 2004 sampling occurred after 2 consecutive summers of below average rainfall. Despite this, the overall pattern of diversity was similar with the highest number of species recorded under the lightest grazing pressure (Figure 1). High species numbers at the lightest utilisation was due mainly to the high number of forb species. This high diversity at light utilisation was dominated by palatable species including the native legumes *Glycine falcata* and *Rhynchosia minima*.

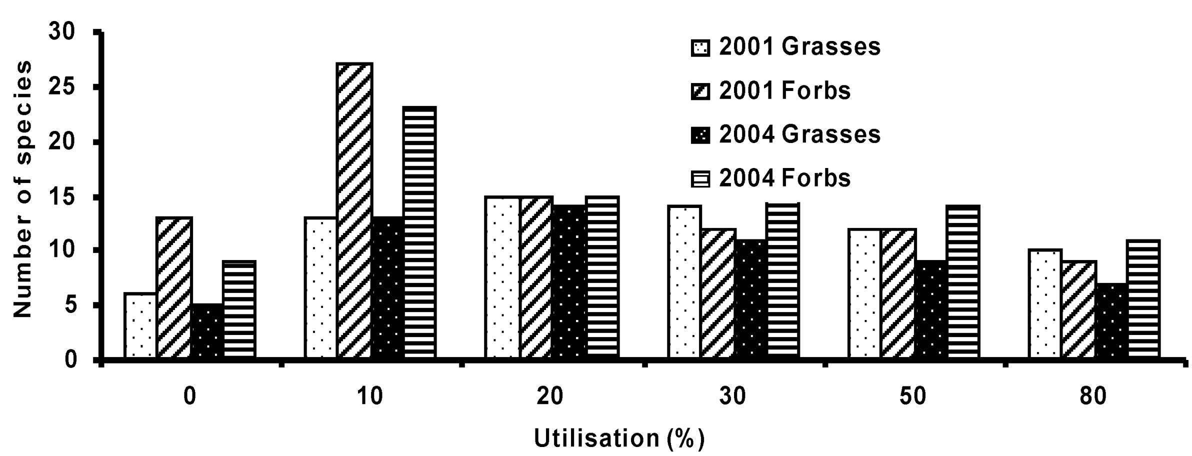

Figure 1 *Number of grasses and forb species present in* <u>Astrebla</u> *grassland in 2001 and 2004.*

Phelps *et al*. (this volume) report 40-50% of the Astrebla grasslands as being in poor" condition following 7 years of drought, based on rapid assessment of pasture, soil and woodland condition. The main indicator of this poor condition was low density of live *Astrebla* spp. tussocks. The data on species diversity presented in the current paper provide evidence of the useful role of soil seed bank analyses to assess sustainable use in *Astrebla* grasslands.

Conclusions High forb species diversity, especially of more palatable species, is indicative of sustainable use in *Astrebla* grasslands.

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A rapid assessment technique to evaluate rangeland health

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Key words: rangeland health, assessment, qualitative ranking, indicator

Introduction Land managers are constantly searching for more efficient methods to assess the condition of rangelands. The concept of rangeland health was advanced as an alternative to range condition (NRC 1994) and is defined as, "The degree to which the integrity of the soil, vegetation, water, and air, as well as the ecological processes of the rangeland ecosystem are balanced and sustained (Pellant et al. 2005)." It can be assessed using quantitative measures (Herrick et al. 2005) and with a qualitative, rapid assessment protocol (Pellant et al. 2005). Qualitative assessments can be used to help prioritize land for restoration and more intensive monitoring.

Materials and methods This technique, which is currently being applied in a number of countries including the US, Mexico, China and Mongolia, utilizes 17 indicators that are rated (Table 1) according to their departure from an expected condition as described in a Reference Sheet. These indicators include a range of biotic and soil based elements that address the integrity of the plant community, soil erosion, and water function. The Reference Sheet facilitates consistent application of the process on each ecological site by integrating all available sources of data and knowledge to a single range of reference conditions for each indicator. An ecological site is a kind of land with specific physical characteristics which differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its response to management. The product of this qualitative assessment is **not** a single rating of rangeland health, but three components called attributes (Table 1).

Table 1 *Attributes of rangeland health and the rating categories for each attribute (and indicator).*

Soil/Site Stability	Hydrologic function		Integrity of the Biotic Community	
Ratings reflect the degree of departure from expected values of each attribute/indicator per the Reference Sheet				
Extreme to Total	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight

Results The outputs from this assessment provide a preliminary evaluation of the attributes of rangeland health at the ecological site or its equivalent, level. The results can be used to communicate fundamental ecological concepts to a wide variety of audiences. Monitoring site selection can be improved using the assessment results and early warnings of potential problems and opportunities in areas that are potentially at risk of degradation or where resource problems currently exist can be identified. Caution must be exercised to ensure that this technique is used appropriately to identify independently the cause(s) of resource problems and follow-up management actions.

Conclusions This protocol will continue to evolve as our understanding of ecological dynamics of global rangelands continues to grow. The use of a qualitative protocol, supplemented by quantitative studies, provides managers with a starting point to better describe and ultimately manage rangelands.

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Resilience of ecosystem structure and function during succession following prescribed burning in a shrub-steppe ecosystem in Wyoming , USA

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Key words : aboveground biomass , roots , soil organic matter , N availability , sagebrush steppe

Introduction Prescribed burning is applied in mountain big sagebrush (*Artemisia tritentata* var . *vaseyana*) communities across the Intermountain West , USA , to reduce shrub cover , increase herbaceous biomass , and enhance wildlife habitat and rangeland health . When properly managed , succession following burning in these upper elevation rangelands follows a predictable pathway . Initially , perennial bunchgrasses (including *Festuca* spp . , *Stipa* spp . and *Poa* spp .) dominate , and sagebrush cover increases to pre-burn levels within about 40 years as grasses decline (Ewers and Pendall 2008) . We hypothesized that N availability would be stimulated following burning , and that aboveground and belowground biomass and soil organic matter storage would increase as shrub cover increased during succession .

Methods We studied the effects of burning on ecosystem structure and function at three chronosequence sites in Wyoming , ranging in age from 0 to ~40 years since disturbance . We measured vegetation cover and leaf area index (LAI) , and developed new allometric relationships for estimating aboveground and coarse root biomass for sagebrush (Cleary et al . 2007) . Fine root biomass , soil organic matter (SOM) and KCl-extractable NH_4^+ and NO_3^- content were also measured at one chronosequence to 2-m soil depth . SOM was further fractionated into active , slow , and non-hydrolyzable C (NHC) pools using long-term incubations and 6-*N* HCl digestion . We applied a vector approach , by repeated sampling of several parameters at multiple time points , and replicated the chronosequences , to test chronosequence assumptions .

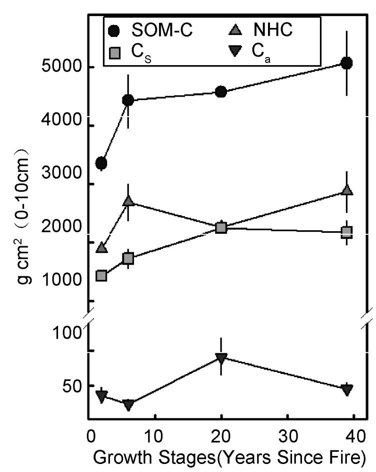

Figure 1 *Soil C pools in top 10-cm over succession . SOM-C , total ; NHC , non-hydrolyzable C ; Cs , slow pool C ; Ca , active pool C .*

Results and discussion We found that increases in aboveground biomass , cover and LAI were driven by sagebrush establishment and growth over 40 years of succession following burning . Aboveground biomass accumulated at a net rate of approximately 15 g C m^{-2} y^{-1} , to a maximum of about 600 g C m^{-2} . Coarse root biomass in the top 25-cm soil accumulated at approximately 8 g C m^{-2} y^{-1} to a maximum of 350 g C m^{-2} . Fine root biomass was maintained near steady state , at approximately 450 g C m^{-2} , throughout succession , for a total biomass C inventory of about 1400 g m^{-2} in the climax shrub-dominated community . Total SOM in the top 10-cm depth increased from about 3200 g m^{-2} to 5000 g m^{-2} over 40 years , with the largest increases observed in the slow and NHC pools (Figure 1) , which have mean residence times of decades to centuries . The regrowth of aboveground biomass and maintenance of belowground biomass and SOM indicate that this ecosystem is resilient to *fire* .

A pulse of available N was observed in the first 3-4 years after a burn , mainly in the form of NH_4^+ (Figure 2) . This available N was likely responsible for vigorous growth of herbaceous biomass following burning . Repeated measurements confirmed the validity of our chronosequence approach . Changes in net N mineralization during succession were not observed due to high variability .

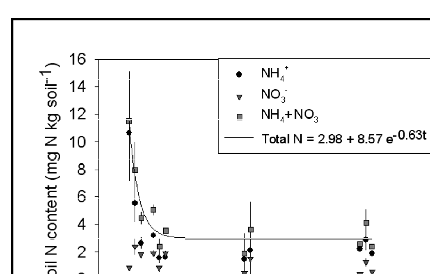

Figure 2 *Annually repeated measurements of soil NH_4^+ and NO_3^- pools during succession in a burn chronosequence .*

Conclusions Aboveground biomass and C stocks in SOM increased during succession , corresponding to changes in shrub cover , while N availability peaked in the first few years following burning . Maintenance of fine root biomass , provided by perennial grasses , appears to be critical to resilience of ecosystem structure and function in sagebrush steppe .

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Decline in land condition in *Astrebla* grassland during prolonged drought in Australia

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Key words: *Astrebla* grassland, pasture condition, sustainable use, monitoring

Introduction Mitchell grasses (*Astrebla* spp.) are arid tropical tussock grasses endemic to Australia which become dormant during drought to escape desiccation and death. Drought is a regular feature of these grasslands. The Mitchell grasslands of Queensland, Australia, cover 33,800,000 ha, support 15% of the cattle herd, more than 40% of the Merino sheep flock and provide employment to 2500-3000 people. The short-term productivity of these grasslands declined as pasture yield was reduced in association with prolonged drought from 2001 to the present. Many Mitchell grass tussocks failed to respond to reasonable rains during the 2003-04 summer and this created concerns about extensive tussock death and hence reductions in long-term productivity and land condition. This paper presents preliminary results from surveys undertaken to quantify the extent of tussock death and resultant reduction in land condition.

Materials and methods A rapid appraisal technique (Hassett *et al*. 2000) was modified to assess pasture condition in western Queensland during winter 2005 and again in the same area in 2006. Nearly 6000 observations of live and dead *Astrebla* tussock density (number/m^2) and response (growth relative to the average) together with pasture species abundance were used to classify 1 ha sized roadside areas into A (good), B (moderate), C (poor) or D (degraded) condition classes.

Results and discussion Less than 10% of observations of condition were assessed as being in A (good) condition in 2005 and 2006 (Figure 1). In 2005, 60% of observations were in B condition but this declined to 41% in 2006 in association with continued drought and in conjunction with the frequency of C condition observations increasing from 32% to 53%. D condition was less than 5% in each year. This decline in overall condition was associated with a reduction in live *Astrebla* spp density and an increase in undesirable forbs and annual grass species. Orr and Phelps (this volume) provided evidence that plant species diversity analyses would strengthen the assessment of land condition in *Astrebla* grassland. Historically, land condition in these grasslands has improved through seedling recruitment associated with improving summer rainfall. However, predictions of greater rainfall variability and increased incidence of drought associated with climate change may restrict future recovery.

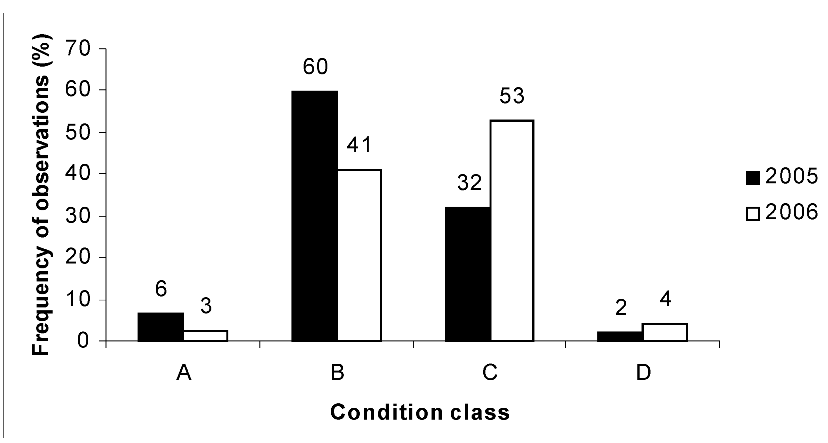

Figure 1 *The frequency (% of total observations) of A (good), B (moderate), C (poor) and D (degraded) condition classes in Queensland's Mitchell grasslands in 2005 and 2006.*

Conclusions *Astrebla* spp. are generally drought tolerant, but the severe drought conditions of 2001-2006 resulted in tussock death and hence reduced land condition. Recovery may be limited under climate change scenarios of increasing droughts.

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Estimation of tree height, biomass, and standing carbon in Miombo woodlands using radar interferometry

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Introduction Miombo woodlands cover about two thirds of Mozambique and estimation of its productivity is critical because it provides food, fiber, and fuel to 39 million rural and 15 million urban communities in southern Africa. However due to rough terrain, these landscapes are usually inaccessible and satellite data has proven invaluable in deriving biomass at this scale, the intent of this study. A jackknife stepwise regression model was previously used with RADARSAT and Landsat Normalized Difference Vegetation Index (NDVI) to estimate aboveground peak biomass at 18 kgm-2 (Ribeiro et al. in press b) and this study intends to compare these results to a radar interferometric method.

Approach A digital terrain model (DTM) that was derived from Shuttle Radar Topography Mission (SRTM) C-band interferometric data was used to estimate tree height in the 42000 km2 Niassa Reserve in northern Mozambique. The Reserve is 72% Miombo woodlands that are subject to anthropogenic fires, elephant herbivory, and climatic control (Ribeiro et al. in press a). Tree heights are estimated by simply subtracting a base-level digital elevation model (DEM) from a calibrated SRTM DTM. Allometric equations that were developed from canopy dominants are used to estimate aboveground savanna biomass and carbon. Due to C-band canopy penetration, underestimates of tree height results thus field plot data was used to calibrate the DTM to average tree height. However, base DEMs in developing countries, particularly Africa, are not usually available, thus we explored the use of 1) archived topographic maps, 2) a land cover bare-ground binary mask DEM, 3) use of the 1-km global DEM (GTOPO30) and 4) the newly-available SRTM C-band backscatter data. The mask DEM is generated by overlay of the bare-ground binary mask against the SRTM to derive ground elevations from the SRTM. The resulting point map of elevations was spatially interpolated using thin plate spines with tension to derive a base-level DEM. The best DEM for this use is the SRTM backscatter data. SRTM estimates of biomass will probably be less than the regression model estimate because it does not include grass biomass.

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Changes in range condition in the arid shrublands of Western Australia : application of spatial and temporal analysis to long-term monitoring data

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Key words : monitoring , grazing , range condition , shrublands , GIS , WARMS

Introduction The effects of climate , herbivore grazing , fire and other natural and anthropogenic disturbances are reflected by changes in range condition , driven by changes in soil and vegetation condition . When range condition is used in an ecological context , an improving trend implies an improvement in ecological or ecosystem integrity . In contrast , a declining trend implies a reduction in integrity , otherwise known as natural resource degradation . This study integrated soil and vegetation condition attributes into a quantitative index of range condition and mapped its variation through time across the shrublands of Western Australia , covering a total area of approximately 760 ,000 km^2 .

Methods and materials The analysis is based on a hierarchical suite of soil and vegetation indices derived from transect field metrics acquired by the Western Australian Rangeland Monitoring System (WARMS) . WARMS is an extensive , long-term , ground-based system established in 1981 to monitor range condition change in the pastoral rangelands and is operated by the Department of Agriculture and Food Western Australia (DAFWA) . By the end of 2006 , 980 sites located on 377 pastoral leases existed at an average density of one site per 77 ,780 hectares of pastoral shrubland . Data collection protocol has remained essentially unchanged since 1992 and new data is captured at each site on a 5-year cycle(Watson , Novelly & Thomas 2007) . The Shrubland Range Condition (SRC) index and sub-indices were partitioned into 4-year time-slices based on data capture date and then spatio-temporal maps showing relative range condition for each time-slice and change between time-slices , each classified into five classes , were produced using Geographic Information System (GIS) techniques . Change maps utilised an Inverse Distance Weighted (IDW) analysis technique to identify clusters of sites displaying similar change behaviour .

Results and discussion Local , regional and shrubland-wide patterns of change are evident . In the northwest of the shrublands , change in range condition is generally more spatially and temporally variable , greater in magnitude and involves larger clusters of sites compared to areas in the southeast . Many clusters of sites show alternate improvement and decline between time-slices whilst several clusters in the Ashburton and Murchison catchments continued to decline over the last 15 years or so . For most sites showing negative change , causal agent(s) of change , usually high grazing pressure but also fire and flood , could be inferred . Only two clusters of sites , located in the upper reaches of the Gascoyne River , steadily improved over the same period . Most sites are in Fair" condition in the Goldfields region and in Poor" condition in the Nullarbor region , however , the concern is that most of these sites in both regions also showed little or no change in range condition , despite a 10-year sequence of average or above average rainfall throughout much of the shrublands . The ecological response to grazing and other disturbances across the shrublands , reflected by change in the SRC index , appears to be related , at least in part , to drainage type . In general , monitoring sites located in endorheic and arheic basins exhibit less change in range condition compared to sites located in exorheic catchments . This is interpreted to reflect differences in rates of incision and soil erosion fundamentally related to ultimate and local drainage base levels . The regional insight provided by this study supports local field observations made by Pringle and Tinley (2003) of certain critical hydrogeomorphic processes involved in land degradation .

Conclusions The combination of hierarchical index framework , use of time-slices and GIS mapping techniques provides a potent analysis platform for the elucidation of spatial and temporal change in range condition or ecological integrity at WARMS sites . The study has shown that natural resources in exorheic catchments are more susceptible to degradation . In this particular catchment type , but also throughout the endorheic and arheic basins , much more ecologically benign land use practices must be implemented to reverse range degradation in the shrublands of Western Australia .

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Modelling trade offs between ecological and economic performances in grazed grasslands : importance of temporal stocking density

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Key words : cost-effectiveness , grassland birds , grazing , trampling , viability

Introduction Recent changes in grassland management have led to increasing threats on farmland birds populations (Newton , 2004) . Through its impact on sward structure , grazing can promote suitable habitats for ground nesting birds (Tichit , Renault and Potter , 2005) . However it can also have negative side effects on birds dynamics through nest trampling . We developed a cost effectiveness approach to asses the effect of nest trampling by cattle on the economic and ecological performances of grazed grasslands .

Materials and methods To study trade offs between ecological and economic performances , we relied on a co-viability model (Tichit et al . 2007) . It comprises two interactive sub-models describing : i) grazed sward dynamics and ii) a staged structured stochastic matrix model of bird dynamics . Both sub-models are linked through the direct and indirect effects of grazing on the demographic parameters of two bird species . During incubation , stocking density has direct effects on bird fecundity through nest trampling . The following month , sward height influences chicks' survival (indirect effects) . The model predicted stocking density sequences satisfying both production constraints (cattle feeding requirements) and ecological constraints (sward height and trampling thresholds during incubation and rearing stage) . We compared different grazing strategies leading to a defined ecological objective according to their economic performance . Ecological criterion correspond to maximum reduction of 10% in both birds' populations after 15 years (starting with 100 individuals at t=0) . Economic criterion was based on the avoided feeding cost permitted through grazing . Grass height constraints were defined so as to compel juvenile survival to be optimal .

Results Several grazing strategies satisfied the ecological criterion . However , the best ecological strategy was the worst on the economic viewpoint . The best economic strategy ensuring ecological objectives in the long term implied a 0 .5 LU .ha^{-1} stocking constraint in April and May . This strategy allowed an economic performance of 235 .8 € . ha^{-1} (Figure 1) and was consequently 27% less profitable than the best reachable economic performance . The initial grazing peak in spring was split in two . A first peak appeared in March and another one in June . This illustrates a need to anticipate grass growth so as to maintain suitable habitats during the breeding months .

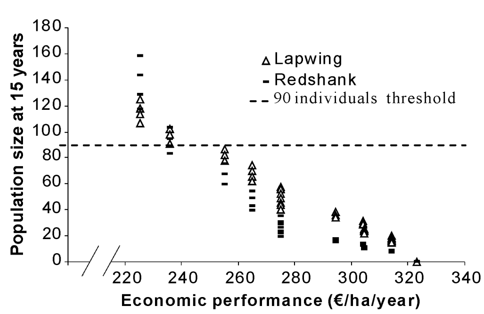

Figure 1 *Ecological and economic performances for different trampling intensities .*

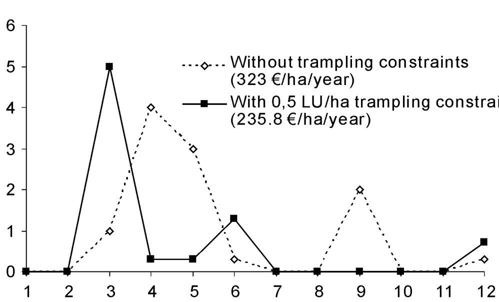

Figure 2 *Shift in stocking density sequences driven by trampling threshold .*

Conclusions The trade off between economic and ecological performances is highly dependent on the stocking density sequences . A maximal economic performance seems to be sorely compatible with ecological outcomes . The impact of cattle trampling on waders is all the more important since nesting occurs during the two months where grass growth is the strongest . Even if it implies lower economic performances , limited grazing is compatible with ecological goals and is essential to produce an optimal habitat for waders . These results are useful to reflect on agri-environment schemes aimed at both economic and ecological objectives .

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Definition of indicators for rangeland health in the Pantanal, Brazil

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Key words: *Axonopus*, beef cattle, grasses, plant cover, sustainable management

Introduction The Pantanal is a vast floodplain that presents edaphic and hydrological heterogeneity, with several landscapes that vary spatially and temporally. In these landscapes, there are several grassland types, generally dominated by one or more forage species. Currently there is a need to understand and know the optimal state of each type of pasture to define appropriate management strategies. The objective of this study is to evaluate a methodology to select indicators for natural pasture of the Pantanal, Mato Grosso do Sul state, Brazil.

Materials and methods The study took place in the Nhumirim farm, Nhecolândia sub-region, Pantanal, in natural pastures with dominance of *Axonopus purpusii*, located around ponds, in seasonally flooded areas, during the dry period, in August 2007. Seven different pasture states were evaluated, ranging from pastures in optimal state to dominated by non-wanted grasses species such as *A. bicornis* or shrubs such as *Vernonia scabra*). First, a principal component analysis was used to define the gradient in according to Gibson e Bosch (1996). The following step was to evaluate the associations among percentages of plant species cover within the gradient and the direction for all states and for each state, through non-parametric methods. Data were analyzed using SAS (2004).

Results The five determinant variables of the gradient direction were: plant cover, soil cover, average height, percentage of dead matter and *Axonopus purpusii* cover. All variables were positively correlated with gradient direction. From 44 identified plant species, only five were considered indicators for monitoring and evaluation of this grassland type. Besides plants species, other variables such as forage cover (Figure 1), weed cover, forage number, weed number and leguminous number were considered indicators.

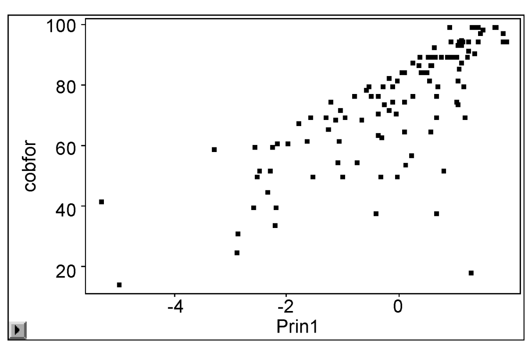

Figure 1 *Response curve of Forage cover along states gradient (principal component first).*

Conclusions This methodology was adequate for the determination of indicators and it could be used in other types of pastures of the Pantanal.

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An operational monitoring program in the grasslands region of western Australian rangeland

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Key words: warms, regional monitoring, Kimberley

Introduction The Western Australian Rangeland Monitoring System (WARMS) monitors and reports on the pastoral rangelands of Western Australia. WARMS is a system of permanent sites for reporting at broad scales, such as by biogeographical region or local government area.

Materials and methods The Kimberley and the Pilbara regions in Western Australia have extensive grasslands used for pastoralism i.e. commercial livestock production. To allocate the WARMS sites, the 220 published land systems (109 in the Kimberley and 111 in the Pilbara) were stratified into 12 major vegetation groups. The more productive vegetation types for pastoral use were allocated more sites, hence tussock grasslands (e.g. species of *Astrebla*, *Chrysopogon*, *Eragrostis* and *Cenchrus*) received a higher density of sites than spinifex communities (*Triodia spp*, *Chrysopogon spp* and *Eraichne ssp*).

Table 1 *Summary of Kimberley and Pilbara regions.*

Region	No. of sites	No. of stations	Station area (M ha)	No. of Cattle (head)	Annual rainfall (mm)	Tussock grasslands: Total area / No. of sites	Tussock grasslands: Average area per site (ha)	Spinifex communities: Total area / No. of sites	Spinifex communities: Average area per site (ha)
Kimberley	385	85	21.4	600,000	500-1100	4.8 M ha 259 sites	18,700	8.2 M ha 126 sites	65,100
Pilbara	248	58	13.7	450,000	300-400	2.3 M ha 144 sites	16,400	6.4 M ha 104 sites	60,700

At each assessment, the frequency of perennial plants by species is recorded on 100 quadrats over a 0.13ha site. Estimates of crown cover by species of shrubs and trees over 1metre are made. Details of site selection and assessment can be found in Western Australian Rangeland Monitoring System for Grasslands: field manual" Craig, Thomas and Watson (2008). Landscape function is also assessed, following Tongway and Hindley (1995).

Discussion WARMS commenced in 1994. Grassland sites are assessed on a three year cycle, thus by the end of 2008 the fifth cycle of assessments will have been completed in the Kimberley. Analysis and reporting is by prescribed vegetation group within each biogeographic region or other appropriate regionalisation. Reporting is to State and Federal Government and the general pastoral community, rather than to individual pastoral enterprises. (See associated paper by Watson, Thomas, Novelly and Craig in these proceedings). Data for grassland sites are stored in Oracle and MS Access relational databases, with links to a medium resolution digital photo for each observation. Currently, for the 633 grass sites, there is a total of 2450 observations, with many sites having 5 observations.

In designing and implementing a regional monitoring program, there is a need to consider the long term institutional commitment of the organisation undertaking the monitoring. There will always be a need to balance the number of sites needed for meaningful reporting and the availability of resources required for their monitoring. Each year about 130 sites are assessed in the Kimberley and 85 in the Pilbara. Not every site will be able to be assessed in any given year. In the Kimberley, about 4% of grass sites cannot be assessed because of recent fire and up to 3% of sites are abandoned due to changes in fence lines and tracks. In the Pilbara burnt or abandoned sites are rare. Ancillary datasets such as, interpolated rainfall and NOAA NDVI, and measures of stocking pressure are used to help tease out likely causal factors.

Conclusions WARMS is an established operating monitoring system of long term, objective data over expanses of the Western Australian rangelands. The system is designed for reporting on similar vegetation types at broad scales, rather than at the scale of the individual enterprise.

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Procedures for estimation of the livestock ecological footprint in US drylands

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Introduction The ecological condition and trend of the United States' 3 ,902 ,000 km^{-2} of Drylands and the extent to which human management actions contribute to degradation are unknown at the national spatial scale (Washington-Allen et al . 2006) . Our research seeks to develop procedures for determining the impact or ecological footprint of livestock grazing on the productive capacity of Drylands at the national spatial scale .

Approach The study approach has been to develop a Geographic Information System (GIS) consisting of digital maps of gross and net primary productivity (GPP and NPP) , U .S . Department of Agriculture National Agricultural Statistics Office (NASO) national livestock number and distribution maps , transportation and power consumption networks , gridded climatic data , land cover , and land use . Maps of GPP and NPP were derived from annually integrated normalized difference vegetation index (NDVI) from the Moderate Resolution Infrared Spectroradiometer (MODIS) and the Advanced Very High Resolution Radiometer (AVHRR) satellite data . Climatic data , particularly mean annual potential evapotranspiration [MAPET ,Zomer et al . (2006)] , was derived from the WORLDCLIM dataset developed by Hijmans et al . (2005) .

Secondly , a Dryland extent map was generated using gridded population , transportation data , e .g . , data of roads and railways , power consumption , land use/land cover and aridity index (AI) data in a subtractive overlay GIS procedure . AI is the United Nations Convention on Desertification's definition of Drylands where AI is the ratio of mean annual precipitation (MAP) to MAPET that is $\leqslant 0.65$.

Thirdly , the NASO data is used to generate livestock number and distribution maps which are intersected with the dryland extent map to yield a livestock footprint map . Lastly , this footprint map is then converted to an annual requirement of forage map and subtracted from a GPP map to yield a livestock appropriation of net primary productivity map (LANPP) .

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Rangeland monitoring in the Kimberley region of Western Australia—changes in perennial grass frequency

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Key words: regional scale monitoring, WARMS, pastoral monitoring, rangeland management, savanna

Introduction The Western Australian Rangeland Monitoring System (WARMS) is used by the state government of Western Australia to help determine the impact of cattle grazing on rangelands in the pastoral region. These rangelands are leasehold, owned by the Crown, and the government has a responsibility to ensure they are managed well.

Materials and methods WARMS consists of a set of permanent ground sites on which aspects of perennial vegetation dynamics and soil surface condition are assessed (Watson *et al.*, 2007). Here we present data on perennial grass frequency from the subset of 280 sites (from a total of 383) that were assessed in the Kimberley region in each of the four assessment epochs. Epochs are sequential three year periods during which the sites were assessed. Epoch 1 (E1) was 1994-1995-1996; E2 was 1997-1998-1999; E3 was 2000-2001-2002 and E4 was 2003-2004-2005. Paired t-tests were used to examine if the average perennial grass frequency changed from epoch to epoch. The number of sites in which perennial grass frequency remained stable or increased was also calculated. Rainfall data and lease level statistics of cattle numbers were obtained from unpublished government databases.

Results and discussion The average perennial grass frequency on the 280 sites was 77% in E1. It increased between E1 and E2 ($p < 0.01$) and between E2 and E3 ($p < 0.01$) but not between E3 and E4 (Table 1). Increased or stable frequencies were found on about 75% of sites between E1 and E2 and over the subsequent period. Rainfall was typically above average from the mid 1990s to early 2000s, followed by a relatively drier period. Cattle numbers increased from the mid 1990s until early 2000s and have not declined since.

Table 1 *Comparisons of change in perennial grass frequency (%) between epochs—Kimberley WARMS sites.*

Epoch comparison	Average change in frequency between epochs	p-value	Number of sites with stable or increased frequency
E2 *vs* E1	+5.4	$p < 0.01$	210
E3 *vs* E2	+4.2	$p < 0.01$	212
E4 *vs* E3	−1.0	$p = 0.20$	167

Conclusions On its own, the increase and then stability in perennial grass frequency under commercial cattle grazing is a favourable result. However, seasonal conditions (i.e. high rainfall) were clearly beneficial for the establishment of perennial grasses for much of this time and we would expect frequency to increase. From the early 2000s seasonal conditions became drier but cattle numbers did not decline. This may be reflected in the plateau seen in perennial grass frequency between E3 and E4, raising concerns that cattle numbers have not been adjusted in line with drier seasonal conditions and may be adversely affecting the rangelands. The fifth epoch (E5) assessment will be finished by the end of 2008 and this will show the changes in perennial grass frequency since E4, which should confirm if cattle numbers are too high. The results from this will be presented to land administrators within the government of Western Australia.

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Physical and hydric characterization of a red-yellow dystrophic latossolo" under different tillage system and grassland sytems

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Key words: soil compacting, proctor normal, soil penetration resistance

Introduction The soil compaction of tillage systems are important soil degradation. The traffic of machines and animal trampling, to promote the increasing of soils physics parameters used to available the soil compaction. Some of these parameters are the compaction degree and soil penetration resistance. The limits adopted for these parameters are respectively: 75% and 2MPa for compaction degree and soil penetration resistance.

The objective of this work was to evaluate the degree of compaction and the soil penetration resistance under different tillage systems and grassland systems.

Materials and methods The present study was conducted in Experimental Farm of University of the State of Minas Gerais, Passos in a Red-yellow dystrophic Latossolo. The systems were: No-tillage system (PDM), No-tillage system irrigated (PDMI), conventional planting system (PCM), grass land (PG) and Natural forest (MN). The compaction degree (GC) it was obtained by the relationship between soil bulk density and the maximum soil bulk density (Dsmax) obtained from Proctor Normal test. The studies of soil penetration resistance (RP) were made in undisturbed samples through a pocket penetrometer. Those samples were saturated and the RP determinations were accomplished in different water contents.

Results and discussion The GC values for the different systems were: PDM=71,5%, PDMI=75,1%, PCM=69,7%, PCMI=75,2%, PG=89,2% and MN=72,1%. Using the limit of 75%, it was observed that the systems: PG, PDMI and PCMI, present values higher than critical values. The soil compaction it is already happening. In the grassland, the animal trampling can be increasing the GC values. For the PDMI, the intense traffic of machines and the irrigation, increasing the GC values. In PCMI, although the soil was mobilized, the same effect that PDMI in increasing of GC value was observed. The no-tillage, the irrigation system and traffic of machines to promoted the increasing in GC value. The soil penetration resistance, indicated that the grass land, was the system what presented the higher soil strucuture modification than other systems (1.92 MPa), followed by the no-tillage irrigated and no-tillage system of 1.91 and 1.88 MPa respectively.

Conclusion We conclude that the handlings PG, PDMI and PCMI, are presenting compaction tendencies and justify the Chizel plow use.

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Heavy grazing of beef cattle combined with supplementary sowing to improve deteriorated pastures

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Key words: deteriorated pasture, heavy grazing, renewal techniques, beef cattle

Introduction There are more than 500,000 hm^2 of improved pasture in Yunnan but about 2/3 have significant deterioration. Trials were carried out on these deteriorated pastures after the beginning of the rainy season by a combination of heavy grazing with beef cattle, controlled by electric fences, combined with supplementary sowing. The purpose of the trial was to determine the efficacy of these techniques for renewing these improved but deteriorated pastures.

Materials and methods The trial was conducted on the pasture at Xiaoshao, Kunming (East longitude 103°00′, north latitude 25°13′; elevation 1960 meters; annual rainfall 889mm; annual temperatures 13.4℃; latosolic soil). At the beginning of the trial, the average vegetation coverage was 86.1% with vegetation mainly native grasses with only 3% improved pasture species. The trial paddock area was 260m^2; 52 beef cattle of three-way crossbreeding were used for the trail. The cattle were divided into two groups (26 herds per group); daily rotational grazing with 7 grazing-intensity treatments (head.hrs./m^2) of: 0, 1.16, 2.32, 3.48, 4.64, 5.80 and 6.96. Each treatment was designed with three replications and a random statistical design. Supplementary sowing of pasture species was conducted on each pasture after grazing treatment. The species and sowing rate for supplementary planting was: *Lolium perenne* .cv .grasland nui 9kg/hm^2 + *Triflium repense*. *cv* .Haifa 9kg/hm^2. The trial started in the rainy season. The output and the proportion of improved pasture species were recorded each year.

Results The output of two-year pasture was increased by increased grazing intensity and reached the highest with the sixth treatment (See Table 1). The pasture output of each grazing treatment was significantly higher than the control group ($P<0.01$). Heavy grazing caused the formation of small hillocks of 20-30cm diameter, in what was otherwise usually hard immature soil. Pasture seeds had difficulty growing in the untreated soil which affected percent cover and biomass output.

Table 1 *The Pasture Output of Difference Treatments (kg.DM/hm^2).*

Treatment (head.hr/m^2)	1(ck)	2	3	4	5	6	7
First year	84eD	164eD	604dC	1036cB	1328bA	1458aA	1428aA
Second year	918eC	2303dC	2686dC	4182cB	5179bcB	6698aA	5440bAB
mean	501eE	1233dD	1646dD	2609cC	3254bBC	4078aA	3434bAB

Note: Different small letters in the same row were significantly different at the $P<0.05$ level and capital letters in the same row were significantly different at the $P<0.01$ level.

The proportion of improved pasture species was increased by the different grazing intensities (See Table 2). The original vegetation was reduced under the trampling of beef cattle and growth of the seeded species was increased.

Table 2 *The Pasture Proportion of the Total Biomass of the Land for Different Treatments (%).*

Treatment(head.hr/m^2)	0(ck)	1.16	2.32	3.48	4.64	5.80	6.96
First year	7.2	13.6	45.1	74.5	83.2	80.4	94.1
Second year	19.8	47.0	54.3	73.3	80.0	83.2	86.5
mean	13.5	30.3	49.7	73.9	81.6	81.8	90.3

Conclusions The most effective methodology to restore deteriorated-improved pasture was by use of electric fences, heavy grazing and supplementary sowing. In 0-6.96 head.hr/m^2 of grazing intensity, the proportion of supplementary sowing pasture increased with increasing grazing intensity. On degenerated pasture, the most beneficial grazing intensity was 5.80 head.hr/m^2.

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Species area relationships in a mountainous agro-pastoral ectone in northern China

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Key words : agro-pastoral ectone , species-area relationship (SAR) , the power model , the exponential model , mountain

Introduction Species area relationships (SAR) in plant communities have been characterized by species-area curves that have been used in the literature to describe an increasing number of species with increasing area of habitat (Scheiner , 2003) . The most widely applied models of SAR have been the exponential model [S=c+z log A (1)] and the power-law model [log S=c +z log A (2)] (Jon , 2003) , where S is the number of species in the habitat whose area was A , and c and z coefficients were constant . The objective of our study was to determine the best-fit model of SAR for a mountainous plant community in the agro-pasture transition zone in northern China .

Materials and methods This study was conducted in a rangeland ecosystem , state-level field science observation and research station in Guyuan of Hebei Province in China (115°41′ E , 41°49′ N) , which is located in a typical agro-pastoral transition region in northern China (Huang et al ., 2007) . This study site contains nine mountains surrounded by farmland , where flax and naked-oat are the main economic crops . The research sites , which have more than 50 years history of cultivation , are located between 15 and 25-km northwest of the station . Three transects were set up from the foot to the top of every southern slope in the study area in August , 2007 to establish a continuous elevation gradient (1400 m-1500 m) . Each transect was 10 m wide and 60-80m long . The total number of quadrats was 189 , each $1 \times 1m^2$. In each quadrat , all species were identified . Species-area curves were constructed for both models . Model fit was evaluated and compared using the adjusted r^2 value (Jon et al . 2003) . Species-area curves were tested using SAS 9 .0 procedures for linear regression .

Result SAR relationships for both the exponential model and the power model for Mountains in the agriculture zone exhibited a strongly linear relationship (Table 1) . The power model had a slightly better fit (adjusted r^2 0 .83) than the exponential model (adjusted r^2 0. 80) .

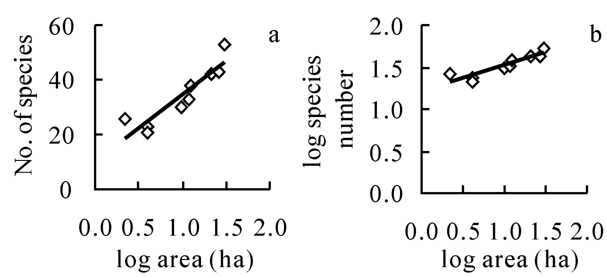

Figure 1 *Exponential species-area curves (a) n= 9 mountains ; power species-area curves (b) n= 9 mountains .*

Table 1 *Comparison of both models of SAR .*

Type of model	Model	Adj r^2	P
exponential	S=10 .32+24 .12 log A	0 .80	0 .0007
power	log S=1 .20+0 .31 log A	0 .83	0 .0004

Conclusion Our research shows the species-area relationship which is most appropriately described by the power model (equation 2 , Figure 1b) for these mountains ecosystems in Agro-pastoral transition zone .

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The influences of land use patterns on wind erosion of meadow grasslands

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Key words: meadow grassland, soil wind erosion, land use patterns, wind tunnel experiment

Introduction More than half of the world's pasturelands are overgrazed and subject to erosive degradation (Pimentel *et al*. 1995). Climate change and human economic activities in arid areas have increased the deleterious impacts of wind erosion (Shi P J *et al* 2004). This study examined the effects of land-use patterns on the ability meadow grasslands to resist wind erosion.

Materials and methods The research site was located in Xieertala in Hulunbeier, which is located in the transition area between the west Daxinanling and the Mongolian Plateau. The grazing intensity in these pastures was related to the vegetation cover which was, in turn, related to the distance from the inhabited area. The vegetation cover of pasture at the following distances from the inhabited area: 150m, 1000m, 2500m was 20%, 40% and 60%, respectively with corresponding grazing intensities considered as mild, moderate and severe. Croplands were also present within the meadow grassland at a distance of 1300m, where summer wheat was grown that was then tilled after harvest. In a representative point within each sample plot, we excavated a soil sample of a length, width and height of 95cm, 30cm, 20cm in October 2006. A vegetation survey was conducted around each sample point of the meadow grassland, in August 2006. The survey items included the vegetation cover, species composition and the aboveground biomass of various plant species.

Results As grazing intensity increased, the change of plant species and reduction of vegetation cover increased the potential for wind erosion of the soil. When the meadow grassland was mildly grazed, the vegetation cover maintained about 60%, which reduced the amount of soil erosion even at wind speeds of 25 m/s. When the vegetation cover of meadow grassland was reduced to less than 35%, soil erosion rapidly increased at lower wind speeds.

Table 1 *Effects of land using on the vegetation.*

Land using Patterns g/m^2	total of plant species	plant species inper square	cover meter	overground %	litter biomass g/m^2
mild grazing	49	23.8±4.7	63±5.7	188.55±57.99	91.47±31.62
moderate grazing	48	18.4±2.8	42±6.4	99.20±11.64	64.63±17.31
severe grazing	35	18±3.5	22±5.6	46.75±14.8	23.61±8.4
No-tillage cropland	0	0	0	0	0

Table 2 *Dominance of main plant species under different land using patterns.*

mild grazing		moderate grazing		severe grazing	
species	dominance	species	dominance	species	dominance
S.baicalensis	0.21868	A.chinense	0.4008	C.korshinskyi	0.3599
A.chinense	0.18298	C.korshinskyi	0.1795	C.squarrosa	0.2253
C. pediformis	0.11203	C.squarrosa	0.1093	P.turczaninovii	0.0220
P.chinensis	0.07208	A.laciniata	0.0411	A.chinense	0.0212

Table 3 *Relationship between land use and the rate of wind erosion under different wind speed. $g.(m^2.min)^{-1}$*

Wind speed $m \cdot s^{-1}$	mild grazing	Moderate grazing	Severe grazing	No-tillage cropland
15	0	0	2.03	2.94
20	0	0.88	3.16	7.21
25	0.05	1.56	9.72	68.12

Conclusions When the Hulunbeier meadow grassland is mildly grazed with vegetation cover maintained about 60%, the dominant species of the community are Stipa baicalensis and A.chinensis, and the vegetation system can maintain it's integrity against wind erosion. The mild grazing is, therefore, a sustainable land utilization mode. Correspondingly, the other land utilization modes in the experiment can cause serious wind erosion, especially in the no-tillage cropland within the meadow grassland. As the no-tillage cropland has reduced vegetation the soil wind erosion rates achieve 682.1kg/hm^2 when the wind speed is 25 m/s, which approaches the average formation quantity of soil (1000kg/hm^2) in a year.

Dynamics of module structures in *Puccinellina tenuiflora* clones in alkalinized meadow in the Songnen Plains, China

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Key words: *Puccinellina tenuiflora*, clone plant, module, vegetative tiller, reproductive tiller, alkalinized meadow, structure dynamics

Introduction *Puccinellina tenuiflora*, a perennial tuft grass (Puccinellia), is broadly distributed in alkali meadows on the Songnen Plains, tolerates salt and alkali stress, and forms large-area monodominant communities in alkali-patches that have low levels of surface soil (Yang et al, 1995). Previous studies have characterized vegetative propagation and sexual reproduction, the effect of different methods of utilization on the dormancy, and phenotypic plasticity and prolonged reproductive growth (Yang et al, 1995; Zhang et al, 2006; Sun et al, 2007). The objective of this study was to characterize the relationships between vegetative and, reproductive tiller production and their biomass at heading and ripening stages of *P. tenuiflora* clones. These relationships may improve our understanding of *P. tenuiflora* population ecology and provided scientific guidance for grassland management in this region.

Materials and methods The research was conducted in natual alkali meadows, located at the Pasture Ecology Research Station of Northeast Normal University, Changling, Jilin province of China (44°45′N, 123°31′E) which has a temperate, half-humid, continental-monsoon climate. Sample plots were located in mono-communities of *P. tenuiflora*. Whole clones were sampled at heading and ripening stages of *P. tenuiflora*. Thirty clones were taken from random locations at each growth stage. The tuft diameters were measured, and the number and biomass of total tillers, vegetative tillers and reproductive tillers were counted and weighted, respectively. The number and biomass of each module were analyzed and tested by one-way ANOVA.

Results The tuft diameters of *P. tenuiflora* clones were 11.0±1.9 cm and 13.6±2.2 cm at heading and ripening stages, respectively. The numbers and percents of vegetative and reproductive tillers were not significant ($p>0.05$) at two stages (Table 1), indicating the quantitative structures of clones didn't change with growth stages. The biomass of each module was significantly higher at ripening stage than that at heading stage ($p<0.05$), and the biomass of vegetative and reproductive tillers at ripening stages were 1.56 and 1.45 times compared with that at heading stage. The differences in percent of the biomass in vegetative and reproductive tillers was not significant ($p>0.05$). This indicated that the biomass structures of *P. tenuiflora* clones didn't change during different growth stages.

Table 1 *Quantitative characters of the modules of P. tenuiflora clones in different growth stages.*

Quantitative characters	Growth period	Vegetative tiller		Reproductive tiller		Total	
		Mean±SD	Percent (%)	Mean±SD	Percent (%)	Mean±SD	Percent(%)
Tillers	Heading	33.6±15.0a	32.3±79.0a	72.4±29.1a	67.7±0.1a	106.0±33.9a	100
($clone^{-1}$)	Ripening	32±19.0a	30.3±0.1a	70.7±26.3a	69.7±0.1a	102.7±35.2a	100
Biomass	Heading	1.7±0.9a	15.4±0.1a	8.7±4.7a	84.6±0.1a	10.5±4.0a	100
($g \cdot clone^{-1}$)	Ripening	2.6±1.8b	17.5±0.1a	12.6±4.26b	82.5±0.1a	15.2±4.6b	100

Conclusions The reproductive tillers were dominant in *P. tenuiflora* clones, and the dominance of biomass was much more obvious than that of tiller numbers. From heading to ripening stage, both the number and biomass of *P. tenuiflora* clonal modules were relatively stable. The clones could regulate the vegetative propagation, sexual reproduction, production and allocation of nutrition substance as plant populations.

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Biodiversity, vegetation measurements, and rehabilitation of foothills of Khanasser Valley (Southeast of Aleppo)

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Key words: biodiversity, vegetation measurements, rehabilitation

Introduction The Khanasser Valley is located in northwestern Syria. The current biodiversity of this area is degraded and unpalatable species dominate this area (*Peganum harmala*, *Noaea mucronata*). Two sites were selected in the foothills of Khanasser Valley to study the biodiversity, herbaceous and shrub biomass, species frequency, species density; species cover%, and economic uses of native plants. At each site were three treatments: 1) open grazing, 2) fenced plot, and 3) improved fenced plot. The main objective of the study was to evaluate rehabilitation of degraded areas by planting adapted and palatable species of fodder shrubs and perennial grasses and legumes such as: *Poa bulbosa*, *Dactylis glomerata*, *Medicago radiata*, *Salsola vermiculata*, *and Atriplex halimu*. The study was conducted during 1999-2004.

Material and methods The study involved determining: 1) plant diversity, 2) vegetation characteristics (vegetation cover%, biomass of herbaceous and shrubs, species composition), 3) plant community characteristics, 4) plant uses, and 5) selection of adapted and palatable species for improving sites.

Results A total of 120 species were observed in the fenced plot and the use of these species (palatable for sheep, medicinal plant, food, fuel, prevent erosion) were recorded. Only 50 species were found in the open grazing plot, and most of these species were unpalatable and poisonous.

Table 1 *Multiple uses of major native species.*

Species	Forage	Food	Improving soil fertility	Medicinal	Prevent erosion
Medicago radiata	√		√		
Hordeum murinum	√				
Teucrium polium	√			√	√
Capparis spinosa		√		√	√
Peganum harmala				√	√

Herbaceous biomass in the fenced plot was 485 kg/ha and in the open grazing plot was 100 kg/ha. Shrub biomass in the improved plot was 200 kg/ha, in the natural fenced plot was 40 kg/ha, while in the open grazing area was 7 kg/ha. The most common plant community contained *Hordeum murinum* and *Teucrium polium*. The highest species composition% was observed for *Hordeum murinum* with 42% and *Noaea mucronata* with 27%.

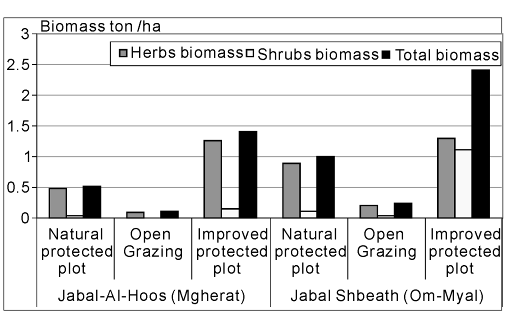

Figure 1 *Biomass (t/ha) for herbs, shrubs at two sites.*

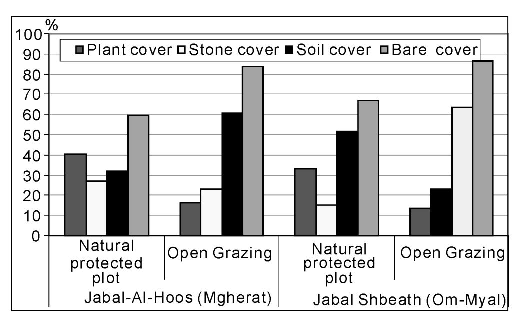

Figure 2 *Plant, stone, soil, bare cover% for two sites.*

The best adapted and palatable species on the improved site included: trees (*Pistacia atlantica*), shrubs (*Atriplex halimus*, *Artemisia herba-alba*, *Haloxylon aphyllum*, *Salsola vermiculata*), perennial grasses (*Oryzopsis miliacea*, *Phalaris tuberosa*, *Dactylis glomerata*), and annual legumes (*Medicago radiata*, *Trifolium tomentosum*, *Astragalus asterias*, *Trigonella monspeliaca*).

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Application of nuclear techniques in improving pasture/range management

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Key words: isotope, nuclear technique, pasture, range management

Introduction Nuclear techniques play an increasingly valuable and often unique role in agricultural research and development. They are one of the tools to solve problems for agriculture or natural resources which cannot be solved using conventional techniques. In this paper, the research activities carried out and the achievements so far obtained in the agricultural specialties with particular reference to pasture/range management—all by using nuclear techniques—will be given.

Soil Nuclear techniques are used to trace fertilizers to determine the best form, timing, and placement to avoid waste and to reduce its movement into the environment. Others are used to detect, measure, and track fertilizer-supplied nutrients in soil and plants; determine the availability of soil moisture; promote the natural process of nitrogen fixation. Nitrogen-15 (^{15}N) and the soil-moisture neutron probe are nuclear techniques to determine the fate of applied N, to follow water and nitrate movement in the soil. Nuclear techniques like using fallout radionuclide to measure soil erosion are fully documented. Fallout radionuclides (FRNs), such as ^{137}Cs, ^{210}Pb and ^{7}Be, have proven to be very powerful tracers of soil movements and soil erosion measurements. Much of this work involves ^{137}Cs to quantify soil loss risks at the watershed scale. Isotopic analysis (particularly of chlorine) is being used to monitor the movement of saline water and to assess the suitability of the salt-tolerant plants.

Livestock Doubly labeled water (^{18}O and ^{2}H labeled) method is for estimating of energy expenditures of grazing animals, body composition, basal metabolic rate, and milk output. $NaH^{14}CO^{3}$ / $NaH^{14}CO^{3}$ infusion is for estimating of the carbon dioxide production which in turn is used to estimate energy expenditure in free-ranging animals. ELISA *(Enzyme Linked Immuno Sorbent Assay)* is a specific kit which can be used to diagnose low levels of disease at laboratory level. It is well known for its use in the campaign to eradicate rinderpest (infectious bacterial disease of cattle and sheep) in Africa. Adding radioactive and stable isotopes in producing of feed supplement as markers to determine how feed material is digested, how the different nutrients are utilized and to discover any deficiency or imbalance in nutrients.

Plant, pest and weed management Improved plant varieties can be produced by mutation breeding e.g. gamma irradiation. It has produced varieties with ability to withstand flooding and tolerance of drought stress. In West Africa, *sorghum*, is undergoing irradiation treatment and, in field trials, some of the new mutant varieties produced have demonstrated increases yield of 30-50%, higher protein content and earlier maturation compared to local cultivars.

Sterile Insect Technique (SIT) is one of the well-known nuclear-based methods to eradicate dangerous insects and pests. The males are irradiated with gamma radiation, which renders them. Then the large numbers of sterile males released out and no offspring result from these sterile mating. Nuclear Polyhedrosis Virus (NPV) is a lower cost and new solution instead of chemical sprays to control the pest. The herbicide, N-phosphonomethyl glycine (glyphosate), is a non-selective foliage-applied herbicide used extensively for the control of many types of perennial weeds.

Conclusions Isotopes and nuclear techniques are very crucial in understanding how various factors influence water-soil-plant-livestock interrelationship in pasture and rangeland ecosystems. Nuclear techniques provide particularly strong tools to understand the mechanisms by which nutrients and water interact. There has been little development of this technique applications in range and pasture management directly. Until now, most attempts have been done to apply the technique to improve agricultural products supply for human demand in developing countries.

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Initial study on the construction of evaluation index system of the herdsman rights and interests protection—Taking Tianshan pasture of Urumqi , Xinjiang as an example

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Abstract At present the study of the protection of herdsman rights and interests is comparatively unspecific , lacking important qualitative analysis and necessary quantitative analysis , especially in the use of indicators to measure the level of the protection of herdsman rights and interests . In this paper , following the scientific , practical and simple principles , it constructs the evaluation index system of the herdsman rights and interests protection , and with AHP method it determines the various indicators weight , which fills the blank of the construction of the protection index system of herdsman rights and interests .

Key words : Grassland Law , evaluation , construction of herdsman rights and interests protection system , Analytic Hierarchy Process (AHP)

Preface The major community of herdsman is the minorities in remote regions . The protection of their rights and interests

The necessity of constructing evaluation index system At present the harm to the herdsmen rights and interests is a serious problem facing the remote ethnic minority areas in China . As herdsmen begin to settle down , they lead a better life and gradually withdraw from the nomadic life . As the masters of grassland , the protection of their rights and interests is especially important .

The construction of evaluation model By using Analytic Hierarchy Process (AHP) the paper determines the weights . With the combination of qualitative and quantitative factors in the decision-making process it establishes judgment matrix , sorting computation and consistency test , which explains man's subjectivity in terms of quantity .

Table 1 *Overall Sorting Level .*

Level A	B_1	B_2	B_3	Overall sorting(Final weight of each factor)
Level C	0 .20	0 .60	0 .20	$W_i = \sum_{i=1}^{m} b_i C_{ij}$
C_1	0 .20	0	0	0 .04
C_2	0 .60	0	0	0 .12
C_3	0 .20	0	0	0 .04
C_4	0	0 .028	0	0 .012
C_5	0	0 .26	0	0 .156
C_6	0	0 .14	0	0 .089
C_7	0	0 .132	0	0 .079
C_8	0	0 .21	0	0 .126
C_9	0	0 .23	0	0 .138
C_{10}	0	0	0 .14	0 .028
C_{11}	0	0	0 .72	0 .144
C_{12}	0	0	0 .14	0 .028

Conclusions By using AHP this paper determines the index system weight of protecting the rights and interests of herdsmen , obtaining evaluation index and importance value such as the reasonable utilization of resources , resistance of grassland disasters , scientific cultivation and raising livestock , implementation of keeping the balance of grassland and livestock , the settlement of herdsmen , raising their legal awareness , grassland compensation in place , the perfection of contract operation right , infrastructure construction of pastoral area , the protection of grassland management and rational development of other industries , which provide a decision-making basis for the protection of herdsman rights and interests , environmental improvement and sustainable development of animal husbandry .

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The effect of the exclude on the improvement of the rangelands in Hamadan province , Iran

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Key words : exclosure , canopy cover , forage production , range improvement , Hamadan

Introduction Study of vegetation changes of grazed and ungrazed rangelands is most important in range management programs (Tuckel , T . 1984) . Vegetation changes were studied for four years (2000-2003) inside and outside of the exclosure in Gian rangelands of Hamadan province . West at al reported that insipid of good rainfall in Utah semi desert rangeland no significant increase in grassland production (West , at al .1998) .

Material and method Measurements were made in permanent plots that have been established in study areas since 2000 . Forage production was measured in randomized plots each year . Data were compared whit T test analysis .

Results The cover of all plant forms , such as shrubs , grasses and forbs increased significantly inside of exclosure in this period (Figure 1) . Decreases , increasers and invaders decreased inside , but outside of exclosure there was an opposite trend . Frequency of good quality plants increased inside and decreased outside . Range condition increased from poor to fair inside and decreased to very poor outside of exclosure . Overall , a positive and negative trend was observed inside and outside the exclosure area (Figure 2) .

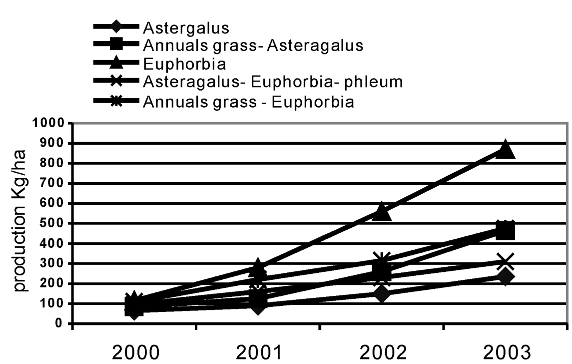

Figure 1 *Production Gradient curve of vegetative form in inside exclusure .*

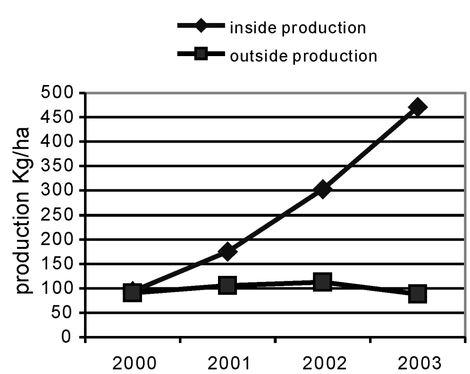

Figure 2 *Production Gradient (Kg/ha) in inside and outside of exclosure .*

Conclusions In second year of study , rainfall was greater than others . In final year annual precipitation was more than first year but seasonal rainfall that is effective in growth , was less than first year . Relationship between species canopy cover and annual and seasonal rainfall evaluated , however the correlation coefficient between rainfall and some species was significant . Overall , in comparison inside and outside , exclosure improved vegetation condition , forage production and range condition , under this climatic .

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Simulation tools and pastoral resources dynamics in Sahelian area : the Senegalese example

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Key words : pastoralism ,grassland/rangeland ,sahelian area ,Agent-based simulation ,GIS

Introduction The Sahelian area in Africa is characterized by multi-uses of the space and resources determined by a set of very precarious bioclimatic and social economic factors . This coexistence between several complementary production systems is currently the theatre of a space competition to access to natural resources . At the heart of these spaces , resource and actor strong interactions , several scientific methods and research tools are trying to apprehend and model the functioning and durability of these surroundings . How then a common approach or concomitant approaches can be built to contribute towards piloting agricultural ecological and social economic systems ? The aim of this paper is to show the contributions of multi-agent simulation and GIS to the understanding of the complex dynamics underlying the evolution of natural resources in the pastoral area in Senegal .

Materials and methods The analysis of the functioning of a production system as complex as pastoralism required the setting-up of a multi-disciplinary team of research in partnership around scientific stakes and development on workshop sites representative of the Sahel pastoral spaces . At the heart of the present approach , complementary tools were instructed :-1-for inventory-diagnosis (investigations , polls , interview guides , positioning) . . . ;-2-for representation and working out knowledge bases (speech analysis , working groups , self cartographical design , workshop result sharing validating) . . .-3-for accompanying the modelling process (participative multi-agent systems design , co-working out of rules , role playing , and scenario , etc) to better grasp the multifunctionality of shared spaces and common resources . The first tools made it possible to better conceptualize the chosen study fields and check the research hypotheses . The second tool category promoted knowledge deepening and its reproduction expression or communication media . The last battery of tools formalized and crystallized the set of information and knowledge in simulation prospective and exploratory models .

Results and discussion Many experiments were carried out by our team in the field of the development of simulation tools for pastoralism combining GIS , Agent-based models (Figure 1) and role playing games (Bah and al . 2006) (Touré and al . 2006) . This research work made it possible :-Starting from a dialogue , discussion and negotiation framework to set up different actors around common stakes of sustainable development of the space of those resources-To design platforms and simulators with interfaces adapted to the actors perception ;-To clarify and formalize local knowledge between researchers and actors .

Conclusions The current research work is moving towards the formalization of an adaptable heuristic and generic approach : The Actor-Group-Role-Resource-Object method (AGRRO) which is supported by a generic platform (Figure 2) . But we can note according to our experience that the co-building and learning process is quite long and onerous even if the appropriation and the use of results from models by the actors is very satisfactory .

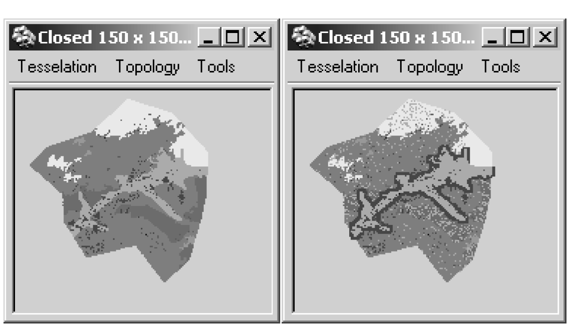

Figure 1 *The simulation space of the Pastoral Unit of Thieul (Senegal) .*

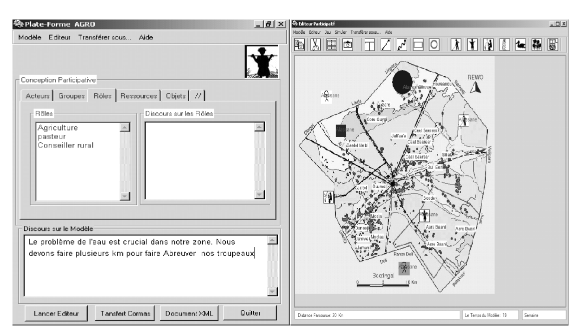

Figure 2 *AGRRO platform .*

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The impact of overgrazing on needlegrass-peashrub-forbs community

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Key words : vegetation structure , type , overgrazing , disturbance , rangeland assessment

Introduction Grasslands serve as part of the daily chain of domestic animals and wildlife for food and survival . There is a need to create an ecologically-based system to optimize management of livestock production and biodiversity conservation . The results show to information on the vegetation structure and coverage of the soil surface with needlegrass-peashrub-forbs type the transition due to overgrazing . The high grazing pressure was significantly reduced productivity and changed vegetation structure and soil properties . The heavier grazing areas had increased densities of Artemisia Adamsii , A .frigida , Carex duriuscula and Salsola collina and reduced plant diversity .

Methods We considered the following principles such as changes in composition of species , weedy plant invasion , and productivity of economically useful plant groups and changes in their ratios as indicators of degradation . The line point intercept method for species richness and soil surface cover was used . 17 indicators were used for the rating of degradation level .

Results The research shows that stocking density above the carrying capacity caused variation in the vegetation structure and soil properties and is distinguished by relative differences between plant community pathways in steppe area (Figure 1 , 2) .

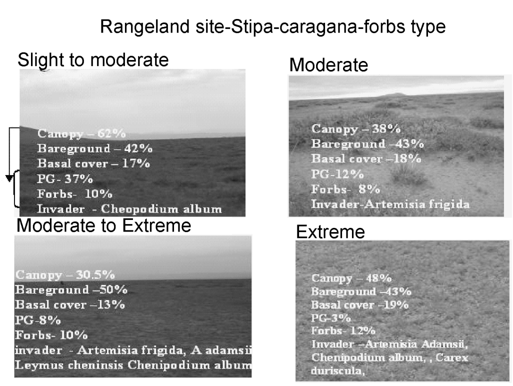

Figure 1 *Vegetation characteristic and degradation level of a plant community .*

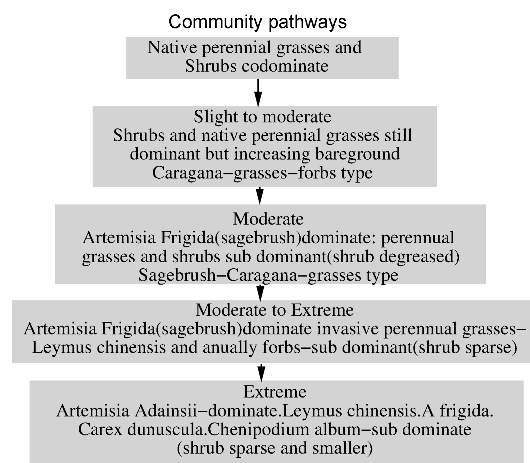

Figure 2 *Transition pathway's of a plant community .*

The normal needlegrass-peashrub-forbs community is canopy cover-60-65% of the soil surface , bare ground-35-40% , and perennial grasses cover is more than 35-40% . As compared to the normal community were the bare ground increased by 12-15% between community pathways and canopy cover decreased by 3-34 .5% and perennial grasses decreased by 3-12 .3% . The surface layer and nutrient were lost in the overgrazed areas and invasive weeds were increased . The percentage of unpalatable and lower value herbs such as Artemesia adamsii , A .frigida , Carex duriuscula and Salsola collina predominated . Over grazing reduced the permanent grasses and their capability to recover (see Figure 1) . Grasses were replaced by shallow-rooted , annual plants of inferior grazing value .

Conclusions The grazing pressure changed the primary characteristics in plant community structure . A proper balance between the number of the livestock and available forage must be maintained by continuous and careful observation of the vigour of grasses on the pasture .

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Cymbopogon nardus, a grass weed in the rangelands of Uganda: impact on plant species biodiversity and livestock performance

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Key words: Cymbopogon, biodiversity, plant species, livestock

Introduction *Cymbopogon nardus* is a dreaded and undesirable (Marshall et al. 1969) noxious grass of south-western Uganda rangelands. The species has replaced the indigenous grass species of the area notably Hyparrhenia spp. and is spreading fast to other areas. It is a tussock grass that establishes naturally from seed with leaves that contain aromatic oils, which impart a bitter taste. The species has leaves that have a rough texture. It grows fast and builds up thick coarse vegetation difficult to traverse by both humans and cattle. The canopy of a well grown plant can cover an area of up to 2 m in diameter. Due to its high competitiveness, the species establishes quickly in overgrazed and burnt areas and maintains dominance over other species. It is unpalatable to both domestic and wild game except at the young leaf stage. A study was conducted to determine impact of *Cymbopogon nardus* on plant species biodiversity and livestock performance in the pastoral systems of south-western Uganda.

Materials and methods Plant species prevalence was determined on three sites visually characterized by low, medium and high-density prevalence of *Cymbopogon nardus* along a 500m transect using a 1 x 1m quadrat laid at 5m intervals along the transect. An estimate of percent basal cover of each species within the quadrat and at each of the sites was made. Percent cover of each species on each site was computed for each site. In another study on 15 cattle ranches, plant species prevalence was estimated also along a 500m transect and at 5m intervals using a 1x1m quadrat. Forage biomass productivity on the ranches was estimated using a hydrologic based plant growth model PHYGROW and verified by regular clipping of quadrats to determine dry matter (DM) productivity and computation of cattle stocking rates for the ranches. Cattle body condition score on the ranches were monitored monthly for 12 months.

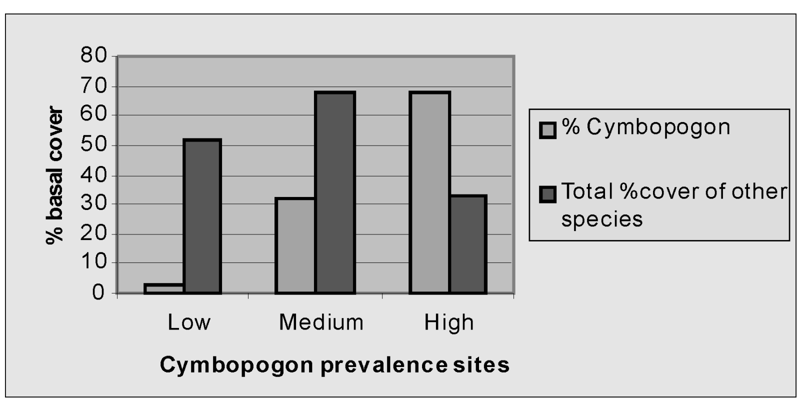

Figure 1 *Plant species prevalence (% cover) by site.*

Results and discussion The low (3%) *Cymbopogon* sites had a 52% prevalence of the other species while the high (67%) *Cymbopogon* sites had the lowest (34%) prevalence of the other species indicating the suppression of other species by *Cymbopogon nardus* (Figure 1). On the 15 ranches, *Cymbopogon nardus* prevalence ranged from 0.2% to 14.3% mean basal cover. *C. nardus* prevalence was negatively correlated with all the other grass species indicating its negative influence on species prevalence, the grazing potential and livestock performance.

C. nardus dominated ranches produced significantly ($P=0.05$) the least forage biomass (25% lower) compared to ranches with lower levels of *C. nardus* (5107 kg/ha), which translated into significantly ($P=0.05$) lower stocking rates for such ranches. Similarly, cattle on *C. nardus* infested farms had the least mean body condition scores among the different ranches surveyed.

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Natural resource management : building the case for civic participation in managing the environment

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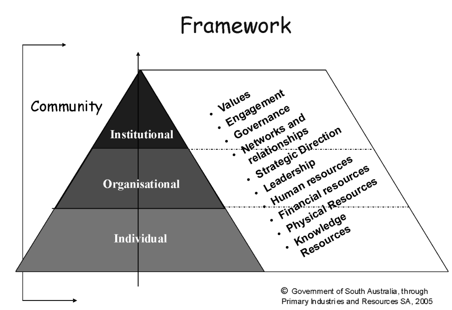
Key words : natural resource management , community , participation , capacity building

Introduction Over recent years increasing attention has been paid to the changing attitude of communities to sustainable development , in particular natural resource management (NRM) . One of the recurring themes of this literature is the importance of an integrated approach to environmental management . This paper presents a project that developed an electronic NRM Community Capacity Assessment tool (the tool) to assist communities to rate the strength of their regional capacity to deliver NRM programs . The tool :1) Identifies ten elements of capacity that span across four types of capital ;2) Operationalises the elements of capacity using 61 statements and a set of social indicators linked to a four-point likert scale ;3) Generates both graphs and matrices to show the relative strength and importance of capacities as perceived by different community tiers , as well as how confident community groups were in responding to each capacity .

Discussion NRM worldwide has many different meanings and is a complex set of ideas and understandings difficult to define (Kilpatrick 2002 ; Stratford and Davidson 2002 ; Kilpatrick 2003) . Understandings and beliefs which underpin NRM range from being strongly conservation-based (Whelan and Lyons 2005 ; Gareau 2007) with the emphasis on protecting natural resources for their intrinsic , cultural and ecological value through to production-based values with their focus on ameliorating land degradation while successfully maintaining production outputs for economic benefit (Stratford and Davidson , 2002) . For example , pastoralists located in the north of South Australia perceive NRM from the perspective of maintaining sufficient pasture cover for their stock , whereas park managers in the same region consider NRM from the perspective of preserving or enhancing diversity of native plants and animals . Stratford and Davidson (2002) argue the interrelationships among such natural , economic and cultural resources are not well recognized because of the focus on economic capital .

Methodology The tool comprises a MS Access database containing ten capacities derived from research by rural sociologists (Webb & Curtis 2002 ; Fenton 2005 ; Cavaye 2005) which are assessed across all three tiers of community .

1) Engagement
2) Values
3) Governance
4) Networks and relationships
5) Strategic direction
6) Leadership
7) Human resources
8) Financial resources
9) Physical resources
10) Knowledge resources



Each capacity is operationalised using a set of statements which were individually presented in an electronic form and projected onto a screen for participants . The group was asked to respond to each statement on a likert scale from 1=Strongly Disagree" to 4=Strongly Agree" . All responses were reached through consensus-facilitation was important to ensure equal participation by all group members . Responses to each statement were guided by a series of indicators presented on a likert scale from 1=Strong Capacity" to 4=Needs Strengthening" . Each assessment group was also asked to rate the importance of each statement relative to delivering or adopting NRM within their region as well as how confident they were in responding to the statement .

Conclusions Benefits of such regional community participation and effective engagement in NRM have been described variously as better outcomes for the natural resources themselves through management at the local scale (Warburton 1998 ; Lawrence 2004 ; Bellamy et al . 2005 ; Lane et al . 2005) . Socially , there were benefits described as the empowerment of local communities through civic participation ,(Kellert et al . 2000 ; Cavaye 2004 ; Lane and McDonald 2005 ; Pero and Smith 2006) the generation of social capital (Coleman 1988 ; Stayner 2003 ; Putnam 2004) and the building of human capital(Putnam 1995 ; Portes 1998) and community capital (Cheers et al . 2002) .Importantly , the participant evaluation of the assessment process has confirmed the literature , affirming participants' capacity to articulate their strengths and weaknesses relative to their capacity to deliver or adopt NRM programs .

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Evaluation of grassland resources in Etuoke front banner

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Key words : evaluation , grassland resources , sustainable utilization , index system , Etuoke front banner

Introduction Grassland resources is the most basic means of production , exploration and utilization of grassland resources have to understand it correctly . Etuoke front banner is a half herding and half agriculture region , it is situated at the Southwest of Erdos city , between 37°38′-38°45′N ,105°31′-108°30′E . It is within the mid-temperate zone with semiarid and arid continental climate . Annual average precipitation is 291 .4mm , with significant amounts occurring in July to September , which accounts for 59-60% of the total annual . It is within desert grassland and typical grassland region . And the area of natural grassland is up to 58 .3% of the total land , so livestock production has an important position for the whole national economy . In this paper , according to index system and methods of evaluation on sustainable utilization of grassland resources are constructed by Liuliming etc . , from such five respects as production , stability , protection , economic feasibility , social acceptability to evaluate grassland resources in Etuoke front banner .

Methods Through analysis hierarchy process(AHP) , from index-evaluation indicators-specific goals-the goal layer(the objective of research) , according to the final evaluation criteria of sustainable utilization is : Above 85 points is very good ,75-85 points is good ,65-75 points is intermediate ,55-65 points is elementary , below 55 points is poor , to determine the type of grassland resources sustainable utilization .

Results Contrast the status quo of utilization and correlative index of grassland resources in Etuoke front banner with index system of evaluation on sustainable utilization of grassland resources in our country , the results are as follows , see Table 1 .

Table 1 *The scores of specific goals of evaluation on sustainable utilization of grassland resources .*

Goals	Evaluation indicators	Weights	Scores	Final scores
Production	Basic productive forces	0 .200	39 .27	
	Carrying capacity	0 .400	31 .34	43 .59
	Production level of reality	0 .400	58 .00	
Stability	The ability to resist disaster	0 .400	46 .97	
	The fluctuation of production	0 .400	40 .00	43 .65
	The input of improvement	0 .200	44 .32	
Protection	The degree of degradation	0 .400	55 .00	
	Grazing approach	0 .200	51 .38	64 .28
	Ecosystem protection policy	0 .400	80 .00	
Economical feasibility	Livestock production efficiency	0 .667	56 .89	71 .25
	Yield potential of animal husbandry	0 .333	100 .00	
Social acceptability	The degree of Satisfying the demand	0 .400	57 .36	
	Utilization system	0 .200	88 .00	80 .54
	Grazing management condition	0 .400	100 .00	

According to production (weight 0 .286) , stability (weight 0 .285) , protection (weight 0 .143) , economical feasibility (weight 0 .143) , social acceptability (weight 0 .413) , the synthetic score is 55 .81 , belongs to elementary sustainable utilization grassland resources . It shows there are many problems in utilizing grassland , while it has broad prospects , several years ecological construction has obtained certain improvement , but still need further perfection .

Discussion Production final score is 43 .59 , basically speaking , natural condition in Etuoke front banner is inferior , and it is difficult to control by manpower . Stability is 43 .65 , although it has already started to enlarge input , but the disaster is very difficult to control . Protection is 64 .28 , degeneration and desertification are serious , they are being governed gradually , protection policy is good , soil erosion starts to be controlled , but because the area of grassland is broad , and have to be governed gradually . Economical feasibility is 71 .25 , which obtains the development through ecological construction of several years . Social acceptability is 80 .54 , which shows some policy measures are good to grassland construction .

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Xinjiang grasslands ecological conservation and herdsman increase investigation and discussion collecting a countermeasure

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Key words: Xinjiang, ecological conservation, herdsman increase collect, problem, construction and countermeasure

Preface There are 70%-80% of Xinjiang livestock products originate from the wide natural grassplot. There are 57,260,000 hectares natural grassplot in Xinjiang of which area occupies third places in countrywide. During the recent 10 years. Based on the livestock of Xinjiang government department the data indicate that income is 1,618 Yuan of per capita in rural area of whole Xinjiang in 2000, but the herdsman average per capita income is 220 Yuan lower than 1,398 Yuan; the income is 2,106 Yuan of per capita in rural area of whole Xinjiang in 2003, herdsman's income average per capita is 1,800 Yuan or so, it is lower 300 Yuan than peasants. In 2006 the whole rural per capita net income is 2,482 Yuan, the per capita income of herdsmen have been less than 1,400 Yuan, the gap is getting wider and wider. The herdsman stratum is a real weak power stratum".

Today's prominent issues in grasslands ecological construction

Coupling effect of grassplots not yet arousing broad common view.
Grassland degradation and poor circumstances of herdsman are extremely austere in Xinjiang.
Investment allocation is inaccurate, not seizing the general orientation that the manpower forage field builds.
Projects disperse, enclosure division, extravagant phenomenon of fund is grave.
Offside the policy returns grass to forest", damages the herdsmen's long range benefits.
The countermeasure to grasslands ecology construction and increasing herdsmen's income Doing master plan well, working out a plan of governing area and implementing in step.
Carrying out returning herding back grass, rebuilding degenerated grassplot.
Building artificial pasture energetically, having an effect to resolve grasslands over-load herds.
Cultivate natural cutting-grass land by enclosures, increasing forage sources feeding in animal.
Strengthen the consciousness construction of herdsmen settling in engineering, speeds up putting engineering construction into practice.
Working out preferential measures, boosting producing and life-style reforming in pastoral area.
Realize diverse unity in producing and manage of pastoral area.
Care the unfavorable factors to restrict herdsmen's increasing income.

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Benefit evaluation of rangeland convertion program (RCP) in typical project area of Inner Mongolia

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Key words: rangeland convertion program, ecological benefit, social-economic benefit

Introduction China launched Rangeland Convertion Program (RCP) for improving grassland eco-environment and promoting economic sustainable development of the pasturing area in 2003. This paper focused on analysis of the short-term comprehensive benefit of RCP in Inner Mongolia in order to improve the long-term effects of the program.

Methods Banners of Ewenke and Alashanzuo, located in east and west Inner Mongolia respectively, are selected as study case areas. Based on the statistical data and investigation of herders there, the RCP effects are evaluated through the comparative analysis of vegetation condition and herder economic status pro and after RCP.

Results Owing to the different grassland types, different grazing systems are conducted between east and west grassland areas of Inner Mongolia, i.e. seasonal non-grazing in Ewenke meadow steppe and prohibiting grazing in Alashanzuo desert steppe. Ecological benefit were both remarkable in terms of the promotion of vegetation condition, involving plant height, coverage and biomass.

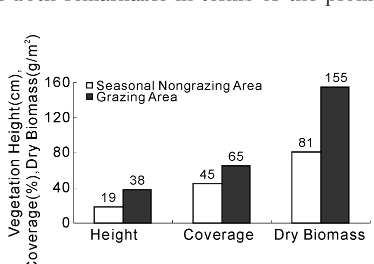

Figure 1 *Comparison of vegetation quantity characteristic between seasonal nongrazing area and grazing area in Ewenke.*

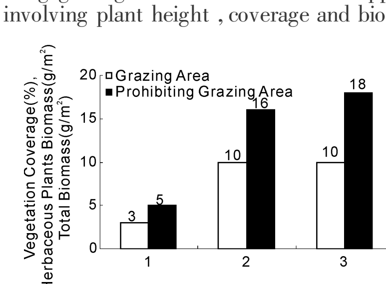

Figure 2 *Comparison of vegetation quantity characteristic between prohibiting grazing area and grazing area in Alashanzuo.*

The grassland utilization efficiency and animal husbandry net income of the project household have been improved after RCP. In Ewenke, the animal husbandry net income of the project household reached 193.05 yuan/hm^2 in 2004, increasing 43.05 yuan/hm^2 compared to 2003. And the animal husbandry income increased 6% and cost decreased 12% at the same time compared to 2003. Although the herders of prohibiting grazing in Alashanzuo had no animal husbandry income and cost after RCP, the grassland net income also increased 10.80 yuan/hm^2 compared to 63.45 yuan/hm^2 in 2003 owing to the project subsidies of 74.25 yuan/hm^2.

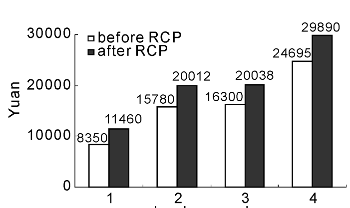

Figure 3 *Net income comparison of 4 typical project herders in Ewenke pro and after RCP.*

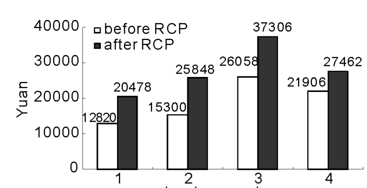

Figure 4 *Net income comparison of 4 typical project herders in alashanzuo pro and after RCP.*

Most herders supported RCP, but they were also full of worries resulting in different herder behaviors in Ewenke and Alashanzuo. In Ewenke, herders mainly worried about fence supervision and forage supply in view of their short-term plan on adding livestock and improving livestock breed. The herders in Alashanzuo cared for how to resovle the employment of local idle herders. As a result of prohibiting grazing and deficiency of education and skills, 60% young herders went out for work in transportation and rest elders and women stayed behind idly at present.

Although the current RCP subsidies in Ewenke and Alashanzuo were reasonable and close to the herders expectation for short term, it should be changed dynamically in future, and many important factors should be considered.

Conclusions It is significant to develop projects in the light of local conditions. It is urgent to strengthen grassland construction and supervision, improve management level and employment skills of herders, and accelerate the transformation of production model and industry in pasturing area.

Revegetation of bare patches in saline-alkali grassland in northeast of China

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Key words: micro site, ridge, restoration, bare saline-alkali patch, saline-alkali soil

Introduction Bare saline-alkali patches resulted from overgrazing and cultivation are distributed throughout Songnen Grassland in northeast of China (Li & Zheng, 1999). The restoration of vegetation in such seriously degraded soil is difficult merely through the withdrawal of livestock alone. Some form of intervention is usually necessary to promote a favourable micro site for the plants establishment (Happer, et al., 1965).

Materials and methods 20 hm^2 bare saline-alkali patches were ridged into two forms with 20cm height, 65cm width (R20), and 10cm height, 100cm width (R10) in May 2002. The direction of ridge was vertical to the wind. After the hay had been packaged, the remainders were collected and broadcasted (150g/m^2) in the R20 (R20+L, 5hm^2) and R10 treatments (R10+L, 5hm^2). Plant composition, density, height, biomass, and soil characteristic were surveyed and measured in R20, R10, R20+L, R10+L and no treatment plot (Control) in August from 2002 to 2004.

Results Only two annual species *Chloris virgata* and *Suaeda corniculata* emerged in the ridge in 2002. The plants grew in the ditch where the topography was relative high or adjacent the peak of the ridge where the topography was relative low. *S. corniculata* established well in ridge treatments without litter, and disappeared at end of the second season. Compare with the control, vegetation of ridge cultivation could be established better regardless of broadcasting litter (Figure 1). *C. virgata* in ridge plug litter treatments grew better than those in which the ridge only was made in 2002, while it was reversed both in 2003 and 2004. *C. virgata* of R10 grew better than those of R20 in 2002 and 2003. However, *C. virgata* of R20 established better in 2004. The soil water content of 0-20cm in ditch was higher significantly ($P<0.05$) than that of control, while soil salinity of 0-20cm was decreased, and was lower significantly ($P<0.05$) than that of control. Compared with R10, the soil of 0-20cm was meliorated more effectively. The ditch had the capability of trapping massive seeds (41957seeds/m^2, 265 seeds in control).

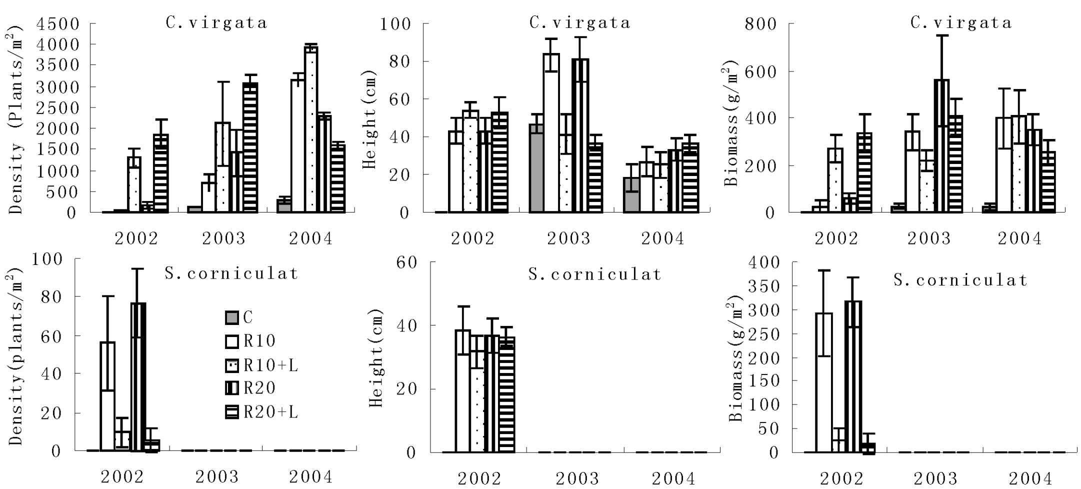

Figure 1 *Plant density, height and biomass by ridging in saline-alkali from 2002 to 2004.*

Conclusions The approach of revegetation in bare saline-alkali patches by ridging was effective, economic, and practicable. The ridge accumulated more precipitation to leach salinity from the surface soil to deep profile, and trapped sand particles and seeds carried by the wind, which provided a favourable micro site for seeds germination and seedlings growth. The operation of ridging plug litter speeded the establishment of vegetation, but the cost is more expensive. The narrow and high ridge meliorated more effectively the saline-alkali soil, and provided a more favorable micro site for the establishment of vegetation.

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Rangeland, ecological integrity and sustainability: an analysis in the Himalayan Mountain context

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Key words: agroecosystem, ecological integrity, Himalayan mountains, rangeland, sustainability

Introduction Ecological integrity of a system is a precondition to sustainability (Singh 2007). Rangelands that occupy large chunk of the geographical area in the Himalayan mountains have a key role to play towards imparting high degree of sustainability to an agroecosystem and thereby to the land-based livelihoods in the mountain areas. Ecological integrity of a system is ensured when there are ecological linkages between components of the system and, as a result, there is considerable flow of water/ moisture and nutrients within the system. Factors influencing bio-geochemical cycles, water cycle and climate regulation are pivotal for ensuring ecological integrity at macro-level of a geographical area. This paper discusses the crucial role of rangelands in imparting considerable ecological integrity vital for the sustainability of agroecosystems in the fragile Himalayan mountains.

Materials and methods The content of the paper is largely drawn on basic principles involved in generating conditions for sustainability through ecological integrity, which is based on long-term experiences of studies in the Indian Central Himalayas.

Results and discussion

Rangeland-livestock-Farming linkages Ecologically more stable rangelands impart resilience to an agroecosystem and appropriately respond to the inherent fragility of the mountains. Livestock feed on range plants and retain a proportion of energy and nutrients for their maintenance, while the rest is converted into draught power and products (milk, wool, meat, etc.). A proportion of the consumed biomass is voided as dung and urine which, as manure, is transferred to the cropland for the maintenance of soil fertility inevitable for food production. Crop residues to come from croplands are also fed to livestock and a proportion of energy and nutrients, as manure, is recycled into the cropland soil. Mediated by livestock, this nutrient flow contributes to the essential ecological integrity and sustainability of the agroecosystems.

Nutrient flows Nutrients are a collection of chemical compounds, minerals and elements essential to the survival of living organisms. Nutrient cycles are a sub-set of broader class of global biogeochemical cycles, including water, carbon, oxygen, nitrogen and mineral cycles (Bourn *et al*. 2005). Plants take up nutrients from soil reserves and atmosphere and accumulate in their biomass. A proportion of this is consumed by animals and the other flows through the environment. The passage of nutrient flows in the environment is a nutrient cycle. Biogeochemical cycles, especially those of NPK, are significantly influenced by agriculture. Livestock also contribute to affect/ regulate the nutrient flows.

Ecological integrity and sustainability Rangelands, as integral component, contribute to enhance complexity and impart considerable ecological stability to the whole agroecosystem. Useful biomass to be used as fuel, fodder, fibre, raw material for industries, edible fruits, vegetables, medicinal herbs, honey, etc. Ecosystem services of ecologically sound ecosystem are more intense, more useful and congenial for the optimum agricultural production. Conservation of myriad life forms, water/ moisture circulation, and maintenance of appropriate micro-climate are the other intangible attributes of the rangeland ecosystems. All these socioeconomic attributes and ecosystem functioning are important indicators of sustainability.

Conclusions Rangelands covering largest chunk of geographical area in the Indian Central Himalayas are pivotal towards generating, regulating, and optimizing factors that ensure ecological integrity of and consequently impart sustainability to the mountain agroecosystems.

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Increasing nitrogen deposition and grassland productivity in Mongolia

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Key words: Grazing, Mongolia, Nitrogen deposition, Primary production, Steppe

Introduction The amount of nitrogen (N) fall-down from the atmosphere to the biosphere (nitrogen deposition) is increasing globally due to increased fossil fuel consumption and chemical fertilizer application (Galloway et al., 2004). As N is essential for plant growth, increased N deposition affects plant primary productivity (Vitousek et al., 1997). However, increased N deposition can also decrease plant diversity (Stevens et al., 2004).

Mongolian grassland is a steppe spread out in the north of central Asia and is utilized for grazing by nomads. Galloway et al. (2004) have estimated that the amount of annual N deposition in this region in 2050 is likely to increase by about 400mg/m^2 over that in the early 1990's. The increase in N deposition may influence the grazing potential of Mongolian grassland through changes in grassland productivity and species composition.

In the present study, N was artificially applied to Mongolian grassland to assess the effect of increased N deposition on grassland productivity. The study aims: (1) to analyze the effect of increased N deposition on the productivity of Mongolian grassland and (2) to evaluate the change in livestock carrying capacity of Mongolian grassland as a result of an increase in N deposition.

Materials and methods The study site, Bayan-Unjuul, is located in a typical dry steppe, about 150km south west of the capital Ulaanbaatar. Annual mean temperature and precipitation are 0.3℃ and 165mm. Plant communities were dominated by the perennial grass *Cleistogenes squarrosa* and the perennial forb *Artemisia adamsii*.

Four experimental plots were established in August 2006. Each plot has two main treatments, grazing and non-grazing. In each main treatment, four nutrient sub-treatments were established: application of nutrient solution with low (LN, 300mgN m^{-2} y^{-1}) and high (HN, 1500mgN m^{-2} y^{-1}) N, application of nutrient solution without N (only water, Control) and no treatment (0N). A nutrient solution containing the required amount of ammonium nitrate (NH_4NO_3) was sprayed in June and August. The above-ground parts of plants were harvested two times each year (in late June and August) and were weighed after drying.

Results Aboveground dry mass just before the experimental manipulation did not differ among experimental plots (Figure 1). Water application did not affect dry mass. The effect of N application was found in non-grazing plots in HN treatment. More than 75% of increase in aboveground dry mass with HN treatment was attributed to *Artemisia adamsii* which is not palatable for livestock.

Conclusions The increase in N deposition expected by 2050 seems to have little effect on primary production of the Mongolian steppe. However, the primary production in this region potentially increases with more N deposition, and the increase may not be accompanied by an increase in grazing capacity of the grassland. Clearly, a longer experiment is needed to attain a more robust conclusion.

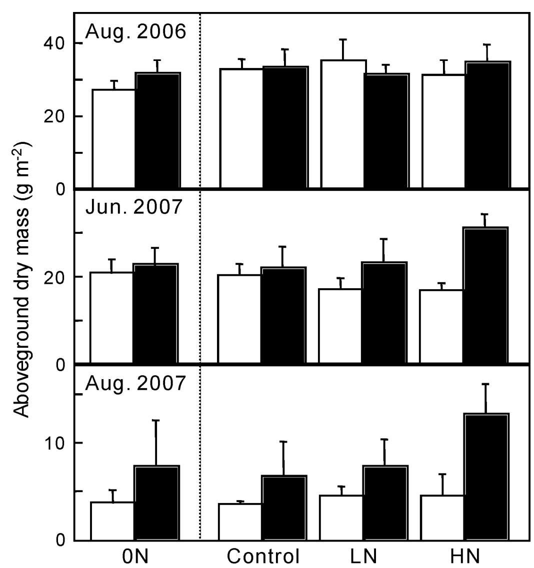

Figure 1 *Aboveground dry mass at August 2006, June 2007 and August 2007. 0N, Control, LN, HN show no treatment, treatment with water application, low nitrogen application and high nitrogen application. Open and closed columns show grazing and non-grazing plots. Error bars represent + 1SE.*

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Application of vetiver grass for revegetation in Rare Earth mine , south China

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Key words : RE(Rare Earth) mine , revegetation , environment pollution ,soil erosion , Vetiver grass

Introduction China is the world's largest RE producer and consumer , Guangdong and Jiangxi province , the RE is of the ionic absorption type which is absorbed on clay particles at ionic state only found in China .Due to its advantages in exploiting and components ,an upsurge had been appeared from 1986 to 1999 . It has bring great benefits and cause a series enviroment problems as well . Vetiver Grass with its unique morphological , physiological ,ecological characteristics and its tolerence to adverse conditions , has a key role in the area of soil erosion control and environmental protection . Main aim of this project was to use vetiver for revegetation and alleviate environmental pollution caused by exploiting RE mines in South China .

Materials and methods Over the past two years a series of research projects conducted at Daping RE Mine ,located at the northeast of Guangdong ,China . Soil erosion is very serious problem in these areas . The trial site , has a gradient of 30-50° . The engineering measurement was conducted first and then the biological method . The engineering measure was dig up a 100 cm wide channel on the top of slope to disperse upper runoff . The biological method was to plant vetiver along contour line in May , 2005 and April ,2006 . Contour platforms with a width of 30-40 cm ,and planting ditches with of 15 cm were first built on a row spacing of 80 cm ,and then vetiver was planted at 10-15 cm spacing ,3-5 tillers for each slip . After planting water quality ,soil chemical properties and the changes of vegetation community were investigated .

Results 12months after planting Vetiver grass , soil orgnic matter increased from 0 .20% to 0 .74% , hydrolysable N decreased from 320 mg/kg to 43 mg/kg , SO_4^{2-} decreased from 13 .1 mg/kg to 7 .46 mg/kg ,EC values decreased from 0 .46 ms/cm to 0 . 062 ms/cm ,NO_3^- decreased from 203 mg/kg to 10 .2 mg/kg ,available K and total S varied slightly ; pH values of water increased from 3 .12 to 4 .82 ,NH_3^- N decreased from 204 .3(N mg/L) to 81 .3(N mg/L) , NO_3^- N decreased from 78 .35(mg/ L) to 53 .6(mg/L) , SO_4^{2-} decreased from 497 .5(mg/L) to 308 .5(mg/L) . The result shows that water quality have been improved after palnting Vetiver grass .;Eco-environment has been improved after planting Vetiver grass and suitable growth condition for the nativer plants created . Eight native species , *Borreria latifolia* , *Gynura crepidioides* , *Blechnum orientale* , *Sphenomeris chusana* , *Paspalum conjugatum* ,*Ageratum conyzoides* , *Miscanthus chinensis* and *Hypericum chinensis* were found in Vetiver hedge . The result of this experiment has shown that Vetiver grass acts as a pioneer plant growing and provides micro-climatic conditions where native species may become established .

Conclusions Vetiver grass acts as a pioneer plant growing and provides micro-climatic conditions where native species may become established . Vetiver Grass for revegetation in RE mine area was practical . The Vetiver grass technology is a effective way for soil erosion and water pollution control in RE mine of South china .

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Study on some models exploiting pasture industry in the south of China

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Key words : planting grass and fish-raising , combination of grass and forest , loss of water and erosion of soil , pasture processing

Introduction Southern china (SC) is located at latitude 15-33° north and longitude 100-125° east ,occurs in the tropical and subtropical zones , and includes the whole of the provinces of Fujian , Jiangxi , Hunan , Guangdong , Guangxi , Hainan , Guizhou , and the most parts of Zhejiang , Yunnan , Sichuan , and southeast parts of Anhui , Hubei , Taibet . Developing pasture models for use in southern China , has great potential for regulating the rearing of animals and developing herbivorous animals .

The models of development and use (1) Taking vigorous action to improve fish raising using planted grass and promoting the development of fish culture . Fish raising using planted grass is cheaper , quicker and has higher economic return than raising livestock on planted grass ;(2) In agricultural regions , making use of rice field to plant grass during the unoccupied winter period , expands the sources of manure and feedstuff ;(3) In hilly lands , rapidly expanding grass growing and utilizing the combination of grass and forest in young growth , was an important method of avoiding short term water loss and soil erosion ; (4) In mountain regions , the seeded artificial pasture could be used to make hay to help regulate the supply at the low and peak seasons .

Discussion The four models of planting grass were summed up by the author according to the production needs and feasibility in SC and with the author's experience over the years . It was thought that was the only way which could develop the grass industry in SC in the future . There were still some problems to be resolved , if the four above models were practiced . The main problems were the following :

(1) Great money-deficiency in mountain regions , where many facilities developed with improving the pasture , such as constructing roads , housing electricity and water facilities , require high investment . It was difficult to provide sufficient money to pasture construction according to the state's financial situation , and an input of foreign investment and jointly management is needed .

(2) Efficiency of energy resources and advanced processing equipment . The resources for processing grass and green vegetable in SC were abundant , but the processing was just during rainy season when the grass was high in moisture and consumed much energy . It was not convenient to rely on the energy from the sun and so must use advanced machinery . At present , there is a lack of the equipments suitable to SC's climate , and lack of electricity and coal .

(3) In mountain ares , the kinds of fruit tree which would be selected and their effects on the natural conditions in this region . And it was necessary to study the combination method of planting grass and tree .

A resource-explicit population model for the management of a dominant shrub that takes into account the ruminants' feeding strategy

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Key words: pastoral resources, dominant shrub species, population demography, grazing, feeding strategy

Introduction European environmental policies encourage the livestock farmers to graze their animals on shrubby rangelands to maintain plant communities in states that are favorable to the protected wild fauna and flora species and then often provide incentives to slow down the encroachment of shrub species with strong dominance ability.

Current scientific knowledge and technical references are often insufficient to encompass uncertainties about the feed value of shrubs and the real impact of grazing on encroachment dynamics. In order to propose management practices at paddock level, conciliating seasonal resources renewal for flock and long term control of shrub dynamics, we propose a new conceptual model of plant population capable of linking the population demography of a dominant plant species and the functional feeding resources offered to the flock.

Materials and methods We carried out direct observations of small ruminant (sheep) feeding behaviour at bite scale and continuously during each meal per day and during whole grazing sequences in paddock (10-15 days) (Parker *et al*. 1993, Agreil and Meuret, 2004). Focusing on scotch broom (*C. scoparius*) as a model of grazed dominant shrub species, we identify the diversity of organs potentially consumed and defined their functional role in the feeding strategy with regards to the potential bite mass they offer (Agreil et al, 2005). Observations and experimentations on *C. scoparius* populations also allowed us to build a basic model of population structure based on the demographic strategy of this species with identification of main developmental stages (juveniles, adults, seedlings, non dormant seeds, dormant seeds, ..) and quantitative estimation of transition between stages (Caswell, 2001). We relate explicitly feed items defined by ruminant feeding strategy with demographic items organizing the population dynamics pattern.

Results Our results show that the feeding strategy of small ruminant is to exploit the diversity of the species-structures through combining small and large bite masses, allowing the maintenance of intake levels until the end of the stay in the paddock. Several organs of scotch broom (Flowers, young pods, young shoots, mature stems) provide feed items but with different functional status for animal feeding according to their mass. (Figure 1). It shows that two main stages (juvenile and adult) produce each, different feed items. As cumulative impact of repeated grazing seems to change adult demographic behaviour towards a long term vegetative status, we create a new demographic item as vegetative adult" revealing through this modification of the population structure possible irreversible impact of grazing.

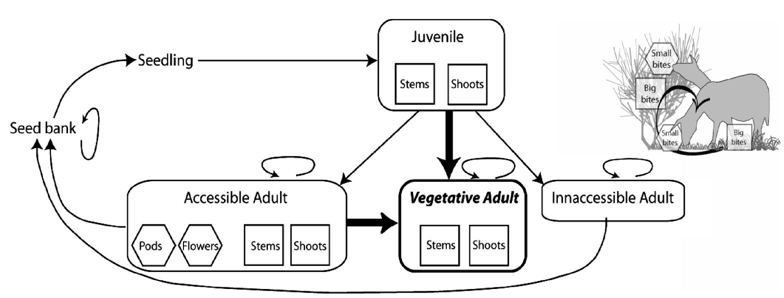

Figure 1 *Life cycle of Cytisus scoparius population built on development stages (seedling, adult, juvenile ...) and feeding resources for herbivores (small bites, big bites). The vegetative adult stage, not present in ungrazed population, is created by repeated browsing.*

Conclusions Such a conceptual model, taking in account the ruminant feeding strategy at bite level, allows us to model the real impact of gazing on shrub population dynamics. It reveals the diversity of the possible ways of regulation as several demographic processes are impacted by grazing according to organs consumed (fecundity, survival rate, maturation age ...). Modelling is now in progress to simulate the impact of different management scenarios.

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Research on rejuvenation and replacement cultivated technology of *Salix Psammophila* in the Hobq desert

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Key words : the Hobq desert ,*Salix psammophila* ,rejuvenation and replacement ,height growth ,stem growth

Introduction *Salix psammophila* is an important species of windbreak , sand-fixation and industrial timber forest in arid and semi-arid area . Recently , Ecological Environment of natural *Salix psammophila* forest was destroyed severely . In this study , We tried to find the effect on height growth and stem growth of *Salix psammophila* .for four kinds of different treatments including Installation of Artificial Sand-break ,Leveling Stubble Along the Surface of the Ground ,Usual Leveling Stubble , Fertilization .

Materials and methods The research was about declining *salix psammophila* bushes in the east of the Hobq Desert . Technical methods :(1) Installation of Artificial Sand-break (Specification : 20cm high , checker board , porosity 20% -25%) .(2) Leveling Stubble (Along the Surface of the Ground) (3) Usual Leveling Stubble (remains 20cm Stubble) . (4) Fertilization (dug a ditch of 20 cm deep filling 2 kg organic fertilizers around each *salix psammophila* bushes) .The data of four kinds of different treatments were analysed by using SAS9 .0 .

Results The results showed that four kinds of different treatments were all beneficial to height growth of *salix psammophila* bushes ($P<0.05$) . Compored with check sample , height growth of *salix psammophila* bushes which were treated with Artificial Sand-break ,Leveling Stubble Along the Surface of the Ground ,Usual Leveling Stubble ,Fertilization had increased by 10 .07% ,6 .06% ,12 .91% ,23 .18% ,respectively (Figure 1) . It is noteworthy that four kinds of different treatments were helpful to stem growth of *salix psammophila* bushes ($P<0.05$) . Compored with check sample , stem growth of *salix psammophila* bushes which were treated with Artificial Sand-break ,Leveling Stubble Along the Surface of the Ground ,Usual Leveling Stubble ,Fertilization had increased by 5 .20% ,3 .28% ,4. 90% ,3 .80% ,respectively (Figureure , 2) .

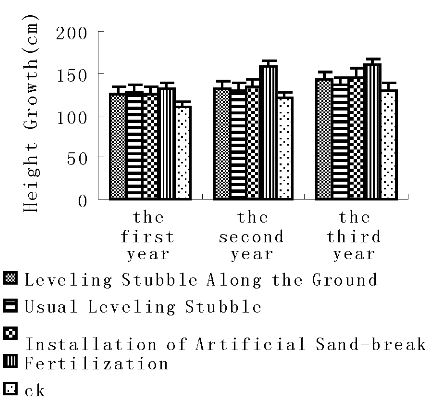

Figure 1 *Height growth of Salix psammophila by different treatment in three years .*

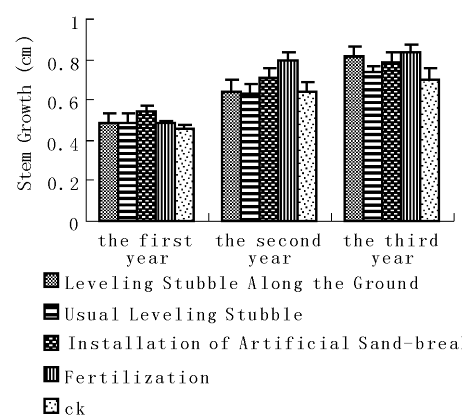

***Figure* 2** *Stem growth of* Salix psammophila *by different treatment in three years .*

Conclusions The results showed that four kinds of different treatments were all beneficial to rejuvenation and replacement of *salix psammophila* bushes ($P<0.05$) . Comprehensive effect of Fertilization was helpful to height growth of *salix psammophila* bushes . On the other hand , Leveling Stubble Along the Surface of the Ground had much more effects on stem growth .

The efficiency of some infiltration models in three rangeland conditions (case study: Savojbolagh rangelands)

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Key words: Horton's equation, Kostiakov's equation, Green-Ampt's equation, rangeland, Savojbolagh region

Introduction Infiltration is one of the important hydrological processes and its accurate quantification is essential for many studies. Infiltration can be either measured in the field or estimated using mathematical models which vary from empirical to physically based models, including physically based models (e.g. Green and Ampt, 1911, Richards, 1931, Philip, 1957, Morel-Seytoux, 1978, Haverkamp *et al*., 1990 and Corradini *et al*., 1994), conceptual models (e.g. Nash, 1957 and Diskin and Nazimov, 1995), or empirical relations (e.g. Horton, 1933, Kostiakov, 1932, Holtan, 1961 and Soil Conservation Service-USDA, 1972) (Chahinian *et al*., 2005). The objective of this paper is to compare the performance of three widely used infiltration models with infiltration measured in Central Iran.

Material and methods The study field is located in South-west of Tehran province and South-west of Nazarabad city in Savojbolagh experimental rangeland site located. The slope, elevation and annual precipitation of the study field are 0-2 percent, 1150-1180m and 229.3mm, respectively. The climate is also cold dry according to Emberger climatic classification system. The rangelands of the study area are steppe that was divided into three regions (critical, key and reference sites) with attention to utilization type and different grazing intensities which each region comprises 5 ha in the area. The critical, key and reference sites were selected in regions with annual long and heavy grazing, proper grazing and desertification station of Savojbolagh region with no grazing condition grazed over past 13 years, respectively. The infiltration rate was determined by using concentric ring infiltrometer in three mentioned regions (i.e. critical, key and reference sites) in May, June and September of 2004 and 2005. First, the rings were inserted into the soil at the minimum depth necessary to prevent lateral leakage from the rings. Then, water was applied at a constant depth. Finally, infiltration rate was directly determined by reading of the burettes at 1, 5, 10, 30, 60, 90 and 120 minutes intervals. Table 1 shows average infiltration rate in different times.

Table 1 *Avarage infiltration rate (mm) in different times.*

Site	Year	2004							2005						
	Time(min) Month	1	5	10	30	60	90	120	1	5	10	30	60	90	120
Key	May	20	9.13	9.37	5.23	4.02	3.48	3.11	67.21	9.13	6.83	3.49	3.05	2.61	2.47
	June	27	12.2	9.83	6.01	5.04	4.54	4.34	30	9	8.33	5.83	4.08	4.02	3.87
	September	20	9.73	8.07	5.49	4.25	3.79	3.53	67.17	9.27	7.23	5.11	4.07	3.65	3.38
Reference	May	33.18	11.33	8.17	5.04	4.09	3.35	3.01	20	6.83	5.83	3.29	2.58	2.25	2.01
	June	67.21	13	10	6.27	5.24	4.53	4.39	25	7.1	5.3	3.33	2.61	2.36	2.18
	September	33.14	10.17	7.93	5.61	4.68	4.19	3.9	33.13	5.6	5.63	3.44	2.78	2.49	2.27
Critical	May	15	8.87	7.7	3.85	2.88	2.55	2.32	33.18	7.33	5.73	2.84	2.79	2.44	2.35
	June	33.14	10.33	8.83	5.77	4.39	3.94	3.80	15	6	6.5	3.42	2.66	2.44	2.19
	September	33.11	8.93	7.07	4.89	3.91	3.52	3.24	33.11	6.93	6	4.02	3.23	2.87	2.64

Three algebraic infiltration equations (Kostiakov's, Horton's and Green and Ampt's) were examined to determine the best fitted formula to the collected infiltrometer data. For this reason, infiltrometer data of 2004 was applied to compute the models. Then, the estimated models efficiency was determined by using relative error index and infiltrometer data of 2005. If the relative error index was under 40 percent, model will be selected (Das, 2000).

Results and discussion The results of current research indicate that, Horton's equation provided a best fit to the infiltrometer data. Horton's equation was better than Kostiakov's and Green-Ampt's equation. The relative error for Horton equation was 14.59%, 20.84%, and 80.31% for the Kostiakov model and Green-Ampt model, respectively. The relative error percent increase in each three models with increase of infiltration time.

Conclusions Since relative error of Horton and Kostiakov equations was lower than 40%, these models were selected as the best equations in this research. This result is the similar to those obtained by Gifford (1976) and Oku (2005).

Diversity and ethnobotany of Fodder plants in the Himalayan rangelands : a case of the Uttarakhand Mountains , India

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Key words : Fodder plants , ethnobotany , rangelands

Introduction Himalayan rangelands are natural repositories of biodiversity . The vegetation is predominantly of forest communities with frequent interruption of scrub jungles , savanna , grassy localities and crop fields . Several environmental factors control the distribution of vegetation . Vegetation is demarcated on the basis of altitudinal gradients because edaphic , topographic , climatic and associated factors tend to be altered with altitude (Gaur 1999) . Utilisation of rangelands in the Himalayan region dominated by livestock-dependent communities is primarily for livestock production . A panorama of the biodiversity presented in this paper counts and characterizes the plant species that have some kind of fodder value . Ethnobotanical values associated with certain fodder plants have also been described .

Materials and methods Enumeration of diversity of fodder plants in the rangelands is based on the extensive survey and collection of range plants from the mountain districts of Almora and Champawat in Uttarakhand . Frequent field trips were made during different seasons of three consecutive years (2003-2006) . Plants species preserved in Herbarium were identified with the help of recent and relevant floras and revisions and compared with the authentic Herbarium specimens of Botanical Survey of India and HNB Garhwal University Herbarium . Ethnobotanical values were known through interviews of local farmers and in discussion with some experts .

Results and discussion The rangelands covered for this study were located in sub-montane and montane areas . As many as 541 fodder plant species belonging to 84 families in the study areas were identified . Largest number of fodder species (164 or 30% of the total) belonged to the family Poaceae alone . Next in order was the Fabaceae which contained 69 species (or 13% of the total species) . The Moraceae and the Asteraceae families had 21 (4%) and 19 (3%) fodder species , respectively , while Rubiaceae and Urticaceae families showed 13 (2%) representative species of fodder value . Other families had only fewer fodder plants . Apart from fodder value , many of the plants also provided edible fruit , fuel wood , fibre , timber , flowers , buds , vegetables , seeds , dye , bee-forage , etc . Some species have unique ecological role , such as specific soil-binding properties , water conservation , pollination , etc . Earlier , Bohra (2006) reported only some 160 fodder plants from the same area and focus of her study was on the fodder value for dairy animals in the mountains .

Some fodder plants are of crucial ethnobotanical importance and are used for various purposes , such as in curing of certain diseases , in health amelioration , religious rituals , cultural rites , etc . Different parts (such as root , shoot , leaves , flowers , and seeds) of a species are used through certain physical and chemical processes in the curing of prevailing diseases , such as skin and eye problems , diarrhoea , dysentery , digestive problems , menstrual disorders , gonorrhoea , dysmenorrhoea , measles , respiratory problems , bronchitis , fever , malaria , dropsy , piles , diabetes , jaundice , suppressed urination , urinogenital problems , delivery-related complexities , etc . Many fodder species are of ethno-veterinary uses and people variously use them to prevent and cure livestock diseases . Certain species are regarded as sacred and are used in various cultural and religious rites .

Conclusions A positive indicator to assess and diagnose the health of Himalayan rangelands is that they harbour enormous diversity of fodder plants so critical for the livestock-based livelihoods of a sizeable population of farmers and pastoralists in the region . Fodder resource utilisation also exhibits one of the unique examples of ethnobotanical knowledge of range-dependent mountain communities . The fodder diversity in mountain rangelands needs to be conserved and enhanced and its sustainable use needs to be ensured to realize an increase in livestock production in the region .

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The role of management in maintaining grassland sustainability in the Carpathian Mountains from Romania

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Key words: sustainability, permanent grassland, organic fertilization, biodiversity

Introduction The pastoral patrimony of Romania is represented by over 4.9 mil. ha, from which more than half are in the mountain zone. This paper's purpose is to underline the dynamics of the phytocenosis' biodiversity, due to the application of some technical practical measures meant to improve the production and the quality of the grasslands ecosystems with minimal effects on the environment. Nowadays, many specialists are concerned by adapting the technologies of fodder production to the new economic and ecological requirements (Belesky David P. et al., 2002; Peeters A. et al., 2005; V ntu V. et al., 2007).

Materials and methods The researches were conducted in two sites: on an *Agrostis capillaris L.* and *Festuca rubra L.* grassland from Campulung-Moldovenesc area (705 m altitude) and on an *Agrostis capillaris L.*, *Anthoxantum odoratum L.* and *Nardus stricta L.* grassland from Vatra-Dornei area (820 m altitude), both from the Carpathian Mountains. The experiments are single factor type, set in accordance to the randomized blocks method, in four repetitions, observing the organic fertilizers' effect, a basic element in maintaining the grasslands' sustainability, in doses of 10-30 t/ha half fermented cattle manure, on biodiversity and productive level. There were observed the following fertilization variants: V_1-unfertilized control, V_2-10 t ha^{-1} manure annually, V_3-20 t ha^{-1} manure once at 2 years, V_4-30 t ha^{-1} manure once at 3 years, V_5-20 t ha^{-1} manure 1st year+10 t ha^{-1} manure 2nd year+0 t ha^{-1} manure 3rd year, V_6-20 t ha^{-1} manure 1st year+0 t ha^{-1} manure 2nd year+10 t ha^{-1} manure 3rd year, V_7-20 t ha^{-1} manure 1st year+10 t ha^{-1} manure 2nd year+10 t ha^{-1} manure 3rd year, V_8-10 t ha^{-1} manure 1st year+20 t ha^{-1} manure 2nd year+10 t ha^{-1} manure 3rd year. The manure was applied in early spring, harvesting was made in hay stock mode, at dominant graminee species' ear-flower formation and the measurements regarding the biodiversity and the species' groups ratio were made in the first vegetation cycle.

Results The management of manure administration and rational use, related with soil and climate conditions positively influenced the biodiversity and the studied grasslands' productivity. Thus, in organic fertilization conditions, the number of species varied between 33 and 42, and the production between 4.28 and 4.69 t ha^{-1} dry matter (d.m.) on the *Agrostis capillaris L.* + *Festuca rubra L.* grassland, while on the *Agrostis capillaris L.* + *Anthoxantum odoratum L.* grassland, the number of species was smaller, between 27 and 37, but productions were bigger, varying between 4.92-5.40 t ha^{-1} (Table 1).

Table 1 *The influence of grassland management on biodiversity and productivity.*

Fertilization variants	*Agrostis capillaris L.* + *Festuca rubra L.* grassland					*Agrostis capillaris L.* + *Anthoxantum odoratum L.* grassland				
	Species no.	Species' groups ratio (%)			Productiont ha^{-1} d.m.	Species no.	Species' groups ratio (%)			Production tha^{-1} d.m.
		G	L	OS			G	L	OS	
V^1	32	45	25	30	3.64	26	79	10	11	3.90
V^2	40	38	33	29	4.28*	27	66	19	15	4.92*
V^3	34	43	30	27	4.40*	29	69	21	10	4.95*
V^4	33	39	32	29	4.53*	37	68	15	17	5.03*
V^5	35	38	35	27	4.69*	34	65	20	15	5.36*
V^6	36	45	28	27	4.51*	35	70	18	12	4.71
V^7	35	37	32	31	4.45*	27	77	10	13	5.40*
V^8	42	39	31	30	4.52*	36	71	15	14	5.27*

G=grasses L=legumes OS=other species * $P<0.05=0.51$ t ha^{-1} * $P<0.05=0.94$ t ha^{-1}

Conclusions The organic fertilization and the rational use of permanent grassland from the Romanian Carpathians assure maintaining the biodiversity and sustain the productive level, with an adequate quality of the canopy.

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CVOR model for assessing the steppe ecosystem health—a case study on the typical steppe in Inner Mongolia , China

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Key word : typical steppe , ecosystem health , model , graze , vigor , organization , resilience

Introduction The typical steppe region of Inner Mongolia , China extends across 41° to 47° north latitude and 109° to 117° east longitude . C_3 grasses , which include *Leymus chinensis* and *stipa grandis* are dominant species without disturbance . While with the grazing pressure increasing , the number of *Leymus chinensis* and *stipa grandis* decrease , else *Artemisia frigida* and *Cleistogenes squarrosa* increase (Liu et al . 1998) . Based on the concept of Ecosystem Health" , Ecological Integrity" , and the theory of information (Ulanowicz 2000) and community characteristics under different grazing pressure , we explored a model for assessing the steppe ecosystem health . This model combines the function , or vigor (*V*) , structure , or organization (*O*) and resilience to perturbation (*R*) of steppe ecosystem and its environmental conditions (*C*) , which we call it *CVOR* model . The objective of this study was to provide a synthetic , simple , accurate and suitable method for grassland ecosystem health assessment and management .

Materials and methods The site was on the permanent field sites of the Inner Mongolia Grassland Ecosystem Research Station (IMGERS) , located in the Xilin River Basin , Inner Mongolia Autonomous Region , China (1168420 E , 438380 N) . The sites have been fenced-off since 1979 , preventing grazing by large animals . But out of the fence , there is still large animals grazing . Except this site , with contrast , we also select a rangeland which named Xilinhua Pasture located on the southwestern of Dowuzhumuqin County . Firstly , we used *Leymus chinensis* steppe in 1981 as a reference ecosystem which can be representative of undisturbed , climax steppe communities , and then established the calculation formulae for simulating the vigor , organization and resilience of steppe communities . In this model , we used the direct effective precipitation as index reflecting the environmental conditions . Finally , the feasibility of *CVOR* model was tested by analyzing the influence of grazing pressure and fencing protection on the health of typical steppe ecosystem .

Results and discussion In order to compare the *CVOR* value and reflect the ecosystem health conditions , we used the quartation to distinguish the health condition of different ecosystems (Table 1) . Through analyzing the correlation between *CVOR* value and other independent index including *C* ,*V* ,*O* ,and *R* , it shows 0 .650 ($p<0.05$) , 0 .710 ($p<0.05$) , 0 .184 ($p<0.05$) , and 0 .876 ($p<0.01$) , respectively . Grazing , especially persistent grazing incurs the decrease of biomass production and the change of dominant species in the communities . So it leads to the ecosystem health on the condition of unhealth or alarm . Fencing and cutting also have effects on the condition of steppe ecosystem health . In this study , fencing and mild cutting have the positive effects on the ecosystem health (Figure 1) . This model was developed on the data collected from typical steppe , so it limits to assess this ecosystem . But the method and the calculation formulae can also be used on other steppe ecosystem if selecting the relevant plant species .

Table 1 *Condition of ecosystem health .*

CVOR Value	Condition of health	*CVOR* Value	Condition of health
[0 ,0 .25)	Crash	[0 .50 ,0 .75]	Alarm
[0 .25 ,0 .50)	Unhealth	[0 .75 ,1]	Health

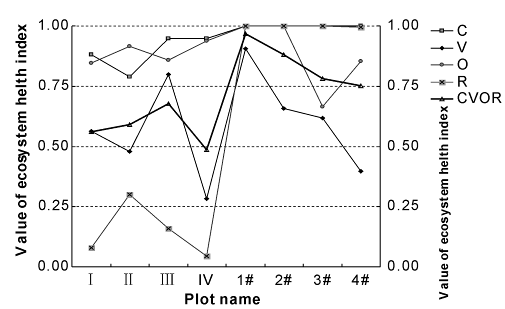

Figure 1 *CVOR of the typical steppe ecosystems .*
(Ⅰ~Ⅲ Field site on 1984 , 1994 , and 2004 , respectively ; Ⅳ outside of fence on 2004 still free grazing ; 1#~4# plots number in Xilinhua Pasture) .

Reference

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Molecular identification of 24 *Cynodon* cultivars using SRAP markers

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Key words: SRAP, *Cynodon* spp., cultivars, molecular identification, UPGMA

Sequence-related amplified polymorphism (SRAP) is a novel molecular marker technique designed to amplify open reading frames (ORFs). The SRAP analytic system was set up and applied to *Cynodon* germplasm identification in this study for the first time. Twenty-four *Cynodon* cultivars were screened by SRAP technique with 90 primer combinations. In the analysis, 30 primer combinations produced stable and reproducible amplification patterns in three repetitive experiments. Among the total 274 amplified fragments, 249 (91%) were polymorphic, with an average of 9 fragments for each primer combination, ranging in size from 100 to 500 bp. The 274 fragments were visually scored one by one and then used to develop a dendrogram with Unweighted Pair-Group Method Arithmetic Average (UPGMA), and the 24 *Cynodon* culrivars were divided into three major groups at the 0.69 similarity level, many of which were in agreement with known pedigrees. From the total 274 fragments, 13 amplified by one primer combinations, Me5-Em7, was able to discriminate between all the 24 bermudagrass cultivars (Figure 1). The DNA fingerprints were then converted into binary codes, with 1 and 0 representing presence and absence of the corresponding amplified fragment, respectively. In the DNA fingerprints, each of the 24 *Cynodon* cultivars has its unique binary code and can be easily distinguished from the others. This is the first report on the development of SRAP technique and its utilization in germplasm identification of *Cynodon* cultivars. The results demonstrated that SRAP is a simple, stable, polymorphic and reproducible molecular marker technique for for differentiating bermudagrass genotypes and for determining genetic relationships among them.

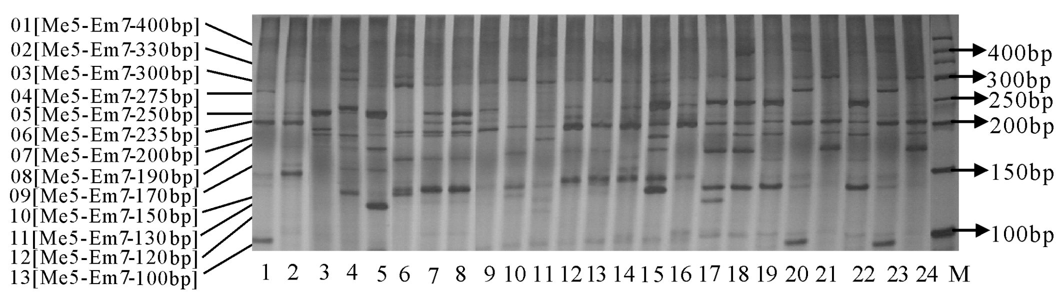

Figure 1 *The 13 selected SRAP fragments used for constructing the DNA fingerprints of the 24 Cynodon cultivars. Numbers below the figure are the numbered samples of the 24 Cynodon cultivars; numbers on the left side of the figure are the sizes (bp) of corresponding fragments of the marker; numbers on the right side of the figure are the fragments that were selected and used for constructing the fingerprints of the 24 Cynodon cultivars.; M: DNA marker (50bp, Promega).*

Affect of fencing on community structure and species diversity of *Eragrostis nigra* on degraded grassland in Karst Area

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Key words : *Eragrostis nigra* , degraded pasture , fencing , community structure , species diversity

Introduction Backspiked lovegrass (*Eragrostis nigra*) played a very important role in grassland resources in Karst area . However , because of over grazing in the long past , it caused a serious degradation of grassland and heavy soil erosion , leading to the continual expansion of bare land in the area . The trial , through three-year observation , was aimed at effect of restoration of *Eragrostis nigra* vegetation on the degraded grassland by means of fencing so as to provide theoretical foundation and practical measures for sustainable utilization of the grassland in karst area .

Materials and method the trail was conducted at hill site in Qiubei county , Yunnan(East longitude 103°52′ , north latitude 24°04′ , elevation 2300 meters , annual rainfall 1120mm , annual temperatures 13 .4℃) with 1hm^2 fenced to compare with natural grazing without fencing . The vegetation of the trial land was dominated with *Eragrostis nigra* and Shiny cinqueflil (*Potentila fulgense*) and the total coverage of the community was about 60% -70% with sward height about 15cm in average . The coverage , density , height and biomass of the vegetation community were measured before the trial and the same items were recorded in September each year during the trial phase .

Results The results showed that :(1) Coverage of pasture was increased from 60% (before fencing) to 100% after fencing . The quantity characters and spatial characters of dominant species changed regularly , such as sward height was increased significantly ,both blackspiked lovegrass and Shiny cinqueflil (*Potentila fulgense)* wereincreased significantly and dominated upper synusia gradually . The density of blackspiked lovegrass was decreased annually . (2) Comparing with control ,richness index of community and indexes of Margalef were increased significantly during three years by fencing . Indexes of Menhiniek was increased significantly in the second and third years . Diversity indexes of Shannon-Weaver was increased significantly in the second year ,but it was not significant in the third year . There was no significant difference on Pielou evenness index in the restoration processing of degraded pasture . (3) Clustering between community of different fencing phase , 5 communities cluster 3 kinds , Ⅰ (before fencing and without fencing) , II(second year and third year) , III(first year after fencing) .(4) Second years and third year after fencing ,the total above-ground biomass ,grass and forbs were increased significantly . The legume biomass after four months of fencing was higher than those of control , sixteen months and twenty-eight months after fencing . After twenty-eight months of fencing , the total biomass of pastures increased 4 times (comparing with control) ,and reached to 5 .8 t/hm^2 (DM) . There was also a obvious change in community of vegetation with ratio of grass and legume increased from 21% to 55% ,forbs decreased from 76% to 43% , and legume decreased from 6% to 1% .

Conclusions With fencing , the vegetation coverage in the trial grassland was greatly improved , which effectively controlled the soil erosion . At the same time , after fencing , the sward height , output of the biomass and the productivity of the grassland all were improved in large standard . The ratio of perennial grass in the vegetation was largely increased , while that of the fords decreased after fencing , which , in turn , significantly improved the quality of the grassland , maintaining the sustainable utilization of the grassland . Fencing treatment improved the species diversity in the community of the grassland , maintaining the stability and capability to stressing of the community of the grassland . Therefore , on the degraded grassland dominated with *Eragrostis nigra* , fencing was an effective technical measure for restoration . In the actual practice , it was suggested that degraded grassland could be used again after third year of fencing . Rotational grazing with adequate grazing was recommended .

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Research on the enaction of right of nomadism in grassland

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Key words : Mongolians , grassland supervision , right of nomadism

Introduction The right of nomadism refers to this right that specified persons carry out nomadism for themselves in designated area based on the lawful administrative license . The nomadic and dynamic styles of producing , living that we have followed tens of thousands of years are gradually dying out in grassland of Inner Mongolia as the appearance of construction on enclosed pasture and grassland contract system since the eighties of the last century . Such supervisor mode that people supervise grassland in supervising arable land way , supervise herdsman in supervising peasant way brings us three-new social problems : 1 .Problems of existence result from pascual farmization and pascual industrialization ; 2 . Problems of ecology result from enclosed pasture and system of set grazing ; 3 . Problems of cultural change result from changes of lifestyle . We do some studies for 8 years so as to resolve these problems as far as possible . We find out the following results through this research : 1 . economically , husbandry system itself whether nomadism or set grazing is an unprogressive style of producing in grassland , but as another point of ecology and cultural transmission , the nomadic function of ecology and culture is irreplaceable ; 2 . Although enclosed pasture and system of set grazing are propitious to the social management and social service , it formed some unevadable problems of existence , ecology , cultural change .

Materials and methods In 8 years , we use three methods to study the three problems . 1 . The historical method . The Mongolians are a legal nationality . In history , Mongolians had once created almost 30 written codes . The Mongolians enforce the system of rule by law for 740 years of history . We arrange the styles of grassland supervision that each regimes use from 1206 to 1947 as the point of the science of politics , the science of religion and folklore in order to learn from history and scan our behaviors by means of historical lesson . 2 . The observational method . We choose part of local governments and peasants in Hulunbuir grassland , Kerchin grassland , Chifeng gongar grassland , Ulan Qab hongar grassland , Xilinguole grassland , Ordos sandy grassland , Alxa gobi grassland according to their respective humidity . After that we carry out systemic observation and record as the point of politics , economics , religion , folk custom . 3 . The comparative method . We carry out comparative studies according to cross-perspective at the same time among the region and direct-perspective at the same region among the history and intersectional-perspective at the different time and region .

Conclusions We can see that nomadism is the best styles of producing and living through history and reality . Nomadism is not only conform to natural property of grassland but conduce transmission of nomadic culture . So we suggest that full-scales system of nomadic license comes into force in grassland of Inner Mongolia . The scale of nomads and nomadism is on the basis of carrying capacity of grassland . 1 .dismantle the enclosed pasture , cancel the system of set grazing and set the right of nomadism legally and carry out the system of admittance in the nomadism according to administrative license . 2 . The government shall carry out transitional resettlement to part of nomads who cannot carry out and refuse nomadism and exceed carrying capacity of grassland .

This project is found by Wu Zhizhong (Assistant Secretary-General of the Inner Mongolia Autonomous Region People's Government ; Director of the Inner Mongolia Autonomous Region People's Government Legislative Affairs Office ; Leading researcher of the project team on Research on the enaction of right of nomadism in grassland" , Inner Mongolia DianZhang Institution of law and sociology) .

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Research on the folk assessment indicator system of the surviving environment of pastoral area-taking Damao banner as an example

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Key words: desertification monitoring, surviving environmentlevaluation indicator system, folk assessment, Arid region

Introduction At present, the monitoring and assessment indicator on grass ecological environment have formed a relatively ripe system. In this paper, all kinds of monitoring and assessment indicator are excavated and reorganized, and a new system is formed in view of the folk community, from which the herdsmen can judge the property and degree of grass surviving environment they face.

Study method According to conducting on-the-spot interview to the herdsmen of the central and western pastoral areas of Inner Mongolia, the method of questionnaire survey is taken to collect and organize the monitoring and assessment indicator existed among the folk and community's surviving environment. The indicator is then chosen and sorted out according to the principle of assessment indicator of ecological environment. The indicator system chosen firstly is taken to operate on the spot to further check and correct, and then a new system of monitoring assessment indicator is put forward on the basic of surviving environment of the community between pastoral areas. An evaluation on ecological environment is carried by the assessment indicator system of both folk and academia, the result of which is compared to confirm the feasibility, serviceability, and representation of this system.

Analysis of result Taking the Damao banner Pastoral Area of Inner Mongolia as an example, from the investigation of the herdsmen of this area, they mainly judge and evaluate the ecological environment by the condition of grass variety, livestock reproductive ability and body weight stable and hydrology river system variety. According to the definite principle of the ecological environment of pastoral area and the character of the plant, hydrology indicator, domestic animal indicator, etc, is definited as the first level indicator; at the same time, the second level indicator is chosen in view of integrity, scientific nature, independence, simple and qualification.

Conclusions Through the research of questionnaire survey to the herdsmen of pastoral area, the combination of the monitoring and assessment indicator system is proposed in view of the folk survival environment of the pastoral area[2]. On the Damao banner grassland of the western Inner Mongolia, the ecological environment assessment is carried according to this new assessment system and the traditional one, compared with the similar reason, the feasibility, operation, and representation are confirmed then.

Table 1 *The monitoring and assessment indicator system.*

Evaluation indicator	Concrete indicator	Rank division and classification		
		mild	moderate	germinates
Plant indicator	Vegetation coverage after the rain time (vegetation coverage area per area) (%)	≥40	40～25	25～10
	Quality and growth of fine grass type after budding in spring (drop/reduction) (%)	≤10	10～30	≥30
	The height of plant stopping growth in autumn (being eaten) (cm)	≥5	5～2	≤2
Hydrology indicator	Drop scope the subsoil water level in the well (m)	≤2	2～3	≥3
	The rainfall time of the time of rain coming and fit grass growth in the season (compared with average level A" in the five years) (reduction or drop) (%)	≤20	20～50	≥50
	Variety of peripheral river system (reduction of basin area) (%)	≤30	20～60	≥60
domestic indicator	The day-increasing weight of the season of lamb reproduction (kg/day)	≥0.35	0.35～0.25	≤0.25
	The increasing scope of domestic animals' weight in autumn(A" compared) (reduction or drop) (%)	≤20	20～50	≥50
	The rate of animals possessing per grass area (sheep/hm^2/half year)	1.45	2.63	5.26

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The Effect of Different Interval between Pasture Belts on Water and Soil Conservation

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Key words : interval , water and soil conservation , soil fertility

Introduction The study was conducted on the impact of different intervals between pasture belts on water and soil conservation as well as on physical and chemical characteristic of soil on the sloping arable land with the elevation of 15° . Results indicated that water and soil erosion could be effectively controlled by planting pasture in belts on the sloping land . The shorter the intervals between pasture belts were , the better results it would be in terms of erosion control . However , if considered the balance of soil erosion control and cropping for proper land utilization , it was suggested that 13 meters of the interval between pasture belts would be recommended .

Materials and methods The trail was conducted on the sloping arable land with the elevation of 15° in Xuanwei city with method of randomized factorial design of each interval treatment with three replications and three different treatments in total as A , 2 .5m×17m , B , 2 .5m×13m and C , 2 .5m×9m in plot size . Each plot was furrowed 15cm in depth and sprayed with chemicals to keep the surface bare all the time with the edge of each plot covered with plastic and brick . At the lower end of the plot , pasture belt of 0 .5m in width was established with Trifolium repens and Setaria sphacelata cv . Narok at ratio of 1 ∶ 1 and 15kg/hm^2 sowing rate in total . A soil runoff collecting ditch was made at the bottom of each plot to measure the unit soil runoff and soil erosion after rain . The soil hardness , unit weight , organic matter and the content of N , P and K were measured in two years of time on different layer of the soil in each plot from 0 to 5cm , 5 to 10cm , 10 to 15cm and 15 to 20cm .The result of the experiment was achieved from the analysis of changing pattern of physical property of the soil and the soil runoff .

Results On the sloping land with elevation of 15° , the soil hardness and unit weight on the bare surface of treatment A ,B and C decreased yearly with soil hardness of B and C reached 56 .60% , 22 .06% and unit weight of B and C , 56 .08% , 38 .04% that of A respectively . Soil fertility of all treatments degraded annually , worse on the top part . The degradation of organic matter content , total and available P , N and K of B and C was in the sequence as A(17m) > B(13m) > C(9m) ,which was the same as that of soil runoff , soil physical property . There was a significant difference between treatment A and B , but not quite significant between B and C . it was suggested from the experiment that considering the ideal combination of soil and water conservation and grain cropping , the treatment B of 13m interval between pasture belts would be the best choice .

Table 1 *Main items analyzed in the experiment .*

items \ Year	2003			2004		
	A	B	C	A	B	C
soil hardness (KN)	0 .0997	0 .1126	0 .1131	0 .1133	0 .1213	0 .1165
soil unit weight (g/cm^3)	0 .9562	0 .9710	0 .9616	1 .0246	1 .0099	0 .9878
organic matter (g/kg)	41 .52	38 .79	40 .14	37 .30	35 .50	37 .45
total N (g/kg)	1 .63	1 .55	1 .56	1 .09	1 .07	1 .08
total P (g/kg)	7 .84	6 .98	7 .62	5 .22	4 .64	5 .15
available P (mg/kg)	7 .44	7 .24	7 .23	4 .96	5 .06	5 .24
total K (g/kg)	5 .44	4 .84	4 .71	5 .06	4 .47	4 .38
available K (mg/kg)	93 .36	88 .82	95 .06	77 .27	74 .74	83 .11
surface runoff(m^3/hm^2)	171 .07	130 .38	100 .32	146 .85bB	128 .38aA	126 .71aA
soil erosion (kg/hm^2)	1280 .7cB	790 .2bA	694 .6aA	1008 .2cB	741 .2bA	626 .6aA

Conclusions Mounttainous area takes up 94% of total land in Yunnan , where soil erosion occurred easily . It significantly protects fertility and soil from lossing by establishing pasture belts while cropping on the intervals , which benefits both livestock grain cropping and is a kind of good maens for soil and water conservency and sustainable production under the practical rural situation in China .

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Desertification mapping by Iranian Classification of Desertification (ICD) method (case study : Kohdasht watershed in Iran)

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Key words : desertification , human activities , environmental factors , ICD

Introduction In order to challenging with desertification , it is necessary to do some scientific research and assessment in different parts of the world . The results may help to control and reduce the damages resulted from this phenomenon . In many regions of the world especially in arid and semi-arid ones , studies have been done to assess the land degradation rate , degradation status and mapping .

Materials and methods At the first maps of landuse and vegetation cover of the region were considered to determine natural desert lands and then work unit map consist of geology , topography and geomorphology were prepared .According to the ICD method the criteria used for assessment of desertification condition include environmental and anthropogenic factors as well as desertification indicators . With this frame work , several factors and sub-factors were considered .

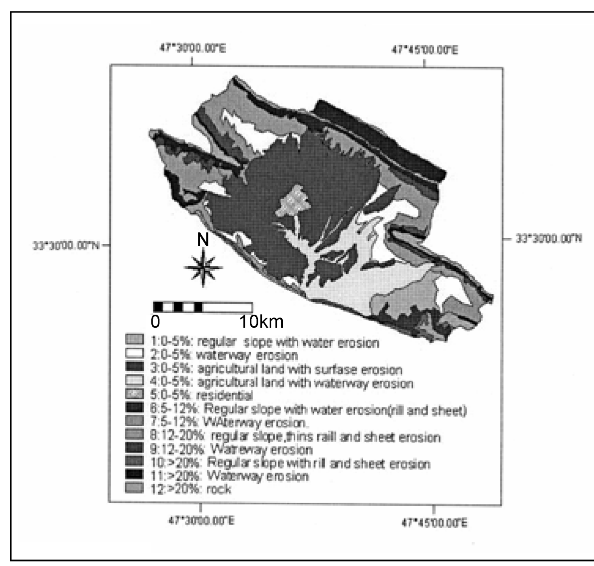
Table 1 *The classification of desertification intensity in ICD method .*

Sever	High	Medium	Low	Slow	Desertification Rate
76 .8-9 .6	57 .6-76 .8	38 .4-57 .6	19 .2-38 .4	0-19 .2	Score
Ⅴ	Ⅳ	Ⅲ	Ⅱ	Ⅰ	Symbol

Results and discussion The results of scoring and evaluation of ICD method is summarizes in Figure 1 .

Legend of Map

Desertification curent condition on the map	Area (ha)	code
Ⅲ—p ,A (ni) A—Id(ch)	1883	1
Ⅲ—A A—W .d(pu)	5812	2
Ⅱ—A(t) A—W .d(pu)	13582	3
Ⅳ—A A .E—W .d(pu) .Se(wa)	5544	4
Ab	653	5
Ⅲ—P A .E—pd(cu .gr) .Id(ch)	635	6
Ⅳ—P ,A(n) A—pd ,W .d(pu) .Id(ch)	7069	7
Ⅲ—P A—pd(cu)	197	8
Ⅳ—PR ,A(n) A—A+1	2307	9
Ⅲ—PR A—pd(cu)	584	10
Ⅲ—P A—pd(cu)	5476	11
Ⅱ—B(m) E—Q(qt)	1854	12



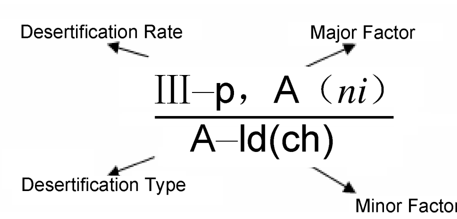


Figure 1 *The map of desertification rate presented by ICD method in Kohdasht .*

The appropriate criteria and factors were selected to evaluate desertification condition in Kohdasht basin . Anthropological factor is a major problem in the study area to environmental factor . Among the effective major factors of desertification , factors of water supply destruction , soil erosion , land degradation , vegetation destruction and quantities condition of water and soil resources have significant roles on desertification phenomenon respectively The average quantitative factors of desertification intensity for the region is DR= *39 .2* which shows medium of desertification class .

Advice on the exploitation and protection of grassland ecotourism resources in China

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Key words: grassland, grassland tourism, eco-tourism resources, exploitation, protection

Distribution and category of grassland eco-tourism resources in China Grassland in China is widespread along the west of northeast China, Inner Mongolia, mountains of northwest desert and Qinghai-Tibet Plateau, lying along 12 provinces between latitude 30-50° north, with an area of 3.57 billion mu. Being the first in the world for its diversities, grassland in China ranges from tropical-subtropical, temperate zone to alpine ones, consisting of 18categories and 37 subcategories with more than 1000 grass types. There live on grass bountiful rare wildlife and produce many kinds of precious Chinese herbal medicines. What constitutes the grassland eco-tourism landscape is mainly the large-scale grassland on plateaus and plains.

Patterns of grassland eco-tourism resources exploitation and utilization The appealing resource foundation-grassland vegetation, integrated with its surroundings like hills, plains, rivers, watercourses and buildings will unfold a tranquil and enchanting tourism scenery. Special herbs, wild edible plants and specialized products can be supplied to tourists. Pleasantly cool weather is the primary attraction for summer resort. Inhabited by various ethnic groups of Mongolia, Kazakh, Tibetan, Manchu and Yugur, the unique ethnic customs are another important attraction of the grassland. Currently, there are different patterns of tourism products, which are typically natural grassland landscape, wildlife tour, grassland popular science education tour, science tour, grassland camping and custom tour.

Superior grassland eco-tourism resources Grassland can be characterized by the geographical position, weather condition, vegetation, eco-system features, and social and humanistic features. *Inner Mongolia steppe* is the largest natural pasture in China, lies across the east to the west, respectively, meadow-typical-desert steppes. *Xinjiang mountain steppe* is in the continental center with typical continental climate, as sub-mountainous meadow plant area, it has been a prominent pasture since ancient times. *Qinghai-Tibet alpine grassland*, over 4000 meters above sea level is the highest plateau on earth's surface, it is mainly large amount of alpine meadow and rangeland, with an area of 2.5 million km^2.

Suggestions on exploitation and protection There are wide differences in grassland eco-tourism resources in China. The varieties of ethnic customs and traditions melted in nature are the superior resources, which can integrate eco tour, academic exchange, science and tech cooperation as well as eco education.

Local governments at all levels around grasslands are recommended, firstly, to have a correct understanding of the role of tourism in integrated utilization of grassland resources, and develop grassland tourism for the sake of the new economic growth engine; secondly, based on profound grassland eco tourism survey in terms of topography, location conditions, infrastructures, and different markets, to analyze and assess the feature scientifically and utilize them by step and by focus; thirdly, to strictly plan the spatial distribution of eco-tourism areas by function, and restrict the tourist amount to eco-environment capacity even in tourist relaxing areas; fourthly, to adhere the principle of eco-bound in product design and project planning with the stress on eco-tourism.

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Grasslands/Rangelands Resources and Ecology

——Application of Information Technology in Monitoring and Managing Grasslands/ Rangelands Resources

Information technologies for rangeland monitoring : what do they need to address ?

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Key points : We advocate that the success of rangeland monitoring can be enhanced with the development of a more encompassing conceptual framework , in addition to greater technological capacity . Important conceptual constraints include ambiguous monitoring goals , minimal integration of scientific , professional and local knowledge , the inability to address multiple ecological scales , and the absence of comprehensive monitoring-management-policy networks . Ecological resilience is proposed as a platform to integrate the complexity of social and biophysical systems and to link local , professional and scientific knowledge sources . We outline the components of a comprehensive monitoring framework that is based on a mutual commitment to collaborative learning and action among multiple stakeholders to promote social-ecological resilience .

Key words : ecological resilience , knowledge sources , rangeland management , social-ecological systems

Introduction

Global rangelands are characterized by diverse ecosystems that represent 40% of Earth's land area . The extent and diversity of global rangelands provide numerous ecosystem services to human societies (e .g . , climate regulation , biodiversity , as well as food , fiber and water) (Havstad et al . , 2007) . Therefore , the sustainability and continued provisioning of these services in response to natural and anthropogenic disturbances is of major concern . Monitoring is required to document and anticipate ecosystem responses to various disturbances , direct management actions , and promote wise stewardship . The ability to anticipate pending ecosystem change provides the greatest opportunity for adaptive management to direct and manage change , rather than merely respond to it (Folke 2006) . Although the importance of monitoring is widely recognized and numerous protocols exist , the rangeland profession is currently in the process of designing and implementing a modified set of monitoring protocols to provide broader ecosystem assessments and more directly address the contemporary needs and expectations of society .

The major components of effective rangeland monitoring have been well defined and they include the following (Western 2003) .

1 . Possess the capacity to scale from local to landscape and regional levels to encompass the complexity of human-dominated systems .
2 . Expand beyond conventional measures of vegetation composition and soil surface characteristics to more comprehensive assessments of ecosystem services and human activities .
3 . Continue to refine models of ecosystem function to encompass the realities of complex , open and adaptive systems dominated by human activity .
4 . Recognize and address multiple stakeholder groups , including cultural , socio-economic and governance considerations .

Even though there is wide recognition and general support for the inclusion of these monitoring components , implementation is complex and variously constrained by numerous issues including , land ownership and use patterns , ineffective assessments of monitoring success , and limited stakeholder participation . Taken to its logical conclusion , the recommended components of effective monitoring encompasses an unique approach to rangeland management that represents a radical departure from the prevailing command and control structure that has dominated natural resource management since the middle of the last century (Holling 1996 ; Reynolds et al . , 2007) .

Our approach to this pivotal , but daunting challenge is to provide a broad conceptual framework for organizing and implementing the recognized components of effective rangeland monitoring . This approach is based on the premise that the limited success of previous monitoring protocols has been a consequence of inadequate conceptual constructs , in addition to insufficient technical capacity . The most important conceptual constraints include broad and ambiguous monitoring goals , minimal integration of scientific , professional and local knowledge , the inability to address multiple ecological scales , and the absence of comprehensive monitoring-management-policy networks . The paper concludes with a brief conceptual framework describing how these critical monitoring components can be organized and implemented to assess the resilience of social-ecological systems .

Significance of Monitoring Goals and Protocols

Monitoring protocols are required to define the status or condition of specific biotic groups or entire ecosystems in response to stresses and disturbances (Dale and Beyeler 2001) . Ecological indicators represent key variables that are assumed or have been demonstrated to provide information about ecosystem attributes and processes that are relevant to managers , but that are difficult to assess directly .

Attributes of effective ecological indicators for inclusion in monitoring protocols include:
1. Easily implemented, cost-effective and provide relevant information to various stakeholders.
2. Provide anticipatory information about ecological processes that can inform management actions.
3. Predictable and responsive to single or multiple stresses and disturbances placed on ecosystems.
4. Applicable or adaptable to a broad range of climatic, soil and vegetation variation and over a wide range of ecological scales (Dale and Beyeler 2001).

However, monitoring is often implemented with ambiguous goals that make little provision for scale of assessment and mutiple stakeholder interests (e.g. management unit, regional and national assessments). This makes it difficult to address specific stakeholder concerns, determine monitoring success, and modify protocols to more effectively address various objectives. The development of explicit monitoring goals should begin with a rigorous, objective reevaluation of current goals with the best local, professional, and scientific knowledge available. Even well-designed and implemented monitoring protocols will not contribute to effective rangeland stewardship if they are not focused on the appropriate goals or issues. This reevaluation of monitoring goals has been prompted by both an advance in ecological knowledge and a modification of societal expectations of the services derived from rangelands. The implementation of ambiguous monitoring protocols produces a high probability of failure because of a potential mismatch between monitoring goals and the specific assessments employed. We argue that additional integration of multiple knowledge sources and greater participation of various stakeholder groups will enhance both the relevance and success of rangeland monitoring.

Multiple Knowledge Sources

Previous monitoring efforts have been constrained by not only the complexity of biophysical systems and diverse stakeholder groups, but also by multiple knowledge sources that influence management decisions (Burns et al., 2006). We recognize three broad knowledge sources that influence decision making on rangelands. First, local knowledge refers to experiential knowledge that is developed from direct interaction with the land, often to provide a source of livelihood, that is transferred between generations and among members of a community. Second, professional (i.e., expert) knowledge represents the conventional wisdom collectively held by formally trained rangeland professionals that has become institutionalized across multiple generations. Third, scientific knowledge is acquired by a systematic process of data collection, statistical analyses, hypothesis testing, and peer review. Professional knowledge is perhaps the most complex because it includes aspects of both experiential and scientific knowledge in varying combinations that have been organized to address various management goals.

Multiple knowledge sources provide a wealth of rangeland information, but they often function in parallel because few mechanisms exist for information exchange among them. Consequently, the convening of multiple stakeholders who hold diverse knowledge sources often produces competing goals, misunderstanding, and occasionally antagonism among groups that hinders the development, implementation, and interpretation of monitoring protocols. We consider effective information exchange among the various knowledge sources to be as great a challenge as that of technical capacity for effective rangeland monitoring (Burns et al., 2006). In cases where various knowledge sources conflict, there may be an opportunity to test hypotheses through monitoring by using adaptive management. In cases where scientific knowledge is absent or inconclusive, local knowledge may be a valuable information source to construct a more robust understanding of ecosystem dynamics. In other instances where scientific information is conclusive, it can be used to validate or modify local and professional knowledge. The rangeland profession desperately requires a mechanism to facilitate communication and foster participation among these various knowledge sources to promote more effective monitoring of global rangelands.

Toward a Comprehensive Monitoring Framework

We perceive the major challenge to the development of effective monitoring to reside in the identification of a framework that can accommodate the biophysical complexity of rangeland ecosystems, multiple sources of knowledge, and the human dimensions of these social-ecological systems (Reynolds et al. 2007; Stafford Smith et al., 2007). We advocate that this framework must have a strong underpinning in ecological theory to accurately represent the biophysical structure and dynamics of rangeland ecosystems. However, it must also explicitly incorporate local and professional knowledge because reductionist science can not answer all ecosystem scale questions relevant to ecosystem management (Herrick et al., 2006).

Ecological resilience as a central tenant of rangeland monitoring

Ecological resilience describes the amount of change or disruption that is required to transform a system from being maintained by one set of mutually reinforcing processes and structures to a different set of processes and structures (Peterson et al., 1998). This interpretation of resilience assumes that ecosystems can be expressed as two or more alternative stable states and emphasizes the potential occurrence of state transitions or thresholds between stable states. Thresholds represent the conditions in which the limits of ecosystem resilience have been exceeded and alternative states form (Figure 1). These concepts are commonly presented as state-and-transition models (STMs) that include identification of potential alternative stable states that may exist on a site and the natural and anthropogenic mechanisms that force states across thresholds to alternative states

(Briske et al ., 2005) .

We advocate that greater attention be directed toward resilience-based monitoring because it emphasizes the conditions and dynamics that influence state proximity and vulnerability to potential thresholds , in addition to identification of the thresholds themselves (Briske et al ., 2008) . Greater knowledge of resilience improves the ability to manage ecosystem change , rather than merely react to it , by providing opportunities to incorporate adaptive management (Folke 2006) . Ecological resilience of desirable states can be reduced by improper land use practices (e .g ., fire suppression , overgrazing) and extreme environmental conditions (e .g ., multi-year drought , intense storm events) , both independently and in combination . The loss of resilience may often be expressed as a slow imperceptible decline over periods of years and decades that increases the probability of threshold occurrence and the formation of alternative stable states (Scheffer and Carpenter 2003) . Alternatively , the loss of resilience may result from an abrupt change in ecosystem pattern and process induced by severe episodic events such as 500 year storms or multi-year droughts that act on low resilience systems (Walker et al ., 2004) . We envision this robust ecological concept to lend itself to monitoring application with various levels of sophistication and at various ecological scales .

The key to successful implementation of resilience-based monitoring is the development of a suite of effect indicators linking ecosystem structure and function . Process is often inferred from structural variables and patterns because it is often impossible or impractical to directly measure process rates given the expanse and complexity of rangeland ecosystems . Recognizable indicators and benchmark conditions can identify when states are approaching thresholds as well as how far states have moved beyond thresholds after they have been crossed (Briske et al ., 2008) . Indicators of decreasing state resilience (e .g ., increasing size and connectivity of bare patches) forewarn managers that actions must be taken to stabilize resilience and minimize the likelihood of crossing a threshold . Similarly , indicators of alternative state resilience (e .g ., height and density of encroaching shrubs) after thresholds have been crossed will provide information concerning both the probability and appropriate prescriptions for implementation of successful restoration procedures to recover former states .

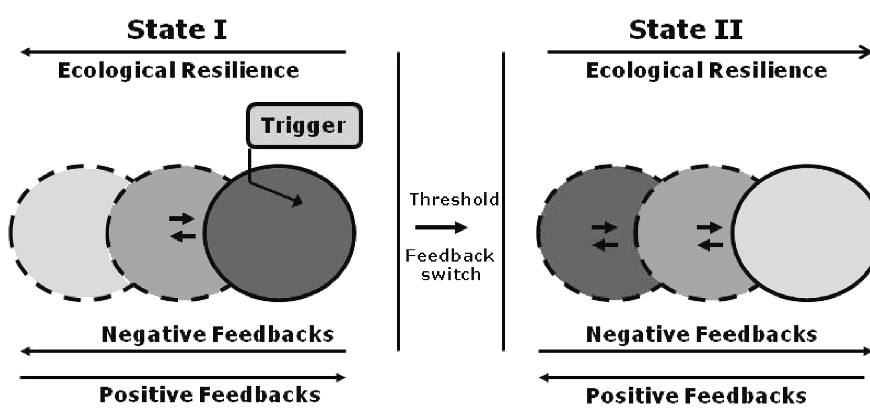

Figure 1 *Ecological resilience can be envisioned as state movement toward or away from potential thresholds . Circles within states correspond to community phases that possess varying degrees of resilience based on their proximity to potential thresholds . An increase in negative feedbacks enhances resilience and moves states away from thresholds , while an increase in positive feedbacks diminishes resilience and moves states toward thresholds . Triggers represent events that immediately induce states to exceed their resilience limits and cross thresholds to alternative stable states .*

Monitoring across ecological scales

Monitoring protocols must be able to assess processes that drive ecosystem change among various scales of organization (Bestelmeyer et al ., 2006) . Key patterns and processes at fine scales include , individual plant growth and reproduction , small patch development and distribution , and plant or patch grazing . Intermediate scales are represented by variously arranged larger patches of self-organized plant groups that affect levels of resource availability by capturing overland water flow and soil deposition . At the broadest scales , the geographic distribution of plant communities and ecosystem resilience is influenced by patterns of geomorphology and climate , and the history and pattern of land use may feedback to affect climate and geomorphic change (Scheffer and Carpenter 2003 ; Reynolds et al ., 2007) .

These scale-dependent processes further interact to form cross-scale interactions within landscapes and regions (Peters et al ., 2004) . For example , impacts on individual plants at fine scales collectively affect larger patch structure and thus broader-scale processes such as erosion . Changes in regional ground cover and land use patterns may further influence climate by modifying atmospheric chemistry , dust emissions , and albedo . Regional climate processes , in turn , determine how local-scale disturbance regimes translate into changes in local patch development and distribution . Broad-scale socio-political processes further interact with biophysical processes when changes in national land-use policies drive changes in local land-use decisions. Monitoring failures can often be attributed to a mismatch between the scale of dominant processes and the scale of assessment. For example, fine-scale monitoring of vegetation transects may not provide an indication of patterns that could be detected by remote sensing of larger scales, such as the acceleration of gully formation and runoff that eventually alters water availability in upland portions of the system (Pringle et al., 2006).

Traditionally, monitoring protocols have focused exclusively on indicators of fine-scale and fast variables such as plant cover and production that are measured at a few discrete locations and points in time (Reynolds et al., 2007). These variables are important for short-term tactical decisions, but they may not necessarily be correlated with long-term ecosystem change. Slow variables represent less dynamic, broad-scale responses (e.g., nutrient redistribution, functional group replacement) that underlie long-term ecosystem change that in turn may feedback to influence subsequent fine-scale change and the response of fast variables. Techniques that assess the spatial pattern of patches, and long-term changes among them, across continuous areas and how fine-scale processes produce contagious effects over long time frames require greater development and implementation (Bestelmeyer et al. 2006; Pringle et al., 2006).

Organization of monitoring-management-policy networks

Monitoring and adaptive management represent mechanisms by which learning and collaborative management actions can be structured to maintain ecosystem resilience and the social systems that depend upon them (Figure 2). The development of more inclusive and effective monitoring protocols requires that rangeland ecosystems be viewed as integrally linked social-ecological systems (Walker et al., 2004; Stafford Smith et al., 2007). Knowledge of ecosystem pattern and process, human and natural impacts upon on them, and feedbacks between ecological and social systems, is critical to determining future management actions (Berkes et al., 2003). In this context, monitoring is the nexus of social-ecological systems because monitoring information provides the foundation for collaborative learning and management action which is critical to ecosystem resilience.

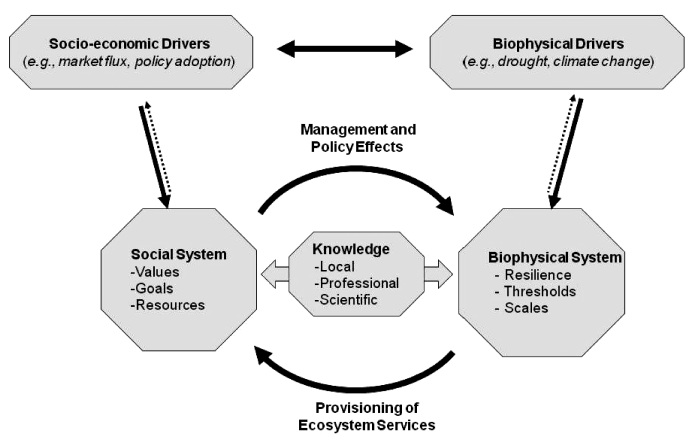

Figure 2 *A conceptual monitoring framework designed to capture critical information describing interactions of social-ecological rangelands systems. Complexities of the biophysical system are rivaled by those of social systems and several knowledge sources exist to interpret interactions among them. Emphasis on biophysical drivers must be paralleled by emphasis on social drivers because their interactions influence monitoring outcomes (modified from Stafford Smith et al. 2007).*

Stakeholder involvement is important because they represent the individuals and groups that are affected by or are likely to affect a proposed management action, and thus will influence the acceptance and application of monitoring outcomes. In addition, if social learning is a goal of monitoring, it can only be achieved by involving multiple stakeholders in the monitoring process, especially the design and interpretation phases. At its best, collaborative, adaptive ecosystem management leads to multiple-loop social learning; that is, learning that transcends new information about cause and effect relationships or management effectiveness and inspires participants to question underlying ecological or social assumptions, and the values, norms and governing institutions that support them (Keen et al., 2005, Fernandez-Gimenez et al., *In Review*). This type of learning has the potential to profoundly influence human behavior and social relationships and it may very likely be required to modify current resource use patterns that threaten ecosystem resilience.

Recommendations for an Integrative Monitoring Framework

How do we reconcile our commitment to science-based monitoring with the need for greater stakeholder involvement and increasing integration of local, professional, and scientific knowledge? The answer partially resides in a mutual commitment to collaborative learning and action by managers, scientists and other stakeholders to promote social-ecological resilience (Walker et al., 2004; Reynolds et al., 2007). Participants must collectively identify the proper scales and assessment procedures that provide information concerning the sustainability of ecological resilience and ecosystem services. In addition, participants must effectively incorporate social complexity into current models focused on the biophysical complexity of rangeland ecosystems. Monitoring must be understood as one critical element in the larger cycle of collaborative adaptive management (Figure 2). In this process multiple stakeholders, including land owners, ecosystem managers and scientists, work to define and assess the system of interest, establish management goals, identify alternative strategies for achieving goals, and design a management strategy and associated monitoring approach that will determine whether goals are being met and decrease uncertainty about the system's behavior and responses to management. Monitoring information can then be collected, analyzed, interpreted and applied to future decision-making. Monitoring critical linkages within social-ecological systems will provide more robust information to inform management recommendations and policy decisions than focusing on biophysical systems alone.

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Information technologies for rangeland monitoring : what is available and what will be available in the future ?

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Key points : We discuss technologies and the systems associated with them that can enhance decision making by rangeland managers . We focus on technology and systems that are publicly available to assist land managers as opposed to those used in research arenas . Technology can provide data that allows informed management decisions across large scales and more repeatably through time . We discuss three groups of technologies and information management systems : (i) technologies to acquire spatial information (e .g . remote sensing) and the software that turns that data into useable management information ; (ii) technologies for remote control and management of infrastructure , livestock and natural resources (e .g . telemetry , automatic drafting systems) ; and (iii) information systems for planning and reporting at larger scales and at typically governmental levels of decision making .

Key words : monitoring , technology , satellite , remote sensing , telemetry

Introduction

This paper outlines the extant and emerging technologies that support rangeland managers' information of current patterns , trends and thresholds . We focus on systems of technology and the outcomes that are achievable with them rather than the technologies themselves . A primary reason for developing technologies and using them is so that managers have information on which to make decisions more precisely and more accurately in time and space . Spatial and temporal precision is becoming increasingly necessary for several reasons . As rangeland landscapes change due to human use and longer term climate change , critical thresholds of change need to be detected and managed (e .g . environmental change , or animal condition) . Running a profitable business in the 21st century requires that livestock are marketed effectively and that business costs are managed precisely . Finally , a rangeland production system is an interrelated system of performance of livestock set against the background of climatic variability , fluctuating market prices , and spatial variability of relatively large land holdings . Markets aside , pastoral land managers need better ways of capturing and integrating information about land and livestock condition when , currently , contact with these can be infrequent and not comprehensive .

Traditionally , monitoring of rangelands landscapes has occurred for livestock production (cattle , sheep , goats , camels , yaks , etc) . Animal growth rates , condition , and reproductive output are all constantly assessed along with environmental conditions . The experienced eye of a pastoralist integrates current information with his or her accumulated knowledge of environmental trends and responses to make management decisions . However , increasingly managers are experiencing forced change to the production system (costs of production affected by environmental certification , rising fuel prices , animal safety concerns , consumer trends) or scale at which it is operated (changing economies of scale) . Under such trends , other sources of expert data are useful to supplement personal observations . Technological advances have provided data that allows more precise management of enterprises in many sectors (e .g . dairy , wine , transport industries , supply chain logistics , and agriculture) . Rangelands pastoral enterprises have been slow to adopt new technologies that could bring more precision and hence efficiency gains , and yet they operate on scales and in environments where technology can make a substantial difference to profitability .

As well as technologies for monitoring , society (through governments) requires that land use is sustainable . A higher-level synthesis of information is thus required to understand change , why change is happening and what its implications are . Not all monitoring done at enterprise or regional scales can be scaled-up to larger scales (e .g . biodiversity) and the challenge for reporting at large scales is being actively tackled . As the final part of this paper , we report on some of these national-level reporting systems .

In this paper , we present technologies and the systems associated with them that can enhance decision making by managers . Much of what we discuss is technological application that is under development and therefore not well publicised . While we have attempted to find examples from many countries , the reality is that most examples are drawn from our knowledge of developments occurring in Australia .

How and why monitoring data are acquired and used

Technologies discussed in this paper provide increased amounts of data and have the potential to improve management precision . In some cases raw data are directly interpretable for management decisions : Is a remote water pump running and does it need checking, yes or no ?" In other cases the technology supplies huge amounts of data that must be analysed to extract management information. There are three broad ways in which information from technology is useful: (i) greater environmental safety, (ii) reduced costs of operating, and (iii) increased productivity, hence profit". These three areas are applicable to the wide range of uses that rangelands are subject to, including livestock production, conservation, cultural homelands, and lifestyle living, and they can operate at several scales. We organise the wide range of technologies and information management systems into three groups set out below: (i) Technologies to acquire spatial information (remote sensing, e.g. digital satellite images showing vegetation cover), (ii) Technologies for remote control and management of infrastructure, livestock and natural resources, and (iii) Information systems for planning and reporting. In the examples below, we focus on the systems that are being developed for application with managers rather than those that are research tools.

Technologies to acquire spatial information

Satellite imagery has long been used by researchers and government agencies. Cost of acquisition, training and the sophistication of computer hardware and software needed to make use of satellite imagery has limited its use by rangeland managers. However, there are emerging trends now to open up the use of satellite imagery for regular monitoring of the vegetation resource. These trends are driven by the availability of inexpensive sources of satellite data (especially MODIS-see below), and development of tools that convert satellite data into useful management information, and that bring that information to managers. Satellite data, suitably processed so that useful management information is drawn out, is mostly used for the purpose of managing for environmental safety through assessment of rangeland condition and trend (e.g. Bastin et al. 1993), and biodiversity patterns (Salem 2003). However, as remote sensing information is made more available to managers, its uses will expand to increase productivity through the precision it can bring to understanding forage availability and forage quality (through greenness) and the rate of change in these.

Satellite data have been improving in spatial resolution, increasing in variety and generally decreasing in price. MODIS currently provides the satellite data of choice for monitoring vegetation and land condition on large properties (see http://modis.gsfc.nasa.gov/, accessed 5/1/2008). Pixel size varies between ~250-m and 1-km. Spectral bands cover the visible and near infrared wavelengths allowing derivation of several vegetation indices and image capture is daily. Significantly, images are free to access. MODIS (and other satellite data) is extremely useful for rangelands monitoring because it regularly covers larger areas than is possible by managers with direct surveillance (e.g. by car, helicopter, aeroplane), and can link to historical archives (to the mid 1970s) so that trends through time can be analysed.

Apart from MODIS, there are now sources of archival digital satellite imagery available at relatively low cost that can potentially assist land holders in managing their natural resources. For example, the Australian Greenhouse Office has made its rectified and radiometrically calibrated archive of Landsat TM and MSS data available such that one year's imagery for all of Australia can be purchased for less than A$1,000 (see http://www.ga.gov.au/acres/prod ser/agosuite, jsp, accessed 6/1/2008) While such purchases are mainly in the realm of government, it is feasible for pastoral companies (or their advisers) to obtain archival imagery showing historical changes in cover due to seasonal variation (e.g. drought), land degradation (erosion or woody thickening) or management practices (fire, changed water-point locations, subdivisional fencing, etc).

Google earth (http://earth.google.com/) is another free source of remote sensed information that may well be useful for rangeland monitoring. At this stage most people's use of it is for looking at earth views, and we are not aware of analytical tools that assist pastoralists or other sorts of rangeland managers to understand changes, trajectories and thresholds. This may, of course, change rapidly in the future.

While inexpensive and potentially useful, satellite remote sensing data are not necessarily accessible to land managers because of the technical challenges of converting the vast amounts of data into useable management information. Privately owned and run holdings (as opposed to government) need this information because management decisions are made daily with limited spatial viewing of their properties, and potentially limited temporal records of historical treatments and trends. A number of approaches to developing software that processes satellite images into useable information have been instigated, though few are yet at a fully developed stage (i.e. commercial) in the rangelands. The approaches include:

Pastures from Space (http://www.pasturesfromspace.csiro.au). This system estimates the biomass of annual-based pastures during a reasonably regular growing season from remotely sensed data. Estimates of pasture biomass (or Feed On Offer") are combined with climate and soil data to produce estimates of pasture growth rate (Sneddon et al. 2001), which farmers can access through a web-based subscription. In many rangelands areas, spatial complexity of vegetation types, tree cover and highly variable growing seasons preclude the derivation of robust statistical relationships between remotely sensed estimates of vegetation cover and pasture biomass, hence other approaches are being developed (see below).

The AussieGRASS model (Rickert et al. 2000; Carter et al. 2003) simulates pasture biomass based on interpolated rainfall (in 0.05 degree grid cells), regionally appropriate pasture growth models and regional estimates of grazing pressure (see http://www.longpaddock.qld.gov.au/AboutUs/ResearchProjects/AussieGRASS/index.html). AussieGRASS products contribute to regional understanding of rangeland conditions, particularly with regard to drought declaration, and subsequent administration (see the National Agricultural Monitoring System, http://www.nams.gov.au/index.cfm?fa=nams.home, accessed 5/1/2008). The various rangeland jurisdictions have contributed to the development and testing of AussieGRASS products, and at this stage the information is largely used by government managers.

Of particular relevance here are Software tools that allow land managers to determine trends in vegetation cover over time, and to separate trends due to their management from those due to climatic variability are particularly useful. VegMachine (http://www2.dpi.qld.gov.au/sheep/12979.html, accessed 6/1/2008) allows Australian pastoralists to view temporal sequences of imagery for areas of interest, but more importantly, generates maps showing areas with positive, neutral and negative trends in cover. Spatial patterning in these maps can then be interpreted with regard to land type, recent seasons and management actions. Trends in cover can also be viewed graphically. In a similar project, MODIS data were processed in conjunction with wool-producers to show contemporary trends in green cover at paddock, whole property, and regional scale (Bastin el al. 2006). The additional information available from remote sensing was welcomed by pastoralists, and web delivery was endorsed. As with VegMachine, the tools have not yet been made available commercially.

Fire monitoring through remote-sensed information (MODIS and NOAA AVHRR) is becoming a major tool for pastoralists in fire-prone areas. In Australia, Sentinel (http://sentinel1.ga.gov.au/acres/sentinel/index.shtml; and http://www.firenorth.org.au/nafi/app/init.jsp) provides up-to-date information about where fires start and how they are progressing so that suppression actions can be taken.

The use of remote sensing to identify weed infestations in agricultural and non-agricultural land allows for greater precision and accuracy specific to the problem areas. The use of remote sensing technology can also result in weed infestations being identified and eradicated in a shorter time frame than previously available (Shaw 2005). Once again, the use of remote sensing in this case is in the domain of government and quasi-government agencies, rather than enterprise managers.

Humanitarian organisations are also using data collected through remote sensing satellite imagery to monitor and assess the extent of current conflicts. Amnesty International's *Eyes on Darfur* uses commercially-available high resolution satellite imagery" (http://www.eyesondarfur.org/satellite.html) to survey villages, identifying destroyed huts, water storages and the presence or absence of livestock as indicators of raids or attacks.

Technologies for remote management and control of infrastructure, livestock and natural resources

Several areas of technology are relevant to this topic: telemetry systems that bring information about remote infrastructure back to the station house, and in turn relay control instructions back to remote equipment; and automatic identification systems that record the identification of individual animals or the type of animal and information about their status as they pass control points. Generally these technologies are being developed for their ability to reduce cost of production and for the increased productivity that can be gained per animal.

Telemetry refers to radio frequency transmissions from one point to another. Telemetry is increasingly useful in rangeland situations for monitoring infrastructure and livestock that are distant from the station house on a frequent basis without the need to drive to that point to visually inspect the situation. An example of the early use of telemetry has been the use of Ultra High Frequency (UHF) radios to transmit information about the level of water in a water tank and start or stop pumps (e.g. http://www.observant.com.au). When this information is transmitted back the station house, it reduces the number of times that a person has to visit a watering point, thus saving on the costs of labour and transport and freeing employees to do other tasks. Such systems can link dozens of remote water points back to the station house via repeater links and eliminate thousands of kilometres of driving per year. Recent work has shown that the cost of these systems is often recovered in less than 12 months due to substantial savings (Ashley et al. 2008).

Future advances in this area will be the use of WiFi and WiMax (IEEE 2007) radio frequencies in place of UHF to allow the transmission of greater volumes of data. Wireless broadband transmission protocols will allow pastoralists to install video cameras and other bandwidth-intensive remote devices for more comprehensive information (see below).

The ability to remotely identify individual animals greatly increases management options available for conservation or production purposes. Radio frequency identification devices (RFID) are now widely used in many animal production systems as a response to consumer requirements for traceability of products. RFID add to the cost of production but increasingly are required as part of a regulated livestock management system to gain access to markets. Producers can capture additional management information once individual identification is possible, such as semi-regular recording of live weight (see below). The remote monitoring of wild animals using global positioning systems and radio or satellite transmitting devices (www.lotek.com) is also possible, but as far as we are aware this usage of technology remains in the research domain and is yet to become a tool for management in commercial operations.

Apart from reducing costs as noted above for telemetry , precision information about where animals are located and how they are performing through time has the potential to increase productivity . Combined with the next generation of telemetry , these systems can gather and store or transmit information such as an animal's unique identification number (from RFID tag) and its live weight via Walk-over-Weighing (WoW) scales (http ://www .sheepcrc .org .au/index . php ?id=143) The advantage of gathering this information daily (or thereabouts) at the station computer is that trends in weight gain can be tracked and forward selling of livestock achieved with more precise estimates of weights by a certain time . In parallel development with WoW is remote automatic-drafting apparatus . Animals that have been identified as varying excessively from expected weights (or identified for other reasons) can be drafted to a holding pen by transmitting a list of ID tag numbers to the auto-draft controlling processor , where they can be medicated , supplemental fed , transported or managed in other ways . While these integrated remote animal monitoring and management systems are under development , their usefulness to pastoral managers will require the development of software that turns large amounts of data into useful management information .

The incorporation of machine vision into monitoring represents a significant increase in the level of management that can be applied to a landscape including identification of feral animals and weeds , the condition of pasture and the health of animals . This is particularly important in places where a variety of grazing animals compete with domestic livestock for water and forage , and predators are a problem . Remote video identification of the species combined with auto-drafting will enable the separation of economic species from non-economic ones , thus improving productivity , although the system is still under development .

Spatial location information from Global Positioning System receivers is being used to develop the concept of virtual fencing whereby animals are contained to areas without the need for wire . This is achieved through programming coordinates into a collar which livestock carry , and cueing livestock to respond to (or shy away from) the virtual boundary by audio and electroshock cues (http ://www .ars .usda .gov/Main/docs .htm ?docid=5564&pf=1&cg _ id=0) . These systems are not yet widely used in commercial operations .

Information systems for planning and reporting

We have focussed on those technology solutions that are aimed at managers (rather than researchers) and made reference a number of times to the need for tools that process data into useable information . In this final section we briefly discuss systems that allow disparate monitoring to be collated for high-level reporting . These systems are generally needed at higher government levels so that obligations to manage resources on behalf of the citizens of a state or country and the global community can be discharged . Such obligations usually involve conservation of biodiversity and sustainable use of rangeland resources , but also cover climate monitoring and forecasting services .

Systems such as the Australian Collaborative Information System (ACRIS-http ://www . environment . gov . au/land/management/rangelands/acris/index .html , accessed 6/1/2008) aim to facilitate data collection and documentation for reporting on regional and national changes in the rangelands . This system is well underway and reported on in a separate paper presented at this meeting (Friedel et al . 2008) . ACRIS gathers data from state governments to periodically provide updates on change at broader scales . Improved management of natural resources at the enterprise scale should translate to improved regional and national outcomes .

In the last decade , climate status and forecasting systems have been developed to give seasonal context and expected direction of change . Examples include :

- The Australian Bureau of Meteorology and Queensland government climate forecast web sites (http ://www .bom .gov .au/silo/ ; http ://www .longpaddock .qld .gov .au/SeasonalClimateOutlook/) .
- The US government SCAN network provides data and interpretation based on climate variables , soil moisture , snow conditions , and biomass (http ://www .wcc .nrcs .usda .gov/scan/) .

Conclusions

We have summarised how technologies and systems of data management are being developed to assist rangeland mangers . We shy away from technologies per se and focus on those technologies that are being used in conjunction with systems that turn data into useful information for management decisions . Much of the technological development in the research domain has not yet been brought to this management end point . We have organised the paper around the concept of precision pastoralism having more spatially and temporally precise management information-and we divide the technologies and systems reviewed into three categories : technologies to acquire spatial information (repeatedly through time) , technologies for remote control and management , and information systems for planning and reporting .

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Can pastures from Space™ accurately predict pasture growth rate in eastern Australia ?

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Key words : Pastures from Space™ , satellite , pasture growth rate

Introduction Pastures from Space™ provides a commercial service delivering weekly satellite-derived pasture growth rate (PGR , kg dry matter/hectare .day) data at a paddock scale to farmers across southern Australia . PGR has a number of on-farm applications , including aiding decisions on grazing management , feed budgeting and tactical application of fertiliser , benchmarking pasture performance and strategic farm planning . The service , developed and commercialised in Western Australia for annual-based pastures , has been taken up by farmers in that state who have since demonstrated increases in productivity and profitability for their grazing enterprises (Gherardi *et al* ., 2005) . There has also been keen interest in the technology in eastern Australia , however uptake has been limited due to the PGR predictions not having been validated for these regions . This project was therefore testing the accuracy of the satellite-derived PGR for South Australian soil and pasture conditions as the initial steps in validating the technology for eastern Australia .

Materials and methods Pastures from Space™ PGR is calculated from satellite-derived normalised difference vegetation index (NDVI) to derive the fraction of absorbed photosynthetic active radiation , intersected with climate (rainfall and solar radiation) , temperature index and soil (water holding capacity) data . Thirty-three paddocks across 13 farms , spread from Karoonda to Mt Gambier in the South East of South Australia were selected as validation sites to provide a range of soil types (clay , loam , sand) and predominant pasture types (annual vs perennial pastures) , however data from only 2 farms (Figure 1) are presented . From the break of the season in April 2007 , feed on offer (kg dry matter .ha) was measured by calibrated visual assessment at monthly intervals at up to seven 1m x 1m exclusion cages geo-located across each paddock and used to calculate PGR for each cage site and provide a paddock average PGR . Satellite-derived PGR's were predicted for each paddock and compared to the paddock-measured values .

Results and discussion Satellite-predicted PGR's for annual pastures (predominantly medic and annual grasses) at the Karoonda site generally relahe Karoonda site generally related well to the paddock values (Figure 2) . In contrast , the satellite-predicted PGR's at the Lucindale site , 150km north of Mt Gambier (Figure 3) , generally underestimated PGR relative to the paddock values , with the perennial grass (*Phalaris aquatica*)-dominant pasture being underestimated to a greater extent .

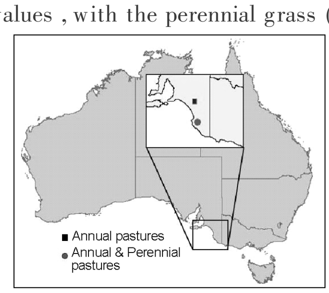

Figure 1 *Location of 2 of the test properties in the south east of South Australia (Karoonda and Lucindale) .*

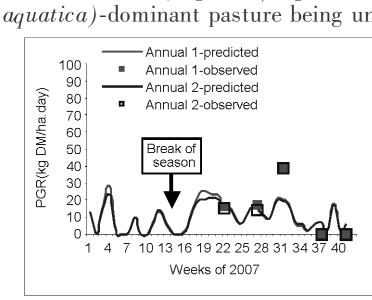

Figure 2 *Observed and model predicted PGR (uncorrected for soil type) for annual pastures at Karoonda .*

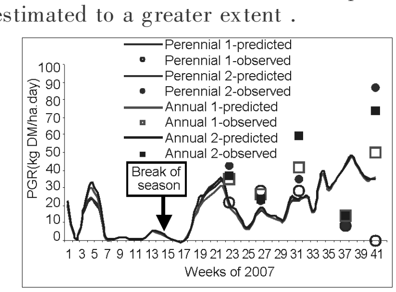

Figure 3 *Observed and model predicted PGR (uncorrected for soil type) for annual and perennial pastures at Lucindale .*

Conclusions Based on this limited dataset , there was a stronger relationship between satellite-predicted and paddock-measured PGR values for annual compared to perennial pastures . The relative contribution of pasture species and/or soil type to the poorer relationship for perennials is not currently known , however the importance of these factors will be clarified as further data is collected and analysed from this project . Appropriate modifications to the PGR model will be undertaken if required to accommodate the different pasture species , soil types and climatic characteristics encountered in south eastern South Australia , resulting in a more robust PGR model for eastern Australia .

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The regional ecology of alternative states and thresholds: strategies for ecological site descriptions

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Key words: ecological site descriptions, state-and-transition models, outcome probabilities

Introduction Land dynamics, ecosystem resilience, and the interaction of management decisions with them vary significantly across space. One-size-fits-all applications across distinct land types have been responsible for many failures in rangeland management. Ecological Site Descriptions (ESDs) and similar land unit classification systems specify the characteristics of different land areas associated with variation in rangeland potential, ecological dynamics, vulnerabilities, and monitoring needs. State-and-transition models (STMs) embedded within ESDs specify the plant community phases, alternative states, and characteristics of thresholds observed within particular land areas. In spite of considerable conceptual advances with regard to general STM structure and mechanisms, strategies for data-driven development of ESDs and STMs have been poorly developed.

Methods We use an empirical example from gravelly soils in central New Mexico, USA to outline a general approach to ESD and STM development that features 1) a hierarchical concept of rangelands and derivative inventory protocol that couples vegetation, climate, and soil sampling, 2) data collection at many points with varying levels of precision, 3) storage of data in a database to link soil, vegetation, and spatial location, and 4) statistical procedures and interpretations that emphasize how the occurrence of alternative states is related to soil and climate properties.

Results and discussion We found evidence to support the notion that the gravelly soils sampled comprise two distinct ecological sites (land units) featuring different vegetation dynamics. Low grassland resilience soils or soils featuring inherent dominance by shrubs occurred in soils with high carbonate content whereas high grassland resilience soils had low carbonate and high clay content. Restoration experiments were initiated to test our initial assumptions about grass recovery in these distinct land units.

Conclusions The linkage of region-scale inventory to expert knowledge and site-based mechanistic experiments and monitoring provides a powerful means for specifying management hypotheses and, ultimately, promoting resilience in rangelands. A major challenge is to systematize the linkage of multiple data sources in ESDs so that they can be evaluated and updated as new information emerges.

High resolution satellite imagery and GPS collars can help assist in the assessment of patch selection by grazing cattle in semi-arid savannas

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Key words: Patch type, Wambiana grazing trial, *Bothriochloa*

Introduction The selection of different patch types for grazing by cattle in tropical savannas is well documented. Advances in high resolution satellite imagery and computing power now allow us to identify patch types over an entire paddock, combined with GPS collars as a non intrusive method of capturing positional data, an accurate and comprehensive picture of landscape use by cattle can be quantified.

Material and methods The study was conducted over the Wambiana grazing Trial (20.54S, 146.14E, average rainfall 650mm, open savanna) (O'Reagain, Bushell et al. 2007). Patch types were identified using a previous study (Table 1).

Table 1 *Description of the different patches and the proportion of patches within each treatment.*

Patch Name	HSR%	LSR%	Description
2P	2.69%	2.55%	Perennial palatable grass species', Enteropogon sp, Sporbolus sp
Bothriochloa sp	14.61%	29.44%	Perennial palatable productive (3P) grass
Annuals	9.66%	10.05%	Annual grasses, mid to low palatability
Aristida sp	11.27%	8.34%	Tough unpalatable perennial wiregrass
Bare	5.42%	2.20%	Bare through all seasons, very small amount of annuals in wet season
Chrysopogon sp	10.80%	9.38%	Perennial palatable low bulk produced
Carissa sp	20.24%	15.70%	Thorny encroaching shrub
Eriachne sp	9.09%	7.29%	Tough unpalatable perennial long lived wiregrass
Eriachne sp/ Heteropgogn sp	2.11%	0.93%	Eriachne patch with a moderate proportion of H.contortos (perennial palatable productive)
MT Annuals	4.72%	4.01%	Annuals on top of stony/salty clay mounds
MT *Bothriochloa sp*	2.05%	2.13%	Low density of Bothriochloa & annuals on top of clay mounds
MT *Carissa sp*	2.31%	2.54%	Carissa on top of stony/salty clay mounds

High resolution satellite images were acquired for Dec 2005 and Feb 2006 and combined. A supervised classification for approximately 300 predefined training regions over the study site was run using ER mapper© (2007). Archival GPS collars were fitted to 6 cattle in each of the heavy (HSR) and light (LSR) stocked treatments for approximately 12 weeks during Jan and March 2005. GPS positional data was collected every hour from a minimum of 4 satellites. The GPS data from the two animals with the most number of fixes per treatment was used in the analysis. Animal activity was classified into a grazing or resting phase. Only the grazing phase was analysed using Jacob's index of selectivity to determine avoidance or selection of patch types.

Results and discussion Animals in the HSR positively selected for patches dominated by *Bothriochloa sp* and annual grass patches, and avoided *Eriachne sp* and bare patches in the wet season of 2005 (Figure 1). The light stocking treatment animals selected for annual and *Eriachne sp* patches and avoided mound top Annuals and *Eriachne sp/Heteropogon sp* patches. The heavy stocked animals selected the annual patches because of the high availability of green feed and high digestibility. *Bothriochloa*, patches produce the bulk of the forage available in these land types. The high number of animals in the HSR and smaller proportion of *Bothriochloa* patches available means that animals had to actively select them to ensure a sufficient grass intake. The LSR animals selected annual patches to maximize their green feed intake. The LSR are selecting the *Eriachne sp* patches to graze a number of abundant forb species which only occur in the early and mid the wet season, these forbs have a relatively high proportion of protein (unpublished data). The LSR are able to selectively graze these forbs despite their low bulk, due to the higher proportion of *Bothriochloa sp* patches available throughout the paddocks, which will meet its nutritional requirement for bulk.

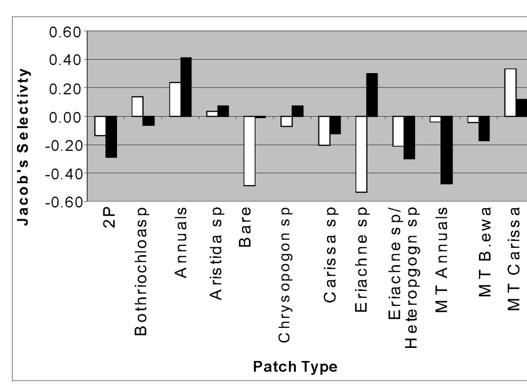

Figure 1 *Jacobs selectivity index for different patch types under heavy (□) and light (■) stocking treatments.*

Conclusions The heavy and light stocking treatments selected different patch types to actively graze. Animals in the LSR are able to select a diet based on quality, where animals in the HSR are constrained by the available bulk within a patch. The high resolution satellite imagery combined with GPS collars gave us new insights into how these cattle are using this landscape.

A model-based approach for mapping rangeland cover using landsat-TM image data

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Key words: biophysical variables, Iran, landsat-TM, multiple regression, rangeland

Introduction Empirical models are important tools for relating field-measured biophysical variables to remote sensing data. Regression analysis has been a popular empirical method of linking these two types of data to estimate variables such as percent vegetation canopy cover, and bare soil. The goal of this study is to find a relationship between Landsat-TM original data from single date image and rangeland biophysical variables using multiple regression modeling.

Materials and methods This study was conducted in semi-arid rangelands of Kolanjin River Basin, 120 km west of Qazvin city (35° 24′ 16″to 35°38′26″N latitude and 49° 24′48″ to 49° 31′ 48″ E longitude). Total area of study site is 17654 ha. Average annual precipitation is 345 mm over the past 30 years.

Field measurements of land cover attributes were taken within a month of the satellite image data acquisition. Vegetation cover, gravel and stone, and bare soil extent as biophysical variables were measured during field survey. Stepwise multiple regression was used to develop the most appropriate statistical models for prediction of rangeland cover based on ground based data and landsat-TM image data. In the given dataset independent variables which have had high significant correlation with dependent variables (field data) were recognized. Ultimately separate regression models were developed for all variables. Then, regression models were applied to produce vegetation cover, stone & gravel, and bare soil extent maps of rangelands. Validation of the model was done using the 20 transects measurement not used in the model development.

Results and discussion The results of applying stepwise multiple regression showed that there is a significant correlation between Landsat TM band 2 reflectance values and field data. There were no significant correlations between other bands and field data. Regression models were produced according to the output of regression analyses and were applied only on rangelands in Landsat TM band 2. The relevant maps were generated for vegetation cover, gravel & stone, and bare soil extent. Preliminary validation of the models in this study suggests that multiple regression is a nonrobust technique for finding relationship between original data of Landsat-TM and rangeland biophysical variables.

We observed some problems such as small size of samples, low number of samples, and sampling on the specific areas are main reasons of producing nonrobust models. Fitzpatrick and Megan (1994) noted that when we use regression analysis to find a relationship, sampling must include the entire range of vegetation cover changes (sparse to dense). Field sampling is based on limited discrete sampling over a continuous spatial dimension. This leads to a blind extrapolation when information concerning unsampled areas is requested. Models were based on a relatively low number of plots, which were perhaps not sufficient to characterize all environmental conditions.

Conclusions We concluded that such problems as an inexact location of field samples on the image, small size of samples, low number of samples, sampling on the specific areas, vegetation heterogeneity may significantly affect modeling of real rangeland-Landsat-TM relationships. If we overcome to these problems, better correlations would be expected (as models would be more widely predictive).

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Remote sensing with GIS and GPS for monitoring steppe degradation

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Key words: GIS, GPS, satellite remote sensing, steppe degradation, Xilingol steppe

Introduction Mr. Xu, the Director-general for the Science and Technology Agency of Inner Mongolia, expressed that the desertification area in China is increasing at 2460km^2 per year. The most important procedure to prevent steppe degradation is to discuss and share the information about steppe conditions with decision makers and herders in a timely and exact manner. The objective of this paper was to review our methodology for monitoring degradation in an experiment in the Xilingol steppe, Inner Mongolia.

Methods How can we grasp the present and future states of grasslands? Grassland conditions are determined by the balance of grass production (GP) and herbage intake (HI) by animals. When HI is higher than GP, grasslands will be degraded. However, if the GP is greater than the HI, grasslands will be conserved and the land will recover (Akiyama and Kawamura, 2007). GP may be regulated by soil fertility and topography of the area, and pasture management and climate conditions of each year. HI will be affected by grazing intensity, animal behavior, and animal management. Geographic information systems (GIS) will be helpful for this type of analysis. This system is intended for real-time monitoring of GP and HI using satellite data, GIS, global positioning systems (GPS) and mathematical models.

Results (1) *Changes in grassland type*: Comparing time series of Landsat data between 1979 and 1997, it was determined that the areas of productive Meadow steppe decreased and croplands and low productive Typical steppe were increased (Akiyama et al. 2003). (2) *Biomass change*: Seasonal and yearly changes of steppe biomass could be shown by composite images of NDVI derived from NOAA and MODIS (Kawamura et al. 2003). (3) *Herbage quality*: Kawamura et al. (2005a) found that MODIS/EVI estimates crude protein concentration in the green biomass. Seasonal changes in quality was detected. (4) *Animal behavior*: Daily traveling distance, location and animal movement was estimated by attaching a GPS monitor to sheep (Kawamura et al. 2005b). (5) *Real-time monitoring system*: GIS database consists from 3-D topography derived from ASTER image, biomass and forage quality maps obtained by MODIS, grazing information by GPS on the sheep, from which we can build a real-time steppe management system.

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Verification of a forage simulation model used for a livestock early warning system in the Gobi Region of Mongolia

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Key words: drought, Mongolia, forage monitoring, NDVI, cokriging

Introduction The assessment of vegetation productivity is especially important in Mongolia where drought and winter disasters (dzud) that deplete vegetation resources represent a major risk confronting herders. During the period from 1999 to 2001, as much as 35% of the nation's livestock was lost to these two disaster events. To help address these challenges to livestock production in Mongolia, a livestock early warning system was implemented with the objective of developing a forage monitoring system that provides near-real time spatial and temporal assessment of current and forecasted forage conditions. As part of this effort, we sought to assess 1) the ability of the PHYGROW forage simulation model to accurately predict forage biomass at selected sites across the landscape using near-real time climate data, and 2) the feasibility of using geostatistical interpolation methods that combine forage model output with Normalized Difference Vegetation Index (NDVI) to produce landscape level maps of forage production.

Materials and methods Using the protocols described by Stuth *et al*. (2005) for implementing livestock early warning systems, 297 monitoring sites were established in 8 provinces in the Gobi region of Mongolia during May 2004 to September 2007. During the first visit to each site, vegetation, soil, and grazing data were collected to parameterize the PHYGROW forage production model (Stuth *et al*. 2005). PHYGROW was driven by near real-time climate data acquired from the National Oceanic & Atmospheric Administration's (NOAA) CMORPH system (Joyce *et al*., 2004). To verify the PHYGROW model, forage biomass was collected at each of the monitoring sites 2 to 4 times after the initial visit. The clipped biomass was statistically compared to the predicted biomass from PHYGROW. For validated sites, the forage model outputs were coupled with NDVI data using the geostatistical method of cokriging to create interpolated maps of forage biomass. Cross validation (Isaaks and Srivastava 1989) was used to assess the performance of cokriging for mapping biomass.

Results For the majority of the monitoring sites, we found a very good correspondence between forage biomass clipped at the monitoring sites and that predicted by the PHYGROW model ($R^2=0.69$). The standard error of prediction for the validation was 83.6 kg/ha which was less than the overall standard error associated with the clipped biomass (115.3 kg/ha) indicating that the variability associated with validation was much less than the variability of the field collected data across all sites. The model had a tendency to slightly under-predict at higher biomass and slightly over-predict at low biomass conditions.

Maps of forage biomass were produced every 15-16 days (to match the NDVI image availability) during the growing season (May to September) for 2005 and 2006 using cokriging. The cross validation of model-predicted forage biomass and the cokriged estimates of forage biomass resulted in reasonable estimates of mapped biomass ($R^2=0.71$). The standard error of prediction for cross validation was 111.74 kg/ha which was very similar to that seen for the clipping data (115.3 kg/ha), indicating that the cokriging procedure variability was similar to that encountered with the field clipping data.

Conclusions The results of this study indicate that the use of the PHYGROW forage simulation model would be useful for predicting forage biomass on a near real-time basis in the Gobi region of Mongolia. The forage model output, when combined with NDVI using geostatistics, results in the production of reasonably accurate maps of forage biomass. These maps provide both a spatial and temporal assessment of forage conditions that can assist herders, as well as local and regional governments, in decision making for livestock in the face of drought or winter disaster.

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National rangeland monitoring and inventory of Iran

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Key words: monitoring, vegetation cover, site, satellite data

Introduction Information for sustainable utilization of rangeland requires accurate and frequent range assessment. Such information will be obtained from monitoring in the long term (Watson 2007) which is important for government agencies, range holders and application of remote sensing (RS) and geographic information systems (GIS). Changes in quantitative parameters, including abundance, vegetation composition, canopy cover and yield, are influenced by climatic conditions and management activities (Arzani and Abedi 2006). So distinguishing and separating these is important for better management (Anderson and Holte, 1981). The objective of this research was to investigate variation of vegetation parameters in the long term and to determine trend and severity of changes.

Materials and methods Main vegetation communities of 17 provinces were considered. In the key area of each community one site was established. Factors including vegetation cover, density, and production along four-400 or six-200 meter transects within 60 two or one square meter quadrats in arid and semi arid areas were measured. Satellite data collected simultaneously to field data was applied.

Results and discussion Primary results showed that in arid regions, range ecosystems are in fragile condition. They were characterized with low vegetation cover and small production (Figure 1). Desirable species were absent in vegetation composition. Biological balance has been lost because of severe grazing. Range condition in semi arid rangeland was better than arid areas. Moderate species were dominant and vegetation cover percentage and yield was higher (Figure 2). Integration of field data and satellite data for a period of five years indicated the possibility of range assessment in wide areas using digital data.

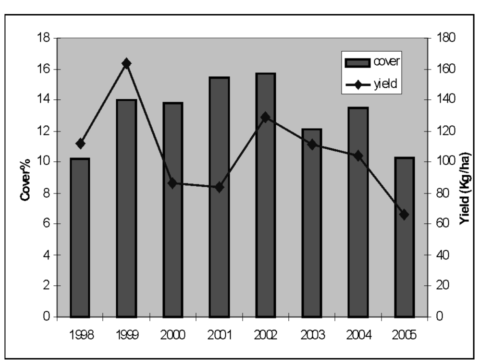

Figure 1 *Variation of canopy cover and yield in arid rangeland of Iran (1998-2005).*

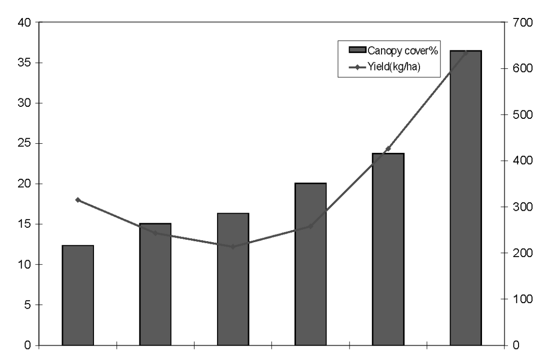

Figure 2 *Variation of canopy cover and yield in semi-arid rangeland of Iran (1998-2005).*

Conclusions Range assessment in wide areas, with the assistance of digital data is possible. A national monitoring system (NMS) for national data analysis collected in different years and various regions is suggested by the study.

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Application of digital data for grassland monitoring in northern Iran

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Key words : remote sensing, vegetation cover, production, vegetation index.

Introduction Rangeland resource management is dependent on increasing scientific capability and remote sensing can contribute information for range management applications (Tueller, 1989). The capability of remote sensing for providing information of changes in cover and biomass has been discussed by previous authors (eg. Arzani 2005). Selection of suitable vegetation indices was the objective of the present study.

Material and methods Simultaneous digital and field data of summer rangeland south of Mazandaran, were analyzed. During 3 years of monitoring, annual grass, forb and shrub cover, and total yield data of sixty 1 m^2 plots were collected. After correction of images, digital numbers were converted to reflectance numbers. Intrinsic indices, soil-line related indices and atmospheric corrected indices were generated. Suitable indices were determined using linear regression.

Results and discussion There were significant relationships between digital data and vegetative characteristics. Among indices VI_{10} with annual cover, VI_6.VI_{10}, $MIRV_1$ with grass cover, Pd_{312}, VI_9, $MIRV_1$, GVI indices with forb cover, $MIRV_2$, VI_6, VI_{10} with shrub cover, VI_{12}, $MIRV_2$, VI_5, $fuse_2$ with total cover and $MIRV_1$.$MIRV_2$, VI_5, Tgr with total production, showed significant relationships in different sites (e.g. Table 1 for the site in Vaz rangeland). Jackson *et al*. (1983) argued that an ideal vegetation index should have the characteristics of high sensitivity to vegetation, insensitivity to soil background changes and be only slightly affected by atmospheric path radiance.

Table 1 *Correlation obtained between vegetation indices and vegetation parameters in Vaz grassland.*

Vegetation parameters	Vegetation indices	Correlation	Regression equation	Correlation coefficient (R)	SE	Significant level
G. cover%	$MIRV_1$	49	$28+263MIRV_1$	0.89	3.30	**
F. cover%	$MIRV_1$	51	$19.3+129MIRV_2$	0.58	5.40	**
S. cover%	VI_6	75	$-22.5+50.8VI_6$	0.74	1.10	**
T. cover%	VI_5	81	$174-125VI_5$	0.92	9.20	**
T. yield kg/ha	VI_5	82	$75-55.7VI_5$	0.82	1.30	**

** Significant at $P<0.01$, G=Grasses, F=Forbs, S=Shrubs, T=Total.

Conclusions Generally, introduced indices, presented accurate estimation of the quantitative parameters. Therefore, it is possible to estimate cover and range production for range monitoring using Landsat ETM^+ data.

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21st Century Pastoralism—Remote management innovations for sustainability in arid rangeland pastoral production

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Key words: arid rangelands, pastoral production, remote management, sustainability

Introduction Beef production in Australia's arid rangelands occurs on extensive properties with an average size in excess of 3800km^2 and stocking rates of 1 head to the square kilometre or less (Oxley et al 2006). Paddock sizes are large (>300km^2) and typically have two to four watering points in the form of bores. Normal management involves physical inspection of watering points 2-4 times per week and requires pastoralists to travel 200-700km per inspection. This project is developing and testing technology to remotely monitor the watering point (water levels, flow rates, animal activity etc.) reducing the need for a physical inspections to once a week, achieving improved water management coupled with reductions in fuel and labour costs

Materials and methods The remote management technologies being investigated for this study are commercially available telemetry systems which collect information and transfer it using UHF radio up to 70 km to another location. The data being collected to assess these systems includes the cost of purchase and installation, cost of water monitoring pre and post installation and the effectiveness and reliability of the equipment. Data is also being collected to quantify the time and distance savings resulting from the telemetry installations. Five properties are involved in the study and are summarized in Table 1.

Table 1 *Properties included in the study.*

Station	Size km^2	No. Remote Management Technology water points / Total	Remote Management Technology Cost	1st year indicative saving	Cost recovery period
Napperby	4452	14 / 29	$80,000	$39,000	24 months
Mt. Ive	852	7 / 14	$25,000	$35,000	8.5 months
Monkira	3730	10 / 10	$40,000	$25,000	18 months
De Rose Hill	1800	4 / 31	$25,000	$0	N/A
Quinyambie	12119	11 / 32	$36,000	$73000	6 months

Results and discussion As Table 1 shows, in most cases the repayment period for the technology is less than two years, and in the longer term remote management is likely to increase the profitability and economic sustainability of the stations. De Rose Hill station has not yet achieved any cost savings as the remotely monitored watering points are located on the route to other watering points that still need to be inspected, resulting in no reduction in distance travelled. All stations in the study have increased the number of times that they monitor their watering points, It is also likely that the producers will be able to use the time saved through this technology to improve other aspects of their station management. Further data is being collected on the time savings to quantify these benefits. The collection of data on reliability of the technology under the harsh climatic conditions of Central Australia is also ongoing.

Conclusions Remote management technology can be utilised in arid rangeland pastoral production systems to reduce the cost of production. Furthermore, remote management technology can allow for increased monitoring of stock watering infrastructure leading to better production and animal welfare outcomes.

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Localization of range improvement plans using GIS and comparing with suggested projects of range management plans in Lar region

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Key words: rangeland reclamation, rangeland plans, Geographic Information System, Lar, environmental factors

Introduction One of the major causes of land degradation in Iran is overgrazing by livestock (Moghaddam, 2001). In order to have a proper management in rangeland ecosystems, ecological factors in nature should be understood. Ecological factors include climate, soil, topography, vegetation and organisms. Present range development programs are based on curtailing the conservation of range land, improving forage production by seeding or transplanting forage species under scientifically sound range management plans.

This study was carried out to obtain an approach for designing range management plans through Geographic Information System (GIS), to make the planning process quickly with accuracy.

Material and methods In this research, some ground information including slope, elevation, vegetation, soil, range trend and condition were recorded. Based on integration of these information with the basic consideration of resource management it is possible to improve the existing condition or stabilize the current optimum state. While the new model is ready, then the new and old model should be compared. Based on the results of this method, the GIS integrated model could help us to achieve the information more convenient and quickly. Clarification is an other attribute of this model. The management of rangeland would be better as well. Information of the basic studies would never been lost during integration. Correction of errors would be done quickly as well. Finally these aforementioned items, would lead to higher accuracy.

Results and discussion Result of this study, which was performed in Lar rangelands, showed that the total area of rangeland which should be managed in balance method is 7805 ha. The area to be managed in natural method is 4998 ha, the area to be under enclosure is 2916 ha, the area to be seeded is 6579 ha, the area to be inter seeded is 6269 ha, the area to be hoe sowed is 2925 ha and the rest is rocky, river and farmland. Comparison of suggested plans for range management projects with results of this study (through integration of information using GIS) indicates that some suggested plans are not corresponded with Lar rangelands ecological condition and needs to be revised.

Regarding the results obtained from this research, when information layers such as soil, climate, vegetation, topography, ... are used and considering plan suggestion indices, range improvement planning will be done with high accuracy.

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Developing a decision support tool for the steppe zone of Ghom-Iran , by implementing a state and transition model within a bayesian belief network

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Key words : qualitative knowledge , state and transition model , Bayesian Belief Network , Iran

Introduction Although State and Transition Models (STM) provide a description of rangeland dynamics , the typical descriptive flowcharts and associated catalogue of states and transitions lack practical application . They also handle uncertainty associated with transitions poorly . It is therefore clear that a mechanism is needed to convert these models into predictive models that can accommodate uncertainty associated with the nature of transitions . Bayesian Belief Networks (BBNs) (Jensen 1996) can be used to overcome this problem . The approach is based on BBNs , which are cause and effect models that relate variables through the use of conditional probabilities . This allows for uncertainty to be incorporated into the models . This paper describes the development of a rangeland decision support tool by combining BBN with STM for the Steppe zone of Ghom , Iran .

Materials and methods The STM was the starting point for model development . An influence diagram was built to show the possible transitions and the factors influencing each transition . Next , the influence diagram was populated with probabilities to produce a predictive model , and finally the behaviour of the model was tested using scenario and sensitivity analysis .

Results The STM consists of 7 vegetation states and 15 transitions . The sensitivity analysis revealed that grazing impact and growing condition were the two most important drivers of almost all but two of the transitions . Grazing impact represents the management influence on transition and growth condition represents the environmental influence on transitions . This result is supported by other studies in Iran , which suggest that frequent droughts coupled with mismanagement (e .g . overgrazing) combine to produce rapid land degradation (Nemati 1986) . This result , however , does not match the beliefs of governors or livestock managers . Most governors believe that grazing is the dominant factor responsible for rangeland degradation , while livestock managers believe that it is drought and growing conditions .

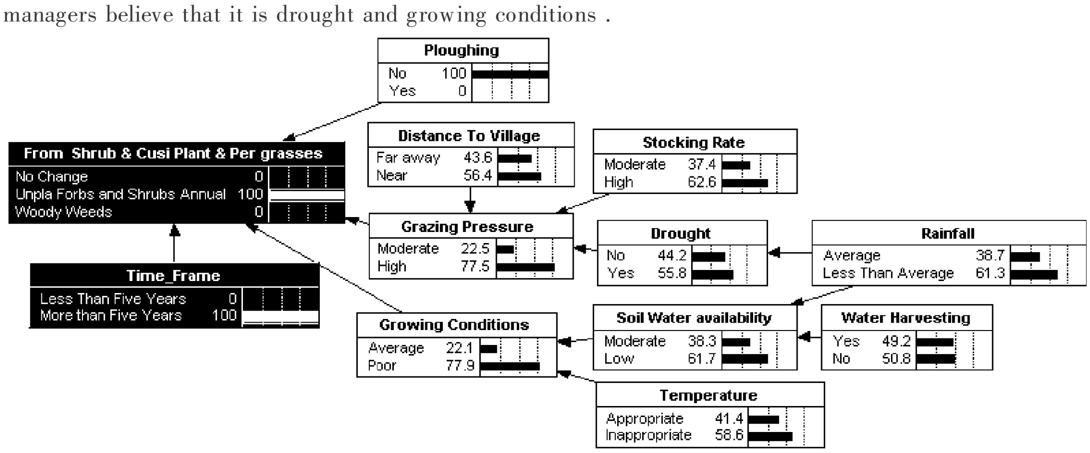

Figure 1 *This figure shows that within a five-year time frame , the transition to Unpalatable forbs & shrubs and annuals" is most likely if grazing pressure is high and growing condition is poor . This is most likely where stocking rate is high and soil water availability is low . The numbers are probabilities . Under this scenario , for example , there is a 61 .3% chance that rainfall is less than average .*

Conclusions Combining STMs and BBN provides a novel means of modeling rangeland dynamics in that it (a) accommodates uncertainty in rangeland dynamics in a straightforward way , (b) captures experiential knowledge of outcomes of rangeland management scenarios , (c) provided a graphical and transparent modeling environment that can facilitate communication about cause and effect , and (d) allows for the consequences of rangeland management decisions to be predicted . It also identifies the management scenarios that are most likely needed to prevent decline in rangeland condition .

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Monitoring urine distribution by grazing livestock

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Key words : GPS , urine sensor , animal behaviour , nitrogen

Introduction Urine patches are a significant source of leaching and gaseous N losses in grazed pastures . N losses increase as urine patch load (g N/m^2) increases , and modelled N losses increase if urine is returned as discrete patches rather than at uniform rate across the pasture . The tools we describe will help to quantify urination frequency and urine distribution patterns within large paddocks .

Materials and methods A urine sensor was developed which comprised a tube placed in the vagina of sheep and cattle , using a CIDR[1] device . It contains two electrodes which measure conduction (mV) , measured as conduction (mV) in the presence of urine passing through a tube anchored in the vagina , (Trials 1 and 2) . Urine created a voltage spike in logged data . In Trial 3 temperature (as mV) elevation to near body heat due to urine in the tube was monitored instead of conductance . Voltage , temperature and time were continuously logged . A custom-built GPS unit was part of the sheep urine sensor circuit . Movement was continuously monitored , and logged when the new position exceeded 3 m from the previous position , and upon urination . The GPS and sensor box was clamped to the fleece on the back of the sheep . The cow urine sensor circuit was located within the vagina and the GPS was attached to a collar . Using mature animals , urination frequency and urine distribution by 15 sheep (Trial 1 , 2) and of 20 sheep and 18 cows (Trial 3) was determined .

Results and discussion

Trial 1(summer) : On the first day in a flat paddock , urinations were generally easily detected by the mV spike , but by the second day it became increasingly more difficult to differentiate urination events , as the background voltage often did not return to zero because of contamination of the electrodes . Intermittent visual observations showed all 350 sheep in the mob exhibited co-ordinated resting , walking and grazing behaviour , with 2 of the 15 monitored sheep demonstrating Leadership" characteristics , e .g . commencing new grazing bouts after periods when all sheep had rested . Of the 149 urinations detected , 30% were close to or under the shade of a large tree . **Trial 2 (autumn) :** There was no shade available in this 10 ha moderately-rolling to steep paddock . Monitored sheep spent little time on the steep hill where pasture quality was poor and available herbage mass low . Camping behaviour during four days in the same paddock , though present , was less apparent than in Trial 1 when shade was sought . Interestingly , over the four days sheep congregated on east-facing aspects of the paddock between 8 to 10 am and on west-facing aspects 12 hours later (Figure 1) . We surmise that raised ambient temperature may have mediated this response . Urination frequency over 96 hours in autumn averaged 24 (range 11 to 36) urinations/day . **Trial 3 (early summer) :** Sheep and cattle grazed two separate steep hill country paddocks over 5 days . Little time was spent on steep slopes by either group , and cattle walked along well-defined stock tracks on the steepest areas . Cattle urine patches were concentrated around water troughs and at campsites (Figure 2) . Cows averaged 13 (7 to 25) urinations per day . Compared to cows , sheep urinated less around their water trough but did camp , as indicated by the congregation of urine patches . Sheep averaged 18 (5 to 28) urinations/day .

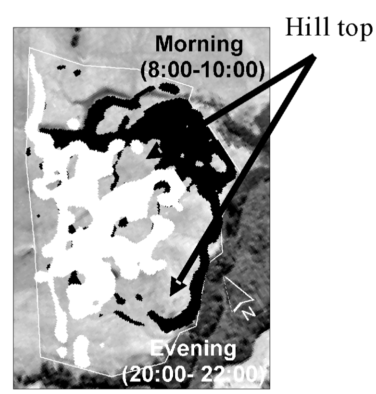

Figure 1 *Distribution of 15 sheep in a 10 ha paddock on 4 days during specified times .*

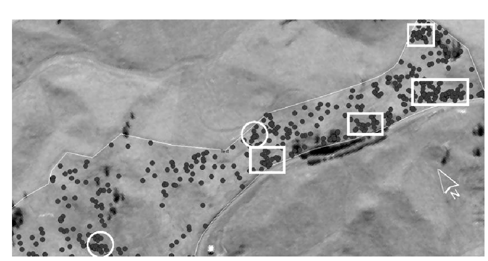

Figure 2 *Urine patch distribution of 16 cows over 5 days on hill country pasture . Circles indicate water troughs and oblongs flat-land camp sites .*

As the temperature sensor is unaffected by contamination , it is preferred over the paired-electrode sensor for detecting urination events .

Conclusions These relatively inexpensive GPS/urine sensor units allow , for the first time , the mapping of urine distribution by a number of ewes and cows in large paddocks . This may allow the identification of critical source areas of pollution on farms . These could be targeted for application of N-loss mitigation practices thereby reducing cost and increasing efficiency .

[1] CIDR Controlled Intra-vaginal Drug Release device , InterAg , Hamilton , New Zealand .

Terrain analysis and digital soil mapping in the Xilin river catchment , Inner Mongolia

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Key words : classification and regression trees , regionalization , soil type classification , steppe grasslands , overgrazing

Introduction The Xilin river catchment is located about 450 km north of Beijing in the continental Inner Mongolian steppe . The upper catchment comprises an area of roughly 3 .600 km , which is exposed to heavy degradation because of overgrazing by sheep and goat . Information in terms of regional distribution of soils is scarce . For their ongoing work the Research Unit MAGIM Matter fluxes in grasslands of Inner Mongolia as influenced by stocking rate" requires a most recent basis of such information i) to link pedological information to landscape and topographical properties ii) to have information on soil texture for further investigation of landscape scale hydrological properties and erosion potential iii) and to be able to point out pedological units for modelling , scenario analysis , remote sensing campaigns and regionalization .

Materials and methods The generation of the digital soil map for the Xilin river catchment comprises three working phases i) selection of sampling points ii) sampling campaign in the field iii) generation of the soil map . For the selection of sampling points 10 ecological units in total were classified on the basis of a land use classification and a topographical distinction using a Geographical Information System (GIS) . For this purpose six land use classes were derived from a Landsat image of the catchment area from August 2005 . These include bare soil , sand dunes , steppe , marshland and water , mountain meadow and arable land . Furthermore the most abundant land use classes sand dune , mountain meadow and steppe were sub-divided into topographic classes . Therefore the compound topographic index (McBratney et al . 2003) was used as a measure of topographic control on hydrological processes . For soil sampling in each class three sampling points were selected to perform a soil classification by digging of soil pits . Additionally 10 samples in each class were taken with a Puerckhauer auger . Sampling points were randomly spread over the ten classes . To avoid clusters of sampling points , which were likely to occur in classes of little spatial extension , the random distribution was supervised . For the generation of the soil map regionalization of pedological information will be done by classification and regression trees (Breiman et al . 1984) . This method allows identifying relationships between landscape features and soil properties so that soil information from the sampling points can be transferred to places with similar landscape features .

Results Terrain analysis resulted in the development of a sampling scheme for the pedological investigations . First results of the sampling campaign in 2007 show the distribution of soil types throughout the upper catchment . As expected Kastanozems are widely spread in this area . They are predominantly found in the in the land use class steppe . However , even some of the soils at sand dune sites , which were thought to show only little soil formation can be classified as Kastanozem . Regosols are another typical soil type for this class . The land use class bare soil , which is characterized by little or no vegetation , shows a similar distribution of soil types as the sand dune classes . Kastanozems and Regosols are most common , also hybrid forms can be found in which Kastanozems and Regosols are associated . Gleysols are mostly found at sites in vicinity of the Xilin river , which are connected to the groundwater . They can also be found in small valleys or depressions where sub-surface waters from neighbouring areas collect . The richest soils are found in the land use class mountain meadow . Pedogenetic conditions here are most favourable and lead to the formation of chernozems with deep humic Ah horizons .

Acknowledgement We are grateful to the Deutsche Forschungsgemeinschaft (DFG) for their generous funding of the Research Unit 536 MAGIM" .

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Gobi Forage : an early warning system for livestock in the Gobi region of Mongolia

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Key words : drought , Mongolia , forage monitoring , NDVI

Introduction During the period from 1999 to 2002 , Mongolia experienced a series of droughts and severe winters that lowered livestock numbers by approximately 30% countrywide . In the Gobi region , livestock mortality reached 50% with many households losing entire herds (Siurua & Swift 2002) . In March 2004 , a program was initiated by the United States Agency for International Development (USAID) through the Global Livestock Collaborative Research and Support Program (GL-CRSP) . The goal of this program was to develop forage monitoring technologies that provide early warning of drought and winter disasters to improve livestock herder decision making in the Gobi region . The program has two major objectives : (1) to develop a regional forage monitoring system that provides near-real time spatial and temporal assessment of current and forecasted forage conditions , and (2) to develop a communication infrastructure that provides stakeholders with data on forage conditions to assist them in making timely and specific management decisions .

Materials and methods Since May 2004 , 297 monitoring sites have been established in 8 provinces in the Gobi region (Figure 1) . At each site , vegetation , soil , and grazing data were collected for input into the PHYGROW forage production model (Stuth et al . 2003) . PHYGROW is driven by near real-time climate data acquired from the National Oceanic & Atmospheric Administration's (NOAA) CMORPH system (Joyce *et al* . , 2004) . The forage model outputs for the monitoring sites are coupled with Normalized Difference Vegetation Index (NDVI) data using geostatistics to create surface maps of forage yield and deviations from long-term average . Statistical forecasting (Stuth *et al* . , 2003) is used to project forage conditions for 60 days into the future .

Results Maps of forage availability and deviation from long-term average are produced each half month . A sixty-day forecast of forage conditions is also provided . Maps are distributed via mail and internet to local and regional governments . Situation reports , derived from model and map outputs , are broadcast weekly on national radio . During the summer and fall of 2007 , the early warning system was able to detect severe drought conditions in the Gobi Altai and Dundgobi provinces . (Figure 1) . A survey conducted in October 2007 indicated that the radio broadcasts were an effective means of communicating the early warning information and that the maps were useful for providing information for livestock movement and decision making .

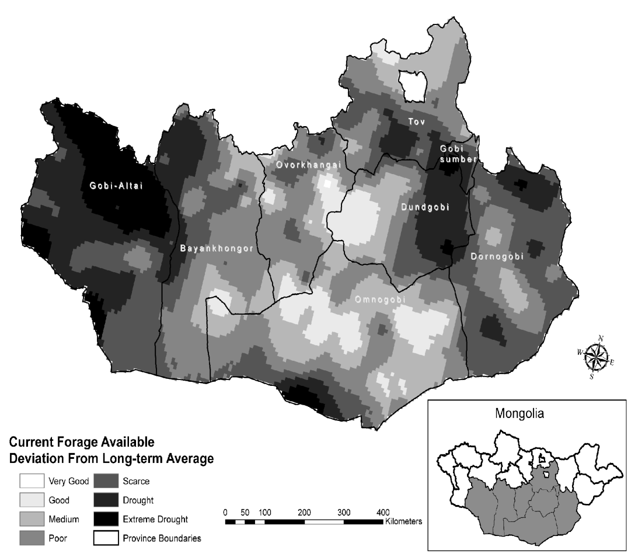

Figure 1 *Current forage deviation from long-term average for the September 1 to 15 , 2007 period in the study area .*

Conclusions A forage monitoring system has been developed to provide early warning for below normal forage or catastrophic winter conditions on rangelands in the Gobi region of Mongolia . The system has been effective in identifying regional drought and providing information on probable conditions within a 60 day window . Information from this system will allow stakeholders access to real-time information to reduce risk of livestock mortality , protect the ecological stability of the rangeland resources .

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Image-based rangeland monitoring at multiple scales

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Key words : ecological assentment , photography , ground cover , remote sensing

Introduction Sustainable rangeland management is enhanced by accurate ecological assessments and these , in turn , can be enhanced by advancing technology and decreasing labor costs . Image-based , multi-scale monitoring can reduce data-collection costs and reveal pattern and process (Wu , 1999) to allow , for example , assessing the relationship between the functional integrity of ecosystems and biodiversity across regions (Ludwig et al . , 2004) . Here we examine the potential benefits of image-based , multi-scale monitoring protocols .

Materials and methods Fifty plots were located in 4 plant communities of the Jornada Experimental Range (JER) , NM , USA . Ground cover for the plots was obtained using , (a) 1-mm ground sample distance (GSD) ground-based images analyzed with object-based image-analyses methods , and (b) the line-point-intercept (LPI) sampling method (Laliberte et al . , 2007a) . A QuickBird satellite image acquired over the study area was segmented at 4 different scales , resulting in a hierarchical network of image objects representing the image information in different spatial resolutions (Laliberte et al . , 2007b) . This allowed for differentiation of individual shrubs at fine scales and delineation of broader vegetation classes at coarser scales . At the Central Plains Experimental Range (CPER) , CO , USA , 1-mm GSD images were acquired for 200 locations across 3 pastures using ground and aerial photography (Booth and Cox , In Press) . Ground cover was measured from the CPER images using SamplePoint software .

Results and discussion Image acquisition and object-based analysis for ground cover at JER gave 80% correlation with LPI data but required half the labor . Work at CPER complemented that at JER in that 1-mm GSD imagery obtained from the ground or the air was equally effective for detecting ground-cover differences due to pasture stocking rate , thus demonstrating the potential to save data-collection time and cost by aerial image acquisition . The combination of multi-resolution image segmentation and decision tree analysis of the QuickBird image facilitated the selection of input variables and helped in determining the appropriate image-analysis scale , thus enhancing vegetation-mapping accuracy over conventional methods .

Conclusions Image-based monitoring using 1-mm GSD ground or aerially acquired images reduces data-collection costs ; multi-scale data expands pattern detection possibilities enhancing vegetation mapping accuracy . Together these technologies contribute to our rangeland monitoring and sustainable-management capacity .

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Hand held computers improve rangeland health data collection and analysis

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Key words: ArcPad, Personal Desktop Assistant, electronic data collection, geospatial data, rangeland health trend

Most British Columbia (BC) Ministry of Forests and Range (MFR) Range staff use paper forms to collect rangeland health data. They have requested improved methods of collecting and analysing data. Monitoring and tracking rangeland health with a hand held computer linked to a Global Positioning System (GPS) enhances field data collection and analysis. Range staff are beginning to use digital forms, a process which notably reduces the time taken to complete analysis and write reports after data collection. This paper outlines the need for advances in data collection, the practicalities of electronic data collection and the uptake of new technology by Range staff.

Prior to 2004, Range staff collected field data with paper forms. A field day required a large paper map for navigation, clipboards to write on and water resistant paper forms to record observations. Staff carried a separate GPS unit to collect spatial data and transferred it to the paper form. Analyzing data and generating reports required three office days for each single day spent in the field. Field observations from one week generated a box full of forms which in turn required nearly a month to analysis and summarize.

The MFR model of electronic data collection requires a Personal Desktop Assistant (PDA), GPS, and ArcPad mapping software to support data collection. Users navigate, orientate themselves and collect data within base layers downloaded from a central data repository and displayed on the screen of their PDA. Available information includes 5 metre resolution satellite imagery, contour lines, a vegetation layer and a blended biological, geological and climatic layer. Data are recorded in the form of shapefiles, which are directly compatible with the ArcMap programs used by the MFR geomatics specialists.

Effective electronic data collection requires an operator with knowledge of the ecosystem, PDA, GPS and appropriate protective cases. A compact flash or secure digital memory card of at least 1 gigabyte is necessary to store base imagery, useful shapefiles and inspection forms. Operators may find useful a telescopic pole to elevate the GPS and a mobile battery to extend field time. Most basic PDAs will have the necessary processing speed and radio receiver to operate the ArcPad software and link with a GPS. Total cost for equipment and software is between $2,000 and $3,000.

Operating time with an extended battery is 6 to 7 hours. Users can increase field time by carrying a spare battery or mobile battery, or charging the PDA and GPS in the truck between inspections. Operators can partially fill out inspection forms in the field and edited them back in the office. The processing power of the PDA allows the operator to carry additional electronic information from each range client or a spread sheet to calculate rangeland carrying capacity. Collecting data with a hand held computer allows for consistent collection of information in the form of a permanent legible electronic file that is easy to store and sort. Electronic data collection can include recording range use, more elaborate inspections to determine rangeland health, identifying the location of range improvements, identifying the location of new invasive plants, determining the carrying capacity of a particular pasture, navigating in the field, linking digital pictures with the appropriate inspection form and recording additional notes.

Range staff have created a guide to system operation because users are located in different areas of the province. The guide addresses topics including: using ArcPad with electronic forms, acquiring and using underlying spatial data and addressing PDA challenges. New users are most successful in learning the technology when they are interested in it and recognize its benefits. Beginners often feel frustrated using this hand held electronic data collection system because they expect the speed and response of their personal computer and underestimate the importance of maintaining a line-of-sight between the GPS and the sky.

Range staff report that the conversion to electronic data collection reduces analysis and summary time by at least 75%. Unanticipated benefits of adopting the new technology include improved navigation and a visual summary of the extent of a monitoring regime, which improves the cost-effectiveness of subsequent field trips. Adopting this new technology is an important step to improving the understanding of the health of rangelands at a coarse scale. In the future, Range staff will be required to perform more mapping work while technological advances will likely provide us with faster PDAs capable of performing more tasks and processing finer resolution imagery.

Estimating the dry matter of grasses and shrubs in semi-arid zones using visible and near-infrared wavelengths recorded by high resolution aerial photographs

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Key words: drone, GIS-GPS, kite photography, NDVI, radiation analysis, remote control, shape recognition

Introduction Non-destructive estimates of plant biomass in semi-arid grasslands were for long hampered by the availability of high resolution radiation data. Recently IKONOS and QUICKBIRD satellite images have become available for all areas worldwide but their costs are in contrast to LANDSAT and SPOT datasets often prohibitive. Aerial photographs with a resolution of 5-10cm taken from kites or small remotely controlled drones are a low-cost alternative for areas where images from airplanes are hard to obtain and the size of study sites ranges from 1-2500ha.

Materials and methods At a weight of about 3kg each, the self-made, 1.8×2.5m kite and the drone of wing span 2.2m is able to carry a digital camera (Fuji F30) to altitudes of 100-1500m above ground (Figure 1). Exposure of pictures (kite and drone) and positioning of the drone (propelled by a battery-powered Hacker 50 geared brushless motor with 350W power) was performed with a standard remote control (Robbe/Futaba FC-28) with 100mW RF output in the 35MHz band. The equipment was used to take aerial images from 250m for dry matter (DM) determination of pearl millet (*Pennisetum glaucum* L.), grass mixtures and the shrub *Guiera senegalensis* in the African Sahel and of *Alhagi sparsifolia* in the Chinese Taklamakan desert. Ground measurements allowed to calibrate and validate the remote data.

Results and discussion For the studies in the African Sahel the GIS based analysis of true-colour and infrared aerial photographs permitted the quantitative monitoring of millet DM development throughout the growing season. Infrared images were most efficient in the detection of vegetation followed by the normalized green band of true-colour images. The red band of true colour images was the least effective because of soil albedo and image vignetting.

Figure 1 *Kite (a) and remotely controlled drone (b and c) taking true colour and near-infrared aerial images of grass and bush vegetation.*

Analysis of true-colour images of the grass mixtures and the bare soil revealed that the number of normalised green band pixels averaged per plot was highly correlated with the DM of grass mixtures ($r = 0.86$) and that red band pixels were related to differences in soil surface crusting. The observed 2-yr residual effects of straw application and phosphorus fertilization on grass growth showed DM increases >100% and 14%, respectively.

Regressions between the DM of *Guiera* coppices and their canopy area were satisfactory ($r = 0.76$ to 0.93) and permitted the calculation of the individual coppice dry matter for the entire field with fewer than 40 destructive measurements.

For the studies in China first and second order polynomial regressions between DM data of 50 ground-truthed *A. sparsifolia* shrubs and their respective canopy area allowed to automatically calculate the DM of all remaining shrubs covered by the photo-graph ($r^2 = 0.92$ to 0.96). The use of non-linear DM regression equations required an automatised separation of shrubs growing solitary or in clumps. Separation criteria were the size and shape of shrub canopies. The results showed that the GIS-based approach led to an overestimation of *A. sparsifoilia* DM in densely vegetated areas, a systematic error which decreased with increasing size of the surveyed area. The application of the described techniques for vegetation monitoring in the Chinese-Mongolian Altay is discussed.

Conclusions Today's image processing techniques true-colour and infrared images taken from self-made high resolution images of desert vegetation allow to quantify their above ground biomass and measure treatment effects. For successful application strong contrasts between vegetated areas and bare ground, simple plant stands of few species, enough geo-referenced points to correct for distortions of the images and destructive DM data for calibration are needed.

Husbandry of free-ranging cows using virtual fencing concepts

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Key words: mustering cows, directional virtual fencing (DVF™), GPS animal tracking, low-stress animal handling

Introduction Virtual fencing is a method for managing free-ranging animals that melds electronics with animal behavior to accomplish animal control in lieu of conventional fences. Sensory cues, most commonly sound and electrical stimulation, have been used to warn an animal that it is approaching an invisible radio frequency (RF) boundary. Today RF signals emanating from satellites, such as those from the Global Positioning System (GPS), replace the need for ground based RF signals. GPS can accurately and precisely determine an animal's location on the landscape, and when combined with a Geographic Information System (GIS), it is possible to administer cues autonomously in a temporal and spatial format that produces repeatable low stress prescription animal management. Directional virtual fencing (DVF™), previously described by Anderson (2001; 2007), has been used successfully to hold and move free-ranging cattle across an arid rangeland landscape. The object of this study is to autonomously gather two groups of free-ranging beef cows into a corner corral containing the only source of drinking water from various locations in a 466 ha brush infested paddock between sunrise and sunset using only audio cues (Albright et al., 1966).

Material and methods Two treatments, each with ten mature crossbred *Bos tarus x Bos indicus* beef cows will be stratified into one of two prior handling treatments and evaluated for efficiency of autonomous gathering. The livestock in the treatment not currently being evaluated will be maintained in an adjacent paddock located approximately 1.6 km north of the corral into which the autonomous gathering is conducted. Electronic devices designed and built by the Massachusetts Institute of Technology (MIT), capable of recording an animal's spatial location using 1 Hz GPS technology as well as hardware and software for administering autonomous audio cues with wireless data transmission capabilities will be mounted on neck saddles attached to halters worn by the cattle. Background on each animal's temporal diurnal pattern of movement to the corral and trails used will be recorded during week one in the absence of any audio cues being administered. Once each day during the following two weeks, five morning and five afternoon autonomous gatherings will be randomly conducted outside the time interval cattle entered and exited the corral during week one. The treated group will consist of ten cows, previously habituated to being gathered into the corral from this paddock using human voice as well as sounds from a gas powered all-terrain vehicle (ATV). Once these treated cows" reached the corral during habituation they were given immediate access to drinking water and a small amount of protein supplement. It was during one of these manual gatherings that all audio sounds were recorded. These recorded sounds will be autonomously played back to both the treated and control cattle in an attempt to move them to the corral in the absence of humans being present. The control cows had never been gathered from this paddock or any other using the audio being autonomously played, however, the cows were trained to wear electronic equipment and eat protein supplement.

Results and discussion Field notes, video and still pictures together with GPS data will be discussed especially in light of whether prior training is essential in order to optimize autonomous gathering of cows using audio cues.

Conclusions Data will confirm or refute that autonomously applied audio cues can be used successfully to gather free-ranging cattle without the need for humans to be present.

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Factors influencing the spatial distribution of beef cattle on Mediterranean rangeland

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Key words: cattle, grassland, landscape, spatial distribution

Introduction The rules governing spatial distribution of beef cattle on rangelands are poorly understood. Nevertheless, animal movement patterns are known to often lead to non uniform utilization of the rangeland. For example, cattle prefer to move along trails that incur low costs of energy expenditure that depend on vegetation quality and paddock size (Ganskopp et al., 2000). Their movements are influenced also by the location of watering points (Ganskopp 2001). The spatial differences in forage consumption lead to high grazing pressure on some patches, while in others cattle presence is low. Understanding the rules of cattle movement can provide us with tools for improving the utilization of rangelands, and can enable us to direct cattle utilization to management-targeted areas. The objective of this research was to study the grazing behavior of free-ranging cattle in a spatially explicit way to better understand the interrelationships between features of the landscape and cattle movement patterns.

Material and methods The experiment was conducted at the Karei Deshe experimental farm in northern Israel (32°55′N, 35°35′E). The area is a Mediterranean rangeland with rich hemicryptophytic vegetation, hilly topography with slopes generally less than 20°, and an average annual rainfall of 570 mm that falls mostly from November to March. During the years 2002 to 2005 data on the movements of beef cows (109 in total) was collected by fitting Lotek GPS collars which provided the location and activity of the animals at a temporal resolution of five minutes. Collars were deployed for periods of 2-10 days during different periods of the year (Feb., Apr., Jun., and Aug.). The paddocks were of approximately 30 ha in size and stocked at a high (HP) or low (LP) grazing pressure of 0.9 or 1.8 ha/cow, respectively. Each paddock included a water trough, an area shaded by trees, and a supplementary feeding site which was used during late summer only. Using suitable GIS map layers each plot was divided into a grid of 25×25 m. For each cell the following attributes were computed: slope, and the distances to the water source, shade area, feeding site (whether or not in use), and the nearest fence. We assessed five factors that might influence cattle distribution: the three resource factors of water, shade and feed supplement locations, the natural characteristic of slope, and the fence line. In three paddocks the water and feed supplement sites were in the vicinity (<100 m) of the shade sites, while in the fourth plot (plot 2) the feeding site was >500 m from the shade site.

Results The proportion of cattle locations within 200 m from water site (Figure 1 and Table 1) shows a dramatic increase (0.29—0.74) in use from winter (Feb.) to late summer in paddocks having adjacent resource factors (plots 4, 5, 7). In plot 2, where the feeding and shade sites were far apart, a relatively similar use for all seasons was obtained. Comparison of the utilization of slopes to their distribution in the paddock showed no significant difference during early winter (Feb.), while in later seasons a high preference of slopes <8° was found. No effect of the fence line on cattle distribution in the different paddocks was found at this stage.

Table 1 *Proportion of cattle GPS locations within 200 m of the watering trough.*

Plot	Stocking rate	Feb/Mar	Apr	Jun	Aug
2	LP	0.45	0.40	0.30	0.46
4	HP	0.33	0.53	0.72	0.86
5	LP	0.29	0.47	0.55	0.60
7	HP	0.17	0.54	0.66	0.78

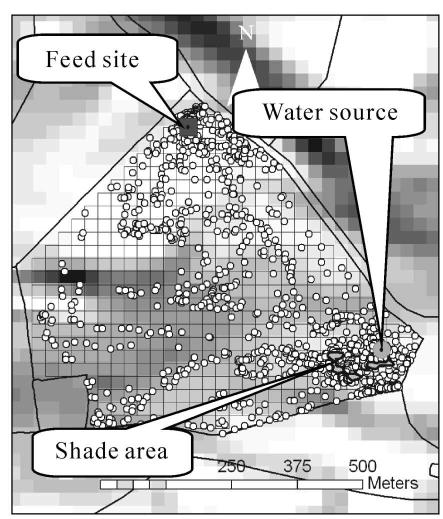

Figure 1 *Cattle spatial distribution (white dots) in plot 2, August 2005. Darker cells have a higher slope. Dotted circle: water trough; dotted square: feed site; colored polygon: trees site.*

Conclusions The relative position in a paddock of resource factors has a major effect on the spatial distribution of cattle. Thus it might be possible to change grazing patterns and improve forage utilization by altering resource positioning. Such changes should be cognizant of the distribution of topographic conditions and other natural resources in the paddock.

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Areas of distribution of cultivated and wild-growing forage plants in electronic "Atlas of Economic Plants and Their Diseases, Pests and Weeds of Russia and Neighboring Countries"

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Key words: cultivated plants, areas, electronic maps

In order to study cultivated plants occurring in Russia and adjacent countries and their wild relatives, as well as major diseases and pests, an electronic Atlas of Economic Plants and Pests of Russia and Adjacent Countries has been developed. The process of its development was a laborious complex work involving expertise of diverse specialization from a number of Russian scientific institutions. This work was supported by the United States Department of Agriculture (USDA) and funded by the International Science and Technology Center (ISTC).

Key objects of the Atlas are cultivated plants and their wild relatives. The N. I. Vavilov Institute of Plant Industry (VIR) has accumulated enormous factual materials on the distribution of these plants over the territory of the former Soviet Union-special reference books, archives of VIR collecting missions in different years, *in situ* collections of cultivated and wild species preserved in the National Genebank of Russia and the Herbarium of Cultivated Plants, their Wild Relatives and Weeds. These sources of information together with floristic lists of regional Flora, Directories, regional and national (Botanical Institute of Russian Academy of Sciences) herbaria, monographs and publications on separate taxa, published maps of areas of distribution and other literary references served as the basic material for mapping the areas of crop species and their wild relatives.

Area maps for 100 cultivated species were developed, among them are 28 forage crop-species maps. The list of cultivated plants was compiled on the basis of the periodical edition Catalog of Commercial Crop Varieties".

The species of Crop Wild Relatives (CWR) were selected for the Atlas according to the List of CWR in Russia" prepared by VIR Department of Agrobotany and taking into account their agricultural significance. Among them are 255 forage species. Forage species of the Atlas belong to three main families: *Leguminoseae* Endl, *Poaceae* Barnhart, *Chenopodiaceae* Vent and some others.

Each object in the Atlas is represented by the following materials: area map layers, metadata, description of the techniques used for map development with references on information sources, brief description of the object and it's image.

Map layers: vector and raster. Vector maps are presented in Mapinfo exchange Format (MIF/MID). Main types of vector layers are polygonal and punctual; for auxiliary layers a linear demonstration variant (polyline) is possible. Datum—WGS84. Scale 1:20000000. Each layer is supplemented with metadata. Raster Maps: data format—Idrisi 32 for Windows—9x/NT/2000/XP. Datum—WGS84. Each layer is supplemented with metadata. Vector layers of boundaries and coastlines are superimposed on geographically bound rasters. Composition saved in **.gif** or **.jpg** formats give information on precision of geographic binding. Metadata include: name of the map; name of the author of the map, name of the GIS expert, release date of the map; scale and precision of the map (units of measurements, for example: raster cell 10x10 km); projection indicating the datum and ellipsoid; basic contents of the map, classifier, accuracy of the classifier; mapping methods (brief, reference), data sources (reference); rights and copyrights, notes. The text is adjusted to the source materials with the help of hyperlinks.

Descriptions include: correct name of the species—Latin (according to the International Code of Botanical Nomenclature, and it's major synonyms), main morphological, geographical, ecological and biological features of the species, utilization and economical value.

The Atlas materials are stored on CD and available on the web (www.agroatlas.spb.ru.) in Russian and in English. Area maps of the species, included to the Atlas, are invaluable for analyzing biodiversity of major crops and their relatives in Russia and adjacent countries. The maps may be used also for breeding purposes-for example, to select plant forms (ecotypes) adapted to certain environments, resistant to diseases and pests, possessing certain commercial characters and potential for growing in similar conditions in another places of the country or of the world. The Atlas can serve also as the basis for analyzing spatial statistics describing the distribution of crop and CWR species diversity over Russia and adjacent countries. The Atlas can also be used as a guideline manual for specialists and students of agronomic, biological and geographic colleges.

Height-weight profiles of two key species to assess utilization of grasslands in Boroujen, Iran

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Key words: Range management; proper utilization; rapid method; *Bromus tomentellus*; *Stipa lessingiana*

Introduction Considering the extent of rangelands, a rapid and accurate method is vital for regular determination of utilization. So far, several, mostly time consuming and expensive, methods have been developed to estimate rangeland utilization. Instead, the height-weight relation (Cook & Stubbendieck, 1986) is a rapid approach to determine utilization. The objective of this study was to establish height-weight profiles for two key species, *Bromus tomentellus* and *Stipa lessingiana*, to assess utilization in semi-arid grassland of Boroujen, Iran.

Materials and methods This study was conducted at Marjan, Boroujen, (32°0′32″N and 51°7′26″E, with ca. 4600 ha, 2197 a.s.l.). Within the study area, a representative area was selected and three transects were established, each 200-m long. Along each transect, 30 mature plants (seeding stage) of each species were randomly selected, cut at ground level after that leaves and culms were held in place by wrapping string spirally around the plant. The samples were oven dried at 65° c and finally cut with 2 cm intervals and weighed. Data analysis was carried out with SPSS v.15 (SPSS Inc., Chicago, USA). Several linear and nonlinear regression models were tested to study the relationship between independent (cumulative height) and dependent variables (cumulative weight).

Results Height-weight relations are influenced by species canopy structure. The main herbage mass of the two species is concentrated in their basal part. The best curve fit between height (X) and weight (Y) for the two species was cubic ($r^2=0.99$ $p \leqslant 0.001$) (Figure 1).

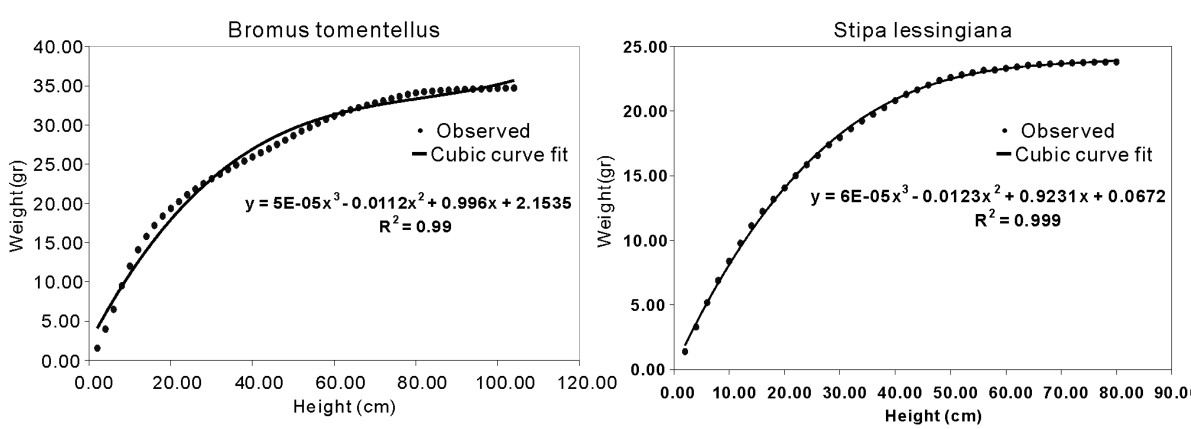

Figure 1 *Height-weight relations of* Bromus tomentellus *and* Stipa lessingiana.

Discussion The very high correlations ($r^2=0.99$ $p \leqslant 0.001$) between height - weight of *Bromus tomentellus* and *Stipa lessingiana* show that this method can be effectively used to determine utilization of grasses in this semi-arid grassland. Since these two species are known as the two key species of the study area (Ebrahimi, 1997), their utilization can serve as an indicator of grazing intensity and utilization. Since grazers are selective for leaves over stems (Ganskopp and Bohnert 2006), further work is needed to confirm the results over different sites and seasons.

Conclusion Height-weight relation as an inexpensive, non-destructive and easy method for determination of utilization, specifically where grasses are the dominant species and the pattern of defoliation is known.

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Using GIS and geostatistics to study spatial variation of soil test phosphorus in grassland

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Key words: spatial variation, soil test phosphorus, GIS, geostatistics

Introduction There is little information on spatial variation of soil test phosphorus. This is now important because of the use of soil test phosphorus as a basis for national and EU policies such as the recently introduced Nitrate Directive (Statutory Instrument 378 of 2006). Systematic soil sampling methods such as grid sampling have been proposed to better evaluate soil fertility (Wollenhaupt et al., 1994). Soil test vaules collected by grid sampling can be directly mapped or may be used to evaluate the values of unsampled locations using spatial interpolation (Mallarino, 1996).

Material and methods A typical permanent grassland (total area: 45 hectares), at Wexford, Ireland, was chosen in this study. A total of 537 soil samples were collected from a point (10 cm diameter) based on a 30m×30m grid system. Soil test phosphorus (P), potassium (K), magnesium (Mg), pH and lime requirement (LR) were determined. Geostatistics and GIS were used to study spatial variation of soil test phosphorus (as an example of soil test nutrients).

Results and discussion A clear spatial distribution of P was mapped in Figure 1. Most of the P values were in the medium range, according to European Communities Regulations (Anonymous, 2006). Some patched high P values was discerned that corresponded to the early slurry spreading in the study area. P data followed a positively skewed distribution. Good spatial correlation of P was observed after log-transformation of the data, which can be fitted by a spherical model (Figure 2).

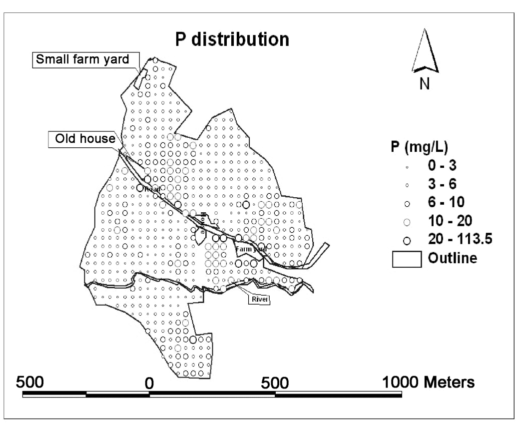

Figure 1 *Symbol map showing soil test P.*

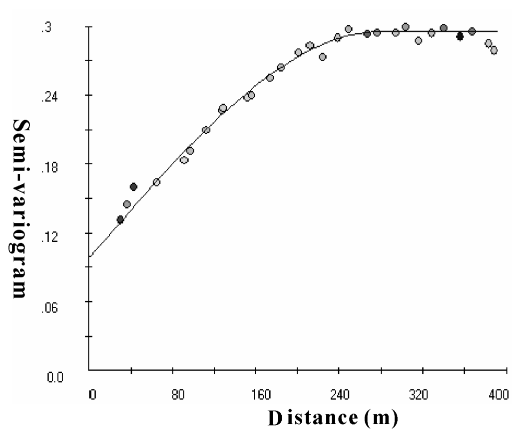

Figure 2 *Experimental semivariogram and fitted P model.*

Conclusions Results indicated that the uneven slurry spread and other management practices (e.g.?) were the main factors for spatial distribution of soil test phosphorus. It is concluded that GIS combined geostatistics was a useful tool to study spatial variation of soil nutrients at farm scale.

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Silvopastoral systems : estimation of understory winter grass productivity by remote sensing

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Key words : NDVI (Normalized Difference Vegetation Index) , rangeland , afforestation , basal cover , C_3 plants

Introduction Silvopastoral systems combine forest production with pastoral use of the understory .Most rangelands of the Flooding Pampas are dominated by C_4 species (Perelman et al . 2001) , which determines a low quantity and quality of forage supply during winter , a critical period for livestock production (Paruelo et al . 2001) . Clavijo et al . (2005) found a lower live herbaceous plant cover , and a lower absolute ground cover of C_3 species but a higher proportion of C_3 than C_4 species in sites afforested with poplars in comparison with the open grassland . This indicates that planting deciduous trees may constitute an alternative for revert the dominance of warm season grasses and therefore increase winter productivity . Remote sensing allows the estimation of productivity of grasslands (Oesterheld et al . 1998 ; Purevdorj at al . 1998 ; Paruelo et al . 2001) . The objective of this work was to identify and interpret by remote sensing changes in the herbaceous winter productivity associated to the establishment of deciduous trees .

Materials and methods We obtained NDVI (as an estimator of primary production) from satellite images , and then we compared it with the field information obtained on the same grasslands . NDVI was compared in 9 Poplar afforestations (F) with their respective paired plots with original grassland (G) . The plots were located at Castelli , province of Buenos Aires , Argentina (36°05′S ; 57°48′W) . Multispectral images of Landsat 5 TM satellite (Path : 224-Row : 085) , of 30 meters of spatial resolution were used during the winter period . Satellite data were accompanied with basal cover and other parameters previously obtained in the field (Clavijo et al . 2005) . Data were analyzed using ANOVA model with repeated measures .

Results and discussion The NDVI from F and G stands was not significantly different ($P=0.97$) . However , F stands had larger NDVI per unit of basal cover of C_3 than G stands ($P<0.07$, Figure 1) . These results show that C_3 species would be on a better condition in F plots than in G during winter period . Trees likely generate better micro environmental conditions for the growing of C_3 species , by decreasing incident radiation and temperature and letting C_3 species exploit radiation during winter when trees are leafless (Clavijo et al . 2005) .

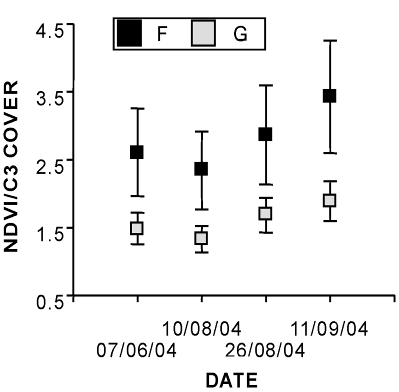

Figure 1 *NDVI affected by basal cover of C_3 of F and G stand in four dates during winter period . Vertical lines show standard error .*

ANOVA	F values	p values
F/G	4 .24	0 .07 *
Date	16 .9	< 0 .001 **
F/G X Date	1 .8	0 .157 ns

Conclusions The combination of remote sensing data and field measurements of plant cover of different functional types allowed us to demonstrate that the decrease of absolute plant cover of C_3 grasses below afforestations did not translate into a decrease of winter ANPP , because the ANPP by unit of C_3 grass cover increased below afforestations .

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The application of remote sensing to ecosystem health assessment in temperate rangelands

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Key words: remote sensing, temperate rangeland, ecosystem health, assessment

Introduction Grassland, covering one fourth of the land vegetation areas (Sims, 1988), plays an important role world wide ecologically and economically (Han, 2007). The temperate grasslands in Inner Mongolia, China have been the focus in the last several decades as the sand storm is getting severe annually in China. It not only affects the environment in China, but also plays a role in the global circulation. Therefore, monitoring the health of the grassland condition is the purpose of this study.

Materials and methods Field level biophysical data were collected in the summer of 2006 in three grassland types, typical steppe, meadow steppe, and desert steppe. Satellite imagery, Landsat Thematic Mapper (TM), was acquired for the same study area as close to field season as possible. Satellite imagery was geometrically, radiometrically and atmospherically corrected. Two study areas were covered with multitemporal images (desert steppe and meadow steppe).

Results and discussion Figure 1 demonstrates that satellite imagery is an effective way of assessing rangeland conditions. A multitemporal approach is more effective than a single image. Spectral vegetation indices especially with soil adjusted indices have significant relationships with biophysical properties (biomass, cover and canopy height) at various levels.

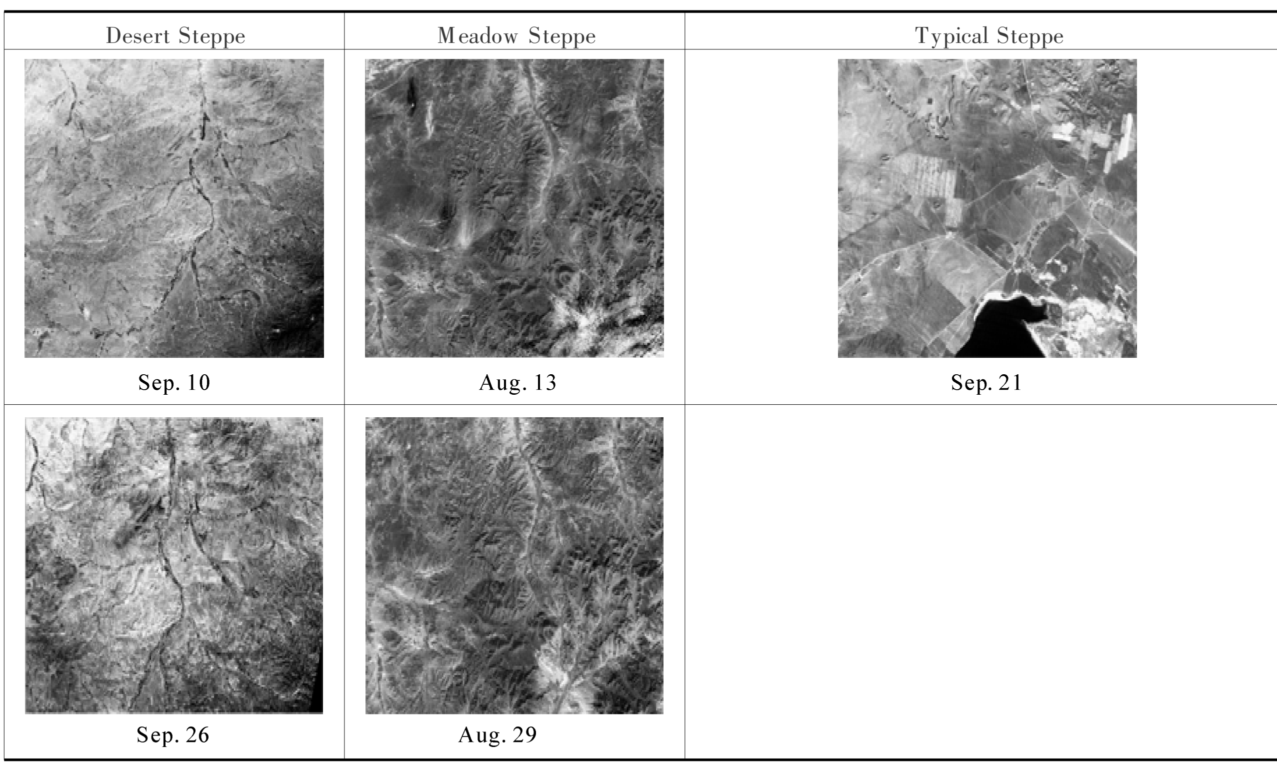

Figure 1 *False color composite Landsat TM imagery. Areas in red indicate green vegetation and in bleu are low vegetation.*

Conclusions This study demonstrated that remote sensing is an effective way to assessing rangeland health. Specific vegetation indices are needed for low vegetation covered areas.

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Alfalfa suitability zone mapping using climatic and soils spatial data and quantitative plant tolerances

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Key words : *Medicago sativa* L . , GIS , spatial analysis , forage , suitability , mapping

Introduction Traditionally , crop suitability mapping has been based on hand-drawn maps depicting general suitability regions resulting in maps being of limited use as decision making tools . Advanced spatial analysis , involving GIS technologies , now allows for creation of highly detailed crop suitability maps based on biophysical characteristics of the region and quantitative plant characteristics (Hannaway et al . , 2005a , 2005b) . This paper describes the application of spatial analysis to the mapping of suitability zones for alfalfa cultivars with fall dormancy and winter survival indices of 3 .

Map development process The Internet Map Server application (http ://mole .nacse .org/prism/forages/) , developed by the PRISM Group (http ://prism .oregonstate .edu) , was used to evaluate parameter values and create suitability maps . Maps were generated based on climatic factors (mean January minimum and mean July maximum temperature and precipitation) and edaphic factors (pH tolerance , soil drainage tolerance , and salinity) . Mean January minimum temperature values were chosen based on northern limits of survivability . Mean July maximum was based on summer survival which is a combination of adequate soil moisture and sub-lethal temperatures . A summary of climatic and edaphic tolerances is presented in Table 1 and the map generated by these values is displayed in Figure 1 ; the tables and figures are based on plant tolerances taken from USDA-NRCS (2006) and Kotuby-Amacher et al . (1997) . Fall dormancy and winter survival were estimated from the National Alfalfa & Forage Alliance (2007) . Climatic values were taken from PRISM interpolated climate grids .

Table 1 *Climatic and edaphic factors and quantitative tolerances for alfalfa cultivars with FD= 3 , WSI= 3 .*

	July Max Temp (C)		Jan Min Temp (C)		Annual Precip (mm)		Soil pH		Soil Drainage(categories)		Soil Salinity (mmhos/cm)
	Low	High	Low	High	Low	High	Low	High	Low	High	High
Well Adapted	15	30	-13	9999	400	1000	6.1	8.4	MWD	ED	2
Moderate	10	35	-18	9999	300	1100	5.5	9.0	SPD	ED	5.4
Marginal	5	40	-22	9999	200	1300	4.8	9.7	PD	ED	8.8

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Progress in grazing management of dairy cows by using the Grazemore DSS

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Key words : software , advanced weather forecasts , herbage utilisation , milk production

Introduction Grazemore DSS is a decision support system (DSS) developed to improve the use of grazed grass in dairy production (Hetta et al ., 2005) . The software consists of a herbage growth model (HGM) (Barrett , Laidlaw & Mayne , 2004) and a herbage intake model (HIM) (Delagarde et al ., 2004) which predicts herbage intake and milk yield as daily averages for the herd during the residence time in individual paddocks . The HGM predicts herbage growth for individual paddocks (kg DM/day) based on information on average day temperature (℃) , precipitation (mm) and photosynthetic active radiation (PAR , MJ/m^2) . Meteorological institutes can provide farmers with advanced weather forecasts where these parameters are predicted in numbers on a daily base . The aim with this study was to investigate the possibilities to improve the grazing management supported by the Grazemore DSS in combination with advanced weather forecasts .

Materials and methods During 2006 a grazing experiment with 120 dairy cows was conducted from the 9 of June to the 31 of August at the Forage Research Centre , Umeå , Sweden (63°45′N ; 20°17′E ; 12 m elevation) . The cows grazed 22 ha of pasture which was divided into seven paddocks . The cows (Swedish Red) were divided into two sub herds ; high and low yielding cows depending on initial milk production . The grazing calendar (rotation order between paddocks) was determined by the Grazemore DSS utilising a seven day weather forecast of the parameters needed to run the HGM . The limitations for the DSS was set by user defined rules were the two groups of cows were kept in a restricted first-last" grazing management system , where the high yielding cows entered a new paddock each day at night from 18 :00 to 06 :00 and there after the low yielding cows grazed the same paddock from 09 :00 until 15 :00 . The DSS was used to keep a high utilisation of the grass meanwhile maintaining a target milk production of 25 .5 kg of milk/cow per day through out the grazing season . When the cows were of pasture they were kept in a louse house stall and fed on average for the two subgroups 8 kg DM of concentrates and 3 kg DM of grass silage per day . Milk production was recorded individually twice daily . Herbage mass was recorded as the mean of DM yield from three cut plots (0 .9 m^2) in each paddock .

Results and discussion The results of the measurements and predictions of HM and MY and are presented in Table 1 . The MY represents the daily average milk yield for the two groups and the HM represents the individual HM above ground level in a single paddock . Comparisons of the actual and predicted MY show that the grazing management suggested by the DSS resulted in a small deviation from the targeted milk production (MPE=9%) . There was a larger deviation (MPE=30%) for the predicted HM in individual paddocks . However the over all bias in between targeted and recorded HM was small and the swards were in good condition trough out the experiment .

Table 1 *Mean values of actual (A) and by the Grazemore DSS predicted (P) milk yield (MY) (kg milk/cow/day) and herbage mass (HM) (kg DM/ha) .*

Target	n	A	Min(A)	Max(A)	STDV(A)	P	Min(P)	Max(P)	STDV(P)	Bias(A-P)	MSPE	MPE
MY	79	23 .5	21 .6	25 .5	0 .96	25 .5	24 .3	26 .5	0 .51	2 .0	4 .97	0 .09
HM	39	2393	1675	3359	487	2460	1754	3504	491	66 .0	518228	0 .30

n=Number of observations , MSPE=Mean square prediction error , MPE=Mean prediction error

Conclusions The high utilization of the grass in the paddocks with nice swards and a MY that was close to target indicate that the use of a DSS for grazing management in combination with advanced weather forecasts , may be an interesting alternative to increase the use of grazed grass in dairy production .

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The Grazemore decision support system to optimise utilisation of grazed grass in dairy production

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Key words: software, grazing management, grazing schedule, milk production

Introduction Grazing systems are complex and requires good management to obtain a balance between high animal production and efficient utilisation of the grass. The Grazemore Decision Support System (DSS) is a management tool to increase the utilisation of grazed grass in European dairy production (Hetta et al., 2005). The system enables simulations of the effects of different grazing strategies and climates on milk production and grass growth. The aim of this study was to evaluate if the DSS is able to provide a schedule for rotation grazing of high yielding dairy cows with high utilisation of grazed grass in the north of Scandinavia.

Material and methods To evaluate Grazemore DSS ability to design a grazing schedule by user defined grazing rules, a grazing experiment was performed during the summer 2005 at the Forage Research Centre, Umeå, Sweden (63°45′ N; 20°17′E; 12 m elevation). The experiment run for six weeks and included forty dairy cows of the Swedish Red and White breed. The herd was rotating between four paddocks with a total area of 11.9 ha. The pastures consisted mainly of timothy (*Phleum pratense* L.) and meadow fescue (*Festuca pratense* L.). The average supplementary feeding was 2 kg hay and 9 kg concentrate/cow/day. During the experiment, the actual milk yield was recorded twice a week and grass samples were cut once a week to estimate the herbage mass.

Prior to the experiment simulations with the software were run to get a grazing schedule, called Grazing calendar 1, which allocated the herd to the different paddocks. Due to practical conditions the grazing calendar 1 was updated during the experiment, which resulted in the Grazing calendar 2. The difference between actual and predicted milk yield were analysed statistically with a regression analysis and the mean square prediction error (MSPE) was estimated.

Results and discussion Comparisons between the actual milk yield and the milk yield predicted by the Grazemore DSS (Table 1) show that the model had a low prediction error of 5 and 6 percent respectively. Both the milk yield observed and the ability of the DSS to predict this value were satisfactory. The herbage mass during the experiment was higher than predicted by the model resulting in a surplus of grass in the paddocks that was not utilised. The herbage growth model in the Grazemore DSS and its ability to predict the herbage mass could be improved to provide a schedule that gives a higher utilisation of grazed grass.

Table 1 *Mean values of actual milk yield (A) and milk yield predicted by the Grazemore DSS (P) in suggested Grazing calendar 1 and performed Grazing calendar 2*

Calendar	n	Milk yield (kg/cow/day)			R^2	MSPE	MPE	Part of MSPE		
		A	P	Bias				Bias	Line	Random
1	13	29.9	30.8	−0.9	0.25	2.1	0.05	0.38	0.00	0.62
2	13	29.9	31.5	−1.6	0.40	3.7	0.06	0.71	0.01	0.28

n=Number of observations, MSPE=Mean square prediction error, MPE=Mean prediction error

Conclusion Grazemore DSS has a good ability to predict milk yield and has potential to be a helpful tool for optimising grass utilisation in dairy production.

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The Grazemore decision support system to predict the quality of pasture grass in dairy production

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Key words: software, herbage growth model, forage quality, milk production

Introduction Grazemore DSS is a decision support system (DSS) developed to improve the use of grazed grass in dairy production in Europe (Hetta et al., 2005). The software consists of a herbage growth model (HGM) and an herbage intake model (HIM). The HGM predicts daily herbage growth (Barrett, Laidlaw & Mayne, 2004) and thereafter the DSS predicts crude protein (CP) and organic matter digestibility (OMD) of the herbage. Based on the information on herbage mass and quality of the grass the HIM predicts milk production, herbage intake as daily averages for the herd during the residence time in each paddock (Delagarde et al., 2004). The aim of this study was to examine if the predictions of the herbage quality of the software Grazemore DSS gives a reliable ground for grass based dairy production in the north of Scandinavia.

Materials and methods Herbage was cut weekly in paddocks of two dairy farms utilising the Grazemore DSS. In 2004 and 2005 samples were taken at farm (A) the Forage Research Centre Umeå, Sweden (63°45′N; 20°17′E; 12 m elevation) and in farm B on a commercial organic farm (B) Nordingrå, Sweden (62°52′N; 18°29′E; 20 m elevation). In 2005 samples were only taken on farm A. Herbage mass (HM) at sampling was determined by cutting several plots (0.9 m^2) per paddock and weighing the harvested grass prior to dry matter determination. The samples from both farms collected in 2004 were analysed for crude protein (CP) determined with the Dumas method and organic matter digestibility (OMD) were determined *in vitro*. The results form the estimations of HM and analysis of the quality of the herbage samples were compared with the predicted values of the DSS with regression analysis and the mean square prediction errors (MSPE) were estimated. Thereafter simulations were run to evaluate if the predictions of milk yield (MY) by the HIM improved when the values of OMD, CP and HM predicted by the DSS were replaced with the results of the cuts and the analysis of herbage.

Results and discussion The concentration of CP in the herbage was underestimated by the DSS on both farms and the relationship between actual and predicted values was poor, mean prediction error (MPE) was 24% and 31% respectively. The OMD of the herbage was slightly overestimated, but there were a significant relationship between the analysed and the predicted values and both farms had a MPE at 7%. The model gave underestimations of the HM in farm A in both in both 2004 and 2005, while the mass was overestimated for farm B in 2004. The relationship was statistically significant ($p < 0.05$) on both farms in 2004, but no significance was found for farm A in 2005. At farm A, the major part of the MSPE was due to bias for CP, OMD and HM. This might be corrected by adjustments in the model. At farm B, the major part of the MSPE was due to random for CP and OMD, and in line and random for HM. The relationship between measured and predicted MY with input from HGM was stronger then when the actual recordings of HM and herbage quality were used. Though, the MPE was relatively low, 6%, when using predicted input and MPE was 16% the MSPE was mostly due to bias.

Conclusion The Grazemore DSS has a good potential to predict OMD and HM in paddocks in the north of Scandinavia, but it takes further development to make predictions of CP more reliable.

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Ecosystem NPP of typical Steppe in Xilinhot based on the improved CASA model

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Key words: Net Primary Production (NPP), short grassland ecosystem, the improved CASA Model

Introduction Net primary production (NPP) is a key component of the terrestrial carbon cycle, and it is defined as the rate at which an ecosystem accumulates energy or biomass, excluding the energy it uses for the process of respiration. The CASA (Carnegie-Ames-Stanford Approach) model is a typical and extensive model of ecosystem NPP based on light use efficiency (Potter et al., 1993), but the classic CASA model has some weaknesses, such as the estimation of maximum light use efficiency (ε_{max}), impact to NPP from vegetation classification accuracy, and parameter calculation of the soil water model. Thus, this study used the improved CASA model (Zhu et al., 2006) to simulate NPP.

Materials and methods Xilinhot, Inner Mongolia was selected as the study region because it represents the most typical temperate steppe in north China. 1991, 2000 and 2005 TM/ETM images for the research region were attained by false color composition, mosaic, geometric rectification, and resampling of gray values, followed by transformation into Albers projection in ERDAS software. The spatial resolution of three images was 30m×30m. Following image processing, NPP ($gC \cdot m^{-2}$) was computed as the amount of photosynthetically active radiation absorbed by green vegetation (APAR) ($MJ \cdot m^{-2}$) multiplied by the actual light use efficiency (ε) ($gC \cdot MJ^{-1}$) by which the radiation is converted to plant biomass increment:

$$NPP(x, t) = APAR(x, t) \times \varepsilon(x, t) \qquad (1)$$

where x is a pixel in a remote sensing image, and t is the period that NPP is cumulated, such as a month. The technology flow chart for APAR and ε are provided by Zhu et al. (2006). In addition, thirty-two samples in the study area were selected to test the result of CASA. The error was evaluated by linear regression model in SPSS, and was found to be acceptable ($R^2 = 0.375$, $p < 0.05$).

Results and discussion NPP was found to be in good condition in 1991. In 2000, in the southern and southeastern part of Xilinhot there was a small quantity of good vegetation, while in the mid-western and northwestern region there was poor vegetation mostly distributed in large areas. In 2005, there were sparse, scattered areas of good vegetation while poor conditions occupied the main part of central and northwestern Xilinhot, although the area was smaller than that in 2000 (Figure 1).

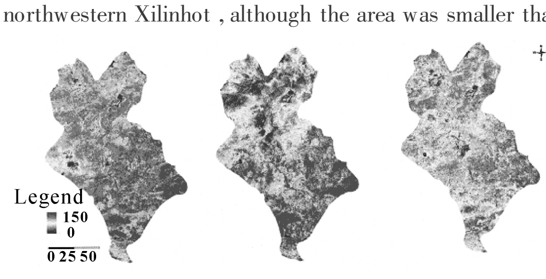

Figure 1 *NPP of Xinlinhot in 1991, 2000, 2005.*

Summary and conclusions This study used the improved CASA model to simulate regional NPP in the short grassland (typical steppe) region of Xilinhot. Image analysis and NPP calculation showed that the ecosystem has been in poor condition over the past decade. Continued degradation will continue unless grazing activities are changed. Remote sensing techniques are effective tools for detecting changes in the regional ecological conditions.

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A new computer program for the calculation of pasture carrying capacity

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Key words: botanical composition, biomass measurement, integrated field method

Introduction The calculation of pasture carrying capacity is essential to the sustainable management. Several methods can be used for the calculation in farms or small territories, mainly: visual comparison, biomass esteem, biomass measurement, analysis of botanical composition (Pastoral Value: Daget & Poissonet, 1972) and integration of botanical composition and biomass measurement (Ponderal Contribution: Pardini et al., 2000). Moreover some parameters can be taken into consideration to improve the quality of the results, these are related to physical environment (slope, orientation) and to the livestock group (cattle, sheep, goat, wild grazers, wild browsers), but this results in complex calculations. A computer program has been designed to elaborate data of specific contribution, biomass measurements, palatability to different livestock groups, productivity in different climatic areas, and average quality of the forage species. The program offers 5 methods of calculation: visual esteem, herbage height, biomass, botanical composition, integration of biomass measurement and analysis of botanical composition (Pardini et al., 2007).

Materials and methods The computer program has been developed by an Italian company that worked in association with the University of Florence (Italy) and the University of Santiago de Compostela (Spain). The program offers five methods of calculation: visual comparison, average pasture height, biomass, botanical analysis (Pastoral Value), integration of biomass and botanical analysis (Ponderal Contribution). A data base on productivity, palatability and chemical composition and eventual presence of toxic compounds in 2,000 plant species of pastures and rangelands has been assembled from former research of the authors and collecting data available on literature. The data base contains data of species from temperate, Mediterranean and tropical-subtropical climates. Results got by the five methods have been compared also with separate fraction weighing that is the most precise but also a very long field method known.

Results and discussion The program design offers a home page with links to the five methods. Once chosen the method, inputs are requested. The number and types of inputs depends on the chosen method. However, they are all easily available for the farmer, being the most complex the botanical composition. The comparison of results suggests that the visual comparison and biomass height methods should be considered just orientative. The pastoral value method is not very reliable as it calculates biomass availability on the base of productivity indexes and introduces subjective conversion indices to calculate the carrying capacity. Also the biomass method is orientative as it cannot consider the quality of pasture, however, it is fast and easy to use and can be useful for gross calculations. The Ponderal Contribution method is scientifically more reliable than the other four and at the same time sufficiently speditive and practical for farmers.

Conclusions Ranger 3.0 program is able to manage complex calculations on pasture and rangeland carrying capacity, it is a versatile tool as the data base can be increased by any farmer and the current botanical composition and the actual biomass availability are considered. Consequently it is more reliable for farm assessments than methods based on aerial or satellite pictures. The program is written in Italian, Spanish and English.

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Gradients of functionality of Australian rangeland landscapes : Assessing changes over time with remote sensing

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Key words : continuums , remote sensing , time-series , savannas

Introduction Unlike Australia's temperate ecosystems , the tropical savanna landscapes are in relatively unmodified condition . Disturbances such as fire , logging/thinning and grazing occur within these landscapes and can be both temporally and spatially variable , increasing landscape heterogeneity but rarely resulting in well-defined patch boundaries . Instead the tree stratum and underlying grassy ground layer varies continuously at the local-scale . Traditional models for analysis of heterogeneity in landscape structure and relevant functionality for fauna species have depicted landscapes as static arrays of vegetation patches with discrete boundaries between habitat and matrix patches . However , many rangeland and savanna landscapes with gradual spatial and temporal variation in structure do not fit this model .

Many species require more than one type of habitat during different life stages or for different functions such as foraging or nesting . Thus , to gain an understanding of change in ecological function with change in landscape structure it is important to recognise the ecological value of a variety of landscape components , and their changes over time . Few previous studies have considered these varying requirements .

This work aims to provide quantitative and continuous measures of habitat quality of relevance to fauna in a tropical savanna landscape . In addition this work will investigate how these measures of habitat quality vary over time by looking at time series of remote sensing imagery , and measure how important temporal changes are for biodiversity .

Materials and methods This study is based in the Desert Uplands bioregion of Queensland , Australia . The Desert Uplands are tropical savannas characterised by open eucalypt and acacia woodlands with grassy understory occurring on alluvial sand and clay soils and flat sand and earth plains . The region experiences a highly variable summer dominant rainfall varying between 350-600mm annually . Taking advantage of remote sensing technology , we map and model changes in amount and spatial configuration of different habitat elements from a time series of Landsat imagery . An object-oriented approach within the software Definiens Professional 5 .0 allows identification of key habitat elements within the imagery , in particular grass cover and tree cover followed by classification of the imagery into cover maps . Using spatial filters within ArcGIS we create continuous surfaces of the vegetation elements , and include information on water availability as a relevant habitat element . Generalised linear modelling and information theoretic approaches are used to describe the relative importance each of the habitat variables for the diversity , presence and abundance of a variety of small mammals , reptiles and birds . Habitat variables are weighted and combined to create a continuous surface measuring overall habitat quality for each image in the time-series . Further modelling establishes the relationship between the temporal variation in habitat quality and the diversity and abundance of fauna .

Results and discussion This work establishes a quantitative relationship between continuous spatial variation of habitat elements and the diversity and abundance of fauna . Our results show that there is much variation in the response of individual species to the variation in spatial structure of different habitat elements . Weighting and combining the habitat elements by relative importance results in a continuous surface of overall habitat quality . This model remains ecologically relevant as the new measures can explain a significant proportion of spatial variation in abundance of individual species and diversity of species . Temporal variation in landscape function , which is often ignored due to time and resource constraints , is also of importance . Significant temporal variation in species diversity and abundance occurs and is well-explained by our model of variation in habitat quality .

Conclusions Using remote sensing technology and time series data allowed us to successfully describe how landscape function can vary across a spatial continuum and through time . The approach used in this study was ecologically relevant as it took into account the different habitat requirements of a variety of species , instead of assuming a generic response to landscape structure covering multiple species . This study was also able to take into account temporal variation in landscape structure and function which is a common shortcoming of most studies of the influence of landscape structure and composition on fauna . Of particular relevance to savanna ecosystems is the ability to quantitatively measure continuums in habitat structure since these landscapes rarely exhibit distinct boundaries between vegetation cover types , nor are the fauna limited to one vegetation type .

Application of forage monitoring technology to track drought occurrences : Experiences from Eastern Africa

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Key words : pastoralist , livestock , drought , early warning , forage , forecast

Introduction Increasing frequency of drought occurrences is threatening livelihoods of pastoral communities in eastern Africa . Chances of drought occurring in parts of the Greater Horn of Africa have increased from a probability of one in six years to one in three years for areas affected . With the declining capacity of traditional coping mechanisms , new innovations are required for monitoring and communicating the emergence of drought conditions in good time . Rainfall and forage availability are early indicators of drought . The Livestock Early Warning System (LEWS) project has developed a forage monitoring system to assess emerging forage supply as an indicator of drought in Eastern Africa region . Tracking forage availability and having ability to predict the future forage conditions are useful tools that can be used to put in place contingency measures aimed at mitigating the emerging drought conditions .

Materials and methods The automated LEWS system is derived from a combination of biophysical models , information communication technologies and spatial analysis tools to monitor the standing crop of forage available to grazing animals using geo-referenced sites (Stuth et al ., 2005) . The model output is compiled for each dekad and processed to produce spatially-explicit forage maps . Ground verification of accuracy of maps is carried out by clipping vegetation at the monitoring points and comparing with model results .

Results The LEWS forage monitoring system generates site products which includes standing crop (kg/ha) , percent forage deviations and 30 , 60 and 90-day forage forecasts (http ://glews .tamu .edu/africa) . Decadal forage map complements the point based data . Forecasts are updated monthly and advisories are constructed from the resulting analysis for multiple levels of decision making . Between 2001 and 2006 , available forage and weather data showed that the LEWS model tracked the forage situation on the ground very well . The forecasts issued in September 2005 before the expected November-December short rains , had warned of emerging forage scarcity and subsequently deteriorating animal condition . This forecast tracked very well with the realized rainfall and forage conditions . The areas forecasted to have severe forage deviations (drought) were in northern , southern and parts of coastal Kenya ; southern and northern Ethiopia ; and parts of northern Tanzania . The drought had devastating effects on pastoral livelihoods following substantial livestock mortalities from November 2005 through March 2006 . In Kenya , average livestock mortality was 16 .2% for cattle , 12 .5% for goats , 20 .5% for sheep and 11 .4% for camels in affected areas . In Tanzania , livestock mortalities were 1 .7% for cattle , 1 .4% for goats and 3 .8% for sheep . When the drought ended in April 2006 , availability of water , pasture and browse improved markedly , but pastoral food security remained precarious . During the drought cattle prices in all markets decreased significantly (http ://links .tamu .edu ; LINKS , 2006) . Due to the weakening pastoralists' terms of trade for cereals , malnutrition rates rose among the chronically food insecure population . This scenario strengthens the case for providing timely flow of early warning information to livestock producers to guide making better decisions to move and market livestock during both normal and distress periods , so as to minimize the risk of having their livelihood assets decimated .

Conclusions The aim of the LEWS system is to offer decision makers sufficient lead time to make rational decisions and if used in a timely way , could enhance capacity to respond to threats of droughts . Efforts are being made to strengthen the use of early warning information and broaden the coverage of dissemination particularly among pastoral communities to enhance their capacity to plan for and respond appropriately to emerging drought conditions .

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Comparison of management effects on rangelands in western USA and Northern Mongolia using remote sensing and GIS

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Introduction Different cultures can have distinct effects on rangeland ecosystems through contrasting grazing management , policies , paradigms , traditions , and values . We are studying rangelands of the Darkhad Valley in northern Mongolia and rangelands of Intermountain Western Idaho , USA , using remote sensing , GPS , and GIS tools , to determine the effects of contrasting grazing management systems in biophysically-similar environments with similar growing seasons , precipitation , and temperature regimes . The Darkhad Valley rangelands are grazed at 3 .3-5 .9 AUM/ha by multiple livestock species of cattle , yaks , horses , sheep , and goats owned by nomadic herders , who migrate on seasonal basis . In contrast , the Idaho rangelands are grazed at much lower stocking rates of <0.62AUM/ha by sheep only and managed by the U .S . Department of Agriculture-Agricultural Research Service , U .S . Sheep Experiment Station (USSES) . We present results from the first year of a 3-year study .

Materials and methods In the field , total plant biomass and percent cover of shrub and herbaceous plants , litter , and bare ground were estimated at 100 random locations during the peak of the growing season in 2007 at both sites for image classification training and validation . Normalized Difference Vegetation Index (NDVI) was calculated using SPOT imagery and compared between the two sites . Spectral unmixing analyses were performed with SPOT and Landsat imagery to estimate and compare sub-pixel percent cover of shrub , herbaceous plants , and bare ground . In addition to the direct comparisons between sites , we compared the similarity index from each site , which was based on ecological site descriptions and site potential . The similarity index was estimated by calculating the difference in biomass production between the site and its reference site that is believed to have the historic climax plant community .

Results and discussion SPOT image analysis indicated that NDVI values estimated in the Darkhad Valley [mean$=0.19$ (± 0.06SD)] were significantly greater ($p=0.002$) compared to those at the USSES [mean$=0.15$ (± 0.10SD)] , which might be due to the high percent cover of herbaceous species in the Darkhad Valley , high percent cover of less spectrally determinable sagebrush species and the drought year at the USSES (Figure 1) . However , total plant biomass clipped in the field at the USSES was significantly greater [$p=0.039$) compared to the biomass measured in the Darkhad Valley (mean$=193$ gr/m^2 ($\pm$22SE) and mean$=143$ gr/m^2 ($\pm$4SE) , respectively] , possibly due to the greater stocking rate in the Darkhad Valley . The similarity index comparison indicated that the Darkhad Valley values were significantly greater ($p=0.05$) than the USSES values [mean$=0.38$ (± 0.01SE) and mean$=0.30$ (± 0.03SE) , respectively] . This suggests that the Darkhad Valley is closer to its reference site biomass production compared to the USSES . This is particularly interesting given the high stocking rates in the Darkhad Valley , which are not recommended or used on USA public grazing lands and are commonly believed to be unsustainable for rangeland productivity .

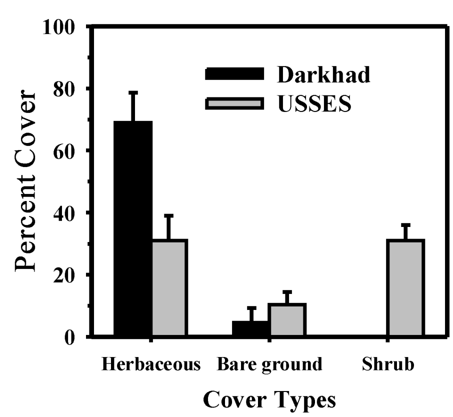

Figure 1 *Comparisons between different cover types at the two study sites .*

Conclusions Our results from the first year of observation reveal interesting contrasts and comparisons between two sites with fundamentally different grazing management systems . In the summer 2007 , the heavily-grazed Mongolia site had no shrubs and lesser bare ground , but greater percent cover of herbaceous species , which resulted in greater NDVI and similarity index values . In comparison , the Intermountain Western USA site had more equally-distributed cover of shrubs and herbaceous species , and bare ground . Our future work will focus on identifying other factors that might affect observed differences in addition to grazing management .

Monitoring cattle utilization and behavior in a Mediterranean oak woodland

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Key words: grazing, spatial distribution, GPS, heart rate, energy expenditure

Introduction The sustainable utilization of woodlands by cattle is a serious challenge world-wide. The domination by woody vegetation of poor nutritional quality and the low yield of herbaceous vegetation limit cattle performance (Perevolotsky 1994). Shortages of alternative grazing areas in Israel necessitate finding an optimal grazing management for the woodlands that, on the one hand, will improve cattle performance and, on the other hand, will create an open, parkland landscape and decrease fire hazards (Perevolotsky and Seligman 1998; Henkin et al. 2005). Recent methodological developments have greatly improved our ability to study animal performance and rangeland utilization. This research integrates these approaches to study the behavior and physiology of cattle in woodland habitats.

Materials and methods The experiment was conducted in the Western Galilee, Israel (long. 35°15′, lat. 33°01′, alt. 200-500 m a.s.l.). The vegetation is dominated by scrub-oak woodland (*Quercus calliprinos* Webb.), interspersed with batha vegetation and patches of herbaceous vegetation which is green 4-5 months a year. The area was classified into six vegetation types using aerial photography and ERDAS imaging, which were verified at the landscape level and then represented as a digital GIS map. The nutritional value of herbaceous and woody species was determined for the winter (December), spring (March) and summer (July) seasons. In each of these seasons Lotek GPS collars with activity sensors and Polar heart rate sensors were fitted on six cows in order to monitor their spatial distribution, activity and heart rate. The activity sensors were calibrated and activity was classified as graze, walk, or rest (Ungar et al. 2005). Energy expenditure was calculated using the heart rate and oxygen pulse method (Brosh et al. 2007).

Results Cattle spatial distribution was related to the different types of vegetation. During the winter and spring growing seasons cattle grazed in the open brush area which was rich in herbaceous species. In the summer, when the herbaceous species were dry, cattle spent more time in the tree vegetation type. No seasonal differences were found in the overall time devoted to each activity; animals spent 46.0±1.2, 52.5±1.5, and 1.5±0.5 percent of the day resting, grazing and walking, respectively. However, there were seasonal variations in the diurnal pattern of activity. Changes in activity over the course of the day were reflected clearly in the heart rate pattern. Daily energy expenditure varied according to reproductive state and the availability and quality of the forage, being 686, 594, and 525 kJ per kilogram metabolic body weight per day in March, December, and July, respectively.

Conclusions The applied methodologies provided a reliable tool for monitoring changes in cattle behavior and physiology even in a dense woodland formation. Vegetation structure and seasonal conditions determined the behavioral dynamics of free-ranging cattle in the Mediterranean oak woodland. Although cattle are naturally grazers, they browsed the woody vegetation in the summer when the quality of the herbaceous vegetation was low. Cow performance on the woodland range was comparable to that of cows grazing herbaceous rangeland in the study region. Therefore it appears that in this system cattle grazing may constitute a sustainable management tool for conservation, and is worthy of longer-term monitoring.

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Monitoring grassland and dynamics in Mongolia

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Key words: vegetation cover, species richness, piosphere, transect, Mongolia

Introduction Grasslands comprise 80% of Mongolia's 1.56 km^2 territory and provide forage resources for the dominant rural pastoral livelihood. Recent change from a collective management system to private livestock ownership has shifted local land use patterns and increased concern about overgrazing with reports identifying over 70% of the land as degraded or desertified (UNEP 2002). Degradation in this arid and semi-arid plateau is a regional problem as northern China experiences expanding desertification due to biophysical causes and human activities such as inappropriate livestock management (Li et al. 2006). As attention focuses on land cover change understanding steppe rangeland conditions and determining sustainable pasture management requires knowledge of current vegetation dynamics. This paper looks at piosphere vegetation density and species richness in the steppe and desert-steppe region of Mongolia. Water points reflect the interaction between pastoralists, livestock, and the environment and can identify land use patterns and potential degradation from overgrazing.

Methods Changes in vegetation coverage are an indicator of degradation (Huang and Siegert 2006). This study investigated 110 piosphere sites in Ovorhangai and Omnogov provinces in central and southern Mongolia using the line-transect method along a 1 km gradient to identify vegetation coverage and species richness around water points used by livestock. Multiple measurements were taken at 25, 50, 100, 200, 500, and 1000 meters and plant samples were collected at each site. SPOT-4 satellite imagery with 1 km resolution was used to detect vegetation cover. NDVI values were then calculated for April through October, 1998-2006 at each site. These were correlated with field data to establish present and historical perspectives of land cover in the provinces.

Results and discussion Results established low vegetation coverage and similar levels of species richness in the two regions. Both sites showed declining vegetation density as distance increased from water points with lowest plant coverage recorded at 500m and 1000m in sites. Average vegetation coverage at the 55 Ovorhangai sites was 13% at 25m and decreased to 7.8% at 1000m ($r^2 = 0.78$) whereas Omnogov showed lower density, declining from 4% at 25m to 2% at 1000m ($r^2 = 0.86$). Species richness was variable, not showing strong correlation to vegetation density or to NDVI land cover values. *Artemisia* was most common in both sites, followed by *Allium*, *Chenopodium*, and *Bassia* in Ovorhangai and *Potentilla*, *Caragana*, and *Iris* in Omnogov. NDVI correlated with field data and reflected a decrease in land cover over 9 years. Values fluctuated within years, particularly in the higher precipitation months of July, August, and September (Ovorhangai—25%; Omnogov—42%).

This study identifies limited pasture resources in the steppe and desert steppe zones that cover approximately half of Mongolia. Unlike the common pattern of sacrifice zones and intensified usage near piospheres identified in other dryland regions (Adler xcx) this highlights the role of abiotic factors, such as precipitation and edaphic conditions, in area vegetation coverage and suggests that overgrazing, often cited as a cause of local degradation and desertification, has less impact on piospheres in Mongolia than other arid and semi-arid regions. Millenia of low density pasture usage by Mongolia's traditional mobile herders points to pastoralism as an effective management approach in an area with limited vegetation resources (Fernandez-Gimenez 2001). Local and regional debate can focus on the importance of variable environmental conditions rather than solely the role of livestock in piosphere decline. Relevant management policies and development strategies, including targeted UNCCD goals and international assistance programs, can be appropriately designed to address humans within the environmental parameters in Mongolia's steppe and desert steppe grasslands.

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Effect of spatial resolution on remotely-sensed rangeland vegetation indices

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Key words: vegetation indices, spatial resolution, semi-arid environment

Introduction Rangeland ecosystems represent a major management concern for the future due to the threats caused by growing human population and loss of biodiversity. More information on the quality and quantity of vegetation is needed to assess rangeland ecosystems. Numerous remotely-sensed vegetation indices (VIs) have been developed to detect and characterize vegetation with limited success in semi-arid environments because of the challenge in detecting low levels of biomass and sparse vegetation cover (Leprieur *et al*., 2000). With the multiplication of image product availability, several studies have attempted to characterize vegetation in arid and semi-arid environments using VIs at different spatial scales and resolutions. However, the effects of scale on remote sensing-derived parameters are not well understood. The goal of this study was to analyze the effects of spatial resolution on VIs in a semi-arid environment.

Materials and methods The study area is located in sagebrush-steppe rangelands of southeastern Idaho, USA. Several common satellite sensors used in arid and semi-arid vegetation studies were selected and synchronous images were acquired (target date: June 26th 2006). For every image, NDVI, NRVI, SAVI, and $MSAVI_2$ were calculated at nominal resolutions and then aggregated at various levels of coarser spatial resolutions corresponding to the other images using an average function. Land cover types were stratified to compare the effects of scale over similar land cover types and to reduce variability. We selected two land cover types: shrub/grassland and cultivated crops/hay in which analysis were performed separately. All statistical analysis used 50 randomly selected pixel values. (1) We compared each VI from the same sensors among four different resolutions of QuickBird (i.e., 2.5, 10, 28.5, and 250 meters), three resolutions of SPOT5 HRG, and two resolutions of Landsat 5 TM. (2) We compared each VI among QuickBird, SPOT5 HRG, Landsat5 TM, and MODIS sensors using their native resolutions. One-way analysis of variance (ANOVA) with all pair-wise post-hoc comparisons were performed.

Results The different scales of QuickBird, SPOT5 HRG, and Landsat5 TM were not significant as predictor variables and no statistically significant differences were found in NDVI, NRVI, SAVI, and $MSAVI_2$ values among different scales of the same sensors (results not illustrated here). However, the different sensors were significant as predictor variables and the post-hoc comparisons indicated significant differences (Figure 1).

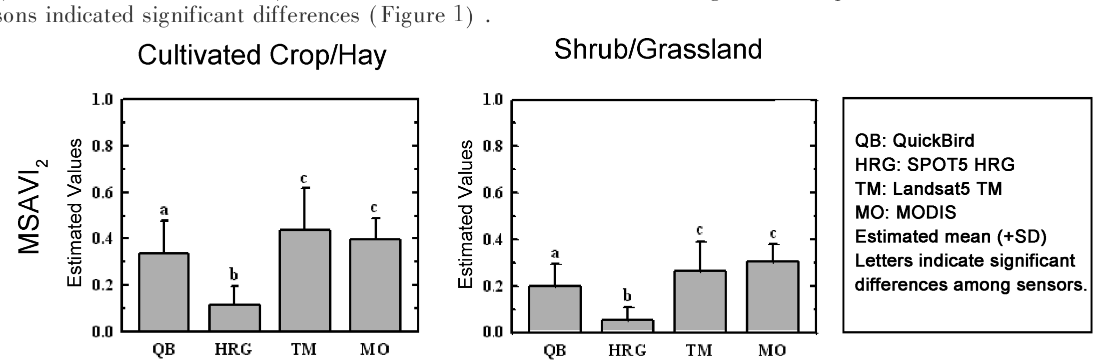

Figure 1 *Vegetation Indices (only* $MSAVI_2$ *is presented here) comparison among sensors.*

All VIs from both land cover types had significantly different values in most pair-wise comparisons. In many cases, VI values were not significantly different only between Landsat5 TM and MODIS sensors. As an example, we present here the $MSAVI_2$ values from cultivated crop/hay cover type and shrub/grassland cover type, which were significantly different in all pair-wise comparisons except the comparison between Landsat5 TM and MODIS.

Conclusions Values of VIs are not significantly different when aggregated at different spatial resolutions indicating a potential for multi-resolution comparability of VIs when derived from the same sensor. However, VI comparability between sensors is variable. In shrub/grassland land cover, Landsat5 TM and MODIS VIs values are comparable which suggests that theses sensors can be used together for direct comparisons or to replace one another. However, VIs from other sensors are not comparable to one another and, therefore, direct comparisons are not recommended.

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Rangeland sustainability modeling using soil exposure and soil moisture parameters

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Keywords: bare soil, soil moisture, remote sensing, geostatistics

Introduction In semi-arid rangelands such as the sagebrush-steppe of southeastern Idaho, USA, the limiting factor for range productivity is moisture, specifically soil moisture (Thomas and Squires 1991). Furthermore, the degree of soil exposure is a driving indicator of rangeland health (O'Brien et al. 2003). Modeling rangeland sustainability then requires the use of reliable soil moisture and soil exposure component models as the foundation for all subsequent work. The goal of this study was to develop and assess these soil moisture and soil exposure component models using field observations and measurements coupled with satellite remote sensing classification and geostatistical interpolation techniques.

Materials and methods The study area is located in the semi-arid sagebrush-steppe rangelands of southeastern Idaho, USA. Percent cover estimates and soil moisture measurements were acquired for 150 stratified random sampling points using a point-intercept method. SPOT5 satellite imagery (acquired concurrent with field sampling) was classified using Idrisi Andes software to produce a soil exposure component model using maximum likelihood classification. To be considered a bare ground presence training site, the field sample had to contain >50% bare soil exposure. ArcGIS 9.2 Geostatistical Analyst was used to produce the soil moisture component model using ordinary kriging interpolation.

Results The bare soil component model achieved 71.28% overall accuracy with Kappa index of agreement of 0.3246. The soil moisture model (Figure 1) cross validation statistics are summarized in Table 1.

Table 1 *Error matrix for the bare soil exposure model developed using maximum likelihood classification.*

	Bare soil Exposure ≥50%	Bare Soil Exposure <50%	Total	User Accuracy	Commission Error
Bare soil Exposure ≥50%	15	17	32	0.4687	0.5313
Bare Soil Exposure <50%	10	52	62	0.8387	0.1613
Total	25	69	94		
Producer's Accuracy	0.6000	0.7536		0.7128 (Overall Accuracy)	
Omission Error	0.4000	0.2464			0.2872 (Overall Error)

Table 2 *Cross validation statistics of soil moisture model developed using ordinary kriging.*

Mean Error	-0.00793
Mean Standardized Error	-0.003888
Root-Mean-Square Error	0.8259
Error Regression	0.665
Average Standard Error	0.7682
Root-Mean-Square Standardized Error	1.134

Conclusions Results indicate that soil moisture can be estimated and modeled relatively accurately using ordinary kriging. To accurately model bare soil exposure (>70% overall accuracy) using maximum likelihood classification requires training sites with relatively high amounts of bare soil exposure (>50%). Maximum likelihood classification used to model bare soil exposure from satellite remote sensing images may not be the best classification method.

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Use of remote sensing satellite images to predict pasture biomass on Waikato dairy farms

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Key words: satellite imagery, remote sensing, pasture biomass

Introduction Efficient pasture management is a key component of profitable dairy farming in New Zealand (NZ), yet feed budgeting is only used on about 20% of dairy farms (Clark et al., 2006). Current methods of pasture biomass assessment by NZ dairy farmers using visual assessment, rising plate meter (RPM), pasture probe or rapid pasture meter are time-consuming. Satellite images can save time and labour by rapidly providing individual paddock yields to assist management decisions. Remote sensing by satellite images relies on the fact that different levels of plant biomass differentially reflect red and near infra-red (NIR) electromagnetic radiation. This information is used to calculate an index of plant greenness or Normalised Difference Vegetation Index' (NDVI). The relationship between NDVI and pasture biomass allows pasture biomass to be predicted at the paddock or regional scale (Mata et al., 2007). Fonterra and Dairy InSight contracted CSIRO and Dexcel to investigate this technology for use in NZ dairying, aiming for real-time delivery of paddock covers to farmers. The project is now in its third year, with further validation of the model continuing along with pilot delivery of satellite-derived estimates of pasture biomass to farmers involved in the project.

Materials and methods From August 2005 to December 2006, 22 images were sampled with pasture biomass data collected from 11 Waikato dairy farms (8 commercial, 2 research, 1 corporate) of flat contour ($<10°$ slope), for calibration and validation of the relationship between satellite-derived NDVI and field estimated pasture biomass (Mata et al., 2007). Further validation and pilot delivery began in June 2007, with 3 more commercial farms and 1 research farm added to increase the number of cloud-free farms available to sample and to add more contour. A further 7 images were sampled from July to November 2007 with satellite predicted pasture biomass delivered to farmers for 2 of these images. Data collection was focussed on the winter-spring period (June to December), where pasture management to match feed supply with demand and maintain feed quality is critical in New Zealand dairy systems.

Paddock average pasture biomass values were collected using a RPM according to recommended industry practice (minimum of 50-80 readings per paddock), Thomson et al., 1997. Satellite images acquired from SPOT-4 (pixel size 20m) and SPOT-5 (pixel size 10m) satellites (*www.spotimage.fr*) were processed using standard remote sensing procedures. A model was developed using the ground measurements of pasture biomass and satellite-derived NDVI at the pixel level to enable pasture biomass predictions from the satellite imagery (Mata et al., 2007).

Results and discussion Validation studies from data collected in Year 2 (Mata et al., 2007) showed satellite estimates of paddock-average pasture biomass were highly correlated with RPM biomass estimates collected on the same day as image acquisition, with combined data giving a 10% error, or 260 kg DM/ha for a pasture biomass range of 1500 to 3400 kg DM/ha. This compares well with other NZ and Australian estimated errors of pasture biomass, using the RPM, of 311-610 kg DM/ha. However validation of the algorithm during 2007-2008 has revealed that between 20% and 30% of the data may exceed these limits and options for addressing issues are being considered.

Cloud-cover remains a constraint to obtaining weekly images, with up to 3 weeks between clear images obtained in late September and November 2007. Pasture growth modelling using interpolated weather data is being investigated to overcome this and may be used alongside satellite estimates to enable weekly data delivery. Long-term, radar satellite technology, which is not affected by cloud-cover, may prove to be a useful tool to link with. Other satellites may also provide more frequent coverage.

Delivery of reliable pasture biomass estimates at low cost would allow farmers to use the data in weekly feed budgets, or provide them with a feed wedge to help make management decisions.

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Monitoring natural pasture status in Uruguay using satellite images and a soil water balance model

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Key words: natural pastures, IDSS, NDVI, soil water balance

Introduction Cattle beef production in natural grasslands is the dominant agricultural production system in Uruguay. Monitoring and information about the current status of natural pastures is very important for planning and decision making at farm and government level, to prevent cattle beef production losses. INIA, jointly with other national and international institutions, has been developing an Information and Decision Support System (IDSS) for monitoring the status of natural pastures in Uruguay. The IDSS is based on tools like remote sensing, Geographic Information Systems and models.

Objectives The main objective of the IDSS is to offer almost real time information about the natural pasture status and the soil water content in natural grasslands areas to support Government and cattle beef producers planning and decision making. The current IDSS is based on two main components: 1) the Normalized Difference Vegetation Index (NDVI) estimated with data coming from the Advanced Very High Resolution Radiometer (AVHRR) sensor, installed in NOAA satellites, and 2) a Soil Water Balance (SWB) model for Uruguayan soils.

Methodology AVHRR-NDVI satellite data is supplied by the Climate and Water Institute from the Argentinean Agriculture Research Institute. The NDVI is a normalized ratio of the red (R=0.58-0.68 mm) and near infrared (NIR=0.725-1.1 mm) spectral wavelengths. Monthly or 10-day maximum values of AVHRR-NDVI are estimated from daily data collected throughout the year. Monthly or 10-day NDVI imagery creates a relatively cloud-free data set by choosing NDVI pixels from days when radiance interference is lowest and sun angle is highest with the assumption that the selected pixel is most representative of actual ground reflectance (Holben, 1986). Also, monthly NDVI anomaly imagery is created based on historic NDVI imagery data set.

The other tool used in the IDSS is the Water Balance Model for Soils of Uruguay" developed by the INIA-GRAS, Unit jointly with the Water and Soils Department of the MGAP, and the National Direction of Meteorology of Uruguay. The model estimates the soil water content by integrating the water precipitation data from 85 climate stations, the atmospheric potential water demand, the vegetation transpiration, and the water holding capacity of each soil type. This model runs daily and generates ten-day and monthly means outputs in map format of: water runoff (mm), and soil water content (mm and %).

Results Monthly and 10-day data and maps of NDVI and SWB are located and continuously updated in the GRAS Unit web site http://www.inia.org.uy/gras. A monthly agro-climate report, including NDVI and SWB information, is also published in the GRAS Unit web site and sent by email to more than 10,000 users.

Conclusions NDVI and SWB components of the IDSS used in an integrated way, have demonstrated to be a powerful tool to monitor natural pasture status, mainly through alerting drought situations (Figure 1 and 2). In these conditions, drought affected areas have been detected by both indices, but usually the SWB showed them earlier than the NDVI, probably due to the delayed response of plants to the water deficit.

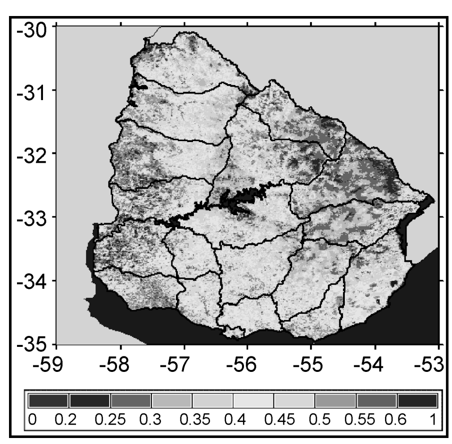

Figure 1 *NDVI (Feb-2005).*

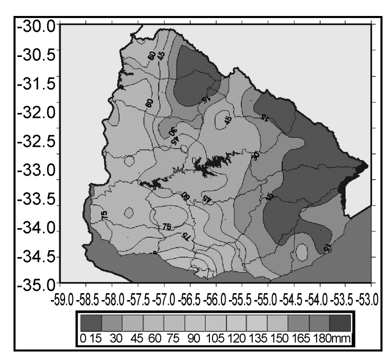

Figure 2 *Soil water content (mm) (Feb-2005).*

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Patch selection by cattle can be quantified using satellite imagery and GPS in extensive, semi-arid savannas

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Key words: patch type, selective grazing, stocking rate

Introduction Patch selection by grazing animals is difficult to quantify, particularly in large, extensive paddocks like those in northern Australia. However, advances in high resolution satellite imagery now allow identification of patch types over an entire paddock which combined with GPS collars to capture positional data, can give an accurate and comprehensive picture of landscape use by cattle.

Material and methods The study was conducted on an established grazing trial near Charters Towers, northern Australia (O'Reagain *et al*. 2007). Average rainfall is 650mm, and the vegetation is an open savanna) Thirteen patch types (Table 1) were identified at every 1m pixel across the site using IKONOS high resolution satellite images for Dec 2005 and Feb 2006. Archival GPS collars were fitted to 6 cattle in each of two replicates of the heavy (HSR) and light (LSR) stocked treatments (paddock size; 100 ha) from *c*. January to March 2005 and positional data collected hourly. Data from the two animals with the most fixes per treatment was used in the analysis (GPS methodology follows Tomkins and O'Reagian 2007). Animal activity was classified into a grazing or resting phase. Jacob's index of selectivity was used to determine patch type selection.

Table 1 *Patch types and their proportion within each treatment.*

Patch type	HSR%	LSR%
2P : Perennial, palatable and/or productive grasses	2.7	2.6
3P : Perennial palatable productive (3P) grasses *Bothriochloa spp*	14.6	29.4
An : Annual grasses	9.7	10.1
Ar : *Aristida spp*., Unpalatable perennial wiregrass	11.3	8.3
Ba : Bare ground	5.4	2.2
Ch : *Chrysopogon fallax*: a, perennial palatable grass of low bulk	10.8	9.4
Car : *Carissa ovata*-A spiny encroaching shrub	20.2	15.7
Eri : *Eriachne* spp, unpalatable, perennial grass,	9.1	7.3
Eri/Het : *Eriachne* with moderate proportion of the 3P grass H. *contortus*	2.1	0.9
M An : Annuals on (?) clay mounds	4.7	4.0
M 3P : Low density of Bothriochloa and annuals on clay mounds	2	2.1
M Car : Carissa on stony/salty clay mounds	2.3	2.5

Results and discussion Animals in both the HSR and LSR selected for annual grass patches (Figure 1), probably because of the high leaf quality of these patches in the wet season. Animals in both treatments avoided Carissa and bare ground for obvious reasons. Surprisingly, LSR animals selected *Eriachne* patches probably because of the availability of high quality forbs and legumes in inter-tussock spaces. LSR cattle are possibly selecting these species despite their low bulk, as they can easily and quickly meet their nutrient requirements due to the higher availability of 3P pasture in the LSR treatment.

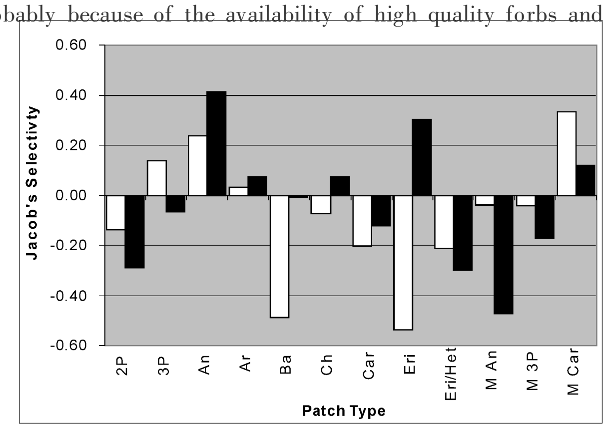

Figure 1 *Jacobs's selectivity index for different patch types under heavy (□) and light (■) stocking treatments.*

Conclusions This study has shown that a combination of high resolution imagery and GPS collars can be used to quantify patch selection at a very fine resolution in large extensive paddocks.

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Rangeland monitoring and adaptive management

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Key words: trend analysis, *m*-Vectors, Multi-Dimensional Sphere Model (MDSM), time series

Introduction Rangeland monitoring data are expressed as three subscripts data, $D_{i,j,k}$, where $i=1,2,\ldots m$, indicates species, $j=1,2,\ldots n$, indicates samples, and $k=1,2,\ldots o$, indicates times (Legendre & Legendre, 1998). Multi-Dimensional Sphere Model, MDSM (Bai, *et al.*, 1997) is designed to discover the changing trends in these data. Model uses *m*-vectors, instead of matrix, to express rangeland: uses magnitude of the vector to express the total biomass, and uses direction of the vectors to express the composition of rangelands. In vector space, it is direction, instead of distances, that makes differences, but in rangeland science, it is the composition, instead of production, that makes differences. For example, three position vectors in shrub-grass 2-space, $\boldsymbol{A}=(1,0)$, $\boldsymbol{B}=(0,1)$, and $\boldsymbol{C}=(3,0)$. $\boldsymbol{A}$ is closer to $\boldsymbol{B}$ than to $\boldsymbol{C}$, but $\boldsymbol{A}$ has same direction with $\boldsymbol{C}$, but orthogonal to $\boldsymbol{B}$. Model clusters $\boldsymbol{A}$ and $\boldsymbol{C}$ as shrubland, but $\boldsymbol{B}$ as grassland. In other words, vector space is a projective space, where $n\boldsymbol{A}=\mathbf{A}$ (*Bai*, et al., 2001).

Methods As collinear vectors have the same composition, rangeland vectors have to be standardized (normalized):

$$\boldsymbol{Y}'=\boldsymbol{Y}/|\boldsymbol{Y}|, \quad (1)$$

Where $\boldsymbol{Y}'$ are the state vectors of the rangelands, or the projection of the rangelands on the unit hyper-sphere, $\boldsymbol{Y}$ are the rangeland vectors, or a point in *m*-space, and $|\boldsymbol{Y}|$ is the vector length, the square root of the sum of the squares. Then, model uses time series to express the rangeland dynamics. It defines changing trends as present state over previous,

$$\boldsymbol{T}_k=\mathbf{Y}'_k/\mathbf{Y}'_{k-1}=(\mathbf{Y}_k/|\mathbf{Y}_k|)/(\mathbf{Y}_{k-1}/|\mathbf{Y}_{k-1}|), \quad (2)$$

Where, $\boldsymbol{T}_k$ are trends, $\boldsymbol{Y}_k$ are state vectors of rangelands, subscript k indicate times. The rangeland growth based on cell duplication is expressed as exponential growth, and trends can be used to project the next year' state (Zhao, et al., 1982),

$$\boldsymbol{P}_{k+1}=\boldsymbol{Y}_k * \boldsymbol{T}_k. \quad (3)$$

Where $\boldsymbol{P}_{k+1}$ are the projection of the next year based on given year' information, $\boldsymbol{Y}_k$ are the state of given year, $\boldsymbol{T}_k$ are the trends of given year. The projection can be modified by next year' actual samples to generate expectation of the next year, and this is so called Kalman filter (Jameson*, 1989):

$$\boldsymbol{E}_{k+1}=\alpha * \boldsymbol{P}_{k+1}+(\mathbf{1}-\alpha) * \boldsymbol{D}_{k+1}, \quad (4)$$

where $\boldsymbol{E}_{k+1}$ are expectation, $\boldsymbol{P}_{k+1}$ are projection based on previous year, $\boldsymbol{D}_{k+1}$ are new samples, and $0\leqslant\alpha\leqslant\mathbf{1}$ is the weighing factor given to $\boldsymbol{P}_{k+1}$. Thus, E have two resources: projection based on history and new actual samples.

Conclusions and discussions vector space and rangeland are (one-one) related: vector magnitude vs. rangeland production, direction vs. composition, addition vs. combination, minus vs. differences, division vs. trends, multiply vs. projection. It has been proven that $\boldsymbol{E}$ are closer to the true values than either $\boldsymbol{P}$ or $\boldsymbol{D}$, and projection error,

$$\boldsymbol{R}=(\mathbf{1}-\alpha) * (\boldsymbol{D}-\boldsymbol{P}) \quad (5)$$

are smaller than either using $\boldsymbol{P}$ or $\boldsymbol{D}$ alone. Furthermore, if we use $\boldsymbol{P}+\boldsymbol{D}$ to replace $\boldsymbol{E}$, and use $\boldsymbol{T}\times\boldsymbol{E}$ to replace $\boldsymbol{P}$, then,

$$\begin{aligned}\boldsymbol{E}_k&=\mathbf{D}_k+\mathbf{P}_k,\\ &=\mathbf{D}_k+\mathbf{T}_{k-1} * \mathbf{E}_{k-1}=\mathbf{D}_k+\mathbf{T}_{k-1} * (\mathbf{D}_{k-1}+\mathbf{P}_{k-1})\ldots\\ &=\mathbf{D}_k+\mathbf{T}_{k-1} * (\mathbf{D}_{k-1}+\mathbf{T}_{k-2} * (\mathbf{D}_{k-2}+\mathbf{T}_{k-3} * (\mathbf{D}_{k-3}+\ldots+\mathbf{T}_0 * \mathbf{D}_0)))\end{aligned} \quad (6)$$

Rangeland expectation are linked to whole monitoring time series, and the trends calculated from expectations have used all information from the monitoring history, even looks like only two points be used (Bai, *et al.*, 2007).

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Application of fractal on ecosystem in grassland

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Key words: fractal, geostatistics, spatial variability, grassland, ecosystem

Introduction Water and soil loss and deterioration of the environment are serious in the western grasslands of China, and this restricts the local sustainable development of the economy. The environment is influenced by spatial and temporal distribution of water, soil, and vegetation. Understanding the complex phenomenon of spatial and temporal distribution of ecological elements is very important for agriculture and safeguarding the environment of grasslands. Since grasslands are complex ecosystems with strong spatial and temporal variability, we can utilize Geostatistics to demonstrate the patterns and the internal relationships of ecosystem elements. Traditional parametric Geostatistics has some short comings for explaining complex phenomenon of ecosystems, while Fractal Geostatistics perhaps is more appropriate. Compared with Geostatistics, Fractal Geostatistics is good at illustrating the nonlinear problems, which provides a totally new idea for the internal regularity study of the complexity and scrambling of ecosystems in grasslands. Fractal Geostatistics has great value in research and application.

Theories and methods Fractal Geostatistics is the organic combination of Fractal theory and Geostatistics. Geostatistics can be used to study relativity in distribution of spatial information in a certain scale. Self-similarity theory of fractal can be used to study the heterogeneity of the spatial information, and then we can simulate and predict the distribution of spatial information by integrating correlation and heterogeneity.

Applications As a complex ecosystem, patterns and processes in grasslands are always the emphasis of ecology and grassland science, which is closely related to spatial variability. In 1993, the 78th annual meeting of ecology (USA) opened, with the subject Geostatistics and Ecology. Some people showed the potential application of Geostatistics in ecology, and since then it has been used by more and more people. At present, the main applications are as follows: (1) Analysis with R/S. It reveals the variety of regional variability in a certain temporal-spatial scale (Wang Kaoli, 2002). (2) Interpolation and simulation. Based on the fractal relationship and correlativity of variable, the value at unsampled locations can be estimated according to the known information (Grane, 1990; Cheng Qiuming, 2001). (3) Characterization of soil in structure. Particle-size distribution, soil water retention curve and current in porosity medium have fractal characteristic, which the variability can be described by Fractal Geostatistics (Tyler, 1990; Huang Guanhua, 2002; Xu Bing, 2007). (4) Variety of vegetation. Shape of vegetation, community and landscape patterns have close affinity with scale. Fractal Geostatistics can explain the complicated variety of vegetation in a certain spatial-temporal scale (Palmer, 1998; Su Litan, 2005; Ren Haibao, 2005).

Conclusions The study on spatial problems are at the forefront of ecological research (P. Kareva, 1994), and Geostatistics has proved to be a good method for the study of spatial variability. With the development of Geostatistics (e.g the development of Fractal Geostatistics), it will be a powerful tool to study the complicated ecosystem in grassland.

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Geoinformatics application to investigate agricultural potential in the Cholistan Desert

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Key words: agriculture, Cholistan, GIS, GPS

Introduction Cholistan is an extension of the Great Indian Desert, which includes the Thar Desert in Sindh province of Pakistan and the Rajasthan Desert in India, covering an area of 26,330 km^2, it lies within Southeast quadrant of Punjab province between 27°42′ and 29°45′ North latitude and 69°52′ and 73°05′ East longitude (Ahmad, 2005; Ahmad, 2007). The area was once green and prosperous, where cultivation was practiced. With the drying up of the river, the area became desert through desertification processes and only a few grazing lands are left.

Materials and methods The use of spatial data for drylands-resource management and planning has been recognized worldwide. However, spatial data are less useful if they are not transformable into information which can be analyzed and interpreted in a systematic and quick way. Hence there is a requirement to transfer and keep spatial data related to agriculture in a standard computer format preferably in a GIS environment (Khali, 2001). A GIS is an integrated resource data base system that has the capability to store, edit and process digital data; and that supports development planning and policy analysis. The use of GIS for evaluating the potential of drylands is becoming very important, especially when immense accumulation of data is unavoidable (Khali, 2001). The Ministry of Environment, Government of Pakistan has set up an Environmental Monitoring System combining NOAA AVHRR data with high resolution Landsat TM data (FAO, 1997) and ground observations with the objective of developing an operational GIS for more effective planning, management, conservation and sustainable development of resources.

GPS application to investigate agricultural compartments Global Positioning System (GPS) is a highly accurate satellite based radio navigation system providing three-dimensional positioning, velocity and time information. In order to achieve GPS co-ordinate readings, the GPS unit transmitter must detect a minimum of four satellites and the more satellites detected by the transmitter, the more accurate the readings tend to be. Better accuracy can also be achieved if differential GPS (DGPS) is used (Spencer et al, 2003). The idea behind the DGPS is to correct bias errors at one location with measured bias errors at a known position. A reference receiver, or base station, computes corrections for each satellite signal. Some of the potential and useful GPS applications in drylands resources include tree location mapping, potential agricultural compartment boundary survey, ground truth activities and resources inventory (Khali, 2001).

Conclusions The analysis of Cholistan desert resources help us to know that the desert tract is full of plant resources, which have not been exploited on a large scale or commercial basis, because of their low output, sparse distribution and very poor management. For the overall development of the desert, it is an urgent need that the existing plant resources should be exploited on sound scientific lines using modern technologies. Because of a traditionally limited approach to dryland management, development, and assessment, current dryland initiatives fail to build the support necessary to effectively accomplish their objectives. On the other hand, an ecosystem approach to drylands monitoring and assessment holds great promise for generating enthusiasm, precisely because of its more comprehensive, forward-looking focus.

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Partitioning of evapotranspiration in four grassland ecosystems with a two source model

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Key words: evapotranspiration, transpiration, soil evaporation, E/ET, ChinaFLUX

Introduction The Shuttleworth-Wallace model (S-W model) (Shuttleworth and Wallace, 1985) is a two source model well known for its good performance on partitioning ecosystem evapotranspiration (ET) into soil evaporation (*E*) and vegetation transpiration (*T*). However, its applications on China's grasslands and for long periods are rarely documented. In this study, we use this model to estimate ET and the two components *E* and *T* over 2~3 continuous years on four grassland ecosystems in China.

Results and discussion Based on outputs of the model, the spatiotemporal dynamics of E/ET were described as well. Results indicated that modeled ET for the four ecosystems agreed well with the eddy covariance measurements at the half-hourly, daily and annual timescales, suggesting a good performance of the S-W model over a long-term period on China grasslands. Diurnally, E/ET was high in the morning and afternoon, and low in the late morning. Seasonally, E/ET decreased with the progress of growing season and declined after the active periods. Processes controlling the dynamics of E/ET at different timescales were different. Half-hourly, E/ET was mainly controlled by canopy conductance, and seasonally and interannually, the leaf area index (LAI) was the main controller. In general, *E* accounts for a great proportion of ET on typical grasslands in China. E/ET ranged from 0.1 to 0.57 during the peak growing seasons and totally 0.52~0.74 for the whole year.

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Measurement of remote sensing in desert plants recovery

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Key points : plant recovery ,remote sensing ,ecological water supply ,NDVI , the downstream of Tarim river

To offer an index of the remote sensing test quantity for the plants living in arid desert area , we prefer the contracting method in this paper , To stop 30a in 2000 and a water(Li Xia ,2006) the bank of the lower reaches of the Tarim River with vegetation MODIS-NDVI change analysis .

The summary of the searching area and the methods The researching area is water interception area lays in the downstream of Tarim river includes Yinsu , Kaerdayi and Alagan sections , plants mainly distribute in the area . With MODIS-NDVI data (geometry corrected and the corrected errors are within one cell) that describe the growing period (May to October) in 2000-2006 .We set the equation according to the NDVI collected before the water supply & after the water supply and the contract section NDVI in corresponding time . (D : the plants recovery degree ; N : NDVI after the water supply ; No : NDVI before the water supply ; Nw : the contract section NDVI .)

$$D=(N-N_O)/(N_w+M_O) \qquad (1)$$

Results and analysis

Analysis the MODIS-NDVI trend between before water supply and after water supply Exact the MODIS-NDVI s average of the data mentioned which is vertical to the watercourse and far away from the watercourse 0～2km with the ERDAS-IMAGIN G soft . The results show that : the NDVI increases when the water supply continues but the increasing slows down when the water extents . The average of Yinsu , Kaerdayi and Alagan s NDVI are 43 .7% ,35 .5% ,20 .8% .

The analysis on the before & after water supply and the depth of the underground water changing trend

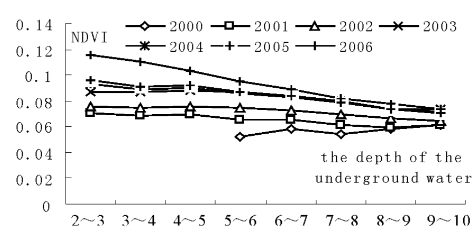

Figure 1 *Study area in 2000-2006 NDVI relations with the groundwater level .*

We paint the graphs on the NDVI and the average of the depth of the underground water when the plants are in growing periods of one year .Shown in graph 1 . As we can know from graph 1 that the NDVI has no evident relationship with the depth of the underground water before the water supply . But after the water supply , NDVI increase evidently in different depth of the water , less deeper means more increasing . And the NDVI increases more with the count of water supply added .

The analysis of the plants recovery degree

According to(1) ,we calculate the plants recovery degree inYinsu , Kaerdayi and Alagan and paint graph 2 . From graph 2 ,we can get the information that the plants recover more and more with the water supply continues .Yinsu is closest to the reservoir and it's recovery is best , Kaerdayi follows Yinsu and show the trend that closing to Yinsu . But the plants recovery degree in Alagan decreases gradually .

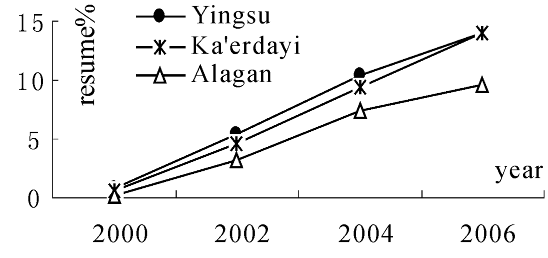

Figure 2 *Vegetation restoration of the section .*

Conclusions Plants recover gradually after the ecological water supply , and the speed of recovery and the degree depend on the time lasts of water supply and the depth of underground water . The recovery degree of NDVI is a contracting fixed quantity of the remote sensing to evaluate the plants recovers in the arid-desert area .

Applications of near infrared reflectance spectroscopy in grassland science

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Key words : near infrared reflectance spectroscopy , grassland science , application review , current situations , home and abroad

Introduction The technology of near infrared reflectance spectroscopy has the characteristics of accuracy , rapidness and free from contamination , therefore , more and more grass workers make much account of it . The application on the aspect of grass of NIRS started late and was more unprogressive compared to that on other fields , and the conditions of which was more serious in China . In recent thirty years , the analytical technology of NIRS has been applicated in the aspects of grassland science in distinguishing the compositions of plant communities , evaluatiing the qualities of forages and feedings , predicting the intaking characteristics of livestock towards forages etc . The aim of this paper was to summarize the applications of NIRS in the field of grassland science .

1 . Predicting products and qualities of forages during the growing seasons (Brown et al . , 1990)
2 . Distinguishing the plant compositions in different communities
3 . Identifying the contents of mineral elements compositions of forages
4 . Predicting the intaking characteristics of livestocks towards forages (Agnew , 2004)
5 . Identifying the qualities of domesticated animal products (Prieto et al . , 2006)
6 . Monitoring the nutritional conditions of ruminants (Landau et al . , 2006)

Conclusions There has been great advances in the achievements of basic and applied studies of NIRS gained in the grassland science . The achievements we mentioned in the paper were mainly from abroad and can not be used directly in the same areas within our country because of the huge regional differences . Therefore , great efforts of utilizing NIRS technology into the various aspects of grassland science should be done to further improve the fundamental researches and application studies of the development of grassland science in China .

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Research on establishing WebGIS of grassland resources for Inner Mongolia

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Key words : grassland resources , webGIS , Java , sharing ,Inner Mongolia

Introduction The natural grassland area in the Inner Mongolia autonomous region of China is 86 .667 million ha , which accounts for 73 .3% of the total area of the autonomous region and 21 .7% of the total area of the national grassland (Li B ,1993) . Grassland is not only important natural resource but also the important base of domestic animal husbandry . The grassland ecosystem of our country is influencing China and global ecological environment . Currently , data and information on the grassland ecosystem are abundant but scattered in many branches and different regions . This fact does not aid the use of data and information (YUAN Qing , 2006) by researchers and students . Furthermore , it is hard for the government to know the condition and the dynamic change of the grasslands over time . So , the digitalizing management and digital-simulation of grassland resource information has become an important direction of study . With this background , we attempted to establish a WebGIS for the grassland resource for Inner Mongolia according to the theory of GIS and using modern information technology .

Date and methods The digital maps(1 :1 ,000 ,000) used in this study , made by the Institute of Geographic Sciences and Natural Resources Research , CAS were as follows : Vegetation type map , Soil type map and administrative map were in Shape File format ; Annual average temperature map , Annual average precipitation map and annual accumulated temperature(⩾0) map were in Grid File format ; Digital elevation map(1 :250 ,000) is in DEM format ; EOS-Modis satellite data were downloaded from the internet . Based on the digitized maps already developed by others , the spatial data and attribute data were saved in separate special format files . We used Java program language and adopted C/S(Client/Server) project developed by a Applet software module in the JDK1 .5 environment . The Applet was embedded in HTML Web Page which is in the server on the internet . Then we established a web site named Geographic Information System of Grassland Resources for Inner Mongolia" through designing web pages and uploading all data and software packages .

Results The WebGIS about grassland resources for Inner Mongolia was established on the internet , and the website is http :// www .grassland .cn . A Java Runtime Environment module (JRE 1 .5 or above) is required for client computers that can be downloaded from this website or Sun website (http ://www .sun .com) . Anyone can enter this system at any time . The system overlays 8 layers of maps , and the software module furnishes the management information , The system offers users the following functions : Users can get multi-dimension geographic information of any point with the mouse pointer on the map coordinates , such as latitude , longitude , vegetation type , soil type , annual average temperature , annual average precipitation , annual accumulated temperature (⩾0℃) , elevation , above ground biomass and district where the pointer is positioned . The multi-dimension geographic information will be displayed in the information box immediately along with user mouse movement , no clicking and no waiting . According to users' interests , the system can designate single or composite geographical information to inquire distribution area , then marked red all regions coincident with the use designated and display the total area on status bar . Users can zoom in or zoom out the display of layer through the button of the panel , and can roam in the enlarged map by dragging the map in any displayed area using mouse .

Remote sensing monitoring for the key phonological stages of rangeland—a case study about Xilingol Grassland

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Key words: the key phonological stages, remote sensing, monitoring

Introduction In the large scale, Clevers (1994) and Luedeke (1996) etc have monitored the phonological stages of global vegetation based on NDVI and model, and thought that RS material has capability of detecting the key phonological stages.

Methods

Collecting field data

Observing and recording the key phonological stages of each rangeland type every ten days from April to September.

Processing RS data

260 scapes RS material have been processed such as atmospheric calibration, geometry rectification, and composed max values of NDVI of every ten days.

Defining the key phonological stages

According to RS definition of phonological stage by Xin Jingfeng (2001): green-up stage is a couple of sequential increase of NDVI in foremost appearance, and maturation stage is as a couple of sequential decrease of NDVI in foremost appearance.

Result and test

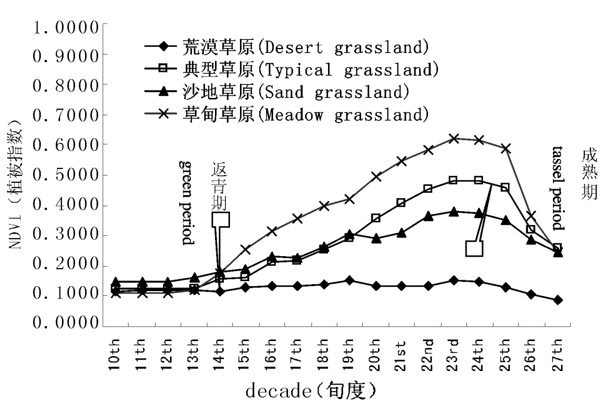

Figure 1 *Showed that the change of NDVI of every ten days has a visible orderliness, so did the field data.*

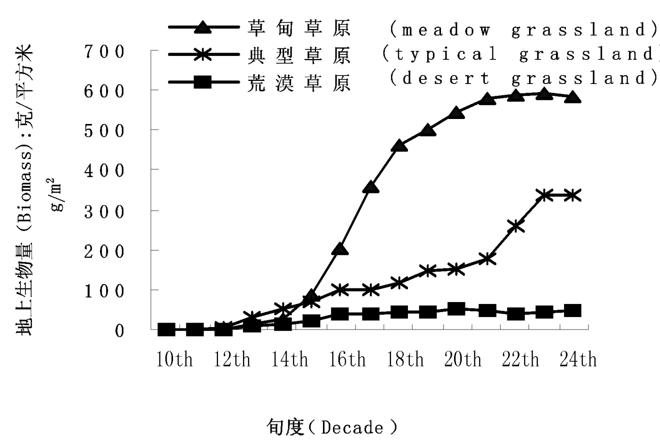

Figure 2 *Dynamic change for decadal NDVI and field data of four types of grassland(forbidden-grazing).*

Conclusion and discussion The change of NDVI of every ten days can distinguish the change rules of phonological stage, particularly two key stages: green-up phase and maturation phase. But most importantly, to select suitable training areas is critical in using RS material of multi-time series.

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Research on dynamic change of grassland based on spatial information technology

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Key words: grassland, spatial-temporal change, dynamic degree, remote sensing images, degradation

The method of study The data processing which included normal false color composing and accurate correction as well as registration and enhancement of images was accomplished by using Landsat data in 1986, 1996 and 2000 and 1:100 000 land-use map. The control points were selected to carry through quadratic polynomial fitting correction based on the recently land-use map. The treated TM images matched with the digital border line well, and the error was two pixels at most. The land dynamic degree is quantitative changes of some or other type of land-use within a period of time in a certain study area. Using dynamic model to analyze the spatial-temporal changes of regional grassland can truly reflect the exquisite degree of its changes. The expression is: $LC=(U_b-U_a) \cdot Ua^{-1} \cdot T^{1} \cdot 100\%$. where: LC represents dynamic degree of a certain type of land-use within study time; U_a and U_b represent the number of the certain land-use type at the beginning and at the end of the research; T represents the time that the study covered.

Results and analysis The area of grassland had reduced 42.1% since 15 years ago, and the average annual reduction was 2.81%. The decreasing trend was obvious, which showed that grassland degradation was from bad to worse. High coverage density area continued to decrease with large quantity change of the area, and the rate of net reduction reached 53%, which indicated that the degradation of this grassland category was most serious. Moderate and low coverage density areas didn't change a lot from 1986 to 1996, but from 1996 to 2000 both areas represented a reducing trend overall respectively. The grassland dynamic degree can be used to quantify the instance of grassland degradation, so the grassland dynamic degrees in the studied region from 1986 to 2000 were calculated. From 1986 to 1996, grassland dynamic degrees changed drastically. Among them, the dynamic degrees of high coverage density grassland were negative, and the values of moderate coverage grassland density were very small though they were also negative. Otherwise, low coverage density grassland dynamic degrees were positive value and the total dynamic degree accorded with the one of high coverage density grassland which were both-2.6%. The values of moderate and high coverage density grassland were relatively small and they developed comparatively slowly. From 1996 to 2000, various types of grassland and the total dynamic degree were all negative, which suggested that all types of grassland were degenerating, and the absolute values of low coverage density grassland dynamic degree were most. Thus the degradation of low coverage density grassland was the fastest. The study showed that from 1986 to 1996, the total number of grassland changed to other land-use types reached 1136843.3hm^2. The grassland most converted to cropland, saline-alkali land and woodland, and especially the converted area of the high coverage density one reached 619765.9hm^2 which was the largest. It showed that the grassland in this period was so exploited in excess by human that caused large areas of grassland to be changed to farmland and woodland, at the same time, grassland degradation and salinization were more serious. Undoubtedly, all above all leaded to the further deterioration of ecological environment in the studied area and seriously affected the development of stockbreeding in Western Jilin, so we should pay more our attention to them. From 1995 to 2000, the grassland degradation represented an increasing trend, and 769268.7hm^2 grassland translated into other land-use types. More grassland degenerated into saline-alkali land compared with the previous period, and the trend aggravated. Especially, the high coverage density grassland degenerated most seriously.

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A study on division of grades and warning of grassland fire

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Key words : grassland fire , grade , division

Introduction China is rich in grassland resource and has a variety of natural grasslands , which serve as not only the bases of stockbreeding but also the green ecological defense . But most of them distribute in arid or semiarid regions in northwestern China of arid climate with the characteristics of less of rainfall , windiness , and long period of withering . As a result , grassland fire occurs frequently , which result in a great loss for stockbreeding , people's life and grassland ecosystems . Obviously it is terrifying that grassland fire has caused so much damage to economy and environment . However , in our country there exist neither a set of systematic and unified indices of grades for grassland fire nor the division map of grades for grassland fire . It is difficult to predict and put out grassland fire scientifically . Therefore , it is very urgent to draw a set of scientific indices of grades for grassland fire and the maps of division of grades for grassland fire of the country and all the provinces respectively . And it is of great significance for the theoretical study of the technology of the prediction and suppression of grassland fire . (Wu Zhengyi , 1983)

Material and methods During the period of withering , the methods of route survey and typical sample survey are adopted to measure the amount of withering grass in main fire disaster areas with field investigation . According to major types of grassland , plots are chosen . There are three sampling spots in each plot , including 1 square meter of herbage , 1 square meter of small half-shrub and 100 square meters of shrubs . The contents of the survey include the coverage and weight of litter layer , the weight and distribution of livestock dung . Meanwhile , according to the features of ground combustible materials and discrepancies of topography and landform , grassland stations in 12 provinces are selected as ground monitoring networks , such as Inner Mongolia , Heilongjiang , Jilin , Liaoning , Gansu , Qinghai , Ningxia , Sichuan , Sinkiang , Shanxi , Shaanxi , Hebei . On the basis of data of grassland with field survey in 1980s and the synthetic study of vegetation height , coverage , the amount , the types and distribution of combustible materials , components and features of typography and landform , those basic data of ground combustible materials in different regions and different types of grassland can be obtained .

Conclusions The distribution area of grassland fire in the country is located in warm steppe belt . Inner Mongolia is the very high fire dangerous area , especially those parts of meadow steppes in Hulunbeir League , Xilinguole League and Xing'an League , which are the major target areas to defense and control grassland fire . High fire dangerous areas are mainly in typical steppes in Hulunbeir League and Xilinguole League . Also Yili and Tacheng in Xinkiang , and Liangshan and Aba in Sichuan are severely afflicted areas of grassland fire . Comparatively , Bashang Plateau in Hebei and parts of mountain steppe in Shanxi are areas with less frequent grassland fire . Mdium and low grassland fire usually happen in Inner Mongolia , Heilongjiang , Gansu and Qinghai . In addition , with the construction of grassland ecological engineering projects , grassland fire in some areas is upgrading per year . What's more , the cases of grassland fire occur in some of areas without such disaster before . Yet they would not happen in such areas as warm desert , alpine desert , alpine meadows and marshy meadows . (Liao Guofan & Jia Youling , 1996)

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The investigation of vegetation on Marl areas for biological controlling of water erosion in arid lands (case study : Semnan Province, Iran)

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Introduction The vast area of arid and semi-arid regions of Iran with unfavorable climatic conditions and erosional bedrock with fine grained clay mineral and evaporative mineral resulted in instability of the ecosystem. Therefore, the drought resulted from climatic conditions; show important role on vegetation of these areas. This project describes characteristics of vegetation on marl formations (calcic, halite and gypsic marls).

Material and Methods

General description of the study area According to the project aim and distribution of marl formation, the area has been studied extensively. The study area is located in Semnan province and is limited approximately by coordinates: 53°, 10′-54°, 45′ East longitudes and 35°, 15′-35°, 40′ North latitudes.

Material The documents and information used for this study include:
1. Topography maps (scales 1:50000 and 1:250000), 2. Geology map (scale 1:100000), 3. Aerial photos (scale 1:55000), 4. Satellite TM images (scales 1:250000, 1:100000), image of Google earth site and 5. Field observations.

Methods Geologic surveys (tectonic and lithology), Geomorphology surveys and mapping (water erosion), Collection and determination of vegetation cover.

Results

Climate The project area has an arid and semi-arid climate. The average annual precipitation is about 140mm and the average temperature is 14℃.

Lithology A major part of the area is covered with marl which is considered as studied area. Marls are unconsolidated rocks with clay content and evaporative mineral composition (calcite, halite, gypsum). Clay content ranges between 35%-65%.
Marls of the studied area have been classified as follows:
-Gypsic marl, this marl contains considerably gypsum (30%).
-Halite marl, which are as evaporative with more than 30% halite (preliminary, secodery).
-Calcic marls, which are marine sediments and their calcite is more than 60%.

Vegetation

Vegetation of gypsic marl in the semi arid region The most dominant plant of this landform is Artemisa heba-alba with other associated plants as follows: Anabasis setifera, Astragalus fridde, Gypsophyla mucronifolia, Moltkia gypsacea. Vegetative covers in the main drainage network of this area are follows: Trachomitum venetum, Phrgmites australis, Lomatopodium strawroph.

Vegetation of gypsic marl in the arid region The plants of this landform distribute in the uphill and downhill (river) and the percentage of vegetation canopy is less than 5%. Anabasis setifera, Salsola arbucula, Salsola turcomanica, Salsola incanescens, Cornulaca momacantha.

Vegetation of saline marl In this marl formation, although, vegetation density is less than other types of marls and reaches up to 2% but vegetation diversity is high. Salsola tomentosa, Salsola arbuscula, Salsola orientalis, Salsola incanescens, Seidlitzia rosmarinus Suaeda fruticosa, Reaumuria alternifolia.

Vegetation of calcic marl In this marl formation, vegetation density and diversity is higher than other types of marls and reaches up to 20%. Artemisia herba-alba, Euphorbia sp., Stachys inflat, Stipa barbata, Teucrium polium, Ziziphora tenuior, Atraphaxis spinosa, Zoegea purpurea.

Discussion In addition to climatic condition, lithologic characteristic have considerable effects on vegetation cover (density and diversity). This research showed that in similar lithologic condition, more humid climate results is improved biologic growth and consequently density and types of vegetation cover increases. Therefore climatic condition is more important than lithology on distribution of vegetation. Also, in similar climatic condition, meanwhile calcic, gypsic and saline marls have improved diversity and density of vegetation cover. Then based on lithology type, availability of salt with high ion exchange provides more limitation than salt with low ion exchange.
The current study also implies that anthropogenic activities on semi arid region marls is more apparent than arid regions. Generally for development and improvement of vegetation, it is necessary to limit human activities and to plant native species in the region.

The study and evaluation on the ecosystem recovery and reconstruction of the southern mountain areas of Ningxia based on the "3S" technology

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Key words : southern mountain areas of Ningxia , "3S" technology , ecosystem recovery ,reconstruction ,evaluation

Introduct The Southern Mountain Areas of Ningxia is located on the east of North-western part of china and also located on the upper reaches of Yellow River , which are covered by loess , uplands and ravines and Liupan Mountain is located in the middle of this region , with less precipitation and dry climate . It is the poorest area in China both in environment and economy because of the serious maladjusted man-land relationship , the lose of water and soil and the deteriorated ecosystem caused by the comparatively small capacity of original natural environment , weak ecosystem and huge population pressure .

In order to recover the ecology and promote the regional social economic development , the Chinese government launched the grand Ecosystem Recovery and Reconstruction Project in 1999—the Project of Returning Farmland to Forrest and Grassland .

Guided by the theory of ecology development , we set Pengyang county as an example to evaluate the Project of Returning Farmland to Forest and Grassland in the Southern Mountain Area of Ningxia based on the 3S" Technology . We chose the different TM satellite image of 2000 , 2002 and 2005 in the same season , built the land use classified system and set up the judge symbol through the field practice of GPS positioning and survey , and got the changes of types of land utilization by using GIS software , DEM images overlay and grade classification . To evaluate the condition of the Project of Returning Farmland to Forest and Grassland in Pengyang county through these analysis .

Results The areas of Returning Farmland to Forest and Grassland is increasing from 2000 to 2005 in Pengyang county , and the returning slope Farmland reached 50239 .029 hm^2 , the forest and Grassland increased from 52570 .228hm^2 in 2000 to 141598 . 499 hm^2 in 2005 , and 38241 .826 hm^2 barren areas become forest , the water area decreased 38 .141 hm^2 and the living area is 91 .632 hm^2 . According to the changes of the land use types in 5 years , the Project in Pengyang county is in favorable condition within these five years .

Among the research areas , Farmland in every grade is decreasing , and the Farmland under 15° grade is also decreasing . The Farmland below 5° grade decreased 12192 .687hm^2 with the change ratio of 28 .525% ; the Farmland between 5-8° decreased 4801 .961hm^2 with the change ratio of 33 .561% ; the Farmland between 8-15° decreased 15887 .362hm^2 with the change ratio of 51 .758% ; the Farmland between 15-25° decreased 13687 .104hm^2 with the change ratio of 39 .859% ; the Farmland between 25-35° decreased 3791 .725hm^2 with 65 .276% change ratio , for those areas above 35° decreased 478 .192hm^2 with 74 .436% change ratio . These data shows that the Project of Returning Farmland to Forest and Grassland in Pengyang county has focused on the Farmland of above 15° grade , which measures up to national policy , ecology development , and the requirement of ecology recovery , and that is really very scientific . However , the Project in Pengyang county didn't distinguish the condition and grade of different lands , that means it returned most areas of Farmland below 15° grade to forest and Grassland .

With regard to the changes of the land use types in recent 5 years , the Project of Returning Farmland to Forest and Grassland in Penyang county is in a favorable condition . We combine planting in barren areas and returning Farmland to forest and grassland together to plant in a large scale . The newly increased forest and Grassland reached 89028 .271 hm^2 . Therefore , the resources of forest and Grassland increased , the structure of land use is getting more reasonable , and the eco-environment is improved , which has made great effects on the water and soil reservation , the self-restrain of water source , to stop the wind and fixation of sand , to make the improvement of environment as well as the promotion of the sustainable development of the complex system of regional nature , economy and society .

Capability assessments of Landsat satellite data for vegetation cover monitoring (case study: Lar Dam Basin)

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Key words: vegetation cover, monitoring, Landsat 7 ETM+, Lar Dam Basin

Introduction Resources assessment using traditional methods is usually time-consuming and expensive. Also high speed of nature dynamism forced specialists to seek for quick and precise methods. Remote sensing and GIS are kinds of new technologies. We used Landsat 7 ETM+ data to monitor this dynamism in a semi-steppic region of Iran.

Materials and methods Landsat 7 ETM+ satellite data of 2002 and also vegetation cover map of 1976 were used for capability assessment of satellite data for preparing vegetation cover categories map and also vegetation monitoring in an area of about 27000 ha in Lar Dam Basin.

Sample points were selected after needed corrections. Appropriate band compositions were selected by paying attention to Optimum Index Factor (OIF), correlation matrix, Principal Components Analysis (PCA) and 2-dimensional diagram analysis. These compositions were classified using Maximum Likelihood, Minimum Distance and Box Classifier algorithms and then Majority Filter was applied. Accuracy of resulted maps was evaluated by pixel to pixel method. Then Overall Accuracy Coefficient and Kappa Index were calculated. By considering these indices, the map resulted from classification of band composition 123457 with method of Maximum Likelihood and applying Majority Filter was selected as the vegetation cover map of 2002. Vegetation cover map of 1976 was used as the vegetation cover map of 1976. Then the changes happened in different categories was detected.

Results and discussion Results showed that 28.55% of total area covered by range types in 1976 was unchanged, 14.03% was decreased to lower categories and 57.42% increased to higher ones. Table 1 shows amounts of change in each category. When we decreased our cover categories from 16 to 4, we observed different amounts of change in the mentioned period and also Overall Accuracy and Kappa indices were promoted. The map of vegetation cover changes was prepared, finally.

Table 1 *Amounts of change in cover categories.*

Category (%)	Area at 1976 (ha)	Area at 2002 (ha)	Change
0-25	0.0	1529.5	1529.5
26-50	18878.1	5729.9	-13148.2
51-75	301.5	11001.7	10700.2
76-100	1790.1	2708.6	918.5

Conclusions We reached to acceptable amounts of Overall Accuracy and Kappa indices in this classification and it could be concluded that ETM+ data are suitable for vegetation cover monitoring in similar conditions. As stated before, when we decreased number of categories, amounts of cover fluctuations and accuracy of resulted maps were changed, as other authors like Darvish Sefat (1998) and Alavi Panah (2000) pointed out. Therefore, we have to pay a serious attention to precisely and accurately definition of categories for classification of satellite data.

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Human migration, squatters and land cover change in the Chyulu Hills, Kenya

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Key words: land cover change, human migration, squatters, Kenya

Introduction Access to land remains critical to the survival and livelihoods for many rural people in Kenya. Migration is a response of the rural poor to acquire land, and when they occupy land for which they have no legal right to, they become squatters. The Chyulu Hills are recognised as a key site harbouring significant ecosystems and threatened biodiversity (GEF 1999) but despite this, continues to attract many spontaneous settlers, which have sometimes triggered forceful evictions when squatter encroach on protected lands. By focusing on the factors that encourage squatter settlements in the hills, the trajectories of land cover change, and the factors considered crucial in driving change, we aim to contribute insights on plausible future changes under different assumptions and how different planning and policy scenarios may be important in averting negative change.

Materials and methods Amigration study is done using quantitative methods and the life history matrix and modelling the pull" factors for the destination location. The study further applies a combination of social surveys using PRA tools, and community mapping to establish settlement patterns and relationships with the land. Black and white photographs taken in 1967 and 1978 at scales between 1 : 20,000 and 1 :50,000 are analysed in Landscape Mapper® and ArcGIS 9.2®. Landsat Imagery from 1987 (TM), 1999 and 2007 (ETM+) are analysed in ERDAS Imagine and ArcGIS. Generalised Linear Models and Regression Trees are used to model the drivers and role of factors responsible for land cover change (Veldkamp and Verburg 2004).

Results and discussion The work is ongoing, and preliminary findings indicate that the abundance of natural resources including relatively fertile soils and wetter climate than the surrounding rangelands are among the important pull factors for spontaneous settlements. The population growth rates are high due to the influence of migration. A multiplicity of land statutes and weak enforcement of land tenure regulations are part of a system of factors responsible for the consequent trajectories of change. Our a priori predictions are that between 1967 and 2007 (a) squatter presence (b) distance to roads (c) distance to parks and (d) agricultural suitability of land are major causes of land cover change. Policy acts as a bouncing pad on which land use decisions are made, which consequently influence land cover change.

Conclusions Knowledge on the forces responsible for the long-term dynamics in land resources use is limited in Kenya. This research integrates biophysical information with socio-economic and policy issues to examine the trajectories of land cover. Spontaneous settlements may act as an accelerator in land cover change, exacerbated by a multiplicity of tenure arrangements and weak enforcement. Policy options to avert the spiral of need created in the Chyulu Hills, currently necessitating allocation of land set aside for other uses to settle squatters are seen as a feasible option. Provision of alternative non-agricultural-based livelihood strategies for those squatters who are being settled could provide some reprieve for the ecosystem.

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Genetic evaluation of sweet potato vine genotypes

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Key words : dry matter , crude protein , morphological , vines

Introduction Sweet potato vines (ipomea batatas) have been reported to be an important source of crude protein (19 .5/CP) with digestibility of 80% (Irungu et al ., 2004) . According to Irungu the vines significantly improved intake in sheep ($P<0.01$) and stimulated digestion of low protein forages . The sweet potato vines therefore can form a major source of nutrients to livestock . They adapted well to wide environmental conditions and require low soil fertilizer , and have few pest & disease infection . The objective of this study was to identify , evaluate and select genotypes with traits of high dry matter content , crude protein (CP) , vigorous morphological characteristics , drought tolerance and resistance to pests and diseases .

Materials and methods Evaluation of ten vine types from a population of twenty three genotypes identified as potential vine types (Ondabu et el . 2004) was conducted at Lanet Research Centre . Lanet Research Centre is situated at an altitude of 1920m above sea level and receives 800mm of rainfall per annum . The soil is deep loam with an average maximum and minimum temperatures of 26℃ and 10℃ , respectively . The experiment used a randomized complete block design (RCBD) on plots measuring 3×5 m and replicated three times using a flat planting method . Vine spacing was maintained at 60×30 cm . Routine agronomic practices were applied . Harvesting was done after 90 days for laboratory analysis . The dry matter content was determined by drying samples in an oven at 105℃ for 24 hours . Crude protein was determined according to official methods of Association of Analytical Chemists (AOAC 1990) . Morphological characteristics were determined by measuring leaf width , length and vine circumference using a flexible tape measure . A sample of 100 vines and leaves were measured from each block . Data collected were subjected to analysis of variance using Genestat (1988) . The means were separated by the least significant difference (LSD) .

Results

Table 1 *Dry matter , crude protein , leaf and vine measurements of ten sweet potato vine cultivars .*

Cultivar	DM%	CP%	Leaf length	Leaf width	Vine circumference	
Sample size	10	10	100	100	100	Tuber weight per sq m
99/1	13 .6[e]	22 .6[a]	12 .0[c]	8 .4[f]	2 .5[b]	2 .7
Ex-mukuruini	11 .9[g]	18 .6[f]	10 .5[e]	11 .5[b]	3 .0[a]	1 .0
Helena	16 .0[c]	19 .8[c]	12 .0[c]	13 .0[a]	3 .3[a]	5 .0
K049	18 .2[a]	21 .3[b]	11 .0[d]	9 .3[d]	3 .0[a]	0 .5
K158	16 .5[b]	19 .5[d]	13 .7[a]	11 .6[b]	3 .0[a]	0 .2
Kemb-10	12 .2[f]	16 .4[j]	8 .6[g]	7 .3[g]	2 .6[b]	1 .5
Kemb-36	9 .7[i]	16 .9[h]	8 .6[g]	7 .5[g]	3 .1[a]	1 .0
Light green	10 .2[h]	16 .5[i]	9 .3[f]	8 .8[e]	2 .3[b]	3 .3
Marooko	14 .6[d]	18 .8[e]	12 .0[c]	10 .0[e]	2 .5[b]	1 .5
Wagabolige	14 .6[d]	18 .4[g]	12 .4[b]	13 .0[a]	3 .4[a]	0 .9
LSD	0 .22	0 .06	0 .2	0 .2	0 .2	

Means within columns with different scrips are significantly different ($P<0.01$)

Conclusions Dry matter , crude protein contents and morphological characteristics of the ten genotypes showed high variability . Genotype K049 had significantly high DM content while genotype 99/1 and K049 had significantly high protein content . All ten genotypes had CP content of more than 16 .4% and are suitable as protein supplements to grass based ruminant diets . Genotypes Wagabolige and Marooko manifested significantly high morphological characteristics , had low weed infestation , tolerant to prolonged drought and had no disease attacks .

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Monitoring rangeland community/health change using multispectral and hyperspectral satellite data

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Key words : rangeland , remote sensing , SPOT , hyperspectral , spectral mixture analysis , decision tree

Introduction This work aims to develop new remote sensing methodology for mapping rangeland change and health indicators in the province of Alberta in Canada . Change monitoring is performed based on cover fraction at ~20m pixel of the following landcover types : trees , shrubs , grasses/herbaceous , soil and water . The percent cover of plant litter , soil and noxious weed species is considered when monitoring the rangeland health .

Methods and results Various satellite data are acquired over four test sites located in southern Alberta . The broad-band multispectral (SPOT) 10m/20m data are collected at least three times during the growing season over each site while hyperspectral (Hyperion and CHRIS) data are collected at least once over each test site . Historical data for both are used to test the developed technologies for mapping rangeland change . In case of the SPOT data , the archived data goes back to 1986 and data from every 5/6 years are used . Hyperspectral data are newer and data goes back only to 2004 .

A spectral library database , including spectra of pure rangeland components and associated targets acquired in situ and in the lab , is also compiled for use in the mapping procedure . Additional parameters indicative of rangeland health such as biomass , water content , and chlorophyll are also acquired .

Discussion The methodology developed applies both the spectral mixture analysis and the decision tree to satellite data to derive the percent cover . Performances of these two methods are assessed against field ground-reference information (field data) and cover fraction maps derived from high resolution (~1/2 meter) aerial digital photos .

Classification of rangeland resource types based on multi-source remote sensing data

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Key words: northern slope of Tianshan Mountains, rangeland resources, classification, multi-source remote sensing data, 3S" technologies

Introduction The sustainable utilization of rangeland resources and the maintenance of ecological balance works on the premise that the information about changing rangeland resources is obtained rapidly. In China, the studies of classification and mapping of rangeland resources can be traced back to the 1960's (LI Jianlong *et al*., 1996), at that time interpretation was conducted using large-scale aerial photos, later they began to adopt satellite photos with the development of space-flight technology. So far researchers of this field mostly use remote sensing data as a reference (ZHEN Shoulin et al., 1990; LIU Fuyuan et al., 1991). In this study, multi-source remote sensing data were applied to investigate and classify rangeland resource types based on the 3S" technical platform.

Materials and methods The site was on the northern slope of Tianshan Mountains in Xinjiang province, China (86°05′～87°05′ E, 43°～43°08′N), the total area is about 5443 km^2. Three kinds of remote sensing data (Landsat-7/ETM+, CBERS, MODIS) were selected to execute supervised classification after a series of technical processes including image registering, format conversion, image enhancement and optimized band combination. With the support of Windows XP and GIS software (ENVI4.0, ArcView3.2, MapInfo 7.0), precision analysis and verification of the multi-source remote sensing data were conducted, combined with on-site square check, digital elevation model (DEM) and experts analysis, respectively.

Results ETM+ can discern and classify well whether in plain, partly mid-mountain, sub-alp or alp region; the accuracy rate was about 73.79% ～ 86.43%, but in low-mountain (1000-1600 m) and mostly mid-mountain it is difficult to classify the rangeland resources types. For CBERS, the accuracy rate decreased 51.12% ～ 83.67% from plain to alp region, and the accuracy rate was higher in low-mountain and mid-mountain than that of ETM+. MODIS could only classify the first units of the rangeland resources types because of its lower spectral resolution.

Conclusions It is most effective to adopt digital elevation model (DEM) to improve the accuracy rate of classification. Both ETM+ and CBERS are suitable for classification in rangeland resources, they can discern types of the first units except for plain and partly mid-mountain which had lower accuracy, but there were mixed types in the second unit; MODIS is not suitable for the application in classifying, however, it can be used for carrying out dynamic monitoring and biomass estimating in rangeland resources.

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Application of Geographic Information System (GIS) for developing range improvement and reclamation plans in Taleghan summer pastures

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Key words : rangeland plans , Geographic Information System , uniform units , Taleghan

Introduction Iran has 90 million hectare in pastures . To manage and develop programs for the renewable resources requires a suitable and rapid method for collecting and analyzing the information . Geographic Information System (GIS) can perform an important role in this process . The program for improving and growing pastures is one of the best plans to obtain the goal of optimum pasture management . The main purpose of this investigation was to examine the capability of GIS in managing the environmental units and range improvement sites , and finally to produce a range management plan and model for a specific area .

Material and methods GIS has high capability in details and resolution and also incorporation of the local data . In this research , some basic data such as slope , elevation , vegetation , soil depth and texture , range trend and condition were collected and mapped using GIS . Different layers of aforementioned information were integrated together in a GIS environment , and the uniform units were produced . Then in accordance to the traits of each unit and with the basic consideration of the vital rules of pasture models , the management model was presented for improving pastures situation or stability at the current optimum state in the study area . The management needs such as grazing system , reseeding and exclosures were specified and scheduled for the study area .

Results and discussion Result of this study , which was performed in Taleghan summer pastures , is shown in (Figure 1) . In accordance with (Figure 1) the total area of rangeland which should be managed by the natural method is 780 ha (code 1) , the area to be managed by the balance method is 1010 ha (code 2) , the area to be manured is 565 ha (code 3) , the area to be in an enclosure is 612 ha (code 4) , the area to be interseeded is 485 ha (code 5) , the area to be hoe sowed is 280 ha (code 6) , the area to be seeded is 785 ha (code 7) , and the rest is rocky , river and farmland and residential areas (Figure 1) .

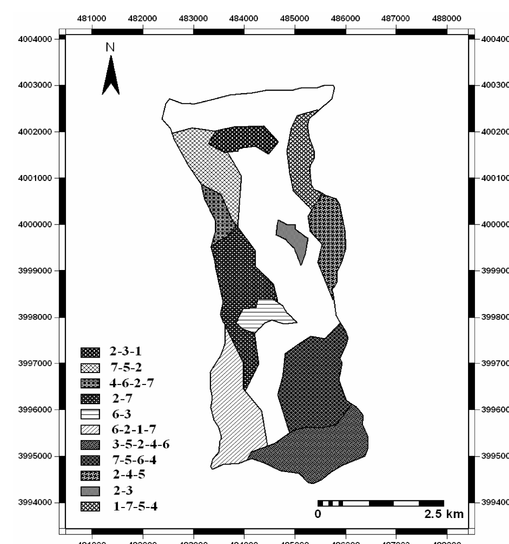

Figure 1 *Proposed reclamation plans by using GIS .*

Conclusions The study shows the area has a great potential for improvement and GIS is a useful tool for analyzing the needs . Combining information layers offers a method to rapidly locate and design pasture management . The GIS integrated model for rangeland management could help us to achieve the information more conveniently and quickly . Clarification is another attribute of this model . It has to be noted that for large-scale planning , some additional data such as climatological , geological , isotherm and isohytal data may be needed . Azarnivand et al (2007) reported similar results .

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The development of Landsat Cover Change Analysis in the pastoral grasslands of western Australia

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Key words: Landsat Cover Change Analysis, summary products, rangeland management

Introduction This paper outlines the use of cross calibrated multi temporal Landsat data in developing summaries for land managers, land administrators and for the wider community information in reporting on vegetation cover change at various scales.

Materials and methods The research was conducted in the Kimberley and Pilbara grasslands. The vegetation within these areas was stratified into like soil and vegetation communities, for example, in the Kimberley, the black soil plains of approximately 500,000 ha over 10 stations, dominated by Astrebla spp. and Chrysopogon spp. and in the Pilbara, the red soil coastal plains, of approximately 100,000 ha over 3 stations and dominated by Eragrostis spp.

A cover index using Landsat data is derived for the stratified soil type to be analysed. Land system and station infrastructure vectors are incorporated through GIS for analysis, interpretation and presentation.

Results and discussion Summary products were developed for a range of scales and questions by various stakeholders as shown in Table 1.

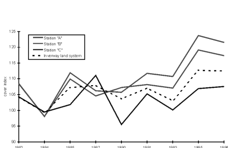
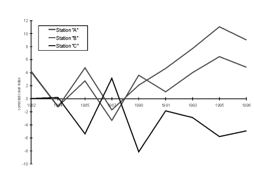
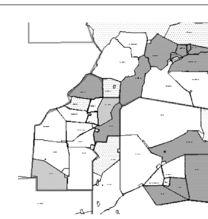
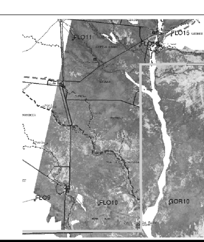
Scale or question	Regional summary Q. what is the stratified vegetation type doing?	Station or management unit scale Q. quantify the relative performance of stations within a district or paddocks on a station.	Management unit Q. Identify areas of above or below average response.	Regional- management unit- monitoring site Q. Identify areas of differing trends.
Stakeholder	State of Environment Government administrators. Departmental Advisers.	Government administrators. Pastoralists. Departmental Advisers.	Pastoralists. Departmental Advisers and Inspectors. Government administrators.	Departmental Advisers and Inspectors. Government administrators. Pastoralists. Monitoring.
Product	Uncorrected time trace.	Corrected time trace, relative to the regional trend shown at left.	Recombined stratified paddock summaries.	Trend maps for defined periods.
Example				

Figure 1 *Example of black soil pasture showing a positive response in cover index (8 units) and monitoring site photograph over an 8 year period, after earlier loss of cover.*

Conclusions Although only developed in relatively small areas at this point, products derived through Landsat Cover Change Analysis have the potential to report on large areas of rangelands at varying scales, depending on the question and stakeholder. The Department of Agriculture and Food Western Australia and Curtin University will be looking at how to further extend this work over the varied vegetation communities in the pastoral rangelands of Western Australia and how best to integrate other ground based datasets from monitoring sites and traversing.

Study on benefit detection of the grassland desertification control project in Xianghuang Banner, Inner Mongolia based on "3S" technology

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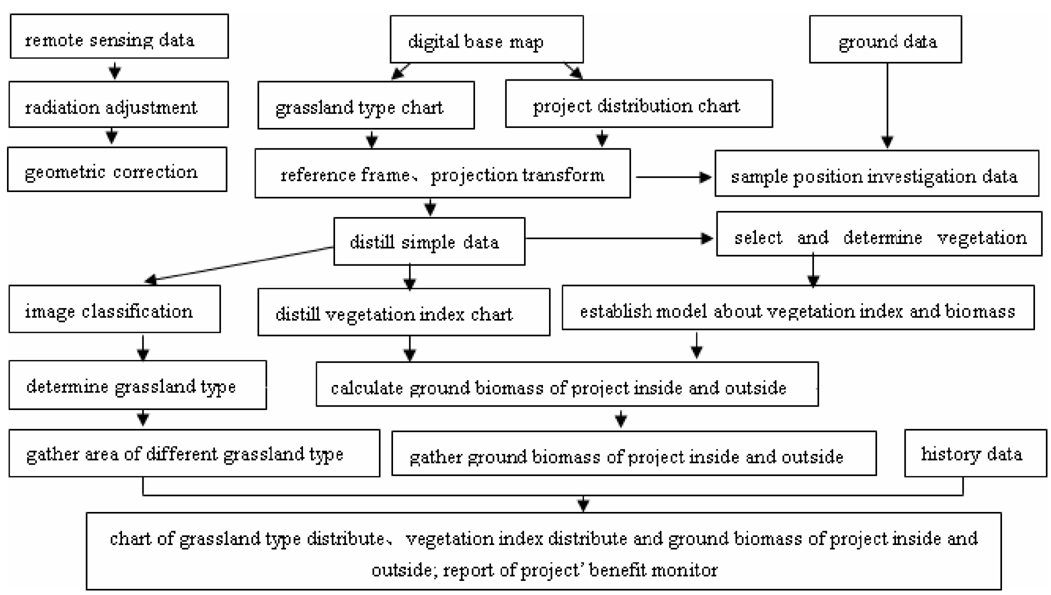
Key words: 3S"technology, grassland desertification control, remote sensing, detect, benefit

Introduction Desertification is now one of the worlds important environmental and social economy questions, that is threatening humanity's survival and development. Our country, is one of most seriously affected by desertification in the world. In order to effectively reduce grassland desertification, we started a series of grassland desertification control projects. But the project implementation's process is a non-natural process, and we don't know the projects' progress or benefit. Therefore, monitoring the benefit of the Grassland Desertification Control Project is urgent and essential.

Research method and technical route Through ground investigation based on Global Position System technology, we determined vegetation condition data at accurately located points. Using remote sensing, we collected image data about the project area. We analyzed multiple source spatial matching data to get the projects' area, biomass on the ground、vegetal composition、vegetation cover etc, based on GIS technology. Finally, we thoroughly and systematically monitored the grassland desertification control projects benefit. Technical route is as follows in Figure 1.



Figuer 1 *Flow chart of benefit monitor of project.*

Results Vegetation cover is an important index to reflect health of a grassland ecosystem. Compared with 2003, the vegetation cover has been improved by 8.64% in the project area in 2004.

Vegetal composition is an important component of a grassland ecosystem, and affects ecosystem function. Compared with outside of project, there were fewer *Artemisia frigida willd.., Ceratoides arborescens (Losinsk.) Tsien et C.G.Ma, Lagochilus Bunge, Potentilla acaulis Linn*. etc. inside of the projects. In general, these plants grow in dry or degenerated habitats. The decrease in density of these species, shows the habitat inside of projects improved.

The above ground biomass is an important factor to appraise productiveness of a grassland. Compared with August, 2003, the biomass on the ground increased by 56.78% in the project area in August 2004.

Conclusions The projects for controlling grassland desertification have effectively prevented grassland degradation, protected bio-diversity, and promoted the sustainable balanced development of the grassland resource.

Mapping and monitoring Inner Mongolia rangeland based on remote sensing

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Key words : rangeland , remote sensing , mapping dynamic monitoring

Introduction Liu Jiyuan (1995) has published methods for surveying and researching resources in China in a macroscopic scale using remote sensing technology (RS) . Data of state and change of rangeland resources can be obtained rapidly and accurately by applying the method of field measurements and RS material , which would provide help when making rangeland management decisions .

Methodology More than four kinds of indicators were specified such as major species , production and plant cover , as well as change in ratio of selected plants . Some important information has been extracted based on 3S technology .
A base map of 1 :0 .1 million and 1 :0 .25 million has been set up , based on more than three thousand orientation data points collected through field measurement , and the corresponding relationship between the field data and RS material has been established . We then used software such as ARC/GIS、ENVI etc . , to map distribution of rangeland types , and calculate and analyze changing trend in the rangeland area , and evaluate rangeland quality .

The result and discussion As result of the Study , the area and map of 8 types were obtained (Tab .1) , and mapping precision is above 90% and production estimating precision is more than 80% . The study also showed that due to non agriculture uses and overgrazing , rangeland area has decreased more than 3810500 ha since the 1980s(Tab .2) , production has dropped by 21 .58% , and the degraded area of rangeland has increased 35 .6% .

Table 1 *Stat . table of rangeland area of Inner Mongolia .*

Types	Rangeland area(ha)	Unit yield (kg/ha)	Types	Rangeland area(ha)	Unit yield (kg/ha)
Meadow steppe	758 .88	1479	Desert	1750 .3	261 .9
Typical steppe	2513 .23	774 .75	Meadow	965 .41	1672 .05
Desert steppe	1068 .23	437 .85	Swamp	14 .63	2213 .85
Steppe desert	380 .71	392 .85	Hilly meadow	47 .99	2848 .65

Table 2 *Change dynamic of area .*

	80s	2003	Compared with 80s	
			Change	Ratio
Area(ha)	7880 .45	7499 .39	-381 .05	-4 .84%
Unit yield (kg/ha)	1068 .75	838 .05	-230 .7	-21 .58%

Conclusion and discussion The study has provided a background database of 12 Leagues and 101 Banners of Inner Mongolia and will provide a basic platform for digital rangeland monitoring .

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Studying of the MODIS data potentials to assess the pastureland production in the arid region of Semirom-Iran

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Key words : MODIS , SWIR , vegetation indices , herbage production , grazing seasons

Introduction Pasture management with domestic animal grazing should be based on an understanding of the spatial and temporal distribution of forage production . To estimate the pasture production in any region , reliable and repeatable techniques are needed for use by land managers . Traditional methods of estimating forage production have spatial and temporal limitations and can not be applied on vast areas . Application of remotely sensed data is a suitable method to evaluate the pasture production and sequentially detect changes . The aims of the present research were : the study of the MODIS data capabilities to estimate pasture production in the Semirom and Brojen regions-Iran , while also selecting the proper vegetation indices to estimate production , as well as studying the pasture production dynamics through the multi temporal data in arid conditions .

Material and method The study area is located in Central Iran with Irano-Toranian vegetation cover . Multi-temporal images from a MODIS sensor were used to study these pastures . Various preprocessing of image analysis , including image geo-referencing to topographic map with an RMSe 0 .5 pixel and the atmospheric and topographic corrections were applied using subtraction of dark objects and the Lambertian methods . Field data collections were begun on June 2005 on 800 ,000 ha and continued for about 4 months for repeated assessments . Various vegetation types were sampled using the stratified random sampling method . Twenty random sampling points were selected , and the pasture production was estimated using a double sampling method . Four multi-temporal MODIS images acquired from 21 May to 18 September were used . The resulting models were processed and the resulting images were categorized into 7 pasture classes . Finally the produced maps were field checked for accuracy . Also post classification method was used to determine changes in the 7 pasture classes .

Results and discussion The results confirmed that the NDVI and SAVI maps are closely correlated with the field data . In addition , the indices involving the SWIR bands are more closely correlated with field data where the cover and yield are high . On these sites the regression R square exceeded 85% . Most of the produced maps had higher accuracies .

Table 1 *Regression coefficient (R^2) between herbage production measurements and four vegetation indices in different dates .*

Indices	22 May 2005	11 July 2005	21 August 2005	18 September 2005
NDVI	0 .63**	0 .4*	0 .42**	0 .55**
SAVI	0 .68**	0 .41*	0 .44**	0 .55**
ARVI	0/6**	0/27*	0/25 ns	0/11ns
$AFRI_{1.6}$	0 .84**	0 .45**	0 .23 ns	0 .3*
$AFRI_{2.1}$	0 .75**	0 .43**	0 .37*	0 .43**

* Significant at the 0 .05 level , ** Significant at the 0 .01 level , ns : Non significant .

During the growing seasons , the most pasture production changes , belong to class 100-200 kg/ha to 10-30 kg/ha in the NDVI and SAVI indices map . The results of this study prove , that Monitoring herbage production changes and vegetation indices on different dates shows that phytomass increases in spring and summer and decreases in August . The pastureland forage production change is very rapidly during the growing season on over 90% of these lands . The results of this study prove that the MODIS data estimates the plant production very well in arid and semi-arid regions . Through this data , one can monitor the forage production , and this is very useful for sustainable resource management as well as decision making for planning pasture utilization .

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Water content of grassland ecosystem and its economic value in Qinghai-Tibet Plateau based on RS and GIS

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Key words : grassland ecosystem , water-holding capacity , ecosystem services , qinghai-Tibet Plateau , economic valuation

Introduction Vegetation change is a key factor influencing regional water balance . Many previous researches have shown there is a close correlation between vegetation cover and soil water . In recent years , many scholars , at home and abroad , have conducted a lot of studies on soil water , but few of them on Qinghai-Tibet Plateau . An accurate evaluation of soil water content of the grassland ecosystem in Qinghai-Tibet Plateau is important for people to understand the functioning of grassland ecosystems and effectively protect the natural grassland . This paper , in accordance with the theory of large scale ecosystem function , will effectively evaluate the soil water-holding capacity of the grassland ecosystem and its economic value in the plateau using RS and GIS .

Material and methods In this paper , the basic data are from standard MODIS 1B data , which has been geographically and geometrically corrected . And the data were attained by : 1) band selection : band 1 (620-670 nm) and band 2 (841-876 nm) ; 2) space selection : the area in 25-40°N and 84-104°E (with the restriction of remote sensing data obtained , which can basically cover the most area of Qinghai-Tibet Plateau) ; 3) time selection : January 2 , February 10 , March 7 , April 8 , May 10 , June 9 , July 20 , August 14 , September 1 , October 17 , November 11 , December 11 in 2002 ; 4) software selection : ENVI 3 .5 and ARCGIS 8 .3 .

Soil water content , an important component of soil , and soil fertility , are critical requirements for plant growth . This paper , therefore , will evaluate soil water content as a basic physical measure . Based on the selected model , the calculations are : 1) data pre-processing ; 2) land cover classification ; 3) Albedo (*ABE*) ; 4) day-night temperature difference ($\triangle T$) , apparent thermal inertia (*ATI*) and real thermal inertia (*RTI*) ; 5) soil water content ; 6) water conservation ; and 7) economic value .

Conclusions Through calculation and analysis , some conclusions have evolved : (1) Grassland ecosystem has large capacity for holding soil water . Owing to the influence of the area and soil water content per unit area of grassland , the contribution rate of various grasslands is different for soil water content . They can be arranged in following order : alpine steppe > alpine meadow > temperate maintain meadow > alpine desert > alpine meadow steppe . (2) A periodical change occurs in soil water in the study area . As a whole , it decreases early and increases late in a year , taking July as the boundary ; moreover , this trend also occurs in the growing season (April-September) and non-growing season (January-April and September-December) . As for the total amount , the soil water is higher in non-growing season than in the growing season , and higher in autumn and winter than in spring and summer . (3) Due to different geographic locations , natural features and ecological functions , the grassland ecosystem in Qinghai-Tibet Plateau varies regionally in both its soil water content and its economic value , i .e . , gradually decreasing from the northwest to the southeast . It is necessary to state that because of the limited images received , the paper did not cover the whole Qinghai-Tibet Plateau . However , this study makes an attempt to reveal the soil water-holding capacity of a grassland ecosystem and its value on a regional scale , and to dynamically evaluate service function of grassland ecosystem .

Study on technical method of remote sensing Monitoring for grassland degradation

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Keywords : rangeland degradation , remote sensing (RS) , mapping

Introduction Yun Shipeng(2001)and others have analyzed grassland degradation of the landscape and rangeland ecology in Inner Mongolia by using remote sensing methodologies XU Peng et al . (1988) also ustilized remote sensing images to classify rangeland types .

Materials and methods Using field observations and remote sensing images , several characteristics were specified including dominant species , production and percent cover , as well as changes in the proportion of indicator plants . Additional important information has been gained using Geographical Information System (GIS) , global positioning system (GPS) , and remote sensing (RS) technologies .

Results and discussion Rangeland degradation status has been determined based on RS , GIS , and GPS technologies . Figure 1 provides data on changes in degradation status and extent since 1980 . Figure 2 indicates the reason for the degradation and extent of changes since 1949 .

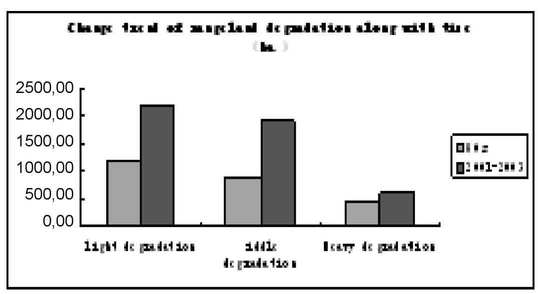

Figure 1 *Descriptive text (use text box or figure caption .*

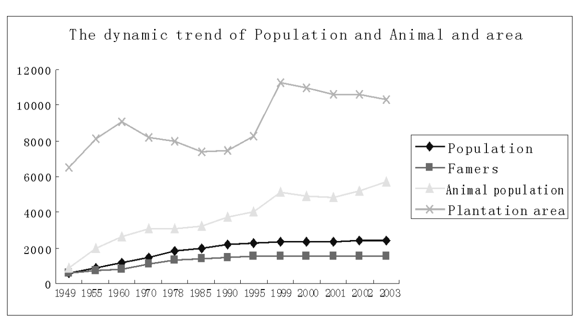

Figure 2 *Descriptive text .*

Conclusions As a result of this study , we find that rangeland degradation on a large scale may be characterized and mapped using RS ,GIS , ,and GPS technologies . In addition , monitoring dynamic changes of four key factors (dominant species , production , percent cover , and change in the ratio of indicator plants) can be as useful determinants in mapping and monitoring rangeland degradation .

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The study of method on estimating aerial net primary production of rangeland by remote sensing —A case study of Xilingol Grassland

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Key words : Rangeland -Remote Sensing Vegetation index Grazing intake Net primary production

Introduction The estimation for standing production of rangeland based on remote sensing(RS) has been reported largely(Huete & Jackson , 1987 ; Beck , 1990) ,but about grazing intake , reported infrequently .

Material and method The study has tried to extract information both grazing intake and aerial NPP by RS . The relationship between GI of once every ten days gained from field test , and estimation model of standing production(SP) and GI index(GII) model extracted by MODIS material , as well as NPP models .

Result and discussion

1 SP model

According to relativity between NDVI and field data , estimation model for rangeland production has been established , the expression is as :

$$Y=EXP(5.77-0.42/X) \quad ; \quad X \text{ is NDVI} . \tag{1}$$

2 GI index

$$GI_{xun}=NDVI_{dangxun}-NDVI_{xiaxun}= b_0=\begin{Bmatrix} a11 & a12 & \ldots\ldots & a1n \\ a21 & a22 & \ldots\ldots & a2n \\ M & M & \ldots\ldots & M \\ am1 & am2 & \ldots\ldots & amn \end{Bmatrix}_{m\times n} \tag{2}$$

a 11～a mn are pixel values in MODIS material , b_0 is GI index .

3 GI model

$$\Delta y = exp\{5.77-0.42/b_0\} , \tag{3}$$

4 Aerial NPP model

$$ANPP= \exp\{5.77-0.42/ndvi_{max}\}+ \exp\{5.77-0.42/b_0\} \tag{4}$$

Conclusion In the paper , the logic of extracting GI is based on the assumption that the difference between NDVI of two decad days in border upon can be ignored or is zero . The limitation of quantitative analysis in the method is lack of verifying and test for results because of difficult to gather data of aerial NPP and GI in field .

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Predicting botanical composition of grass-clover pastures mixtures using near-infrared reflectance spectroscopy

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Key words : NIRS , botanical composition , binary mixtures , predication equation

Introduction The development of a reliable and rapid approach for determining botanical composition has been a research goal for many years . Several researchers have attempted to use NIRS as an approach to determine botanical compositions . Some researchers have already proven the capability of NIRS to determine species content in legume-grass mixtures (Pitman et al ., 1991) . Our objective was to compare NIRS to other methods for separating complex mixtures of species .

Materials and methods Twenty-four cool season clover and grass cultivars were used for this study . Clover species included three red clover(*Trifolium pratense* L) cultivars , four white clover (Trifolium repens L) , and one kura clover (Trifolium ambiguim . Bieb) cultivar . The grass species included two festuloliums (*Festulolium braunii* , *K . A .*) cultivars , four orchardgrass (*Dactylis glomerata* L .) , seven perennial ryegrass (*Lolium perenne* L) and three tall fescue (*Festuca arundinacea* Schreb) . The experiments were arranged in a randomized complete block design (RCBD) with three replications . Each replication consisted of 67 entries of different combinations of grass and clover cultivars . Samples were hand clipped within a 0 .25 m^2 quadrat in each plot when plants were 20 cm in height and dried at 65 °C then ground to pass through a 1mm-screen . Calibration equations were developed using 1-artificially pure mixed samples , 2-hand-separated samples from one location and year and 3-hand-separated samples from multiple locations and years . Standard deviation of calibration (SD) , standard error of calibration (SEC) and calibration coefficient of determination (R^2) were used to evaluate the calibration equation . Prediction coefficient of determination (R^2) , standard error of prediction (SEP) , slope , and bias were used as validation criteria of the equations .

Results Data from artificially pure mixtures shows a very strong calibration equation with R^2 of 0 .99 and standard error of calibration (SEC) of 1 .4 . However , regression analyses of the spectral data with botanical composition resulted in prediction coefficient of determination (R^2) of 0 .31 and 0 .24 and SEP of 28 .1 and 26 .7 for grass and clover , respectively . The variation in plant maturity and weed content observed in the field samples were not represented in the lab mixed samples . Thus , the calibration equation developed from the artificially mixed samples of several grass and clover species did not accuracy predict the species composition clipped from three different locations over three growing seasons . A higher prediction may obtain if the calibration equation was derived from samples representing all locations and years (Shaffer et . al ., 1990) .

Equations developed from hand-separation from one location and year had R^2 of 0 .97 for grass and 0 .95 for clover . However , when this equation was applied to predict the botanical composition of samples collected from three locations and three years , similar predictions were obtained to the results of the artificial pure mixed samples with validation R^2 of 0 .25 for grass with somewhat improvement prediction for clovers with R^2 of 0 .37 . This clearly reflects the problem of obtaining enough representative samples that can include all spectra data from other locations .

On other hand Calibration equations developed from hand-separated samples collected from three locations over three years had R^2 of 0 .82 for grass and 0 .84 for both clovers and weeds . The validation statistics for these equations resulted in an R^2 of 0 .67 to 0 .72 , SEP of 6 .9 to 12 .8 , and a bias of 0 .3 to 0 .6% . Slopes were close to one for the grass and clover . In spite of there being multiple species in the weeds portion , SEP for weeds was lower than grass and clover components . It is possible the weed species were more similar in reflectance values than the different species of grasses .

Conclusions Even though we had some success in predicting grass-clover mixtures based on multiple locations and years as compared with the equation created from a single location and year , this study did not result in as high R^2 as those observed in other studies (Locher et al ., 2005) . The lower R^2 observed were due to various factors . Environmental conditions and the grinding and storing processes can affect NIRS prediction . This study , which presented two different strategies for developing a calibration equation , has shown that creating an equation from representative samples of a larger database of previously hand-separated mixtures can increase the prediction accuracy .

The study of changes detection of land covers in Zagros Mountain ,West of Iran .

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Key points This study was performed using TM & ETM+ data taken in 1990 and 2002 ,in order to investigating the trend and rate of cover degradation in Zagros Mountain ,Iran .The study area was located in part of central Zagros Mountain .The supervised classification was performed for the images using ML (maximum likelihood) .Ground truth maps were prepared for degradation cover class in 63 ha of area and also for forest sparse / non forest classes ,in 200 ha of area (3% of total area) using GPS .Also ,the overall accuracy and Kappa were obtained 83 .38% and 53 .23% for classifying forest sparse/non forest classes . With respect to comparison of classified map of 1990 and 2002 datasets ,12 year period .The degraded area is calculated on 81 .47 ha .The average of degradation per year has been 6 .8 ha or 0 .1% of area .
Key words : change detection ,Zagros Mountain ,degradation cover .

Introduction Change detection and monitoring involve the use of multi date image to evaluate differences in land cover (Singh ., 1989) .Rangeland and forest ecosystems of the Zagros Mountain in west of Iran are remarkably diverse and productive concluding to variety in landforms ,hydrology ,flora ,fauna ,and ecosystem processes .Satellite data over various spatial and temporal scales offers the most reliable ,time and cost effective means of assessing land cover change .Change detection essentially comprises the quantification of temporal phenomena from multi-date imagery (Coppin .,2002) .The usefulness of satellite data in change detection is dependant not only on radiometric and spatial resolution of the data but also on subsequent processing and quality of the preprocessed data (Anuta .,1984) .Degradation of vegetation is as a critical problem in Zagros Mountain ,west of Iran ,that regions have rangeland ,forest sparse ,in generally .In this study TM and ETM+ images recorded in time frame between 1990 and 2002 was evaluated to produce land cover maps for change detection analysis and determination Zagros plant cover change .Comparison of classification results each other and also with the available maps was realized in the GIS environment to show the cover changes happened in the interest area .

Materials and methods
Data This study performed in Zagros central mountain ,western of Iran ,is located in the between 46°33′ & 46°26′E longitude and 33°43′ & 33°37′ N Latitude (shown in Figure 1 .) .This area have heterogeneous topographic with 1300 to 2650 m .

One was the TM image acquired on July 5 ,1990 and the other was the ETM+ image on august 7 ,2002 .Hence ,the resampling was done using non-parametric method ,nearest neighbor interpolation and affine transformation ,for both of datasets .The 2002 image was registered to available reference map (RMSE=18 .35 m) ,using 8-GCPs with 1 nd order polynomial statistics using nearest neighbor interpolation and affine transformation .which further acted as reference image for image to image registration with 1990 image .Image to image registration was done using 13- GCPs uniformly distributed over the image plane (RMSE= 13.05 m) .

Methodology Training areas were selected in two datasets with (TM4 ,3 ,2 and ETM+4 ,3 ,2) band combinations and field work . The ground truth map determined of the areas that degraded by road construction ,using by GPS in 63 ha .Of the area by field work ; in order to this ,the boundaries of degradation used as ground truth for cover degradation .Also forest sparse and non-forest ground truth map provided using systematic-random method from 3% of the total area (about 200 ha .in samples with 300×300 m^2) .For tacking the classes information used GPS (field work) ,FCC image and toposheets .Post-classification change detection technique was applied .In order to better detection of plant cover for classification ,used NDVI .After selecting and correcting training samples histogram ,their separability was controlled using Bhattacharya distance index .The maximum of separability between training areas were 1 .99 and 1 .93 for ETM+ and TM data respectively .

Results and discussion The degraded area is calculated on 81 .47 ha .The average of degradation per year has been 6 .8 ha or 0 . 1% of area .Hence ,1 .84% of total area has been degraded in the 12 year period of time .Overall accuracy and Kappa coefficient were obtained 91% and 92% for determining degradation ,respectively .Land degradation processes in the study area are ; degradation of natural vegetation due to new road construction and fuel consumption ,fire .This needs to be seriously studied , through multi-dimensional fields including socioeconomic ,in order to preserve the newly reclaimed land .

Conclusions The changes in land cover led to vegetation degradation(81 .47 ha .) and water logging in part of the study area . studies regarding change techniques have been carried for a long time ,and have had developed many useful techniques .As these studies do not provide uniform methods ,hence ,further investigation is needed with the scale of application for different studies . Further ,an integration of other aspects as slope ,digital elevation model ,socio-economic attributes etc by the aid of GIS layer seems to be a promising for change detection analysis .It is necessary to used of high spatial resolution as SPOT ,IRS 1C (5 m resolution) and more recent IKONOS (1 m resolution) satellite imaging systems .

Regionalization of plant bioclimatic of Karoon Basin using statistical multivariate methods and GIS

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Key word : climatic regionalization ,karoon Basin ,Factor Analysis ,Cluster Analysis

Introduction Climatologists and ecologists have studied a lot on generalization of plant bioclimatic .There are numerous methods for climatology classification presented by botanists and climatologists such as Guassan , koppan and Emberje . These classifications mainly were based on a few parameters (such as temperature and precipitation) .Whereas weather is very complicated in spite of we use consider 2 or 3 factors only .It is require considering adequate parameters for climatologic zonation purposes (Stinger ,1965) .

Material and methods Karon basin with 4275400 hectares area is located in southeastern of Iran .This region has a variable climate due to intensive topographic conditions .In this study ,seasonal scales were used for precipitation .For other parameters , average annual used July and January months (as an indicator for the first and the second half of a year) and April (as an effective month in vegetation growth) .Data matris of Q from was prepared .Factor analysis with two methods of component factors and varimax rotation was used to decreasing matris size .Then cluster analysis with method of hierarchical cluster analysis and ward was performed to determining bioclimatic regions .Maps of these changes were drawn with Surfer software

Results Results of factors analysis indicated that 5 factors had the highest effect on bioclimatic of study area .These factors include 94 .26 percent of variance with eigen value more than 1 .Cluster analysis was performed on 5 factors scores using ward method .Regard to the dendrogram ,regionalization of bioclimatology was done .It is require selecting name for each climatology class .These names indicate general characteristics of the region climate .Map of each climatology region prepared and factor scores classified climatic region that are :Very hot and dry region ,Very hot and semi dry region ,Hot and semi humid region , Semi hot and semi humid region ,Hot and semidry region ,Semi cool and wet region ,Cold and very wet region ,Cold and wet region and Cold semidry with spring precipitation(Figure 1) .

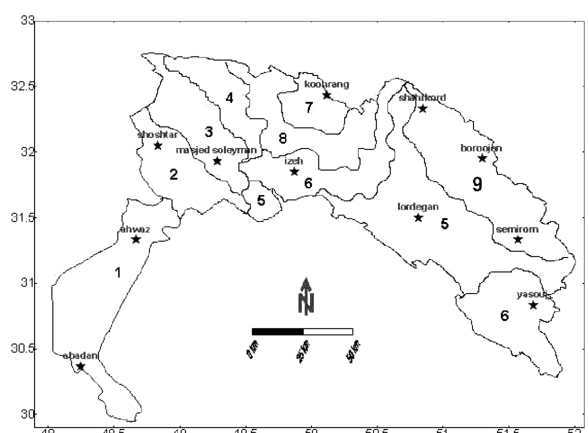

Figure 1 *Regionalization of plant bioclimatic of study area .*

Discussion In this study 52 climatic variables were selected that have more influence on natural plants growth .These variables reduced to 5 factors using factor analysis .Bioclimatic regions were named regard to factor score and correlation maps of factors . Scores show a lot of changes of extraction factors .Primary variable in 9 climatic regions are similar in each region ,but are different in one or a few factors with each .Results indicated that multivariable method is capable in classification of bioclimatic regions compared with traditional method .It was proved by many researchers .Statistical methods of multivariable have several advantages such flexibility and data reduction that can be used for regionalization purposes and are more suitable than traditional methods .

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Pasture grass and fodder evaluation and selection for dry season feeding in Nakuru ,Kenya

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Key words : Digestible ,dry season ,quality feeds ,yield ,nutritive content ,dry matter ,crude protein

Introduction The major constraint to livestock production in Kenya is availability of quality feed resources throughout the year . Farmers offer their livestock with natural pasture and other grown fodders such as Napier (Pennistenum perpureum) or crop residue such as maize stover or wheat straw .Nutritional characteristics of these feeds mentioned are of low digestible nutrients with crude protein of less than 6% .As a result animals fed solely on these feeds do not produce to their potential .The objective of this study was to evaluate and select pasture and fodder species for quality ,tolerance to drought ,for dry season feeding in Nakuru Kenya .

Materials and methods Data were obtained from established pastures and fodders at Lanet Research Centre Nakuru .These included Star grass ,Rhodes grass ,Guinea grass ,Sweet potato vine types ,Lecauna and Sesbania sesban .Lanet Research Centre is situated at an altitutde of 1920 m above sea level and receives 800 mm of rainfall per annum . .The soil is deep loam with an average maximum and minimum temperatures of 26℃and 10℃ respectively .Grass leys were sampled using a quardrant at half flowering stage when dry matter (DM) and the protein levels are at their optimum .The sweet potato vines were sampled after 90 days and the leucaaena and Sesbania sesban at 1 metre high .The sampling was done in both dry and wet season and averaged DM analysis was done by drying samples at 1050C 24 hours in an oven .Crude protein was analysed using official methods of association of analytical chemists (AOAC 1990) .

Table 1 *Yield and nutritive composition of ley grass legumes sweet potato vines and fodder trees on dry matter basis .*

Ley grasses	DM%	CP%	NDF%	ADF	ADL
Star grass	29 .8^{b}	9 .36	69 .29	42 .78	4 .93
Elmba Rhodes	20 .33	12 .45	64 .31	49 .94	4 .57
Boma Rhodes	21 .73	11 .18	68 .34	42 .62	4 .35
Guinea grass	17 .55	14 .36	62 .78	40 .95	3 .96
Sweet potato vines cultivars :					
Wagabolige	14 .6	18 .4	34 .82	31 .19	7 .86
Marooko	14 .6	18 .8	32 .73	31 .36	6 .76
K158	16 .5	19 .5	28 .16	35 .16	6 .30
Fodder tree legumes :					
Lauceana	38 .51	26 .12	44 .98	20 .98	4 .66
Sesbania sesban	18 .84	26 .74	33 .70	27 .58	3 .91

Dry matter and crude protein content of the grass ley species showed variability . Star grass had the highest DM while guinea grass had the highest protein content with lowest DM .The sweet potato cultivars showed excellent nutritive characteristics . Cultivar K158 had the highest dry matter 16 .5% and 19 .5 crude protein content while cultivar Wagabolige had the lowest crude protein content of 18 .4 .These cultivars showed high tolerance to drought and had digestibility of 80% when fed to sheep (Irungu et al ,2004) .Fodder trees ,Laucaena ,Sesbania sesban ,had significant differences in dry matter content with Laucaena showing high content of 38 .51% while Sesbania sesban had 18 .84% .The fodder trees however showed excellent tolerance to drought .

Conclusions The pasture and fodders species tested showed potential for dry season feeding .Sweet potato vine cultivars had excellent nutritional characteristics .Star grass had highest dry matter yield in the pasture grass group while boma Rhodes had the highest protein content of 12 .17% with good dry matter of 21 .73 .Laucaena had the highest dry matter content 38 .51% while Sesbania had 18 .84% .All the pasture and fodder species evaluated could be used for dry season feeding in Nakuru Kenya .

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Grasslands/Rangelands Resources and Ecology

—— Reclamation of Grasslands/ Rangelands

Reclamation of saline soils through revegetation in Australia : plants , processes and people

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Key points : Secondary salinity (salinity induced by human activity) is a major world problem . Hydrological imbalances in landscapes cause watertables to rise , drawing salt from deeper in the soil profile to the soil surface , where the combined stresses of salinity and waterlogging threaten the growth of crops and pastures . The reversal of salinity by the broad-scale reintroduction of perennial plants back into landscapes may not be economically feasible , but watertables may be at least partly directly drawn-down by the growth of salt tolerant plants (halophytes) on saltland . This review summarises data from Australia in which the water use by perennial halophytes has been sufficient to facilitate the growth of the less salt tolerant under-storey legumes balansa clover (*Trifolium michelianum*) and burr medic (*Medicago polymorpha*) . Although the halophytes may have undesirable nutritive value traits , these plants , mixed with the under-storey species are then able to be utilised profitably by grazing sheep .

Key words : Salinity , waterlogging , water-use , forage , nutritive-value

Introduction

About~10% of the world s land surface is naturally salt affected ; in addition the world faces a major problem of land and water salinisation . Secondary salinity (salinity caused by human activity) is estimated to occur on about 80 Mha of land that was originally suitable for agriculture (Ghassemi et al . , 1995 ; Barrett-Lennard , 2000) . In many situations saltland is found adjacent to the world s major rivers : salinity therefore also impacts on the security of drinking water—an increasingly important issue as we deal with climate change .

Australia has a major problem of dryland salinity , a form of secondary salinity that has arisen because of the clearing of our deep-rooted sclerophyll forests to make way for European agriculture . Basically , the shallow-rooted annual crops and pastures that were planted after clearing used less than the complete rainfall , allowing percolation of excess water (recharge) deep into the soil profile . Watertables rose over the hundred or so years after clearing and when the groundwater came to within~2 m of the soil surface , large areas of land became saline , particularly in the broad relatively flat valley floors . It is estimated that~5 . 66 Mha of land are presently at risk of dryland salinity , and this area is forecast to increase to~17 Mha by the Year 2050 (National Land and Water Resources Audit , 2001) .

Secondary salinity is often a relatively complex issue because plant growth can be affected by two stresses : salinity and waterlogging . The ways in which these stresses interact to affect plant survival , growth and location in the saline landscape is still being elucidated (Barrett-Lennard , 2003) .

Secondary salinity is human rights issue . Because it can strike relatively quickly , families and communities may have little time to adapt . In developing countries , communities affected by secondary salinity can experience high levels of illiteracy , poor health care and a far lower capacity to purchase normal household goods (Barrett-Lennard , 2000) .

Secondary salinity is not democratic-communities can be affected to differing extents depending on where they are located in the landscape . In my home State of Western Australia , dryland salinity affects about 10 ,000 of our 15 ,000 farmers . For about half of these farmers less than 3% of the farm is salt-affected ; however the upper decile of farmers have at least 18% of their farm salt-affected , and some farms are more than 30% affected (Damien Shepherd , pers . comm . , 2006) .

I have spent the bulk of my career studying the effects of salt and waterlogging on plants , and in developing agricultural industries for saltland ; most of this work has been in Australia and this paper draws on that experience . The paper has one principle theme : if saltland is better managed it can be partly reclaimed ; if it is partly reclaimed it can become more valuable ; if it becomes more valuable then such management can be justified . While the case presented here is specific to southern Australia , I believe that the principles and approach are more universally applicable .

Plants for saltland

Halophytes (plants that complete their life cycles in saline environments) constitute about 1% of the world s flora (Tim Flowers and Tim Colmer , pers . comm . , 2008) . The United States Department of Agriculture halophyte database lists about 1800 species with their potential uses (sl.arswww.us.usda.gov/pls/caliche/Halophyte.query) . However , saline agricultural systems around the world probably focus on no more than~20-30 species .

Although salinity has affected agriculture for thousands of years, the recognition that salt-affected land can be used for agriculture is relatively recent (see papers cited in Barrett-Lennard et al., 1986). Initially the focus was on the better use of land that was becoming salinised because of irrigation; focus is now moving to dryland salinity (Ghassemi et al., 1995).

In Australia, interest in saltland revegetation began in the 1940s and 1950s when tall wheatgrass (*Thinopyrum ponticum*), saltwater couch (*Paspalum vaginatum*), small-leaf bluebush (*Maireana brevifolia*), old man saltbush (*Atriplex nummularia*), and creeping saltbush (*Atriplex semibaccata*) were promoted for saltland revegetation (Teakle and Burvill, 1945). The first screening of herbaceous germplasm (69 grasses and forbs) occurred from 1954 to 1959 (Rogers and Bailey, 1963) and resulted in the release of the Turkish grass *Puccinellia ciliata*. Subsequent screenings of halophytic shrubs (Malcolm and Swaan, 1989) resulted in the widespread use of wavy-leaf saltbush (*Atriplex undulata*) and river saltbush (*Atriplex amnicola*).

Can dryland salinity be reversed?

If salinisation is caused by the removal of perennial plants from the landscape, then surely we should be able to reverse salinisation by re-establishing perennial plants (trees, shrubs or deep rooted herbaceous plants) back into the wider landscape. These plants should act as functional mimics of the original vegetation system, decreasing recharge to the groundwater, and reversing the processes leading to landscape salinisation (Hatton and Nulsen, 1999).

In practice the problems with this approach are two-fold. Firstly, to achieve change on the scale required, deep-rooted perennial plants need to be re-established over a substantial proportion of the landscape. For example, in a survey of 78 sites revegetated with trees in Western Australia, the rate of watertable rise or fall was linearly related ($P < 0.001$) to the percentage cover of the landscape planted to trees (George et al., 1999). On average, revegetation of ~20% cover was required for watertable equilibrium, and revegetation with about 50% cover was required for watertables to fall by ~0.4 m/yr (recalculated from George et al., 1999). Using a two-dimensional hydrological model called *Flowtube*, George et al. (2001), modelled the effects of the re-incorporation of different levels of perennial vegetation on the predicted expression of salinity moving up the length of three catchments in the Western Australian wheatbelt. Their work suggested that with traditional agricultural practice, 72-94% of the valley floor length in each catchment would become saline over the next 100 years. However, even with the incorporation of sufficient perennial vegetation to decrease recharge by 30-50%, a substantial proportion of the valley floor length (40-60%) would still become saline after 100 years.

Secondly, farmers need to make a living from their land and will only change their farming practices if new industries based on perennial plants can compete financially with their current annual-plant based industries (cereal crops and annual pastures). Unfortunately there are no *exceptionally attractive* industries based around perennial plants for low-medium rainfall (350-500 mm) zones of southern Australia. Because of their mediterranean climate, southern Australian farming systems generally have a fodder deficiency in summer and autumn, and deep-rooted perennial pasture species have premium value at this time of year. However, even plants that are able to fill this role like lucerne (*Medicago sativa*), have decreasing economic value to the farmer as they become incorporated into more than 10-20% of the farm area (Bathgate and Pannell, 2002; Robertson, 2006).

Clearly given the above issues, it is unlikely that perennial plants will be adopted into lower rainfall Australian agricultural systems on the scale required to reverse the rising watertables that are causing salinity. Farmers therefore need strategies to live with salinity.

Using saltland plants to lower watertables

Research shows that in the wheatbelt of Western Australia, watertables that rise to ~2.1 m from the soil surface are critical to the growth of wheat (Nulsen, 1981). At depths greater than this, the movement of salt towards the soil surface by capillarity is less than its leaching downwards by rainfall and good wheat growth is possible; at shallower watertable depths than this, the reverse is true, the land becomes increasingly saline and the growth of wheat is threatened. This raises the question: can halophytic plants growing on saltland help draw down watertables to levels where the growth of a wider range of less salt tolerant plants is possible? In this scenario, the halophytes could be considered to be a kind of biological pump".

There is now a range of evidence to suggest that the growth of some halophytes can sufficiently lower watertables to at least partly drain saltland in a mediterranean environment. Additional modest drainage using shallow drains to help control flows of surface water would further assist with this (Barrett-Lennard et al., 2005).

The key factors that will govern rates of water use by halophytic plants on saltland are:

1. Rates of water use will depend on the amount of transpiring leaf relative to the soil surface area. Stands of small plants at close spacings can therefore achieve similar rates as large plants at wide spacings.
2. Soil conditions (especially levels of salinity and waterlogging) will affect the amount of leaf relative to soil surface area (point 1 above) and will therefore also affect rates of water use.

3 .Rates of transpiration will be affected by evaporative demand . Better soil drying will therefore occur if plants are managed so that they have a full leaf cover in summer .
4 .Although many halophytes can accumulate salt in their leaves , water will always be taken-up faster than salt . Salt will therefore accumulate in the root-zone in the capillary fringe above the watertable , which may eventually decrease rates of water use because of adverse effects on plant growth and leaf formation (see point 2 above) .
5 .As watertables are lowered locally beneath individual plants , water will increasingly move laterally along the hydraulic gradient towards the transpiring plant . Large-scale watertable drawdown will therefore require large-scale plantings .

Evidence in support of these rules of game comes from the following studies .
1 .*Salt accumulation in the root-zone* . Using measurements of salt accumulation in the root-zone , Barrett-Lennard and Malcolm (1999) estimated that stands of five different saltbush (*Atriplex*) species at spacings varying between 10 ,000 and 1 ,333 stems per hectare used between 60 and 100 mm of groundwater over two years . This was an under-estimate of the rate of water use as : (a) it didn t take account of the use of rainfall (460 mm fell over the two year period—use of this water would not have resulted in an accumulation of salt in the root-zone) , and (b) it didn t take account of the increase in salinity of the groundwater immediately below the plants . Plant spacing and plant species both affected use of groundwater through their effects on the ratio of leaf weight to soil surface area . Linear relationships between use of groundwater and ratio of leaf weight to soil surface area were highly significant ($P < 0.001$) in both cases .
2 .*Measurements of evapo-transpiration* . Rates of evapotranspiration (ET) can be measured directly using ventilated chambers or estimated from the daily rise and fall of watertables beneath stands of perennials . Using these two techniques , Bleby et al . (1997) estimated rates of ET by stands of tall wheatgrass (*Thinopyrum ponticum*) at 4. 2 mm/day in summer (potential ET 5 .4 mm/day) and measured rates of ET of 1 .3 mm/day in winter (potential ET 2 .8 mm/day) .
3 .*Watertable drawdown* . In the summer of 2006/07 , watertables became stabilised at a depth of ～1 .6 m deep beneath relatively small (20 m x 20 m) plot of old man saltbush (*Atriplex nummularia*) ; in an adjacent control bore watertables were～1 .1 m deep . In this case the plot was so small that the lateral movement of water into the plot prevented further declines in watertable depth beneath the plants (Barrett-Lennard and Altman , unpublished) . However on another stand in which saltbushes were established over many hectares , and lateral intrusion of groundwater beneath the plants was no longer an issue , watertables were drawn down from～1 .2 m in summer to～2 .5 m in summer over a period of five years (Barrett-Lennard , 2002) .

In conclusion , the growth of perennial halophytes can lower watertables sufficiently so that less salt and waterlogging tolerant plants can be grown adjacent to or as an under-storey .

Industries for saltland

If partial reclamation of saltland is possible through the growth of halophytes , how can such revegetation be paid for ? Ideally we would like to see agricultural industries developed around the use of halophytes so that the environmental benefits of revegetation can be achieved through the intervention of farmers .

So what industries can be established using plants grown on saltland ? While several researchers have proposed a range of products or services that could be developed using salt tolerant plants (see Barrett-Lennard , 2000) , the most extensive industry for saltland that has developed in Australia is the grazing of sheep on salt tolerant forages . This industry has the advantage that the animals process the plants directly into useful products (meat and wool) , the farmers who seek to become involved already understand the industry and have facilities for handling sheep , and the industry has well-developed markets and a marketing process .

The grazing of sheep directly on halophytic plants has faced three practical problems . The halophytes (especially *Atriplex* species) produce relatively low yields of leaf , the material has a relatively low digestibility so the net energy that the animals can gain from the feed is low , and the plants can accumulate such high concentrations salt in the leaves (20-30% of leaf dry weight) that grazing animals will limit their feed intake (reviewed by Barrett-Lennard et al ., 2003 ; Masters et al ., 2001) .

As a result of these two problems , the saltland grazing industry in Australia went into decline from～1994 to 2004 . However , as the benefits of the halophytes in drawing down watertables and partly restoring the productivity of saltland became evident another possibility for saltland pasture design presented itself : why not use halophytes to lower watertables so that less salt and waterlogging tolerant understorey species could be grown , and graze the sheep substantially on these other species (Barrett-Lennard and Ewing , 1998) .

This is now the major approach used today . On saltland in much of the 300-500 mm rainfall zone of southern Australia , saltbushes (*Atriplex* species) are grown primarily as agents of hydrological change . However , the stands incorporate an under-storey of annual legumes , especially balansa clover (*Trifolium michelianum*) and burr medic (*Medicago polymorpha*) to improve the nutritive value of the feed on offer . Economic analyses show that these systems can deliver benefits to farmers of $AUS 40-80/ha/yr (Andrew Bathgate , Felicity Byrne , John Young and Ziaul Hoque , pers . comm ., 2007) .

Recognition of the importance of under-storey plants in generating economic benefits from revegetation has forced us to consider the importance of saltland capability assessment . Clearly such under-storey will best grow on land that is on moderately affected by salinity and waterlogging . Can we really identify such land ?

Recent research suggests that a reasonably robust saltland capability assessment tool can be based on assessments of the levels of salinity (average ECe values) in the upper 25 cm of the soil profile , the average depth to watertable on saltland and the presence of plant indicator species" (Barrett-Lennard et al ., 2008 ; Bennett and Barrett-Lennard , 2008) . The profitability of the grazing system will be highest if plantings are confined to land with average ECe values less than 8 dS/m and watertables in summer less than ~1 m . These sites are indicated by a high cover with annual species like capeweed (*Arctotheca calendula*) and annual ryegrass (*Lolium rigidum*) (Bennett and Barrett-Lennard , 2008) . Of course , saltbushes will also grow under more severe conditions (average ECe values in the range 8-16 dS/m and a depth to watertable of ~ 1 m in summer) indicated by high cover with cotula (*Cotula coronopifolia*) , slender iceplant (*Mesembryanthemum nodiflorum*) and annual ryegrass (Barrett-Lennard et al ., 2008 ; Bennett and Barrett-Lennard , 2008) , but these pastures are likely to be deficient in energy for grazing animals and sheep will need to receive an energy supplement of hay or grain .

Mobilising people

Scientific research has its limits . Major change on the ground can only occur if our ideas are adopted by farmers . Many farmers are sceptical about the idea of productive use of saline land . And why should they not be : salinity has been an enemy of agriculture for thousands of years .

So working in partnership with groups of farmers is critical . Incentive schemes also have their place . In the Sustainable Grazing of Saline Lands initiative that operated between 2002 and 2007 , farmer groups were offered the chance to conduct an experiment" on their own land ; we offered the farmers some technical assistance , some financial support (sufficient to cover about 50% of their costs in trialling the saltland pasture) . Over 120 sites were supported across the four southern States of Australia . Not surprisingly , the results were variable : results on some sites were affected by factors that we had no control over-drought occurred in eastern Australia and some sites were affected by plague locusts . Nevertheless the program had the effect of kick-starting" a major change in attitude across Australia in terms of what could be possible for saltland (Barrett-Lennard et al ., 2005) . These incentive schemes are now being continued by the Western Australian Saltland Pastures Association , a farmer group promoting saltland pastures , working in collaboration with the Avon Catchment Council , one of Western Australia s major regional authorities concerned with natural resource management .

Future research

Australian researchers from the Future Farm Industries Cooperative Research Centre (FFICRC) believe that further development of this saline agricultural system is possible . Over the next six years we will investigate two further areas in development of the saltbush/annual legume under-storey system .

- Bio-economic modelling by O Connell et al . (2006) has suggested that the economic gains associated with the growth of saltbush species will double if the digestibility of the feed on offer can be increased by ~10% . The FFICRC has therefore assembled a major collection of *Atriplex nummularia* germplasm from throughout southern Australia (27 provenances from 3 sub-species) . Over the next six years , this material will be screened at four sites for productivity and morphological and biochemical traits associated with improved nutritive value . Our aim is to commercially release clones of the best material within three years .
- Both our current major under-storey species (burr medic and balansa clover) have limitations in terms of their tolerance to combinations of salinity and waterlogging (Nichols et al ., 2007) . Attention has now moved towards *Melilotus siculus* which has tolerance to both these traits . However , the application of *M . siculus* may be limited in the field by its ability to fix nitrogen over the relevant range of soil conditions and salinity stresses . Research is therefore focusing on the selection of elite strains of root nodule bacteria (*Rhizobium*) that can be reliably introduced , and that will persist and effectively fix nitrogen .

Acknowledgements

The development of saline agricultural systems in Australia was the lifetime quest of the late Clive Malcolm who pioneered this work for 50 years . I am also grateful for the more recent contributions of many other colleagues from the Cooperative Research Centre for Plant-based Management of Dryland Salinity . Financial assistance for our work came from the Sustainable Grazing on Saline Lands initiative , an activity within the Land , Water and Wool Program , which was supported by Australian Wool Innovation Ltd , Meat and Livestock Australia , Land and Water Australia and the Cooperative Research Centre for Plant-based Management of Dryland Salinity . We also received important support from a number of farmer partners .

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Restoration of desertified grassland and challenges in northern China—for the possibility of sustained desertification reversion

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Key points: There is about 0.39 billion ha of grassland in China, covering about 40% of the country s land, of which 52% is in the western five provinces. However, about 70% of the grassland is desertified due to climate and land use changes. Through more than 50 years of efforts in combating desertification, grassland desertification was reversed in northern China, particularly in Horqin Sand Land of Inner Mongolia.

Research in Horqin Sand Land showed that desertification of grassland has been reversed since the middle of the 1980s. Reversion occurs over a much longer time period than degradation and the restoration of grassland function is far slower than that of grassland vegetation characteristics, such as height and coverage. However, this reversion is challenged by several factors, such as reduction of water availability and increasing land use change.

Key words: grassland, desertification, climate change, land use change, reversion

Introduction

Grassland is one of the important biomes in the world, and it has nourished not only lives, but also different cultures in the long history of its succession. However, grassland has been rapidly decreased due to degradation caused by climate change and human activity (UNEP, 1997).

China is one of the countries in the world with the largest grassland. The total grassland in China is about 390 million hm^2, covering about 40% of the country s land (Q. Zhang, etc., 1998), and about 52% of the grassland is distributed in Inner Mongolia, Gansu Province, Qinghai Province, Xinjiang Uyur Autonomous Region and Tibet. However, grassland has been severely degraded in the last century threatening about 120 million people and more livestock, and unknown wild species (Zhao Halin, 2004). The agro-pastoral transitional area, covering 0.80-1.00 million km^2 in northern China has been identified as one of the areas of high risk of desertification due to its ecological fragility.

In the last 50 years, the Chinese Central Government and local organizations have made a great effort in restoration of degraded grassland. However, the general trend of desertification expansion has not changed. That is why people persistently ask how desertification has changed and what are the challenges or obstacles to the reversion of grassland desertification now and in the foreseeable future. These questions on desertification in Northern China were discussed with Horqin Sand Land as a case study in this article.

Horqin Sand Land is a typical agro-pastoral transitional area, located in the northeastern part of Inner-Mongolia of China. The landscape is mainly characterized with gently undulating sandy land dotted with various sizes of dunes, meadows and farmlands. The zonal soil is chestnut, but it is almost replaced with eolian sandy soil due to desertification. The underground water table is 2-5 m. The aboriginal vegetation is tree-scattered steppe, but now, mostly replaced by psammophytes. Desertified land was increased from 20% of the total land in the 1950s to 53% in the 1970s and 70% in the 1980s. In the past 40 years, approximately 400,000 ha grassland and 270,000 ha farmland had been buried under drifting sand in Tongliao Prefecture, which covers about 56% of Horqin Sand Land. Monitoring has found that desertification, as a whole, in Horqin Sand Land has been revered since 1987. However, this reversion is challenged by the reduction of water availability, degraded vegetation components and function.

Materials and methods

Data of grassland and desertification changes and sand and dust storms are from the database of Naiman Desertification Research Station, Chinese Ecosystems Research Network (CERN). Vegetation data is from the Grazing Experiment. MS Excel 2003 and SPSS 11.4 were used to analyze the data.

Results

Grassland Distribution in China

As mentioned above, China is one of the countries with the largest grassland in the world. However, grassland distribution is very diverse, about 52% of the grassland is distributed in the five western provinces, such as Inner Mongolia, Gansu, Ningxia, Xinjiang and Tibet. Inner Mongolia has the largest area of grassland. Of this grassland, about 70% has been degraded due to overgrazing and fuel wood harvesting (Liu Xinming, etc., 1993).

This distribution pattern means that grassland is mainly distributed in the arid and semi-arid and sub-humid area of China and this puts the grassland ecosystems into severe risk of high fragility. Since the late 19th century, cropland has invaded the frontier of grassland, the agro-pastoral area, and this invasion has been identified as one of the primary forces leading to desertification (Zhu Zhenda, 1994; Zhao Halin, 2004).

Grassland Degradation

It is calculated that desertified land covers about 740,000 km^2 in China and is expanding at an annually averaged rate of 1,560 km^2 in the period of 1950's to 1970's, 2,100 km^2 from 1970's to late 1980's, and 2,460 km^2 in the period from 1980's to 1990's, as well as-1250 km^2 from 2001 to 2004 (Zhu Zhenda, 1989; 1994; Wang Tao, 2003; Wu Wei, 1997; 2001; National Forestry Administration, 2005). About 50% of the desertified land is from grassland degradation in the five provinces due to over-grazing, cropland invasion into grassland, fuel wood collection and misuse of water.

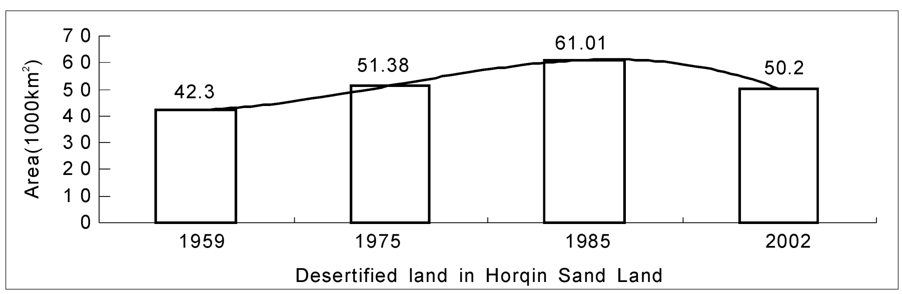

Figure 1 *Desertified land change in Horqin Sand Land (Wu Wei, 2001).*

Horqin Sand Land is once one of the four larger grasslands in Inner-Mongolia. However, according to Wu Wei (2001), it went through a phase of rapid desertification from 1959 to 1985. Since 1987, desertification has been reversed from 61.01 thousand km^2 to 50.2 thousand km^2 in 2002 (Figure 1). This reversal is being questioned, given the recent increase in the frequency of sand and dust storms and decreased water availability (Zhaohua Huang, 1997; Xueyong Zhao, 2001).

Causes of Grassland Degradation It is impossible to quantify the historic causes of desertification. Fortunately, there is a series of records of sand and dust storm frequencies and population change in the history of China.

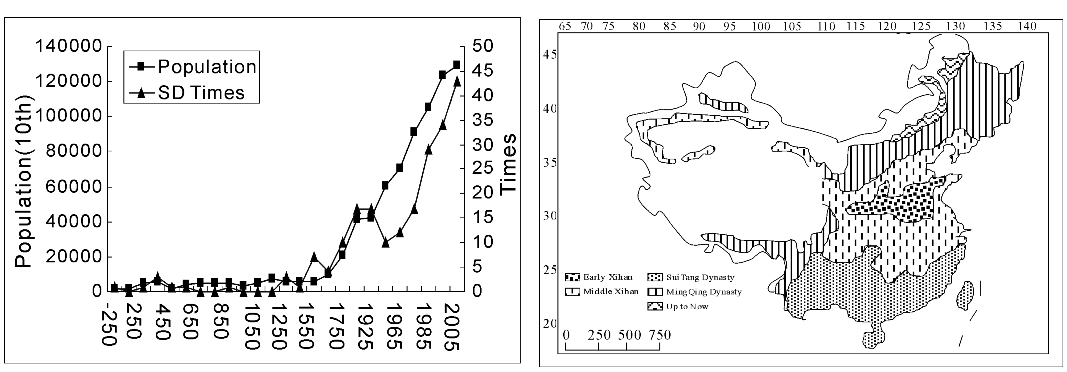

Figure 2 *Population and dust storm changes (left, SD = sand & dust) and land use change (right, redrawn from Gao Qinghua, etc., 1994) in China.*

Figure 2 (left) shows a close relation between the population and sand and dust storm frequency. Is this relation just a haphazard or reflection of the inner characteristics of these two parameters? More data and research are needed.

Figure 2 (right) shows the land use change in China since the Xizhou and Xihan Dynasty (206b.c.-a.d.220). It is clear that cropland in the Early Xihan was distributed in the Middle of the Eastern Part of China and then expanded to the large area between the Huanghe and Yangtze River and westwards to Southern Xinjiang in the middle of the Han Dynasty. This coincides with the facts of expansion of desert and desertified land in Xinjiang. In the Sui and Tang Dynasty (581-907), cropland extended further to the Southern Part of China and in the Ming Qing Dynasty, cropland was expanded to the northeastern part of China and Northern Xinjiang . Since the early of last century , cropland has extended even far northwards into the grassland of Inner Mongolia , which is more fragile to human activity . As one of the results , cropland land in Horqin Sand land accounts for 36% of the total of Inner Mongolia . This change in land use has made this area into a part of the most severely desertified land during the period of 1950s to 1980s and it has become the leading cause of the reduction of water availability and the top challenge to desertification reversion in this region (Zhao Xueyong , 2001) .

Climate Change

Figure 3 showed that in the past 40 years , the air temperature has increased by about 0 .6-0 .98℃ , and the annual mean precipitation has reduced by 50-180 mm in Horqin Sand Land , particularly since 1999 . This change has greatly reduced the water availability , characterized with drying-up of the West Lakes and Xiliao River and the reduction of underground water by 2 .4 to 4 .6 m (Zhao Xueyong , 2001) . It also clearly showed that there is a general trend of aridification in Horqin Sand Land since the late 1990s . This trend has impacted severely on the ecosystems and socio-economic activities .

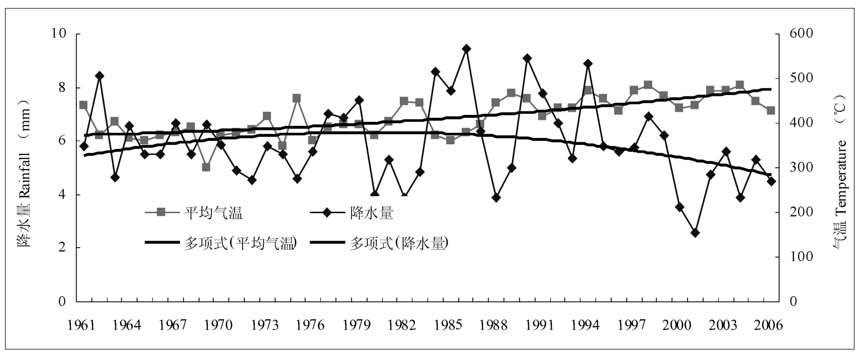

Figure 3 *Changes of annual precipitation and air temperature in Horqin Sand Land(Data from Naiman Desertification Research Station) .*

Restoration of Degraded Grassland

China has put the greatest efforts in desertification control , including promoting desertification research and related techniques for shifting dune fixation and strategies for sustainable land use . The most influential effort is implementation of the national projects Re-afforestation in the Northwestern , Northern and Northeastern Part of China , known as the Three Northes Re-afforestation Project , and Restoration of Cropland into Grassland or Woodland Project . In the past 20 years , the Three Northes Re-afforestation Project has planted 25 .16 million ha of trees and bushes , and about 1 .5 million ha of grassland was protected and 30 .03 million ha of degraded grassland restored from 1999 to 2004 . Inner Mongolia has also restored 2 .44 million ha of cropland into grassland . In addition to these projects , the Chinese government has made a series of laws to enhance and/or secure desertification control , such as the Soil and Water Conservation Law , Forest Law , Law of Desertification Prevention and Control , and Grassland Law . Horqin Sand Land is one of the first places that is implementing these projects and adopting the related laws .

Monitoring has shown that grassland has only changed slightly between 1980 and 2004 in Gansu , Qinhai , Xinjiang and Tibet . However , it has increased from 0 .79 million hm^2 in 1980 to 0 .89 million hm^2 in Inner Mongolia . This increase is mainly attributed to the implementation of the project's restoration of cropland into grassland and/or woodland . For example , about 23 .0 thousand km^2 cropland was restored into grassland from 1999 to 2002 in Inner-Mongolia .

However , either in the restored grassland or abandoned cropland , vegetation restoration needs a long time and is influenced by various factors . Figure 4 (left) presented the results of a grazing experiment . This experiment includes one control of no grazing (NG) , one heavy grazing (HG) , one moderate grazing (MG) and one light Grazing (LG) . From 1991 to 1996 , these three treatments were applied . Since 1996 grazing was prohibited and the grasslands were restored . From Figure 4 , it is clear that the vegetation height was gradually restored after grazing was excluded but has declined since 1999 when this area suffered from drought . Those of the heavily grazed , moderately grazed and slightly grazed treatments decreased from 1991 to 1996 , and then were restored after grazing was excluded in 1996 (Zhao Halin , 2004) .

After 20-years of restoration , the vegetation change of the control represented the natural restoration process of the degraded grassland . It is interesting that *Ulmus pumila* , one of indicative aboriginal species in the region , has been gradually restored . But this restoration is challenged by the evidence that productivity has consistently decreased from about 500g/m^2 in 1937 , to 370 g/m^2 in 1982 , 220 g/m^2 in 1993 and to 192 g/m^2 in 2002 (Figure 4 right) (Zhao Xueyong , 2007) .

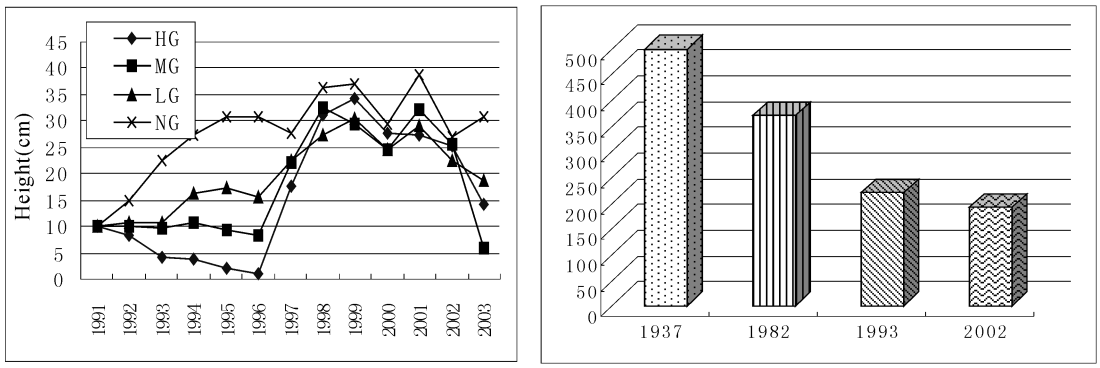

Figure 4 *Height Change of Restored Grasses (left) in Grazing Experiment Sites and aboveground biomass (right) in Horqin Sand Land.*

Discussion

Grassland covers about 0.4 billion ha in China, and about 52% of this grassland is distributed in Inner Mongolia, Gansu, Ningxia, Xinjiang and Tibet. This distribution pattern puts grassland ecosystems into a high risk of degradation, with about 50% of the grassland in theses provinces degraded.

China has put a great effort into combating desertification, and have been rewarded by local restoration of degraded ecosystems, however as a whole, desertification is still expanding at an arguable rate. Ecological vulnerability of northern China is the leading factor of desertification; however, problems in the implementation of the laws and projects that are aimed at reversing degradation are obstacles to progresses in desertification prevention and control. The growing population and the expectation of the locals for growing capital income are also driving forces to challenge combating desertification in northern China (Sara Brogaard, 2002).

Restoration of the degraded ecosystems should include the restoration of both composition and function, such as diversity and bio-productivity, of the ecosystems. Taking the reduction of water availability and bio-productivity into consideration, clearly, desertification reversion in Horqin Sand Land means only restoration of vegetation cover (Zhao Xueyong, 2001; 2007). Even this restoration strongly showed the potential of natural restoration of degraded grassland ecosystems driven by the annual precipitation of 300-500 mm (Xueyong Zhao, 2001). That is why research-based objective assessment of the restoration of desertified land and the development of a set of indicators for this assessment has become the top two issues in desertification research and desertification prevention in grassland ecosystems.

The emergence of *Ulmus pumila* in the controlled grazing experiment showed the potential and possibility of natural restoration of the degraded grassland to its original state or near-original state (Zuo Xiaoan, 2007). It seems clear that improper human interference is the key obstacle to restoration of grasslands to their near-original states, as a whole, in China, and how to get sustained reversion of desertification will be the impending challenge that faces both the researchers and decision makers.

Conclusions

From the above, it is tentatively concluded that China has the largest area of grassland in its western, northern and northeastern part, but about 70% the grassland has been desertified. In the past 50 year, China has made some progresses in combating desertification of grassland through restoration of desertified grassland, particularly in the region of annual precipitation of 200 to 500 mm. But the progress has been challenged or even compromised.

These challenges were mainly caused by the problems of inappropriate land use driven by the ever-lasting increase in population, and expectation of the locals for growing capital income, in addition to the high ecological vulnerability of the ecosystem.

Through more than 50 years of efforts in desertification control and rationalization of land use, desertification in Horqin Sand Land was reversed. But reduction of the water availability and nearly stagnant restoration of the degraded ecosystem function and diversity, compared to the degradation process, leave several key issues for researchers and decision makers.

Gratitude

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Zoning of risk of death of *Brachiaria brizantha* in the State of Acre, Brazil

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Key words: Amazon, mapping, *marandugrass*, *pasture degradation*, *soil drainage*

Introduction The establishment of cultivated pastures is the main cause of deforestation in the Brazilian Amazon. In Acre, cultivated pastures represent 82.5% of the total area deforested (ACRE, 2006). Since 1994, farmers in the Brazilian Amazon started to observe the death of marandugrass (*Brachiaria brizantha*) in some pastures under poorly-drained soils, a process that have caused widespread degradation of pastures in the region (Andrade & Valentim, 2007). The objective of this study was to define zones of risks of death of marandugrass as a support decision tool for policymakers and farmers in dealing with this problem in the Brazilian Amazon.

Materials and methods In 2006 the Government of Acre concluded the State's Ecologic and Economic Zoning (ZEE Acre) in the 1:250,000 scale integrating studies of natural resources, socioeconomic, cultural and policy aspects (ACRE, 2006). The soil's data bank of ZEE Acre was structured based on 230 soil profiles containing morphologic, physical, chemical and mineralogical attributes. This data bank associated with the map of soils of Acre was used as the basis for the zoning of edaphic risk of death of marandugrass. Previous studies indicated that this syndrome was associated with plintic soils with low permeability (Valentim et al., 2000). Therefore, the following soil attributes that contribute to low permeability and hidromorphism conditions were selected to define zones of risk of death of marandugrass: plintite, drainage, depth of horizon A, depth of solum, silte content in horizon A, clay activity in horizon A, carbon content in horizon A, content of iron oxides in horizon A, content of iron oxides in horizon B and clay activity in horizon B. These parameters were treated within the same mapping unit with a ponderated mean and were reclassified to generate the map of indexes of risk of death of marandugrass. In order to improve visual comprehension of the results, this map was reclassified in the following categories: extremely low risk; low risk; moderate risk; high risk; very high risk; and extremely high risk. Field validation of the map was carried out during the rainy season by crossing the different categories of the map of risk with visual evaluation of marandugrass in the different soil mapping units.

Results and discussion The results indicate that the State of Acre has the following proportions of its territory in the different categories of risk of death of marandugrass: 3.1% with extremely low risk; 3.5% with low risk; 46.6% with moderate risk; 23.8% with high risk; 5.6% with very high risk and 17.5% with extremely high risk. Field validation of the resulting map of risk confirmed that all areas classified with moderate risk or above presented symptoms of the syndrome of death of marandugrass.

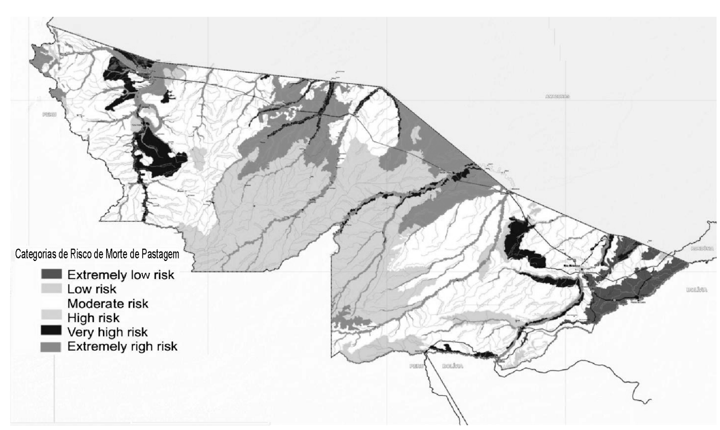

Figure 1 *Syndrome of death of marandugrass risk map for the State of Acre, Brazil (scale 1:250,000).*

Conclusions Soil attributes that contribute to low permeability can be effectively used to identify areas suitable or unsuitable for the establishment of marandugrass pastures or areas already established with this grass cultivar which are under moderate to extremely high risk of degradation. The zoning of risk of death of marandugrass is an excellent support decision tool to help policymakers and farmers in dealing with this problem in the Brazilian Amazon.

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Induced plant succession as a strategy to reclaim degraded pastures in the Brazilian Amazon

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Key words: African stargrass, *Brachiaria brizantha*, disease, forage peanut, waterlogging

Introduction Succession, the change in botanical composition over time, is currently a subject of great importance in both natural and sown pastures (Tow & Lazenby, 2001). In sown pastures, scientists worldwide have been working hard to overcome and prevent degradation and to improve long-term performance of these pastures, almost always by using techniques to help stop plant succession (e.g. avoiding weed invasion). However, plant succession can also be induced by human actions to improve pasture performance and sustainability (e.g. overseeding of legumes).

During the 80's and 90's marandugrass (*Brachiaria brizantha* cv. Marandu) was widely planted in Brazil to substitute signalgrass (*B. decumbens*) and *B. humidicola* pastures suffering from spittlebug attack. However, when planted in poorly drained soils, marandugrass started to die due to its low adaptability to waterlogging, which predisposes the plant to infection by some soil phytopathogenic fungi (Andrade & Valentim, 2007). When marandugrass started to die in mixed pastures with *B. humidicola*, signalgrass or tropical kudzu (*Pueraria phaseoloides*), these species progressively dominated the sward, a plant succession that prevented weed invasion in these pastures. Farmers initially viewed this process as those plants killing marandugrass. Researchers viewed this kind of plant succession as an excellent opportunity to reclaim degraded monocultures of marandugrass in poorly drained soils.

In this work we describe the development of a pasture reclamation strategy, based on plant succession, which is now helping hundreds of farmers to reclaim degraded marandugrass pastures in the Western Brazilian Amazon.

Materials and methods From 1998 to 2004, a team of pasture scientists of Embrapa Acre interacted with some farmers in the State of Acre to establish participatory on-farm trials to validate and generate technical coefficients of a new pasture reclamation technique. This involved manual planting of stolons of one or more forage species into the empty spaces left in the pasture soon after the death of marandugrass tussocks. Soil preparation or fertilization was not applied. The species tested were *B. humidicola*, african stargrass (*Cynodon nlemfuensis*), tannergrass (*B. arrecta*), tangolagrass (*B. arrecta* x *B. mutica*) and forage peanut (*Arachis pintoi* cv. Belmonte).

Results and discussion This method of pasture reclamation was successfully applied, especially in the beginning of the pasture degradation process (low weed percentage). Once established, the stoloniferous species were able to gradually colonize new bare areas left by the death of marandugrass plants and to efficiently prevent weed infestation. Generally, three to five years are necessary for a complete colonization of the sward (plant succession). Some advantages of this technique are: 1) its low cost, since only manual labour (8 to 12 man-days/ha) are involved during two to three rainy seasons; 2) the soil is not exposed to erosion; and 3) grazing is not interrupted. Because of the moderate to high fertility of these poorly drained soils, fertilization has not been used. Some lessons were learned during the development of the technique: a) plant succession is faster when pasture is intermittently stocked; b) the process is cheaper and faster when started soon after marandugrass begin to die; c) pasture colonization by grasses, especially African stargrass, is faster when tropical kudzu previously dominated the sward; and d) forage peanut is the most efficient specie to colonize sites dominated by the grass weed *Paspalum conjugatum*. This technique has been called ecological pasture reclamation" and is now helping small, medium and big farmers to overcome the syndrome of death of marandugrass in the Western Brazilian Amazon. It has been successfully applied also to pastures suffering from repeated spittlebug attack.

Conclusions Plant succession in sown pastures can be induced by planting stoloniferous forage species in situations where the original forage specie has problems with diseases, pets or poor environmental adaptation.

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Syndrome of death of marandugrass in the Western Brazilian Amazon

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Key words: *Brachiaria brizantha*, disease, low permeability soils, palisadegrass, pasture degradation, waterlogging

Introduction *Brachiaria brizantha* cv. Marandu (marandugrass) is well adapted to deep and well drained soils with medium to high fertility. Since its release in 1984, the high speed of establishment, resistance to spittlebug, vigorous plant regrowth, high forage yield and quality led to rapid adoption of this grass by farmers throughout Latin America. This resulted in over 60 million hectares of marandugrass pastures in Brazil, with more than 50% in the Legal Brazilian Amazon. In 1994, farmers of Acre began to observe the death of marandugrass plants in some pastures (Valentim et al., 2000). The problem has also been reported in other regions of Brazil (Teixeira Neto et al., 2000). Since 2000, the seriousness of the problem led the Brazilian Agricultural Research Corporation (Embrapa) to establish a multidisciplinary research task force to identify the causes and develop solutions for this problem. In this paper we describe the results of these studies.

Materials and methods During 2000 research specialists from Embrapa in the areas of soils, pastures, plant pests and diseases conducted several field expeditions in the Brazilian Amazon to diagnose the Syndrome of Death of Marandugrass-SDM. These studies were conducted in healthy and unhealthy pastures and consisted of: 1) soil physical and chemical characterization; 2) evaluation of root distribution and biomass in the soil profile; 3) investigation of possible plant pests and pathogens; and 4) evaluation of nutrient content in aboveground biomass. Besides that, greenhouse studies were conducted in order to evaluate physiological and morphological responses of this grass to flooding (Dias-Filho & Carvalho, 2000) and to some phytopathogenic fungi isolated from diseased marandugrass plants (Duarte et al., 2007).

Results and discussion Low soil fertility and pest problems were not involved with the syndrome. Field and greenhouse studies confirmed that the lack of adaptation of marandugrass to waterlogged soils is the triggering factor of the SDM, predisposing the plants to attack by soil phytopathogenic fungi of the genus *Rhizoctonia*, *Fusarium* and *Pythium* (Andrade & Valentim, 2007). The solution for this problem has been the use of other grass and legume cultivars adapted to low permeability or waterlogged soils and resistant to the pathogens involved with the syndrome. The association of the SDM with poorly drained soils allowed the zoning of the risk of death of marandugrass in the State of Acre (Amaral et al., 2008). Simple and low cost methods has been developed to reclaim degraded marandugrass pastures (Andrade & Valentim, 2008).

Conclusions The syndrome of death of marandugrass occurs when this cultivar is established in low permeability soils, a condition which affects plant physiology, morphology and metabolism and predisposes the stressed plants to the attack of soil phytopathogenic fungi.

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Plant functional groups composition associated to management practices in temperate natural grasslands (Flooding Pampa, Argentina)

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Key words: C_3/C_4 species, Flooding Pampa, glyphosate, stocking rate, temperate natural grasslands

Introduction The natural grasslands of the Flooding Pampas are characterized by a yearlong coexistence of C_3 and C_4 species. In the last decade there was a 2-fold increase in stocking rates above the historical levels as a consequence of the agricultural pressure. In addition, a technique called annual ryegrass promotion" is being fostered to increase cool season herbage production. It is based on prescribed applications of glyphosate for removing the interference of C_4 vegetation to the establishment of over-sown or seed-bank resident annual ryegrass" At present, there is concern about the impacts of both driving forces for the ecosystem function. Our purpose was to carry out a vegetation inventory to diagnose the status of representative grassland types as related to the degree of modification generated by grazing and by the intensity of promotion".

Materials and methods Data were collected from February to June 2007, 31 vegetation stands being sampled along a E-NW geomorphological gradient. Two landscape positions defined with GIS support were selected: 40-50% (Site L) and 30% (Site H) water lodging risk (*Vázquez* et al., 2007). A multi-scale botanical composition sampling was achieved in nested areas along a randomly placed 64m transect. Botanical composition and species functional groups (annual C_3 and C_4 grasses, perennial C_3 and C_4 native grasses-PC3 and PC4-, dicots and legumes-Leg-) contribution to total aerial biomass were estimated. ANVA and curve fitting was performed to data.

Results and discussion Lowest species number (19.7±5.0) were observed for the oldest *promotions"* (10-11 consecutives), no significant differences being detected between natural grasslands (NG), abandoned *promotions"* (Abn) and 3 to 7 consecutive *promotions"* (40.8±8.5, 38.0 ± 8.2 and 29.1 ± 8.9, respectively). Botanical composition differed between vegetation groups: *promotions"*, annual ryegrass >80%; Abn, perennial native grasses ≦15%; NG, perennial native grasses ≦50%. A dimensionless classification of the degree of modification (Dm) was achieved: *Promotions"* -$y_{(i)}/y_{(max)}$ (y = years of consecutive promotion"; negative x values in Figure 1); the rest, $\#PC_{3(i)}/\#PC_{3(max)}$ (PC_3 = perennial C_3 grasses; positive x values in Figure 1), according to Agnusdei *et al.* (1989) and Jacobo *et al.* (2000). *Promotion"* abandonment would lead to an increase of PC_4 (11% per unit Dm) and no significant response of PC_3. This suggests a greater sensibility of the soil propagation bank (seeds, vegetative organs) with respect to PC_4. The reduction in the Dm was associated to increases of PC_4 and PC_3 groups in both sites. Abundance of C4s was higher in Sites H than L, both sites having similar total C3 abundance with maximums of ≦35% made up by grasses or a combination of grasses and legumes, respectively. While positive results might be expected in response to rehabilitation practices applied to degraded highly stocked or promoted" vegetation, more information is needed to analyze transitions and restoration likelihoods.

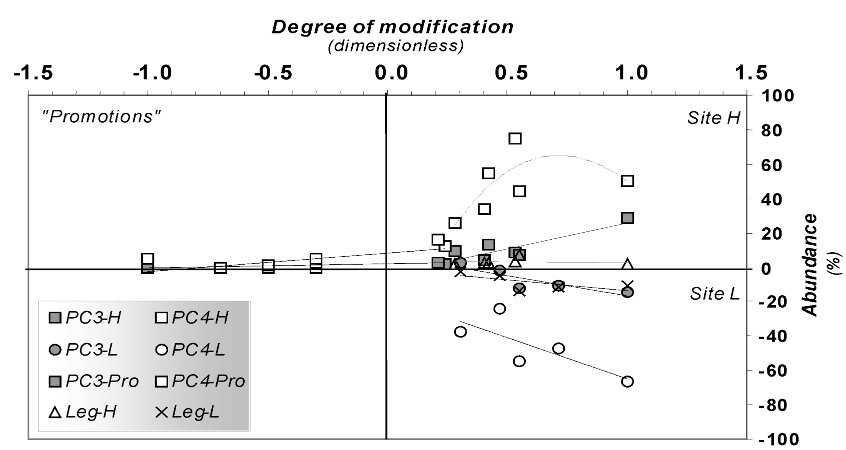

Figure 1 *Functional groups abundance (% aerial biomass) and degree of modification. -1 and 1 denote oldest promotions" and less stocked natural grasslands.*

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Grassland deterioration in the source region of Yangtze-Yellow Rivers in China and integrated control of ecological environment

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Key words : grassland deterioration , black barren , ecological environment , integrated control

Introduction Black Barren indicates seriously deteriorated alpine meadow . It is a comprehensive symbol for ecological environment deterioration in Yangtze-Yellow Rivers' source region in China , displaying serious grassland degeneration and spreading of desertification ; aggravation of soil erosion and water loss ; threatened biological diversity and increased frequency of natural disaster .

Materials and methods Gansu Grassland Ecological Research Institute applied remote sensing , geographic information system and ground survey ; by comparative analysis of Dari county's 1985-1997 ground survey data and remote sensing image data , established dynamic monitor model of grassland resource remote sensing .

Results Comparing surveys in 1985 and 1997 , reveals that Dari county's forage yield and carrying capacity decreases annually 2.17* 10^4 t fresh yield and 1 .00* 10^4 SU separately (Table 1) ; black barren increases to 818 .97 km^2 (Chen , 1998) (Table 2) . There is overgrazing in specific place , time , partial grassland ; speaking as a whole , however , entire grassland is not overgrazed (Table 3) . Change by global temperature rise should be the major cause for grassland deterioration and occurrence of vast sheets of semi arid-semi humid area's Dari county's black barren (Ding , 2001) .

Table 1 *Change of animal husbandry condition of Dari county .*

Year	Totalarea km^2	Crassland km^2	Usable grassland km^2	Dense brush km^2	Black barren km^2	Bared rock and other km^2
1985	14842 .47	13689 .80	11172 .53	326 .47	145 .13	680 .17
1997	14842 .47	13225 .90	10793 .66	319 .62	818 .97	477 .98

Table 2 *Change of landuse of Dari county .*

Year	Usable grassland			Theory yield 10^4 t	Theoretic stocking rate 10^4 SU
	4 level	5 level	6 level		
1985	1033 .60	5824 .43	4314 .20	371 .38	172 .43
1997	0	5356 .10	5754 .30	345 .45	160 .39
year decreases				2 .17	1 .00

Table 3 *The theoretic and real stocking rate of Dari county between 1985 and 1997 .*

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Stocking rate (104 head)	52 .0	54 .2	46 .0	40 .4	38 .8	40 .9	44 .0	45 .0	45 .0	47 .0	47 .0	49 .0	50 .0
Sheep unit (SU)	126	131	111	97 .7	93 .8	98 .9	106	109	109	114	114	119	12
Theoretic Carry Capacity(SU)	172	171	170	169	168	167	166	165	164	163	162	161	160

Discussion and recommendation Climatic warming up is the principal cause of deteriorated alpine meadow in this region , and unreasonable grassland utilization enhances the expansion and damage of the Black Barren . Four recommendations are made around changing unreasonable grassland utilization , i .e . to combine ecological control with grazing adjustment , to carry out integrated control on base of small river valley , to apply 3S technology in accurate planning and to introduce key technologies . Fencing natural grassland , warm pen construction , establishment of perennial pastures , use of solar energy are key techniques to be introduced soon .

Establishing a dynamic US federal national vegetation classification process standard in partnership with non federal partners

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Key words : vegetation types , vegetation classification

Introduction The overall purpose of this Federal National Vegetation Classification Standard (NVC) is to support the development and use of a consistent national vegetation classification in order to produce uniform statistics about vegetation resources across the nation , based on vegetation data gathered at local , regional , or national levels .

Material and methods The following is the twelve step process for formal development of a FGDC Standard (OMB 1990) . 1-develop proposal ; 2-review proposal , 3-set up project ,4-produce working draft , 5-review working draft , 6-review and evaluate committee draft , 7-approve standard for public review , 8-coordinate public review , 9-respond to public comment , 10-evaluate responsiveness to public comments , 11-approvestandard endorsement , 12-endorsement .

Results This will facilitate cooperation on vegetation management issues that transcend jurisdictional boundaries . It is therefore important that , as agencies map or inventory vegetation , they collect enough data to translate it for national reporting , aggregation , and comparisons . The ability to crosswalk other vegetation classifications and map legends to the NVC will facilitate the compilation of regional and national summaries .

Conclusions The overall purpose of this standard is to facilitate and support the development of a standardized vegetation classification for the United States and its use for information sharing . It also will define and adopt standards for vegetation data collection and analysis used in support of the classification to maintain scientific credibility of the national classification through a peer review process . Finally this Standard will facilitate inter-agency collaboration and inter-agency product consistency .

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Rethinking overgrazing and strategies for its management in Inner Mongolia

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Key words : grassland degradation , overgrazing , animal husbandry , Household Production Responsibility System

Introduction During the last fifty years , grassland degradation has become more and more serious . Most methods for restoring degraded grassland are based on the assumption that overgrazing is the main reason for grassland degradation . However , this presumption has not been tested scientifically .

Materials and methods Data was obtained from the Animal Husbandry Management Station of Inner Mongolia , Inner Mongolian statistical yearbooks and field work . The technique of energy analysis is used to identify the livestock population sustained by energy derived from outside the pastoral system created by the Household Production Responsibility System (HPRS) . This includes sources such as anti-disaster bases maintained by both government and herders and also ecological compensation forage transported by government from rural areas .

Results Livestock population figures in statistical yearbooks of Inner Mongolia show a continued increase which should lead to overgrazing and grassland degradation . However , as shown in Figure 1 , livestock population depending on natural grassland in Inner Mongolia decreased after 1990 , and do not support this supposition . In fact , statistical data do not only include livestock grazed on natural grassland , but also livestock that rely on energy inputs from outside of pastoral system . Moreover , this has been increasing rapidly under the HPRS for three reasons . (1) Herders have to buy forage from outside , such as in rural areas , to maintain their herds during natural disasters as the HPRS prevents them from moving livestock to other places to avoid disasters . (2) In order to prevent serious livestock loss from natural disasters , herders and government have invested significant effort to build systems to combat disasters . (3) Natural grassland has continued to decrease and degrade due to reduction in grazing scale (Dalintai et al ., 2005) , repeated trampling by livestock and increase in cultivated grassland . Therefore , the proportion of livestock living on energy from outside the pastoral system has increased sharply under the HPRS . Unfortunately , this cannot be shown through statistical data , and this has led to the false presumption that overgrazing is universal on natural grassland in Inner Mongolia . Measures taken to eliminate overgrazing and restore grassland based on this false assumption are unable to achieve their objectives .

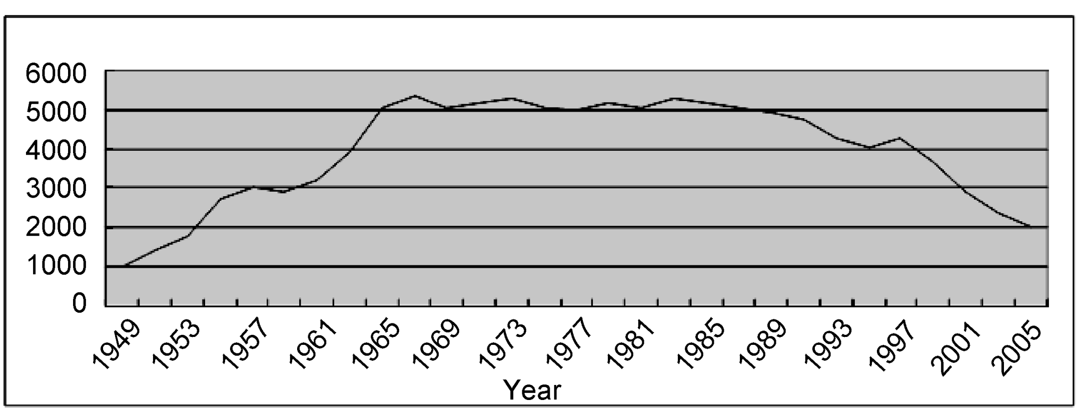

Figure 1 *The change of Livestock population (sheep unit) depending on natural grassland of pastoral area of Inner Mongolia(1949—2005)(unit :10 ,000 sheep Unit) .*

Conclusions By using energy analysis , it is concluded that most livestock in Inner Mongolia are not sustained by natural grassland , but by energy derived from outside this system . Therefore , it is unreasonable to identify reasons for natural rangeland degradation as overgrazing by livestock living on outside energy . Change in grassland use and disaster management due to HPRS implementation should be carefully studied to reveal the underpinning reasons for grassland degradation and to identify appropriate countermeasures .

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Self rehabilitation of degraded Mongolian rangeland by grazing exclosure

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Key words: pasture degradation, overgrazing, fencing, grazing exclosure, resting

Introduction Due to its continental and dry climate, Mongolia is one of the world's large rangeland areas. Nomadic pastoralism on these rangelands is the backbone of Mongolia's agricultural sector and builds the basis of income for many herder families. However, large areas of Mongolian rangeland pastures are heavily degraded, mainly due to overgrazing. We examined whether a resting time without grazing results in self rehabilitation of degraded rangeland.

Materials and methods At five sites selected according to their level of degradation grazing exclosures with fences were installed. After four years vegetation inside (rested) and outside the fences (grazed) were compared. Standing biomass and biomass proportions of grasses, forbs and sedges were measured by cutting ten replicates of 1 m^2 areas. Canopy cover, basal cover, litter cover and proportion of bare soil were measured using the line point intercept method. Data were analysed with analyses of variance.

Results and discussion Degradation was characterised by a strong decrease in canopy, basal and litter cover resulting in a strong increase in open soil. The proportion of grass species dramatically decreased with increasing degradation as observed by Sasaki *et al*. (2007). In parallel the species number and the standing biomass decreased. All these strong effects (all $P<0.0001$) indicate how much the different services rangelands provide are impaired by degradation.

Resting time of four years strongly increased canopy ($P<0.0001$) and litter ($P<0.01$) cover and thus reduced open soil ($P<0.0001$). These changes may have protected soils from erosion and formation of hard soil crusts. This may, in turn, have ameliorated the conditions for the recovery of the existing vegetation. In fact, key grass species as *Agropyron cristatum* and *Stipa sibirica* strongly profited from the resting (grass proportion, $P<0.0001$).

An important finding of the study was that the success of fencing strongly varied among the three levels of degradation for important characters as canopy cover, litter cover, bare ground, standing biomass and grass proportion (degradation level x resting; $P<0.001$). The lacking effect of resting on species number (P: ns) and the still nearly inexistent grass proportion in the totally degraded site suggest that the capacity of a plant community for resilience may be high as long as adapted plant species are still present above a minimum threshold. Reintroduction of species that were lost during the process of degradation seems much more difficult (Ulambayar *et al*. 2008) and time consuming.

Conclusion Self rehabilitation of degraded rangeland by grazing exclosure was successful as long as the adapted plant species were still present in the plant community i.e. as long as degradation was not too severe.

Table 1 *Effect of degradation level and four years of resting (grazing exclosure) on species number (SpNr), cover of canopy, plant bases, litter and bare soil, standing dry mass (DM) and dry mass proportion of plant types. (SEM: standard error of mean; n=20 for slight and heavy degradation and 10 for total degradation).*

Degrad. Level	Resting	SpNr (m^{-2})	Cover(%)				DM ($g\ m^{-2}$)	DM proportion(%)		
			Canopy	Basal	Litter	Bare		Grass	Forb	Sedge
Slight	Yes	13	64	17	28	8.3	68	37	58	4.9
	No	13	61	22	14	25	60	26	68	5.1
Heavy	Yes	11	93	5.7	5.5	1.7	99	48	33	19
	No	11	80	2.8	6.7	14	54	24	45	32
Total	Yes	5.1	74	0.0	4.7	21	53	1.6	86	12
	No	2.7	47	0.0	0.3	53	24	0.3	84	16
SEM		0.8	2.5	2.0	2.3	2.5	10.2	3.8	4.2	4.0

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Strategy and issues of ecological grass construction in Jilin province

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Key words : Jilin province ,ecological grass construction ,strategy ,existing problem

Introduction Ecological grass is conservation and restoration of vegetation through combination of grasses , shrubs , and trees , both natural and artificial , to improve ecosystem functions and environmental conditions in the areas of severe sandification , alkalization and degradation . Based on ecological principles , ecological grass construction includes a series of engineering approaches such as prohibiting grazing and other human activities on desertification grassland through enclosure and fences , planting shrub and sowing grass , and promoting development of understory vegetation , to control and manage desertification . The total area of desertification has reached 0 .7 10^6 hm^2 in western Jilin , which significantly reduces productivity of farmland and grassland (Yanchun Liu 2007) . Ecological grass construction may have potential to significantly reduce degradation and salination of grassland that has been a severe issue in environment management of Jilin Province .

Material and method Analysis was based on the field reconnaissance survey of ecological grass construction project in Changling , Qianan , Qianguo and Tongyu County , western parts of Jilin Province , interview with local farmers and foresters , and review of existing literature . Problems and issues were identified and strategies were proposed to improve ecological grass construction in Jinli Province in this paper .

Results

Development of ecological grass construction The action Converting Thousands of Desertification Land Into Greenland" was initiated by the Forestry Department of Jilin Province in 2000 , as a major step for ecological grass construction . Prominent achievements in the control and management of desertification has been made since then . By the end of 2006 , total accumulative investment reached 0 .3 billions RMB and over fifty thousand people took part in ecological grass construction through various ways . About 410 ,000 ha ecological grass land has been constructed and covered over 62% of severe desertification land . The total vegetation cover in Jilin Province has reached 44% , after establishment of 33 natural conservations with a total land cover of 2 ,217 ,900 ha . The ecological grass construction has contributed to the increase of vegetation cover , biodiversity , biomass , and organic matter , nutrition and moisture in the soil , and reduction of salination soil . Desertification has been reversed .

Issues in ecological grass construction Despite of significant achievement , ecological grass construction is still low in species diversity , and lack of high quality species and variety and quantitative results for further scientific evaluation . Local residents sometimes did not pay adequate attention to ecological grass construction such that inappropriate use of rangeland such as grazing on prohibited land or overgrazing still occurs . There is a level of risk that restored grassland through ecological grass construction degrades again . Production of high quality forage is at a lower level .

Strategies to improve ecological grass construction According to the objective of achieving ecological Province in Jilin , efforts need to be made to accelerate ecological grass construction through sustainable development , greater control of desertification , sandification , alkalization and degradation of grassland , and increases of vegetation cover and use of science and technology . We suggest decision and policy makers to enhance public awareness and education of ecological grass construction through various media and more intensive propaganda and to secure funds from various sources . Legislation should also be made to protect ecological grass construction from illegal grazing , releases of waste materials , water , and gases , and destructive use of land , to ensure the responsibility and benefits of stakeholders , and to support science-based engineering approaches for ecological restoration of grassland (Jingmin Shang 2003) . Some of the focused areas can include development of high quality forage variety , establishment of seed orchards for high quality species and varieties , introduction of high quality variety and culture techniques , and increase of commercialization and economical scale on ecological grass construction (H .Y . Ni ,2006) .

Conclusions Ecological grass construction has played significant roles in restoration of ecological function of grassland in Jilin province . Despite of great achievement , some issues exist and must be addressed to order to achieve the objectives of ecological grass construction . Ecological grass construction may provide a platform to meet the needs of community energy , economic and social development , and ecological restoration on sustainable basis .

Bush encroachment : a major threat to pastoralists livelihood in Ethiopia

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Key words : Bush encroachment , Pastoralists livelihood , rangeland

Introduction Ethiopia has a vast area of rangeland (61 to 67% of the land area) located around the periphery and they are found below 1 ,500 m .a .s .l . They support pastoral and agro-pastoral communities (mostly Somalia , Afar and Borana) of about 9 .8 million people belonging to 29 ethnic groups . The rangelands are not only important for livestock raising but also for wildlife habitats , ecotourism , irrigated agriculture , medicinal plants , conservation of biodiversity , and exploitation of natural resources (Abule *et al* ., 2005) . However , bush encroachment , the process of open grassland savanna being transformed into bushes & shrubs , is a major problem . Therefore , the objective of this paper is to review the status of bush encroachment and its effect on the livelihood of the pastoralists in Ethiopia .

Materials and methods Ethiopia , with a land area of 1 ,104 ,300 km^2 , is located in the horn of Africa bordered in the north by Eritrea and Djibouti , in the south by Kenya , in the east by Somalia and in the west by Sudan . The rangelands have unreliable and erratic rainfall , with regularly high temperature . This paper is based on reviewing literatures and documents .

Results According to the pastoralists compared to the past , the rangelands are bush encroached and the major triggering factors were the lack of prescribed fire , severe overgrazing , drought and the expansion of farming into the rangelands . Accordingly , there is a change in the species composition of livestock they keep from grazer (cattle and sheep) to browsers (camel and goats) . Furthermore , the pastoralists have noticed that bush encroachment is leading to agricultural and biodiversity problems . It has created a decrease in grass production , difficulty in livestock herding , damage by wildlife , and problems of bloating . The encroaching species and their density also varied from rangeland to rangeland . The major encroaching species in the Afar region are *Prosopis julifloria* , *Acacia seyal* , *Acacia mellifera* and *Acacia senegal* while in the Borana rangeland species of *Acacia* and *Commiphroa* and in parts of the Somalian rangeland , *Acacia nubica* and *A . Mellifera* . The communal grazing lands are more bush encroached (greater than 2 ,500 woody plants/ha) than the other grazing types and *Parthineum hysterophores* is becoming a major concern . In some rangelands , the bush encroached area is about 52% of the total land area . There is no visible bush control method being undertaken by the pastoral communities on their own effort except in the Borana rangeland which was supported by different organizations (Oba *et al* ., 2000 ; Gemedo , 2004 ; Abule *et al* ., 2005 ; Admasu , 2006 ; Amaha , 2006 ; Belaynesh , 2006 ; Teshome , 2007) .

Conclusions Bush encroachment has created a difficulty for the pastoralists to plan effective resource management and utilization strategies . Accordingly , the control of bush encroachment must be given due attention which requires a proper understanding of causal factors , invasive species , the degree and extent of encroachment , the mechanism and the population dynamics of invasive species and long-term community based control programs .

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Ecological indicators in a derived savanna disturbed by oil spillage and vegetation fire in Nigeria

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Key words: Savanna, oil spillage, fire, change indicators

Introduction Guinea and Sudan savannas covering about 546,400 sq. km., representing 60% of the entire Nigeria's land mass, harbor a significant proportion of Nigeria's population who are engaged mainly in nomadic and arable farming and are where a larger proportion of Nigeria's domestically grown food is produced. Oil pipelines that transverse these grasslands are frequently subjected to vandalization by restive youths which cause oil spillage and vegetation fire (NEST, 1991). This study examined the indicators of this growing ecological problem in Nigeria's savannah ecosystem.

Materials and methods The investigation was carried out in a community with a derived savanna vegetation near Ovim, Abia State, Nigeria where there was oil spillage and vegetation fire on a land area covering about 3 ha in 2003. Starting from the point of punctured pipeline 2 transects were cut perpendicular to each other and transversing the fire burnt area passing through a border area and reaching the unaffected adjacent plot. Along each transect, sample plots with size of 5m × 5m were created and replicated at 3 points using an interval 20 m on both the affected, border and unaffected areas. In each sample plot vegetation survey was done to identify, enumerate and classify species according to families and lifeforms. Twenty gram soil samples were also collected at 0-15 cm and 15-30 cm soil layers from all the sample plots and analyzed in a laboratory for N; P, K; Organic Carbon; pH; Fe and Pb using appropriate analytical methods. The data collected from soil were later statistically analyzed.

Results and discussions The mean total population of plant species in the unaffected, border and affected plots were 5406.25, 5007.5 and 6435 plants/ha respectively. In terms of family representation 7, 10 and 16 families were encountered in the affected plot, border and the control plots respectively. Although the area affected by oil spillage and vegetation fire had higher plant population density than the other 2 areas surveyed yet it had less species diversity. *Bracharia deflexi*, *Ipomea involucrata* and *Pennisetum polystachion* were the most abundant species but they existed in the 3 plots *Andropogon gayanus*, *Perotis indica*, *Adiatum caudatum and Schizachyrum exile* were 4 plant species with occurrence only in the land area affected by oil spillage and vegetation fire, and they appear to be adapted to the changed environment which could have significance in any planned land resuscitation. Re-growths of wood species were not encountered in the area affected by both oil spillage and vegetation fire unlike where the savanna disturbance was vegetation fire alone. Chamaephytes dominated the affected area.
The soil pH was reduced to 6.01 in the affected plots compared to the unaffected plots and this continued to the deeper soil level (5.43). Magnesium level was significantly lower in both 0-15 and 15-30 cm soil depths. The pattern would have been the reverse if the disturbance was from vegetation fire alone which releases Mg from the ash products into the soil. The N and K levels were 0.044% and 0.071 Cmol/kg respectively at 0-15 cm in the area affected by oil spillage and fire; and these were significantly lower than that of unaffected plots. The reduction in N content by oil spillage and vegetation fire was not limited to 0-15 cm alone but extended deeper into soil (15-30 cm). Levels of P and organic carbon were significantly low in both the border and control plots when compared with the area affected by oil spillage and vegetation fire. The oil products, which in itself contained hydrocarbons, spilled in the disturbed area apparently contributed to the observed increase in the level of organic carbon. The observed impacts on most soil parameters manifested at 15-30 cm which were different from reports of ordinary vegetation fire alone whose effects were restricted to the initial 0-10 cm depth (Tongway and Hodgkinson, 2000) but that of oil-fueled fire penetrates deeper and persist for a longer period in the soil (Al-sawari et al, 1998). The concentrations of Fe and Pb (mg/kg) at both 0-15 and 15-30 cm soil depths were all significantly higher in the disturbed area than either the border or control plots. Fe and Pb in the affected plot were 76% and 400% higher than the control plot at 0-15 cm soil depth. The involvement of oil spillage in the fire disturbance of the derived savanna of a community near Ovim in Abia State Nigeria, made the vegetation and soil to respond differently in terms of reach and they need to be accommodated in subsequent land use management.

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Study on soil properties of degraded desert plain grassland in north Tianshan of Xinjiang

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Key words: degraded desert grassland, degradation stage, grazing, livestock, soil properties

Introduction Xinjiang is one of China's main pastures, but its grassland has been degraded as a result of overloading grazing. In this study, the soil physical and chemical properties of the degraded desert grassland were studied to reveal the relationship of livestock-vegetation-soil.

Materials and methods The study was conducted in *artemisia* desert grassland at Ashili rural of Changji city in Xinjiang. Through field investigation of the status of species, the degraded series were divided into three stages: moderate degradation, heavy degradation and over degradation (Liu Hong-lai, et al. 2007), and 12 representative plots were set. From moderate degradation to over degradation, the predominance species is: *Gagea bulbifera* + *Seriphidium transillense* → *Gagea bulbifera* + *Geranium pratense* → *Petrosimonia sibirica* + *Trigonella arcuata* + *Geranium pratense*. Soil samples of 0-30 cm depth were dug for analyzing the mechanical composition, bulk density, density, organic matter, total salt, total nitrogen, total phosphorus, total potassium, available nitrogen, available phosphorus, and available potassium.

Results and discussion From moderate to over degradation stage, the soil clay content increased gradually, the sand / clay ratio descended significantly, decrease was 85.9%, which indicates that the surface soil is not rough so as to emerge the land desertification. Soil bulk density increased, and porosity decreased, the two were very significant negative correlation. Compared the soil bulk density of moderate degradation stage with heavy and over degradation stage, the difference was significant. In over degradation stage, the total salt content was minimum, but in the other stages, it was rather high, but soil had not yet reached the soil salinization.

Due to the number of livestock was large, a large number of animal manure were added into the soil, the organic matter was gradually accumulated, which caused soil organic matter and soil nitrogen content to gradually increased, the total nitrogen increased 31.8%, available nitrogen increased 35.9%, the three were very significant positive correlation, Some researches consider that grazing accelerates N cycle of grassland, especially heavy grazing (Unkovich M, et al. 1998), so that the amount of available nitrogen conversion to the total nitrogen is increased, this study also proved this opinion.

Soil phosphorus and potassium levels were reduced and then increased followed the degraded series, and the relation of total and available nutrient was significantly positive correlation. The influence of grazing intensity and livestock excretion on soil phosphorus and potassium was great (Yu Jun-ping, et al. 2000).

Conclusions With the intensification of grassland degradation, soil physical properties changed bad, bulk density increased significantly. The soil organic matter, available nitrogen and total nitrogen gradually increased. The contents of available phosphorus, total phosphorus were undulate. The stability of grassland ecosystems has been depressed, so measures should be taken to reduce grazing intensity for promoting grassland ecosystems to benign development.

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Preliminary study on classified index system of grazing subalpine meadow in northwest Sichuan

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Key words: subalpine meadow, grazing degradation, standing crop, organic matter content, index system of evaluation

Introduction Through studies in north-west of Sichuan, a study on an index system of degraded grassland was conducted which has a practical and instructional function for the ecological regeneration of grassland.

Materials and methods A study using method of spatial changes in place of temporal changes on grazing subalpine meadow was conducted in northwest of Sichuan Province. According to the standing crop, the theoretical grazing feed intake, the area and the time of grazing grassland, the grazing degree was determined as 4 levels: zero(CK), slight(SG), moderate(MG), and heavy(HG) in which the randomly-selected $1m^2$ quadrat sampling was conducted for 5 times. Record and description of the community characteristic were conducted. Soil of 0 to 30 cm, area of which was 100 cm^2, was taken using trench method from 5 randomly selected points. Every 10 cm deep accounted for a layer. A general soil analysis was conducted.

Results The correlation of total coverage of community between HG and MG was significant ($P<0.05$). But correlation between SG and MG was insignificant ($P>0.05$). Total coverage of community, richness and biodiversity were advisable as secondary indexes. There were 2～3 indicators plants for moderate and heavy degradation, such as *Potentilla anserina*, *Ranunculus tanguticus*, *Plantago depressa*. Standing crop in plant community and variety range of organic matter content of top 0～10 cm soil could be direct indexes. (Table 1)

Table 1 *The classified index system of degraded grassland of subalpine meadow.*

Index (Primary indices)	Zero Degradation	Slight Degradation	Moderate Degradation	Heavy Degradation
PNP AG biomass (%)	Few <10%	A few 10～20%	Abundant 20～30%	Mostly PNP >30%
Ground Coverage	Few bare-ground	A few bared	Abundantly bared	VE disappears or bared
AG Biomass(kg/hm^2)	>9000	6500～9000	4000～6500	<4000
0-10cm OM (g/kg)	>100	65～100	45～65	<45
Soil Surface	Hardly eroded	Seldom eroded	Rather eroded	Eroded

(AG=Above Ground; PNP=Poisonous and Noxious Plants; OM=Organic Matter; VE=Vegetation)

Conclusions In allusion to the degradation characteristics and degrees of subalpine meadow in North-west Sichuan, poisonous and noxious plants above-ground biomass, ground coverage, above-ground biomass, organic matter of 0-10cm soil and soil surface condition are advisable as primary indices in this area.

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The degeneration evaluation of Xilamuren grassland

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Key words : Xilamuren grassland , situation evaluation , degeneration mechanism , overgrazing , exclosure

Introduce At present , about 90 percent grassland has degenerated , Xilamuren grassland is a typical dry grassland of Inner Mongolia plateau , which is a good grass production base . However , with the development of local tourism , the grassland is further degenerating . In order to seek a effective way , the nature and characteristics of local community need to be fully understood (Valle 1998) . The object of this paper is to analyze the degradation mechanism and establish a reasonable evaluation system , to reverse the bad trend and provide a scientific basis for rational use and management of grassland .

Materials and methods the cite is on a hilly grassland in Xilamuren (41°20′E ,111°10′N) ,mean rainfall is 281mm/year . In the process of experiment , three different treatments including tourist area , rotational grazing area and exclosure are studied respectively , using nesting quadrat" (Ames 2003) of French ecologists to select 23 quadrats with each area of 25×25m (located by GPS) in different types of units randomly ,the investigation indicators are floristics , height , coverage , biomass and dominant species coverage , the experiment has last 4 years . This study make an initial draft of three programs to evaluate the grassland : (1) evaluate no exclosure areas (The State Forestry Bureau 1998) .(2) evaluate less degenerative areas .(Gao Shang Wu 1998) . (3) classify the degeneration standard (Wang Ji 2003) .

Results Xilamuren grassland is already in a state of overall degeneration . most of it is in a state of moderate degeneration , . slight degradation exists in exclosure , severe degradation is seen only in tourist areas .

Table 1 *Evaluation of xilamuren grassland degeneration .*

treatments	biomass(g/m^2)	coverage(%)	height(cm)	clay content(%)	grades
tourist area	40 .33	21 .79	5 .23	9 .79	severe
rotational grazing area	89 .83	39	7 .94	14 .28	moderate
exclosure	139 .17	55 .2	12 .01	23 .65	slight

Conclusions Xilamuren grassland is already in a state of overall degradation , degradation degrees can be divided into three grades , slight , moderate and severe , overgrazing and unreasonable development of tourism are the main reasons for grassland degradation .

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Impact of wildfire and seeding on the range plant community in the dry forests of southern British Columbia

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Key words: seeding, wildfire, weed invasion, species richness

Introduction Much controversy exists over the use of seeding as a rehabilitation tool after wildfires. The role of using seeding to limit invasive weed spread is poorly understood and some findings suggest that the seed mixes themselves could be considered invasive and lead to a decrease in species richness of the native plant community (Keeley 2006). Also, it has been well documented that, although much postfire seeding occurs, not much quantitative monitoring occurs to assess whether or not the seeding was effective (Robichaud et al. 2000). The objective of this study was to track vegetation change in seeded versus unseeded areas that had been impacted by wildfires and specifically to determine if seeding after wildfire 1) is an effective method to reduce weed invasion and 2) impacts the native plant community that may become established on the site.

Materials and methods In late summer of 2003 three large wildfires burned through the dry forests in the southern interior of BC. In 2004 two treatments, burned and seeded (seeded) and burned and unseeded (unseeded), were established as paired plots and replicated at seven sites in the burned areas. At each site 20-1×1 m quadrats were systematically sampled along 2-50 metre transects to determine % cover and frequency by species in 2004, 2005 and 2006 and 2-1×1 m (per sample line) areas were clipped, dried and weighed to determine total biomass production.

Results The seeded sites had a significantly ($P < 0.05$) higher total cover (Table 1) than the unseeded sites in 2004 and 2005. Not displayed on the table is the information that grass cover was also significantly higher in the seeded sites in 2004 (41.3 vs 4.8%) and 2005 (84.8 vs 11.7%). Seeding also significantly increased the overall species richness in all years (Table 1) but when the seeded species were removed from total species there was no significant difference between treatments. There was no treatment effect on weed cover (%) although weed cover on all treatments in all years remained low (Table 1). In general the plant community components did not differ between treatments (forb cover, shrub cover, and tree cover). One of the main species used in the seed mixes, *Lolium multiflorum*, significantly decreased ($p = 0.017$) from 2004 (19.4%) to 2006 (3.3%).

Table 1 *Total cover, species richness and % weed cover in the seeded versus unseeded sites in 2004, 2005 and 2006.*

Variable	Year	Seeded	Unseeded	SEM	P Value
Total Cover (%)	2004	72.3	43.2	6.10	0.005
	2005	170.5	116.6	20.08	0.036
	2006	102.7	89.2	13.41	0.339
Species Richness (no.)	2004	20.7	26.0	1.90	0.014
	2005	36.4	29.7	3.52	0.025
	2006	39.9	29.7	3.96	0.043
Weed Cover (%)	2004	0.6	1.2	0.56	0.304
	2005	7.4	7.9	2.44	0.849
	2006	3.5	5.8	1.96	0.301

Conclusions Seeding in this environment did not alter weed cover but overall weed cover was low in both treatments indicating weeds may not have been a major problem at these sites. Seeding did temporarily increase total cover which could be beneficial in areas where erosion is a concern or where weeds might be present in higher amounts. The plant species seeded did not indicate invasive qualities. The long term effects of seeding after wildfire on plant community change needs to be investigated further and monitoring on these sites will continue for a ten year period post fire.

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Land application of biosolids to restore disturbed western rangelands

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Key words : biosolids , agronomic rate , disturbed rangelands , lime stabilized

Introduction Many rangelands in the western U .S . have been degraded through improper grazing . Biosolids are an inexhaustible resource that can be utilized to restore disturbed rangelands . Application of biosolids poses little threat to groundwater resources in areas with adequate groundwater depth because evapotranspiration generally exceeds total precipitation (Evans et al ., 2001 ; Harris-Pierce et al ., 1995) . The current study compared effects of biosolids application to disturbed rangelands .

Materials and methods Biosolids were applied to private rangeland in Tooele County , Utah . A control plot served as a treatment performance baseline . The agronomic application rate of nitrogen (N) in tons/hectare was determined to be 168 kg of N/ha (McFarland , 2001) . Biosolids were applied at 1X , 5X , 10X and 20X the agronomic rate . Soil and forage samples were taken from each .13 ha plot .

Results and discussion Nitrate concentrations increased with increasing depth . Phosphorus values were highest at the soil surface and decreased with increasing depth . Electrical conductivity was similar to that of nitrate while ammonia levels remained relatively low for all application rates . Treatment forage production ranged from 147 to 744 kg/ha compared to 94 kg/ha for the control . Forage crude protein levels were significantly greater for treatment (20%) than for control (10%) .

Conclusions The increase in forage yield and quality underscored the value of biosolids land application while providing the following advantages in restoring disturbed rangelands : reduction in the use of costly , petroleum-based , fertilizers , reduced soil erosion , improved soil aeration/moisture infiltration , reduced water use (greater moisture retention capacity) and enhanced plant biodiversity .

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Reasons of the deterioration of grassland eco-environment in Inner Mongolia pasturing areas

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Key words : Inner Mongolia pasturing areas , grassland eco-environment , overgraze , predatory management , the sustainable development

In the past over twenty years , the drastic deterioration of grassland eco-environment in Inner Mongolia pasturing areas not only endangers the North ecologic safety , but also affects the eco-environment safety of neighboring countries ; therefore , it has aroused great attention of people at home and aboard , especially academic circles .

With the deterioration of grassland eco-environment , reasons of grassland eco-environment deterioration have been become a focus of debate . And there are some theories about deterioration reasons , such as theory of over-grazing , theory of extensive management , theory of drought , theory of population overloading , theory of disappearance of nomadic (change of culture) , theory of traditional nomadic , theory of meadow property rights , theory of goat-eating and theory of development of society and economy . In this all , the theory of over-grazing become the mainstream point and the fundamental basis for rules and policies by government .

By contrast the actual and theoretical animal number of the grasslands in Inner Mongolia for the past fifty years , we can draw a conclusion : the basic reason of the deterioration of grassland eco-environment in Inner Mongolia pasturing areas is located herd" mode of production by the system of grassland contracted to households and un-herdsman destructive activities such as grass mowing , medical materials digging , unauthorized and wasteful mining ; not overgrazing by herdsmen and livestock . Especially , located herd" mode of production by the system of grassland contracted to households is the basis ; other predatory activities are appeared on the precondition of the policy of grassland contracted to households .

Some pursuing national policies is not fundamental control measures , such as Treatment Project of Sandstorm Sources of Beijing and Tianjin , keeping the balance of grassland and livestock , rest-grazing in spring , forbid-grazing and fencing and population migrating . Government must adapt policy about the pasturing areas . First , by grassland shareholding and national support , establish modern nomadic management , rebuild benign running mechanism of man-land relationship of pasturing areas , raise the overall efficiency of animal husbandry and recover dry grass layer of meadows . Second , issue certificates to certify the right to use the land that collectively owned by herdsmen , resolve the main body to original herdsmen . Third , the grassland is protected by government legislation . Government must improve the ecological efficiency compensation and control mechanism , prohibit any destructive activities of grassland eco-environment .

Study on responses of *Leymus chinensis* of degraded grasslands to kinds of improved measures

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Key words : *Leymus chinensis* , degraded grassland , improved measures , response

Introduction As a result of influences of climates and human beings , more than 70% grasslands are degraded and gradually increasing . The pasture husbandry is highly influenced and so the income of humans . This study was used kinds of improved measures in order to increase constitutes of dominant species and the productivity of grassland (Vallentine , 1980) .

Materials and methods The site was on the country of Tai Pusi , Xilin Gol League of Inner Mongolia (114°51′～115°49′E , 41°35′～42°10′N) . The altitude is between 1400m～1500m and the mean rainfall was 407mm . The dominant species of pasture was *Leymus chinensis* , and other species such as *Pottentilla acaulis* ,*Pottentilla bifurca* ,*Cleistogenes squarrosa* ,*Agropyron michnoi* ,*Stipa* ,*Thalictum petaloideum* ,*Artemisia frigida* etc . From May 2007 to Sep . 2007 , 5 treatments were adopted in a randomized uniform block and each treatment plot was 800m^2 . They were : (1) meadow cutting (H) :10cm depth along the contour line ; (2) irrigation (G) : 40m^3 water each plot ; (3) meadow cutting and irrigation (H + G) ; (4) fertilizing and irrigation : four concentrations of urea (46% nitrogen) as follows : N1(25kg/hm^2)、N2(50kg/hm^2)、N3(75kg/hm^2)、N4(100kg/hm^2) , each plot was 5 m×2 m with 3 replicates ; (5) fertilizing : 50kg/hm^2 of urea (46% nitrogen) . The indexes of height , density ,coverage and weight of *L . chinensis* were measured once every month . Data were analyzed using SPSS 13 .0 .

Results The height , density , coverage and DW of *Leymus chinensis* in each treatment were increased more or less and the DW were highest in August . The increasing percentage of DW were 99 .34% ,196 .48% ,282 .49% ,183 .08% ,114 .28% ,360 .94% , 200 .76% and 201 .44% separately (Table 1) .

Table 1 *Effects of improved measures on DW of Leymus chinensis (g/m^2) .*

Treatment	June	July	Aug .	Sep .
CK	8 .11 a	17 .04 a	17 .29 a	16 .73 a
H	7 .89 a	14 .44 a	54 .97 ab	40 .65 b
H+G	19 .52 bc	41 .19 b	72 .92 bcd	41 .8 b
G	24 .19 bc	51 .92 bc	98 .52 cd	51 .69 b
S	9 .62 a	35 .19 ab	69 .17 bc	53 .52 b
N1	17 .48 b	36 .01 ab	34 .73 ab	38 .57 b
N2	33 .86 d	70 .28 c	110 .48 d	58 .12 b
N3	23 .14 bc	44 .54 b	59 .58 bc	50 .7 b
N4	27 .26 cd	55 .08 bc	48 .34 ab	47 .68 b

Conclusions Water is the limiting factor to the productivity of grassland . Meadow cutting can promote the reproducibility of *L . chinensis* . These measures were all effective to degraded grasslands . They were all significantly increased the productivity of *L . chinensis* . The concentration of 50kg/hm^2 of urea (46% nitrogen) was critical and it was the most effective way to improve the grasslands in the treatment .

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Predicting soil erosion and deposition effects on plant establishment: a key to increasing restoration success

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Key words: restoration, land degradation, soil erosion, seedling establishment

Introduction Land degradation is frequently associated with soil erosion and deposition. This can result in significant modification of the soil profile, including changes in soil surface texture and structure. Soil surface texture and structure affect plant water availability through their effects on infiltration rate and plant available water holding capacity. Plants in arid and semi-arid environments are particularly susceptible to desiccation during establishment. Consequently, changes to soil surface texture, structure or depth can affect establishment, as well as the productivity of the established plant community. In extreme cases, re-establishment of the original plant community may be impossible, even with significant external inputs (Bestelmeyer et al., In Press).

While the negative impacts of soil erosion are widely recognized, the potentially positive and negative effects of deposition on restoration potential are often ignored. Large areas of the world are affected by soil deposition. The most visible examples are associated with dune systems, but significant soil deposition can occur without dune formation downslope or down wind of cultivated fields, roads and other disturbances.

Where all other factors are equal, deposition of small quantities (several centimeters) of coarse-textured material on top of fine-textured material should increase infiltration and surface water holding capacity while reducing evaporative losses. Exposure of a fine-textured layer by erosion of coarse-textured material should have the opposite effect. The effects should depend on the depth of soil added or removed, and on initial soil profile characteristics. Soil surface structure degradation or the addition of degraded soil tends to reduce both infiltration and water holding capacity.

Materials and methods A series of field studies and modeling exercises are currently being completed at the USDA-ARS Jornada Experimental Range, located in the northern Chihuahuan Desert in south-central New Mexico, USA to examine the effects of soil erosion and deposition on plant establishment. This area receives approximately 245 mm of precipitation, over half of which arrives in convective storms during the growing season. Several areas of fine textured soils on the Jornada are being buried by sand from upwind areas. This study design exploits these landscape dynamics.

Results Examples of the effects of a change in soil surface texture on soil water availability are shown in Table 1. As predicted, model results showed that sand addition to the soil surface affected establishment differently depending on the amount of sand added and the initial soil texture. Field studies of areas where sand deposition has been occurring during past several decades indicate that plant community dynamics are controlled by a number of different factors in addition to sand deposition, and that feedbacks with the plant community itself are likely to be important.

Table 1 *Sample effects of surface texture change from loam to sand based on agricultural soils (Saxton and Rawls 2007). Input texture and bulk density data are from a depositional site on the Jornada. Effects on rangeland soils may be different due to differences in soil structure, but general patterns should be similar.*

Texture	Sand	Silt	Clay	Bulk Density	SOM (est.)	Available Water	Available Water Top 10cm	Sat. Hydr. Cond.
	%						mm	mm/hr
Loam	39	34	27	1.36	1.0	13	13	15
Sand	90	5	5	1.51	0.1	4	4	126
Change	+51	-29	-22	+0.15	(-0.9)	-9	-9	+111

Conclusions Careful characterization of site conditions and soil profile characteristics should be completed before restoration. At a minimum, changes in soil water characteristics should be predicted using texture relationships.

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The response of *Potentilla acaulis* population property to desertification grassland in agro-pastoral ecotone of northern China

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Key words: *Potentilla acaulis* population, desertification grassland, agro-pastoral ecotone, quantitative characteristics, clone plant

Introduction *Potentilla acaulis* is a typical perennial clone plant in desertification grassland of Northern China and it has a strong adaptability to sanded soil, which is always the last existent plant population in the process of grassland desertification (Wang and Li, 1999). Quantitative characteristics of *Potentilla acaulis* population were used to evaluate vegetal adaptive strategies to habitats in this study.

Materials and methods Three typical sample regions were selected and set up in northern of Hebei province in accordance with vegetation, soil and meteorology properties (data no shown), which separately presented the light, medium and heavy desertification degree of grassland. 30 replicated *Potentilla acaulis* tufts (60cm<diameter size<80cm) were randomly selected in every experiment region. In each replicated dose, the above-ground and below-ground biomass of 15 cm×15 cm quadrat was collected in 5 incessantly months of growing period. The Roots, stems and leaves of plant tufts were separately treated with suitable methods. The data were analyzed by SPSS13.0.

Results During all the growing periods, the below-ground biomass of heavy degree region was the lowest level of the three sample regions (Figure 1). This was demonstrated that the desertification degree of grassland was the crucial factor that effected on the below-ground biomass of *Potentilla acaulis* population. With the desertification strengthened, the ratio of above-ground to below-ground biomass was increased, which showed *Potentilla acaulis* population distributed more nutrients to the above-ground. Specific leaf area, leaf longevity and specific stolon internode weight of *Potentilla acaulis* population were obviously affected by desertification degree of grassland (Table 1).

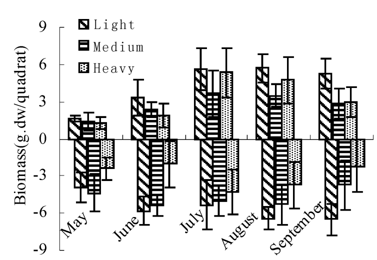

Figure 1 *Above/below-biomass of Potentilla acaulis population under various desertification degreed in 2007. Data of biomass is dry weight of 15×15 cm quadrat.*

Table 1 *Specific leaf area, leaf longevity and specific stolon internode weight of Potentilla acaulis* population in different desertification degreed.

Treatment	Light	Medium	Heavy
Specific leaf area (cm^2/g.dw)	389.18^c	263.82^b	182.79^a
Leaf longevity (day)	27^{ab}	65^c	22^a
Specific stolon internode weight (mg/cm)	2.42^a	4.81^b	6.25^c

Conclusions Different desertification degrees of grassland caused changes of biomass allocation and modules of *Potentilla acaulis* population. Fast-growth of leaves and adventitious roots were the growing strategy of *Potentilla acaulis* population responding to desertification grassland.

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Remote sensing to detect deterioration of Flooding Pampa rangeland by the use of glyphosate

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Key words: temperate grasslands, photosynthetically active radiation absorbed, seasonal variation

Introduction A technique based on spraying glyphosate to Flooding Pampa's rangelands in late summer has been widespread during the last decade. This technique eliminates green vegetation growing in late summer with the aim of improve germination and establishment of cool season (C_3) annual grasses, which, in turn, increases winter forage offer and allows increment of meat production. We postulate that this technique would negatively affect plants that vegetate in summer, causing changes in the seasonal pattern of above-ground net primary production (ANPP). Considering that ANPP of Flooding Pampa's grasslands can be accurately estimated using the spectral information provided by remote sensing (Piñeiro et al, 2006, Grigera et al, 2007), we used the amount of photosynthetically active radiation absorbed (APAR) by the capopy to compare the seasonal pattern of the APAR of non-treated vs. glyphosate-treated rangelands.

Materials and methods We used data provided by a geographic information system (GIS) built and maintained by the LART (Laboratorio de Análisis Regional y Teledetección, Faculty of Agronomy IFEVA, UBA/CONICET). The spectral information was provided by the MODIS and consisted of gridded-16 days composite images at a spatial resolution of 250 m^2. We selected 7 paddocks of native rangeland (never treated with glyphosate) and 8 paddocks that have been treated with glyphosate in late summer from 1 to 5 years consecutively. Monthly, from June 2003 to June 2005, we calculated APAR as the product of PAR obtained from the nearest weather station and fPAR derived from MODIS NDVI for each paddock. We compared monthly APAR among non-treated vs. glyphosate-treated paddocks during two consecutive periods (June 2003-May 2004 and June 2004-May 2005). Kruskal-Wallis test by ranks was used ($p<0.05$).

Results and discussion APAR of glyphosate-treated paddocks during the warmest months was significantly lower than that of the non-treated paddocks in the first (Figure 1a) and in the second (Figure 1b) period. APAR of glyphosate-treated paddocks during the whole warm season (from November to March) was lower than that of the non-treated paddocks in both periods (558 vs 826 MJ/m^2 · 150 days in the first and 605 vs 876 MJ/m^2 150 days in the second period), which may be a consequence of the increment of dead material of cool-season grasses and the reduction of warm-season species population.

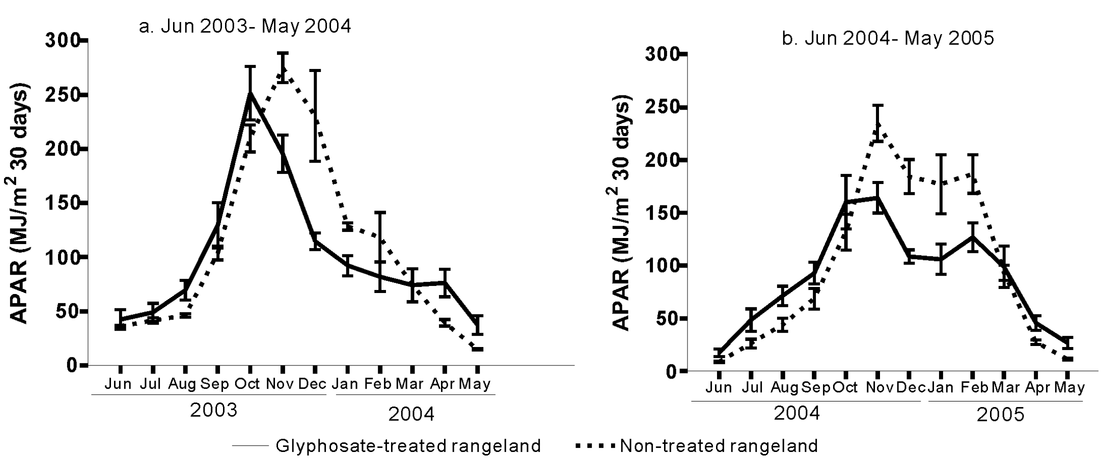

Figure 1 *Amount of photosynthetically active radiation absorved (APAR) by the capopy of glyphosate-treated and no-treated paddocks in the first (a) and in the second (b) period.*

Conclusions The reduction of the APAR during the warm season as a consequence of spraying glyphosate annually in late summer suggest a deterioration process related to the lost of warm season species and the reduction of biodiversity.

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Efforts to reduce wind erosion from unpaved roads cut through environmentally sensitive Alaskan and Hawaiian rangelands

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Key words: wind erosion, off road vehicles, dust palliative

Introduction Wind erosion is a critical issue on lands disturbed by off road vehicle us in the Delta Junction area, Alaska and in the saddle between Mauna Loa and Mauna Koa, Hawaii. Low visibility for off road vehicles, impacts on restoration potential, public transportation and quality of life for area neighbors are concerns. In Alaska, cold temperatures slow plant growth and soil genesis; thus erosion losses have long-term (100+ years) effects (Grantham et al. 2001). Reduction of accelerated wind erosion is a significant first step to insuring ecological integrity, and minimizing safety and quality of life concerns.

Materials and methods The study area in central Alaska has soils derived from glacial and glaciofluvial deposits that are dry, gravelly, and well drained. The area is needleleaf forest that annually averages 381 mm precipitation and temperatures of-3.9℃. The study area, centered on the island of Hawaii has poorly developed and excessively drained soils, derived from nearly barren lava flows. It is cool tropical averaging 1862 mm rainfall and temperature of 12.8℃. Threshold friction velocity measurements (u^*) through a portable wind tunnel were successfully used to evaluate changes in soil surface characteristics (Williams et al. 1995). In Hawaii, we tested the affect of dust palliatives on the threshold friction velocity of soil particle entrainment for disturbed rangeland sites. Five treatments were applied to soil surfaces with and without Hydretain® to promote plant establishment. Five treatments over four replications with sampling were two concentrations (9.5 l/plot, E1; 4.7 l/plot, E2) of Envirokleen®, a continuous life dust control agent applied directly over disturbed sites, and the application at two concentrations (3.8 l/plot, S1; 1.9 l/plot, S2) of Soil-Sement®, a polymer emulsion dust retardant, both treatments non-hazardous, and untreated controls (C). Threshold wind velocity data were analyzed by a fixed effects General Linear Models Analysis of Variance (GLM ANOVA) with mean separation by Fischer's Least Significant Difference (LSD). Dust palliative treatments and data analysis were the same for Alaska—no Hydretain was applied.

Results In Hawaii, pre-palliative testing of plots treated with ($P > 0.05$) and without ($P > 0.05$) Hydretain showed no significant change in threshold friction velocity. Threshold wind velocity means were significantly different among soil surface treatments after dust palliative application and with ($P < 0.05$) and without ($P < 0.001$) Hydretain (Figure 1). LSD separated means between Soil-Sement when compared with Envirokleen and controls with and without Hydretain. In Alaska, pre-palliative testing of plots showed no significant background changes in threshold friction velocity ($P > 0.05$). Mean threshold wind velocities were significantly different among soil surface treatments after seeding, raking and dust palliative application (Figure 2, $P < 0.001$). LSD separated means of both Soil-Sement treatments (S1, S2) from both Envirokleen treatments and control plots.

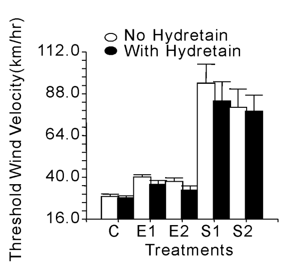

Figure 1 *Post-treatment threshold wind velocity means and standard errors for the control in Hawaii (Vertical bars=s.e.).*

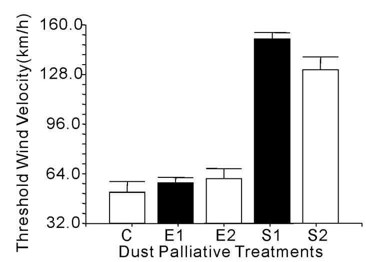

Figure 2 *Post-treatment threshold wind velocity means and standard errors for the control in Alaska (Vertical bars=s.e.).*

Conclusions At both locations with different soils, Soil-Sement (S1) provided superior retention of possible airborne particles to wind velocities greater from 80-160 km/h. Soil-Sement (S2) bound soil particles and resisted wind erosion less, from 72-128 km/h, still far superior to Envirokleen and controls. Both E1 and E2 produced large surface aggregates that were mobilized from 32-64 km/h. Soil-Sement is less viscous that allows for greater infiltration, a more uniform application that provides deeper cementation of surface soil particles. However, surfaces bound by Soil-Sement were observed at times to completely peel away at higher wind velocities. Plots with higher soil moisture when treated with Soil-Sement appeared to produce a stronger bond.

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The study for grassland nutrition of typical grasslands difference degradation grade

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Key words : Typical Grassland , Degraded grade , Sum nutrition digestion , Study

Introduction The grassland degradation leads tovegetation decay , reduction of grass yield , growth of coarseness grass , soil erosion , soil salination . And it results in weight of livestock losing , outbreak of rats and pests .

Materials and methods Based on the distance from the village , the grassland was divided into four degradation grades . They are heavy degradation area , moderate degradation area and light degradation area , the no grazing pasture as the comparison area (LiBo ,1997) . For each degradation grade , three quadrats of 1×1 square meter were established . Cut grass in quadrats and analyze the grass nutrition components in terms of *Forage analysis and forage quality examine technique*(YangSheng 1993) .

Result and analysis

Table 1 *The grass' nutrition component of different monitoring quadrats (DM)* .

Quadrats	Degradation grade	EE	DF	CP	Ash	NFE
	Comparison area	0 .978	27 .288	10 .108	7 .150	47 .703
No .1	Light degradation area	1 .892	29 .443	9 .355	5 .961	47 .985
	Moderate degradation area	1 .346	32 .096	12 .920	6 .848	40 .895
	Heavy degradation area	1 .738	25 .056	20 .931	9 .247	36 .864
	Comparison area	2 .164	35 .563	10 .269	7 .115	37 .461
No .2	Light degradation area	2 .321	29 .261	10 .640	6 .068	45 .524
	Moderate degradation area	2 .520	32 .826	12 .936	6 .618	38 .605
	Heavy degradation area	0 .856	24 .477	16 .440	7 .954	44 .018

The Table 1 showed that the Crude Fibre variety tend and the Crude Protein variety tend , i .e . the more the grasslands degenerates , the better the nutritional quality of the plant flora . The more vegetation was utilized so as to the grass' growth period is delayed in the heavy degradation area . And the grass is tender leaves with lower coarse fibre . The grass is growing and becomes scorch quickly when the comparison area isn't grazing and the leaves is less than stalk so that the more Crude Fibre .

Conclusions The study results showed that the degradation grade would increase extremely , the Crude Fibre will drop off and the Crude Protein will increase gradually , as well as the better nutritional quality of the grass . The research results were close to the reports of others research . The reasons , on the one hand , the grazing grassland was done by sustainable utilization so as to the grass was more rebirth in the natural grassland growth period . On the other hand , annual grass was more growth with fresh so more protein of the grass . But when the grass was utilized lower and the grass grow up fast so as to the Crude Protein will decrease in light grazing area .

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Changes of persistent soil seed bank in degraded *Seriphidium transillens* desert grassland

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Key words : *Seriphidium transillense* desert grassland , degradation stage , soil seed bank , species diversity

Introduction *Seriphidium* desert is generally the dominant native grassland type and is extensively distributed in central Asia , especially on the northern slopes of the Tianshan Mountains . It playing an important role in stockbreeding and ecosystem . Persistent soil seed bank plays a key role in vegetation restoration after disturbance ,but research about *Seriphidium transillens* desert seed bank is relatively few . In this paper we address the following two questions :(1) what changes happend under different degradation degreea about soil seed bank ?(2) why the changes happened ?

Materials and methods The study area is the spring – autumn pastures of Ashili village (N43°49′～43°56′ ,E87°02′～87°05′) , is open flat alluvial plain and located on the northern side of the Tianshan Mountains , in Xinjiang , China . The dominant flora on the study sites is *Seriphidium . transillense* , the companion species are *Petrosimonia sibrica* , *Tulipa iliensis* , *Trigonella arcuata* and *Ceratocarpus arenarius* . We divided grassland into four types according degradation gradients , non-degradation (ND) , media-degradation(MD) , heavy-degradation(HD) and over-degradation(OD) . Samples of soil seed bank were collected on April 17 , 2006 , sample's area is 38 .5 cm^2 , and soil depth are 0～5 , 5～10 and 10～15 cm respectively , and every degradation stages set four repetitions . Use Germination Method to identify the seeds in greenhouse .

Results and discussions Composition of soil seed bank :ND has 6 species , *Seriphidium transillense* , *Tetracma quadricornis* , *Eragrostis pilosa* , *Chenopodium alubum* , *Amaranthus retroflexus* , and *Malcormia africana* , MD has 8 species , *Seriphidium transillense* , *Petrosimonia sibirica* , *Eragrostis pilosa* , *Tetracma quadricornis* , *Chenopodium alubum* , *Amaranthus retroflexus* , *Trigonella arcuata* , and *Ferula ferulaeoides* , HD has 7 species , *Eragrostis pilosa* , *Tetracma quadricornis* , *Chenopodium alubum* , *Amaranthus retroflexus* , *Trigonella arcuata* , *Peganum harmala* , and *Amaranthus mangostanus* , and OD has 8 species , *Kochia prostrata* , *Petrosimonia sibirica* , *Salsola bracchita* , *Eragrostis pilosa* , *Tetracma quadricornis* , *Malcormia africana* , *Trigonella arcuata* , and *Peganum harmala* . We use Mehinick Richness Index(MRI) , Alatalo Evenness Index(AEI) , Gini Diversity Index(GDI) to study species diversity of the persistent soil seed bank . The three indexes have the same change tendency , and least in ND , increase from ND to MD and then decrease little from MD to OD . In the course of degradation , invasive species occupy the niche of dominant species , so the species diversity of soil seed bank increased . But it will decrease as the degradation enhanced . The seed number are 683 , 455 , 374 , and 611 seeds/m^2 respectively in four degradation stages . In ND , the rate of constructive species seeds , *Seriphidium transillense* , is 50% , but 5% in MD , 0% in HD and OD . Constructive species can not complete its life history under higher grazing stress , so seed number decrease . But in OD , invasive species replaced constructive species gradualy , and their reproductive strategy made seed number increase . To the three vertical layers , the distribution rate of seeds is respectively 62% , 14% , 24% in ND , 72% , 14% , 14% in MD , 44% , 35% , 21% in HD , 83% , 6% , 11% in OD . The total seeds number decrease gradually with soil depth , and 66% of total seeds distribute in 0～5 cm soil depth . Grazing stress made soil compaction increase , so it is difficult for seeds to sedimentate , and most of total seeds exist in surface layer of soil .

The soil seeds of suffrutex artemisia and ephemeral/ephemeroid species are both more than the number of their overground plant seedlings , but result of annual species is reversed . Grazing stress made the two types of species sufferr much more , they have no chance to produce seeds , so convert to agamogenesis strategy , furthermore most of seeds remain dormant in soil , so give annual community an opporunity to grow and propagate .

Conclusions As the grazing stress enhanced , (1) Richness , evenness , and diversity of vegetaton all increase more or less , and species invade severely in MD . (2) Seed number decrease from ND to HD , but increase much in OD . And most of seeds exist in surface layer of soil . (3) Seeds of suffrutex artemisia and ephemeral/ephemeroid species , select temporary dormancy strategy to evade adversity , but these stimulate the seeds of annual species to bourgeon and propagate .

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The role of *Sansevieria intermedia* in degradation and recovery in Kenyan drylands

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Key words: Kenya, succulents, overgrazing, competitive release, facilitation, biotic crust, resilience

Introduction In some heavily grazed rangelands of north-central Kenya, many local pastoralists are concerned over the proliferation of *Sansevieria intermedia*, a leaf succulent that forms dense patches and prevents livestock foraging and passage. As a first step toward understanding the dynamics of the increase of *S. intermedia*, this paper presents findings of both traditional and scientific ecological knowledge of the system, which suggest two key hypotheses regarding degradation and recovery dynamics.

Methods I interviewed 14 residents (men and women, age range 21 to 71 yrs) of Koija Group Ranch, Laikipia District, Kenya to begin building a local environmental history of the proliferation of *S. intermedia* and other environmental changes. In 306 50x50 cm quadrats along transects that passed through *S. intermedia* patches and inter-patch areas, I measured percent cover by plant species and functional group, biotic crust cover. I used Wilcoxon nonparametric means comparisons and chi-square tests to compare the variables between patch and inter-patch quadrats (JMP, 2007).

Results Of 14 interviewees, 13 stated that *S. intermedia* abundance had increased noticeably during their lifetimes. Nine believed the increase had occurred mostly during the last 10-20 years. Three respondents pointed out particular sites that had no *S. intermedia* in the past, and now contained 13-45% cover of *S. intermedia* patches. All respondents believed that livestock forage had decreased at Koija; 8 of the 14 felt that the decline started 10 to 20 years ago (Figure 1). Quadrats in *S. intermedia* patches had significantly higher biotic crust cover, associated vegetation cover, and species diversity, than inter-patch quadrats (Figure 2). Perennial grasses and the most common annual grass species at Koija, *Eragrostis tenuifolia*, occurred more frequently in *S. intermedia* patches than inter-patch areas (Figure 3).

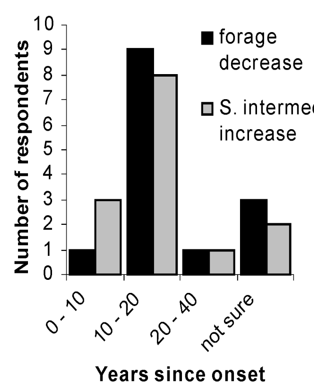

Figure 1 *Koija Group Ranch residents' perceptions of changes in forage and* S. intermedia *abundance (n=14).*

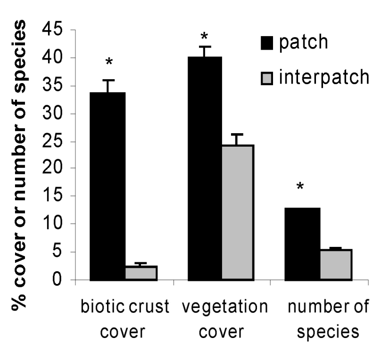

Figure 2 *Comparisons soil crust and vegetation (+1)SE in* S. intermedia *patch quadrats (n = 144) and interpatch quadrats (n = 162). * Wilcoxon rank tests: $p<0.001$.*

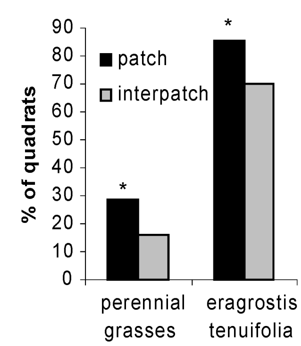

Figure 3 *Perennial grasses and* E. tenuifolia *occurred more often in patch quadrats (n = 144) than interpatch quadrats (n = 162). * χ^2 tests: $p<0.01$.*

Conclusions According to local ecological knowledge, *S. intermedia* has always been present at Koija, but the onset of its proliferation coincided with, or followed, forage degradation in the area. Thus the first key hypothesis suggested by this study is that *S. intermedia* has proliferated due to competitive release as surrounding vegetation became less abundant. Comparisons of patch and inter-patch quadrats indicated that soil and vegetation conditions are more favorable within *S. intermedia* patches than in the inter-patch areas. This may be due to the protection that *S. intermedia* leaves offer from livestock herbivory, due to shade increasing soil moisture, or due to soil disturbances created by the growth and emergence of *S. intermedia* ramets. These findings led to a second key hypothesis: after proliferating in response to overgrazing, *S. intermedia* patches in turn facilitate the recovery of degraded vegetation. The proliferation of *S. intermedia* may enhance ecosystem resilience by preventing runaway degradation in patches throughout the landscape (Walker and Salt, 2006). Manipulative tests of these hypotheses are currently underway.

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Restoration technologies to improve the grazing capacity of degraded arid-and semi-arid rangelands in South Africa

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Key words : Passive and active , monitoring , reference/benchmark sites

Introduction About 80% of the total land area of South Africa is regarded as rangelands of which most are arid-or semi-arid . It is estimated that approximately 66% of the rangelands are moderately to severely degraded (Snyman , 1988) and many have passed the thresholds of self recovery . Once irreversible transitions have occurred , restoration practices have to be implemented to assist the recovery of these degraded ecosystems (SER , 2002) . In most cases , the general aims of restoration is to increase the biodiversity for higher resilience , increase the vegetation cover to combat erosion and to improve the production potential for a higher grazing capacity (Bakker , *et al* . 1996 ; Van den Berg & Kellner , 2005) . Restoration procedures include both active (burning , clearing , re-seeding and cultivation) and passive technologies (withdrawal of livestock/game) (Milton & Dean , 1995) . All these technologies are very complex and the connection between ecological succession and ecosystem goods and services over time have to be addressed . The challenge is to investigate which technologies are most suitable for mitigating the poor environmental conditions , especially low rainfall and anthropogenic impacts that are responsible for the degradation in different livestock production systems .

Materials and methods Depending on the degree of degradation selected restoration technologies were introduced in the three main types of land-use systems found in South Africa , i .e . commercial , communal and game/conservation . In bare , denuded and heavily degraded areas , active technologies were applied , which included one or a combination of certain cultivation methods to increase the water use efficiency , re-seeding with indigenous , ecotype specific species , covering the area by brush (woody twigs) and the application of organic material to improve the soil structure and fertility . Where vegetation cover was still present , passive technologies were applied which means that grazing by livestock was controlled or withheld in exclosures . The success of the restoration experiments were assessed against selected reference or benchmark sites .

Results and discussions Depending on the degree of degradation and the land-use system , vegetation cover and density of especially high palatable , perennial species increased by > 50% in sites that were actively restored and the grazing capacity improved by > 60% , especially in communal managed systems that were formerly highly degraded and subsequently withheld from grazing . The dry matter (DM) production of grass species increased by > 60% and the biodiversity improved by >30% , depending on the condition of the surrounding vegetation and habitat . Monitoring took place over a period of 5 years and compared to the reference/benchmark sites . The soil type and rainfall , before and during the restoration activities , and type of plants species used in re-seeding activities , influenced the success of the restoration activity .

Conclusions The aim of restoration will determine which type of technology to apply in the different land-use types . Proper management of restoration activities will contribute to the success and long-term sustainability of the restored site . The sites and results are used as demonstration plots to make farmers aware of land degradation , desertification and the application of restoration practices and to apply more sustainable rangeland management practices in the long-term .

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Establishing vegetation on mine waste areas in northern Sweden

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Key words: reclamation, sludge, soil amendment

The studies concern vegetation establishment in mine tailings from the Aitik copper mine at Gällivare in Northern Sweden (67° 0,06′N; 20° 0,8′ E). The studies were carried out between the years 1996 and 2006. The tailings consist of the rest remaining after enrichment of metals from the crushed and milled copper ore. The material has been dispersed in water and pumped to the pond during somewhat more than 30 years. The deposit covers an area of about 1400 hectares and is enclosed by the slopes of a valley and by constructed dams. The tailings have the texture of fine sand and are prone to wind erosion when getting dry. Thus, there is a need to cover the surface when the tailings are no longer pumped into the pond. Since the area is so large, covering the tailings with soil from the surroundings is out of question. Covering the whole area with water is possible, because the climate is humid, but there is a risk of dam-break. Thus, to cover the deposit with vegetation probably is the most sensible action for erosion control.

The overall aim of the studies has been to find out how the establishing of vegetation should be performed, and to elucidate what consequences the measures taken at establishment will have for land use and the environment. The specific aims have been to get new knowledge on how trees, bushes, small bushes, herbs, grasses, lichens and mosses, naturally occurring in the Aitik area will develop in pure tailings and in tailings amended with organic material and alternatively mineral plant nutrients. Also a few plants from other environments were tried. Other specific aims were to find out which soil amendment that has the best positive and sustainable effect on development of plants, and to clarify the change over time in the amended tailings. The main environmental questions included how nitrogen and heavy metals behave at the plant establishment stage and later, and to state the risk of pollution of those elements. There were a number of field, greenhouse—and laboratory trials performed to reach the goals.

Grass-and clover species are recommended as initial vegetation. Many species from the surrounding area were self seeded in the trials, indicating that the tailings deposit will be easily colonized by species naturally occurring in the area.

In several trials the pH decreased, due to the oxidation of pyrite occurring in the tailings. This resulted in a low survival of the plants. However, the mining company has decided to alter the metal enrichment procedure, in order to remove as much pyrite as possible. It was also shown that only the additions of organic material to the tailings lead to a successful plant establishment. Digested sewage sludge was found to be suitable, and also potentially available in the large amounts needed. It was clear from the results that there is a risk of nitrogen pollution during the first growing season from the mineralized organic material. To prevent this, it is recommended that drainage water from the tailings pond should be taken care of during the first years. However, in the long run the nitrogen pollution from the vegetated pond probably is smaller than from the surrounding natural land, due to a smaller total amount of carbon and nitrogen.

There is a risk that the plants may take up high amounts of metals from the tailings, which might make the plants toxic to grazing reindeers and moose, but only if pH decreases to values below 5.

Growth characteristic, productivity and nutritive value of forages by reseeding methods in forest fire burnt pasture

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Key words: Forest fire, pasture, reseeding, dry matter yield, nutritive value

Introduction Periodic burning is a management tool used to rejuvenate old stands of grasses. Burning maintains the vegetation in a more youthful and productive state for grazing. How a plant responds to fire depends on the height above ground of its growing points, a function of plant maturity and plant-growth characteristics. Limited imformation is known about the use of fire on cool-season grasses. However, these may include many of the same objectives associated with burning, such as woody plant control or thatch removal. Also, grazing distribution and uniformity may be improved by burning cool-season bunch grasses, which accumulates dead stems that block access to new growth. From April 4-6, 2005, there was a huge fire in Yangyang-gun, Kangwon-do, Korea, which burned over 250 ha of forests and 246 buildings including 160 houses. Therefore, effects of reseeding rate and timing on growth characteristic, productivity and nutritive value of forages in the forest fire burnt pasture were investigated in this study.

Materials and methods This study was conducted from April 2005 to December 2006 in a private farm in Kangwon-do, Korea. Six treatments were considered namely: existing vegetation, damaged vegetation (Forest fire burnt pasture in the region) without any modification and damaged vegetation with modifications such as 30% and 50% reseeding 10 days and 20 days after the forest fire. The existing vegetation was seeded with 15 kg of orchardgrass, 10 kg of tall fescue, 3 kg of Kentucky blue grass and 2 kg of white clover. During the establishment period, fertilizer was applied at a rate of 80 kg N, 200 kg P and 70 kg K/ha and 210 kg N, 150 kg P and 180 kg K/ha for management distributed equally across the experimental area in the spring and time after every cutting. The forages were harvested by cuttings 3 times in 2005 and 4 times in 2006. Estimates of yield were determined by harvesting forage in a 1 m^2 area in each plot. Fresh forages were oven dried for 72h at 75℃, weighed and converted to DM yield. Forage nutritive value was evaluated in terms of ADF and NDF (Goering & Van Soest, 1970), and *in vitro* dry matter digestibility (IVDMD; Moore, 1970).

Results The DM yield for existing vegetation was the highest in the 1st year (2005) of the study (Table 1). In the 2nd year study, DM yield obtained from damaged vegetation with no treatment was the highest. The highest yield was not significantly different, however, from the DM yield of other treatments in this study.

Table 1 *Dry matter (DM) yield of forages in 2005 and 2006.*

Treatments	DM yield (kg/ha)		
	2005	2006	Mean
Existing vegetation	8,587	7,803	8,195
Forest fire burnt pasture	6,296	9,482	7,889
30% Reseeding, 10days after burning	7,045	7,772	7,408
50% Reseeding, 10days after burning	7,910	8,288	8,099
30% Reseeding, 20days after burning	7,332	8,049	7,690
50% Reseeding, 20days after burning	7,100	8,879	7,989
LSD (0.05)	NS	NS	NS

Conclusions Although there were no significant yield differences obtained in this study, the mean DM yield for existing vegetation was the highest. A benefit of reseeding burnt pastures was not found. We concluded that forest fire resulted in reduction of the pasture yield for a short period but it did not have any significant effect in the long term.

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Studies on the effect of applying fertilizer on *Pinus tabulaeformi* in Shen Dong Mine

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Key words : Shen Dong Mine , Pinus tabulaeformi , Applying Fertilizer , Shoot Growth , The diameter of pinus

Introduction Application of fertilizer to trees in an effort to increase their growth for protection from wind erosion and aesthetic value is low in our country but required (Chen Jun et al 1998 , WuXiaofu et al 2002) . Rates of greening in SHEN DONG Mine are 70 percent , but the harsh nature of the environment seriously affects the normal growth of trees . This paper reports a study on the effect of increasing growth of Pinus tabulaeformi under the different fertilizer rates which will provide fertilizer recommendations for forestation .

Materials and methods The experimental area is located on ShenDong Mine in Inner Mongolia in the semiarid region of north China . We selected 7 kinds of fertilizer treatments : , 1(CK) , 2(urea 200g) , 3(phosphate ammonium 500g) , 4(sheep manure 2kg) , 5(urea 100g , SSP 200g and potassium chloride 50g) , 6(urea 200g , SSP 250g and potassium chloride 50g) , and 7(sheep manure 2kg , urea 100g , SSP 200g and potassium chloride 50g) . The amount of fertilization above was for one tree . There were 5 trees per treatment and 9 replicates . Each treatment is radial arranged . Specific fertilization methods are as follows : first , chemical fertilizer , stiletto 60 cm at each corner of tree well with Luoyang spade ; second , organic fertilizer , embedding it in ringy ditch or radial ditch , the depth of ditch >40 cm . Fertilizers were applied in Autumn of 2003 and Spring of 2004 . Diameter of pinus was measured by vernier caliper at September of 2003 (1 m above of ground) and signed , after that , measuring the diameter and shoot growth of Pinus at October of 2004 and September of 2005 .

Results For shoot growth , in 2004 , only the third treatment had a significant effect . In 2005 , the fifth treatment significantly improved the shoot growth . For the diameter , there was no significant difference in 2004 . In 2005 , besides the third treatment being lower than the control , all of the others were significantly higher . In general , the compound fertilizer had a better effect than the single-effect fertilizer . The result of 2005 is better than 2004 . The difference of diameter increment was higher than the difference of shoot growth . The amount of shoot growth in 2005 was 1.4 times of 2004 and the diameter increment is 2.3 times .

Table 1 *Influence and variance analysis of Pinus growth amount under different fertilizer conditions in different years*

Year	Growth amount Probability(P)	Treatment							
		1st	2nd	3rd	4th	5th	6th	7th	Average
2004	Shoot growth(cm)	19.4	19.9	13.8	17.9	18.6	17.8	17.3	17.8
	Probability(P)		0.5915	0.0054**	0.1716	0.61	0.1357	0.0707	
	Diameter(mm)	6	5.8	4.8	5.7	6.9	5.7	6.7	5.9
	Probability(P)		0.8613	0.3401	0.7693	0.3612	0.7693	0.5045	
2005	Shoot growth(cm)	24.3	25.6	22.4	25.4	28.6	24.1	25.8	25.2
	Probability(P)		0.6271	0.1359	0.3865	0.0145*	0.8095	0.1124	
	Diameter(mm)	12.6	13.8	10.8	13.2	14.5	14.4	16.3	13.7
	Probability(P)		0.016*	0.0252*	0.0408*	0.0043**	0.0082**	0.0002**	

Conclusions After fertilizer application , Pinus's growth rate increased and the compound fertilizer had a better effect than the single one . An acceleration of was shown in the third year indicating a temporal effect , so , fertilizer could be applied earlier .

Acknowledgement This work was funded by the 11th Five-Year Technology Support Project (2006BAD03A0307 ; 2006BAD26B0102)

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Effect of land use on soil quality in a small arid catchment of Upper Yangtze River Valley

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Key words: dry valley, soil property, soil quality, rehabilitation, Minjiang River

Introduction Vegetation recovery, such as reforestation, and natural succession may also change soil quality. Degradation of land is among the most serious environmental problems in Southwest China. There is a need for research to be conducted to determine the effects of land cover change. Taking the Dagou catchment with a reforestation history in the Upper Minjiang River as an example, a study was initiated to characterize ecological effects in reforested and adjacent cultivated or shrub sites. The objectives were to (1) investigate soil propertie changes associated with different land use types, and (2) to identify changes on soil properties and plant diversity brought about by the reforestation.

Methods and materials The conditions of the study area are now better than the dry valley adjacent to the study area which has very high evaporation and very limited precipitation. The annual rainfall is 900 mm while evaporation is 795 mm, and the mean monthly temperature is approximately 8.9℃. Soil types are mainly mountainous umber and brown soils. The landscape of the catchment still exhibits large heterogeneity. Land use types were identified into four categories including shrub, cropland, potatoes, reforested land, and woods planted with Chinese pine for periods of 5 years to 30 years (orchard land). In total twenty-nine plots were investigated. At each site all individual trees were identified and diameter measured at breast height, layer coverage, stem height (height of the first major branch) and total height. Shrubs were identified and measured for diameter, layer coverage and total height, while herbaceous vegetation were identified and counted. Soil samples were collected to assess effects of land use change on soil properties. The number for orchard land, shrub land, cultivated land and reforested land was 4, 8, 4, and 13, respectively. The QI was calculated by soil quality factor membership values and their weight as following *equation*.

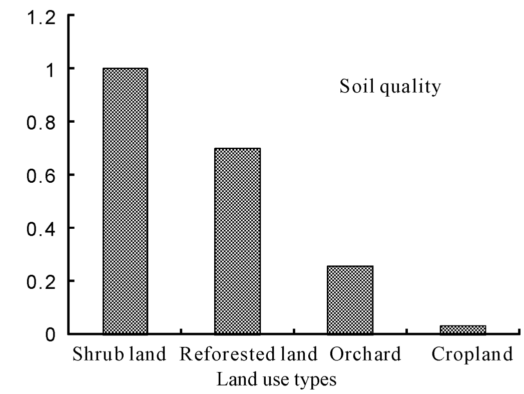

Figure 1 *Soil quality of different land uses in the Dagou catchment.*

Results The results showed that OM, TN, AK, SW had statistically significant differences between the four land use types. The values presented that OM and TN of cultivated land were dramatically lower than shrub and reforested land. Figure 1 showed that the land use changes had resulted in very different soil quality levels. The QI values for shrub land, cropland, orchard and reforested land were 1, 0.03, 0.25, and 0.70 respectively. Figure 2 showed that reforestation could greatly change soil properties. The OM, TN, AK and SW had good relationship with reforested years. The results showed the QI values increased with the reforested years, from 0.08 to 0.89.

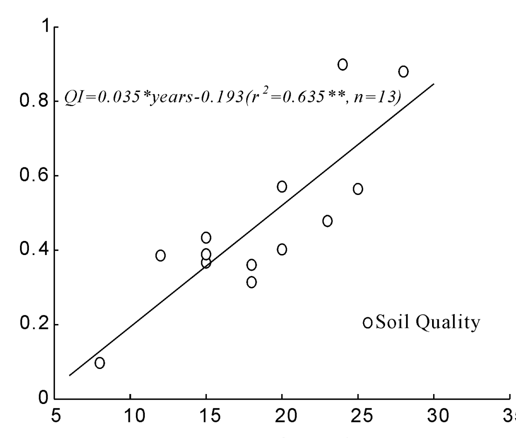

Figure 2 *Positive linear relationship between soil quality and years since reforestation.*

Conclusions The study assessed the effects of land use and forest recovery on the soil properties. The results showed that cropland had the lowest soil quality level and the shrub land had the highest level. The soil quality index increased with vegetation recovery. The study suggested that in the dry valleys shrubs had a good capacity for soil improvement and reforestation, if well restored, could also improve soil quality and biodiversity. The project was supported by National Natural Sciences Foundation of China (No.40501067).

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Evaluation of fencing gbrassland and stopping grazing on grassland restoration in Inner Mongolia

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Key words: grassland degradation, grassland fencing, grazing ban, grassland restoration

Introduction Grassland degradation has happened in many parts of China during the last twenty to thirty years. It is vital to protect these grasslands by taking steps to restore vegetation. Fencing grassland and prohibiting grazing have been regarded as the most effective means for achieving this and have been widely promoted by central and local governments. However, the results of these methods have not accorded with expectations.

Materials and methods The data in this article comes from two vegetation investigations in May and June of 2007 in Inner Mongolia. Sample plots were selected from four types of vegetation growing in typical grassland, desert grassland, desert and sandy area in grassland zone respectively.

Results In the short term, cessation of grazing yielded good initial signs of grassland restoration. Vegetation was restored to some degree or even grew abundantly in some places. However, in the longer term, these results differed from expectations and indicated that grassland fencing and grazing bans were inappropriate methods for restoring degraded grassland (Table 1).

Table 1 *Results of grassland fencing and grazing exclusion in sampled plots.*

	Sample plot locations	Original vegetation	Time since fencing and grazing exclusion	Results
1		Degraded *Leynus Chinensis*	two years	Increased production and proportion of *Leynus Chinensis*
			twenty years with some livestock in winter, cutting and burning	Amount of withered grass was six times that outside the fence; species numbers per m^2 decreased by over ten; vegetation became *Stipa grandis*.
2	Desert grassland in Sunite Left Banner in Xilingol Prefecture	Degraded *Stipa klemenzii*	Five, nine and thirteen years	The production, species number, and proportion of original plants decreased; withered grass and indicator species for grassland degradation increased.
3	Desert in Alashan Prefecture	*Haloxylon ammodendron*, *Reaumuria soongolica*	Five and nine years	Production, length of green parts of shrub branches and proportion of green parts decreased; mortality caused by withering increased.
4	Low-lying in Hushandake Sandy Area, Xilingol Prefecture	Seriously degraded	Two to three years	Abundant growth due to good water conditions and accumulated manure. The production was over 100 times that before fencing.

Note: the result is concluded based on the average value of sampled plots.

Conclusions The grassland ecosystem does not only include grass, but also includes animals and herders. They have evolved together for thousands of years. The method of fencing grassland and stopping grazing has failed to restore degraded grassland because it excluded livestock and herders, who are important components in the grassland ecosystem. In order to protect grassland, it is necessary to consider advantages of livestock in grassland management and make full use of them.

Aspects of range condition recovery in the southern Jebel al Akhdar , northeastern Libya

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Key words : monitoring , exclosure , grazing , soil-condition , vegetation-condition , foliage biomass

Introduction The extensive grazing of sheep , goats and camel occurs in the southern Jebel al Akhdar rangelands of northeast Libya . Climate is Mediterranean , characterised by winter precipitation between October and April . Annual average rainfall declines rapidly from 250 mm in the northern uplands to less than 30 mm in the south . Vegetation is zoned dwarf shrub steppe . Perennial shrubs include *Artemisia herba-alba* , *Haloxylon scoparium* , *Anabasis articulata* , *Suaeda pruinosa* , *S . vera* and *Salsola tetrandra* (SWECO 1986) . Inappropriate and unsustainable historical and contemporary land use practices have resulted in widespread severely degraded soil and vegetation (SWECO 1986 ; Anon . 2004 ; Russell 2006) . The study objective is to quantify range condition improvement in areas protected from grazing .

Methods and materials This integrated study utilised plant inventory surveys and a suite of permanent monitoring sites located within and outside fenced exclosures at three localities to investigate differences in perennial plant species richness , size and density , foliage biomass , energy and nutrient yield , landscape function , soil surface condition and soil micro-nutrients . Plant inventorying was undertaken during the 2006 spring flowering season and the other data were collected in early summer with a second biomass sampling in early autumn 2007 . Monitoring site layout and data collection protocol is based on the Western Australian Rangeland Monitoring System (Watson , Novelly & Thomas 2007) .

Results and discussion Statistically significant differences between exclosures and open areas were found for all vegetation and soil attributes except soil micro-nutrients and some physical and chemical properties . Levels of erosion are less and species richness and plant biomass are markedly higher within exclosures . For example , within the most productive exclosure (Maduar Zetun , natural regrowth protected for six years) , foliage biomass was approximately 222 kg (DM) per hectare and available gross energy was approximately 2 ,182 MJ per hectare , compared to values of 122 and 1 ,198 respectively , in the adjacent open area . A total of 33 perennial species were recorded in the exclosure compared to 22 in the grazed area . Mean soil surface condition (index value 103) , driven mainly by improved water infiltration and soil stability , had improved 27% during the six years of protection compared to the adjacent area subject to intensive , continuous grazing . This study highlights the interaction between vegetation and soil in land degradation . Protection from high grazing pressure allowed vegetation cover , richness and standing biomass to increase with concomitant reduction in soil erosion . Improved soil surface condition probably facilitated plant recruitment .

Conclusions This quantitative study supports visual observations that improvement has occurred in the protected areas but not in unprotected grazed areas . The study also supports forage biomass energy yield improvement predictions made by SWECO (1986) as part of their range management recommendations to protect areas from grazing . It is estimated that at least 10 years of protection in the higher rainfall areas , and longer in the low rainfall areas , is required for range condition to improve sufficiently before being opened to controlled grazing .

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Suitable species for the reclamation and sustainability of saline land in southern Australia

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Key words : genetic diversity , plant salt tolerance , soil salinity

Introduction Dryland and irrigation induced-salinity remain serious environmental problems in many parts of the world and may worsen in scale due to the effects of climate change . In Australia , it is believed that around 5 .7 million hectares of agricultural land are currently affected by dryland salinity—the majority of which is in Western Australia . In addition , due to a prolonged period of drought and water shortage , there are now large areas of land in south eastern Australia that can no longer be irrigated and which are potentially saline . Selecting suitable grassland species to regenerate and rehabilitate saline land throughout southern Australia is a research priority to ensure that production and sustainability is maintained .

Materials and methods This collaborative project , which involved four states and territories in Australia , commenced in 2004 . Priority plant genera that showed good potential for salt and waterlogging tolerance were identified in the literature and using practical knowledge (Rogers et al ., 2005) . These species were evaluated for salt and waterlogging tolerances under glasshouse conditions before promising species entered into a field assessment .

Results and discussion Suitable plant species that performed well included both introduced species and native Australian species (Table 1) . Ideally , species most suited to reclaiming saline land are those that combine good relative salt and waterlogging tolerance with vigorous growth under non-stressed conditions—however not many of the species evaluated fell into this category . Consequently listed species range from productive , annual species (e .g . *Melilotus indicus*) suitable for grazing , to slower-growing perennial species (e .g . *Sporobolus virginicus*) that propagate vegetatively and are effective at colonising and stabilising saline salt scalds . For some species (e .g . *Melilotus siculus*) , further research is required to identify suitable matching rhizobia before this species can reach its maximum potential in saline areas (Rogers et al ., 2007) . Further research is also required in some annual species (e .g . *Medicago polymorpha*) to select for salt tolerance at germination (Nichols et al ., 2007) . It is important that all selected species are evaluated for their weed risk before being introduced into saline areas .

Table 1 *Some identified legumes , grasses and herbs with salt and waterlogging tolerance .*

Plant Category	Species
Legumes	*Lotus glaber Medicago polymorpha , Medicago sativa , Melilotus indicus , Melilotus siculus (syn . messanensis) , Melilotus sulcatus ssp . segetalis , Trifolium hybridum , Trifolium argutum , Trifolium ornithopodiodes*
Grasses	*Aeluropus lagopoides , Austrodanthonia carphoides , Austrodanthonia linkii , Austrodanthonia setacea , Austrostipa bigeniculata , Distichlis distichophylla , Poa sallacustris , Puccinellia ciliata , Puccinellia distans , Sporobolus mitchellii , Sporobolus virginicus*
Herbs	*Lawrencia spicata , Plantago coronopus .*

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Range rehabiltation technologies in Uzbekstan

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The arid rangelands of Uzbekistan are extensive and cover an area of up to 17 .5 million ha , about 70% of the total land area . This is one of the largest remaining rangeland ecosystems in the region of Central Asia .

Recently , rapid land degradation and desertification have been disturbing these rangelands areas (T .Mukimov et al ., 2003) . Overgrazing by small ruminant domestic animals , inadequate management of grazing area and unsustainable uprooting of shrubs for domestic use has mainly induced this land degradation and desertification .

Overgrazing due to higher pressure of animals per unit area and unsustainable , nonsystematic utilization is one of the primary causes of desertification in the region for the last decade .

The natural factors of desertification and land degradation such as aridisation , deflation , salinisation in addition to anthropogenic ones , have sharpened the problem and decreased socio-economic standards of the local population
Both overgrazing and under grazing have negative effects on vegetation cover and disappearance of palatable species and replacement with unpalatable ones . Only sustainable grazing strategies such as range rotation , and reasonable numbers of animals per area etc can help to rehabilitate severely degraded rangelands .

Creation of higher yielding artificial pasture ecosystems made from deep rooting (7-10 m) shrubby species , which use moisture and nutrition from lower soil horizons is a promising way of range rehabilitation . Species *of Haloxylon aphyllum* , *Kochia prostrata* , *Salsola orientalis* , *Artemisia diffusa* etc and others are valuable fodder resources . Plantations of this pastures consist of fodder plants in a different ratio mainly 25% shrubs , 50% semi-shrubs , 25% forbs , which creates an optimal canopy .

These types of pasture , after 3-4 years , contain about 40-45 species of ephemeris and ephemeredes and provide 1 .7 t of dry matter and 600-1200 fodder units . Different species allow the use of this pastures all year round .

The unique feature of this technology is the planting of fodder species with physiological germinated seeds to specially prepared seedbeds and partial soil cultivation . The preliminary investigations have shown a good potential for yield to increase up to 1 .5-2 times .

These technologies offer ecologically safety , due to the partial range ploughing and economic efficiency due to application of germinated seeds , which guarantee an optimal plant population per hectare and are applicable for small farms .

Economic benefits occur after 3-4 years of work and farmers can then maintain it without extra investment during further use .

Fire and grazing to improve wildlife habitat on introduced grass monocultures in Texas

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Key words: fire, grazing, exotic grasses, wildlife

Introduction Guineagrass (*Urochloa maxima*) and bermudagrass (*Cynodon dactylon*) were introduced into the USA with the objective of improving forage production for cattle. However, these grasses became invasive and replaced native plant communities valuable for wildlife. Invasive plant species are considered the second most important threat to conservation of biodiversity (Zalba et al. 2000). Prescribed fire can be used to stimulate regrowth, and improve quality and preference by grazing animals as well as to increase insect abundance, wildlife and cattle usually concentrate on burned areas due to these factors. This phenomena provides an opportunity to use prescribed fire, followed by grazing, to reduce stands of invasive exotic grasses and allow native plants an opportunity to recolonize these areas.

Materials and methods We conducted two companion projects in Willacy and Bee counties, Texas, to test the idea that prescribed fire followed by cattle grazing can reduce the amount of invasive exotic grasses present. In the first study (Willacy County) we evaluated the effect of a summer (June) burning and intensive cattle grazing on guinegrass density and native plant species richness. Guineagrass density and native plant composition were monitored monthly for 7 months post-burning. Four treatments with three replications resulting from the combination of prescribed burning (burning and no burning) and intensive grazing (grazing or no grazing) were evaluated. In the second study (Bee County) we evaluated the effect of prescribed burning (November) and overseeding of armadillo burr medic (*Medicago polymorpha*) on cover of forbs and insect abundance. Four treatment combinations with three replications were evaluated: seeding or no seeding, and burning or no burning, all treatments were grazed by cattle. In both studies a randomized complete block design with a factorial arrangement of treatments was used to analyze the information. Main effects and interactions were considered significant at $\alpha < 0.05$.

Results and discussion At the Willacy County site, prescribed burning reduced ($P < 0.05$) guineagrass density with an average of 58,667 plants/ha compared to 93,333 plants/ha in non-burned areas. These results agree with Skovlin (1971), who indicated that guineagrass is susceptible to hot fires. Native plant species richness in the burning—grazing treatment increased from 1 to 4.3 species/0.25 m^2, an increase of 330% at the end of the study. Contrasting information has been reported by Drawe and Kattner (1978), indicating that percent composition of grasses and forbs was affected by early summer burns when combined with mowing. Ten important forbs used by white-tailed deer (*Odocoileus virginianus*) and six used by northern bobwhite (*Colinus virginianus*) were newly recorded or increased 1 yr after application of the burning treatments. Cattle and white-tailed deer preferred burned areas.

At the Bee County site, cover of forbs in general was greater ($P < 0.06$) in the burned areas with more than 60% compared to less than 33% for the unburned areas. Overseeding armadillo burr clover did not affect the cover of forbs ($P > 0.05$), however, insect abundance of three different families was higher ($P < 0.05$) in the burned and seeded areas. Abundance of insects is very important for diets of birds such as northern bobwhite.

Conclusions The results of these studies suggest that prescribed burning and cattle grazing can lead to an increase in native plant species richness reducing guineagrass density and increasing insect abundance, both of which are desirable for wildlife.

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Food crops as temporary cover before pasture sowing in mountains of central Italy .

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Key words : forage production , *Solanum tuberosum* , shrub encroachment , *Triticum dicoccum*

Introduction A consistent reduction in pastoral and agricultural activities has caused and degradation in marginal pastures of Central Italy . Many pastures are being invaded by unpalatable grasses and encroached by shrubs . . The recovering of the area is based on crop diversification , reintroduction of native crops and livestock breeds , development of farm services connected to tourism (Pardini et al . , 2002) . However the preliminary restoration of good pastures is necessary . We compared productivity and costs of 2 strategies for rehabilitation of mountain pastures . The research has been fund by ARSIA agency of the regional Government .

Materials and methods We compared 2 succession strategies (debrushment-pasture , debrushment-crop-pasture) including 3 treatments : T1 (debrushment-pasture sowing) , T2 (debrushment-one year potato crop-pasture sowing) , T3 (debrushment-one year cereal crop-pasture sowing) .

An enchroached area of 2 ha was cleared in September 2003 , cultivated and sown in summer 2004 . In T1 40 kg/ha pasture misture has been sown , this comprised 6 species : 25% *Festuca rubra* Engina" , 17 .5% *Phleum pratense* Clima" , 17 .5% *Lolium perenne* Lisabelle" , 15% *Trifolium repens* Huja" , 12 .5% *T . pratense* Start" , 12 .5% *Lotus corniculatus* S . Gabriele" . Contemporarily , a native *Solanum tuberosum* was planted in T2 at the dose of 1 t/ha tubers , and a native *Triticum dicoccum* was sown in T3 at the dose of 100 kg/ha . After one year crop (potato or cereal) the two plots (T2 and T3) were sown with pasture mixture (the same of T1) in March 2005 .

Measurements done were the following : Crop and forge yield (sampling areas of 5 m in 2005) . Costs and theoretical incomes (investigation in local markets in 2005) . Pasture botanical composition (linear analysis in 2007) .

Results and discussion Crop and forage yield in 2005 were good (4 ,8 t ha^{-1} forage hay , 10 .0 t potato , 2 .4 cereal) .
Costs and gains (Table 1) . The most convenient strategy for pasture rehabilitation in the area was one year potato cropping followed by pasture sowing (gain of 5370 € per hectare) however establishment costs were the highest of the 3 treatments . The cereal gave only 840 € per hectare , however this system gives some gain already at the first year with limited costs slightly higher than direct pasture sowing . Direct pasture establishment is not convenient for the first 1-2 years (balance − 312 € per hectare) as it takes time before the pasture can be grazed and some livestock sold .

Table 1 *Comparison of costs and gains .*

	T1(€/ha)	T2(€/ha)	T3(€/ha)
Costs	840 .00	1630 .00	980 .00
Gains	528 .00	7000 .00	1820 .00
Balance	-312 .00	5370 .00	840 .00

The specific contribution of the sown species in 2007 was better were the pasture sowing was preceded by one year crop (45 . 14% with potato , 39 .68% with the cereal) than were pasture was sown directly (22 .31%) , probably the new cultivation after harvesting has destroyed more weeds .

Conclusions There is economic convenience for pasture rehabilitation in mountains of Central Italy , moreover there are environmental benefits . Higher incomes and better botanic composition suggest that encroached pastures are sown better after one year cropping phase than with direct pasture sowing .
Finally , an overall return for the economy of the area is possible by pasture rehabilitation thanks to links with naturalistic tourism .

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A strategy to select and implement restoration projects in the Great Basin desert

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Keywords: Great Basin, restoration, soil survey, ecological site

Introduction The Great Basin is North America's largest desert, encompassing nearly 55 million ha of land between the Rocky and Sierra Nevada Mountains in western North America. The US Department of the Interior, Bureau of Land Management (BLM) is the largest land holder in this desert and is responsible for managing 30 million ha of rangelands. BLM initiated the Great Basin Restoration Initiative in 1999 to maintain healthy shrublands and to restore degraded lands infested with invasive species that were promoting wildfire expansion. Currently, funds for restoration are limited, stimulating the need for a land, potential-based strategy to prioritize restoration treatments.

Materials and methods A pilot study was initiated in 2005 on 4 million ha in the Owyhee Uplands area where the states of Idaho, Oregon and Nevada join to develop assessment tools that could be used to develop a strategy to prioritize restoration treatments. The basis for determining the potential plant communities are USDA soil surveys (Third Order Soil Survey) and the ecological sites associated with mapped soils (Figure 1). Current plant communities are mapped using remote sensing, image analysis software, and ground data (Figure 2). Comparing the potential plant communities on a landscape with the current plant communities allows managers to identify potential treatment areas to restore desired native plant communities. In this example, encroachment of Western Juniper (*Juniperus occidentalis*), a native conifer tree, is replacing big sagebrush (*Artemisia tridentata*) and associated herbaceous species due primarily to fire exclusion.

Figure 1 *Soil mapping unit (dark gray) with sagebrush potential and 15% historic juniper woodland inclusions.*

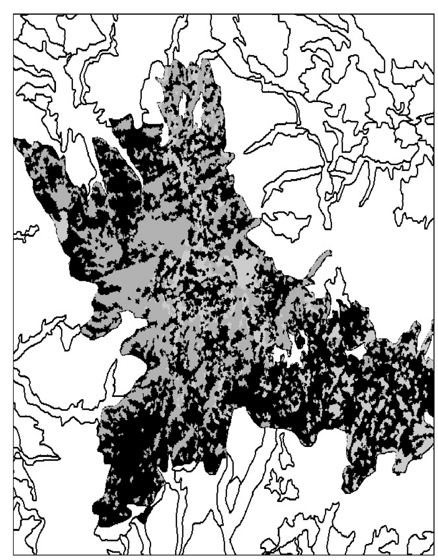

Figure 2 *Existing plant communities showing historic juniper communities in black, juniper encroachment in dark gray, and sagebrush in light gray.*

Results Managers would like to reduce juniper encroachment and restore native sagebrush/herbaceous species while maintaining the historic juniper woodlands. This approach classifies the western juniper encroachment areas suitable for treatment and the historic juniper woodlands where treatments should be avoided. Treatments to reduce juniper encroachment include prescribed fire, mechanical cutting, and herbicides. This landscape scale approach provides information for the strategic prioritization and selection of treatment areas after considering additional resource and economic criteria.

Conclusions Large landscapes can be evaluated for departure from the potential plant community by comparing edaphic/climate-based soil surveys and their associated ecological sites with existing plant communities derived from remote sensing data. Land treatments to restore desired plant communities can be focused on areas with the greatest ecological benefits and potential for success.

Assessment of plant biodiversity in the over grazed marginal lands of Kovilpatti

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Key words : thatching grass-*Ophiuros exaltatus* , *Prosopis juliflora* , biodiversity , goat grazing

Introduction The study area is located in the outskirts of Kovilpatti (9° N 78°E) , Thoothukudi district , Tamilnadu , India and many farmers have abandoned their semi arid marginal dry lands due to drought , marginal yield and the change in their life style . The abandoned marginal lands were utilized for goat grazing and herbal collection . The conservation of plant biodiversity is uncertain in the marginal lands by over grazing , and human activities .

Materials and methods Two study areas were selected . Both the study sites were adjacent to each other with similar soil and environmental condition . Site A (90 ha) which was abandoned since 2004 . Site B (110 ha) was abandoned since 2001 . About 10 numbers of permanent quadrates (4 meter wide and 25 meters long) were marked randomly in each study sites during December 2006 . The rainfall falling was observed above the annual median during the months of October and November . The highest number of species was noted during November , December and January . The frequency density of plant species in the quadrates was analyzed . The data obtained during December 2006 was taken for this study .

Results and discussion The study assessed the impacts raised by the over grazing of goats and human activity on the plant biodiversity . Some 34 species of plants were identified in the study areas (Table 1) .

Table 1 *shows the species density in the study area (* unpalatable species) (** Medicinal plants)*

Plant species	Density		Plant species	Density		Plant species	Density	
	Site A	Site B		Site A	Site B		Site A	Site B
*Abutilon indicum***	20 5	12 7	*Gloriosa superba***	0 1	0	*Scilla hyacinthiana*	0 2	0
*Aerva lantana***	5 5	1 2	*Hibiscus micranthus*	20 5	9 7	*Tragia canabina***	0 1	0
*Anesomeles indica***	0 2	0 2	*Indigofera tinctoria*	0 2	0	*Trichodesma indicum***	0 1	0
Aristida depressa	17 9	18 4	*Jatropa gossipifolia*	0 5	0 2	*Triumfetta rhomboidea*	24 2	11 6
Barlaria cuspidata	0 2	0 2	*Leucas aspera***	0 5	0	*Vicoa indica*	0	0
Biophytum sensitivum	1	0	*Melotheria species*	0 1	0	*Shrubs*		
Caraluma pauciflora	0 1	0	*Mullugo nudicaulis*	0 3	0	*Acacia arabica*	3	2
*Cissus qudrangularis***	0 1	0 1	*Ocimum sanctum***	1 2	0	*Cassia auriculata*	1	0 2
Cleome monophylla	0 7	0 2	*Percularia daemea*	0 1	0	*Morinda tinctoria*	1	1 9
Cleome viscosa	1 2	0 7	*Phyllanthus nirurii***	0 1	0	*Prosopis juliflora**	1	7
*Enicostema species***	1 2	0	*P . maderaspatensis*	0 1	0 1	*Zizypus species*	0 4	0 3
Evolvulus alsinoides	0 1	0 1	*Ophiuros exaltatus**	9 6	28 5			

In site A , the tree species— *Acacia arabica* , and herbs like *Triumfetta rhomboidea* and *Hibiscus micranthus* were dominant than the other species . The thatching grass *Ophiuros exaltatus* and *Prosopis juliflora* showed emergence in the site A along with other dominant species . *Acacia arabica* and *Hibiscus micranthus* showed a decrement in distribution in site B . Thatching grass—*Ophiuros exaltatus* , herb—*Triumfetta rhomboidea* and the hedge bush-*Prosopis juliflora* were dominant and other species were scanty in the site B . The goats are capable of penetrating the thickets of the study site and able to forage 95% of plant species in the sites . Palatable species are lesser in density in site B than A . The establishment of unpalatable plant species was evident in site B . The loss of biodiversity and the lost plant species has not been recognized immediately (Abel et al . 1998) . The dominant grass *Ophiuros exaltatus* was unpalatable and avoided by goats . The sticky seeds of *Triumfetta rhomboidea* were dispersed elsewhere by sticking through goat's body . Prosopis seed pods were consumed by goats and seeds are dispersed through guano pellets of the goats . Understanding the biodiversity of plant communities is essential to sound land management (Burrows 1998) . Regulated goat grazing and herbal collection may help the biodiversity management of marginal lands . Further studies are continued .

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Soil compaction by slurry injection and the effect on soil quality

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Key words: grassland, soil compaction, slurry injection, soil physical, soil biological

Introduction In (organic) dairy farming, fertilization of grassland with manures, such as slurry, is important to maintain yield level and soil quality. Slurry is mainly applied by shallow injection (4 cm) into grassland. During injection, trafficking may adversely affect soil structure by compaction. This risk is largest in early spring, when the soil is relatively wet. Soil compaction can result in deterioration of physical and biological soil characteristics. The objective of this experiment was to quantify the effect of soil trafficking in early spring on physical and biological soil parameters.

Materials and methods The experiment was carried out on a sandy soil with a 10-year old permanent grass-clover sward (*Lolium perenne* and *Trifolium repens*). The experimental design consisted of four treatments in five replications: with and without trafficking, and with and without slurry application. On the 14 th of March 2005, treatments were established with a 25 Mg weighing tractor pulled sod-injector. On the 18 th of March and the 9 th of May 2005, soil samples were collected on the unfertilized treatments to determine physical and biological characteristics. Soil physical characteristics were bulk density (0-30 cm, undisturbed ring samples of 5 cm high), penetration resistance (0-50 cm, penetrologger), soil structure (0-20 cm, visual score), number of roots and macropores (at 10 and 20 cm depth, visual score). Soil biological analysis were number, biomass and development stage of earthworms (0-20 cm), number and species distribution of nematodes (0-10 cm), and bacterial and fungal biomass (0-10 cm).

Results After the single pass with the sod-injector, tracks were clearly visible. However, the single pass with the tractor pulled sod-injector had no effect on bulk density, soil moisture content, visible soil structure, number of roots and macropores, number and development stage of earthworms, number and species distribution of nematodes, and bacterial or fungal biomass (see Table 1). Specific for nematodes, Bouman and Arts (2000) found a shift in tropic groups of nematodes when the soil was compacted frequently for five years. Soil penetrability in the upper 50 cm was always lower in the tracks, but only significantly lower in the soil layers 0-10, 10-20 and 40-50 cm. The cell volume of bacteria in the tracks had significantly increased. This could point to lower predation by protozoa and nematodes in the soil food web. Nine weeks after the single pass of the tractor, the biomass of earthworms seemed to have decreased ($P=0.09$). Aritajat et al. (1977) found no effect on earthworms after trafficking the soil once. However, after ten passes, the number of earthworms was significantly reduced.

Table 1 *Selection of soil parameters measured in soil with and without trafficking.*

	Penetration resistance (MPa), 18th of March					Earthworm biomass ($g\ m^{-2}$)		Cell volume bacteria (μm^{-3} per cel)
	0-10cm	10-20cm	20-30cm	30-40cm	40-50cm	18th of March	9th of May	18th of March
Without trafficking	1.15[a]	1.41[a]	1.68	2.40	2.73[a]	84	131	0.40[b]
With trafficking	1.02[b]	1.21[b]	1.59	1.89	2.35[b]	90	78	0.50[a]

Values indicated by the same letter within a column are not statistically different at the 5% error level.

Conclusions A single pass of a heavy tractor-pulled sod-injector had only small effects on physical and biological soil characteristics. However, frequent trafficking leads to significant changes in physical and biological soil characteristics.

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The choice and siting of natural vegetation in reclamation of disturbed land

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Key words : Reclamation , vegetation types and composition , habitat identification , emplacement

Introduction It is often desirable , or required by law , to reclaim disturbed land with natural vegetation . In the steppes of the world this involves large areas disturbed by cropping , marginal cropping (CRP) , road building , and mining . For example , in Montana's 365 thousand square kilometers of steppe--environmentally comparable to adjacent states and Mongolia--these disturbances are currently 14% , 0 .6% , 0 .6% and 0 .01% respectively and with energy development un-paved roads and mine/gas sites are increasing .

We suggest that the best natural reclamation targets are the communities that occupied the site before its disturbance . And that these communities will establish best if they are seeded into landscape units ecologically equivalent to those they occupied before disturbance . Methods for application are tested .

Methods Our data base came from points surveyed by the Absaloka mine , Hardin MT as one requirement for acquiring coal mining permits . At each of 840 pre-disturbance sites , plant species were listed (with estimates of their percent cover) and presumptive landscape factors/variables were measured , i .e . topography (egg bottom , slope , ridge) , configuration (convex , straight , concave) , slope and aspect , and soil (clay and rock%) .

Target vegetation types were identified with three tools : ordination (to relate all samples one-to-another) , classification (to provide a hierarchical grouping of samples) and pruning analysis (to determine an optimal number of types) .

The correlation of each of the eight pre-mine vegetation types with landscape factors was calculated/ presented by three methods . The vegetation types were logistic regressed against landscape factors . The vegetation types were CART regressed against landscape factors . And after identification of the primary factors , the presentations were simplified by plotting calculated occurrence on axes in a space defined by those factors , i .e . by plotting actual observations , probability of presence (logistic regressions) , and most likely community (CART) .

Results and conclusions Ordination , classification , and objective pruning objectively identified eight pre-disturbance natural communities appropriate for the mine's post-disturbance landscape . The best sub-optimal alternative community numbers were five and sixteen . A summary releve table characterized and compared the communities by listing all the species present , their constancies (% of stands in a type in which the species appeared) , and their percent ground cover . We suggest that that seed mixes should contain most of the high to moderate constancy species , no exotics , and in amounts consistent with reestablishing the original cover levels .

Siting by logistic regressions , CART regressions , and graphical models was compared . CART carpets a site with the single most probable [best'] community for each landscape facet . The logistic regressions provide a basis for calculating the probability that any vegetation type will occupy any facet of the site . Thus they offer more flexibility to engineers by presenting alternatives which may be nearly as likely to establish and perhaps more satisfying with respect to other criteria including aesthetics , rarity of species , and forage quality . We also favor the logistic models because they have more regional generality , i .e . because they can be more validly extrapolated to areas with slightly different climate and soils . After the identification of primary controls (correlates) it is desirable to simplify application of the regressions by use of graphical models .

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Study on wind-sand defending mechanism of single shrub

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Key words : single shrub , wind velocity , sand-transporting quantity , mechanism , wind-sand flow

Introduction Sand-fixing grass belt is an important part of Wind Erosion Protective System (Dong Zhi , 2004) . By studying the wind velocity and sand-transporting quantity around single shrub in this area , wind-sand defending mechanism was analyzed in order to provide a theoretical foundation for the building of sand-fixing grass belt .

Materials and methods In the sand-fixing grass belt , using PC-2F multichannel Anemometer and Sand Collectors , wind velocity and sand-transporting quantity around single shrub were observed . The Observation height was decided based on the height of shrub . The wind velocity recording time was one time for one minute , 60 minutes for one experiment . At the same time , sand (0～20cm from ground) was collected every 3 minutes . Then sand was weighed by 1/1000g electron balance , and the sand-transporting quantity was calculated .

Results On the windward side of the shrub , airflow was blocked and wind speed declined , when arriving the top and the side of shrub , it accelerated . On the leeward side , wind velocity was declined on different degree , away from shrub , wind velocity start increase and renew to original velocity . For the shrub with closed structure , wind velocity declined quickly and renew quickly . For porous structure , wind velocity declined most and renew slowly . For ventilation structure , wind velocity declined least (Figure 1) . In addition , on the leeward side , Sand transporting quantity is the least , while , on the other two sides , it is the most , which is the same with the change of wind velocity . Therefore , on the windward and leeward side , sand was accumulated , but on the other two sides , there is a wind erosion area . However , wind direction usually changed with season , which will result in sand sediment around every side of the shrub and form the shrub-sand pile (Figure 2) .

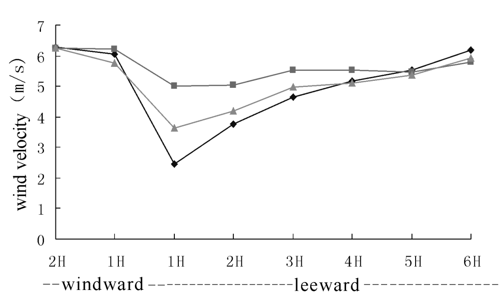

Figure 1 *wind velocity around the shrub .*

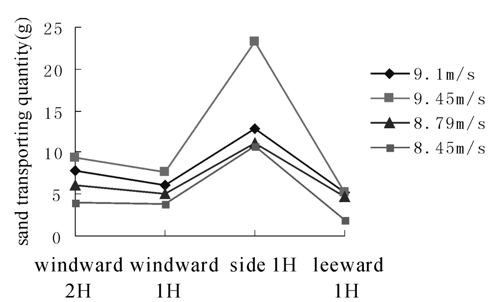

Figure 2 *Sand transporting Quantity around the shrub .*

Conclusions Shrub , higher than ground , is a holdback of airflow movement , when the airflow go though it , velocity will declined on the windward and leeward side , which is the main factor of wind-sand flow cumulating , and is also the mechanism of sand fixing of shrub . Based on the above experiment , shrub with porous structure has the best wind-sand defending effect .

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Design of Leylus-chinensis grassland root-cutter

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Key words : degenerated glassland ,Leylus-chinensis ,soil hare layer , root-cutter ,the curve of blade

Introduction Eliminating the soil subsurface hard layer and cutting off the transverse roots of Leylus-chinensis to promote its propagation and self-reproduction by a mechanical method is a way to improve degenerated Leylus-chinensis glassland (Yan Zhijian ,2002) . Shallow ploughing can loosen the soil and promote root system reproduction (Burgess , C .P ,2000) .In order to serve the above purpose the gap disc harrow is usually used , the rotary cultivator , the no-wal-coulter and so on . However , these tools may cause soil wind erosion or water erosion , and destroy the pasture vegetation . Therefore , designing a new root-cutter , which can shut off Leylus-chinensis root with little destruction to vegetation and soil ,is necessary .

Methodology As Figure .1 shows , the root-cutter designed is composed of the blades and the cutter head base which were built in the axletree by symmetrical keyways and driven revolving at high speed by lat key transmission load , to complete the cutting root process . Every blade is fixed in the cutter head singly , so it is replaced easily if broken ,6 ～12 blades could be built in the cutter according to the pasture situation .The cutting edge curve is a section of the concentric circle , which satisfies the sliding-cutting performance (Gupta , J . p , Pandey . K . P , 1996) . The cutter radius of gyration is 350mm , its head base radius is 150mm ,and the . When used in the experimental plot ,it`s approaching speed was 1 .2～1 .5m/s , and the rotational speed was 500r/min .

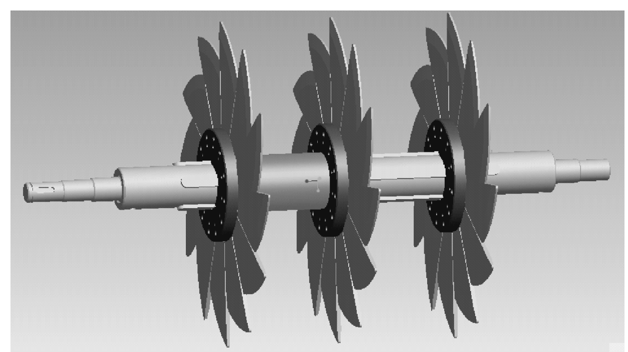

Figure 1 *Sketch chart of root-cutter .*

Results and discussions Experimental plots were placed in *selected Leylus-chinensis degraded grassland in The Hebei Guyuan Grassland Ecosystem observation research station . The root-cutting rate (the roots*`s proportion which were cut off) and the width of slot on the soil surface were increased when the cut root depth changed from 150mm to 200mm , Even if the depth is only then 150mm , the rate also achieved above 90% , and the width is only between 10～15mm . After cutting work had finished , the pasture plot looked like that in fig .2 . Compared with other soil cultivation conditions ,the cutter had broken the soil hard layer ,but it did not turnor plow the soil , . It created a slot which is a litter thicker than the thickness of the blade . The cutter had cut off most of roots ,but it did not destroy native vegetation , and there were fewer roots which had been drawn out of the soil .t he use of this cutter could protect the soil against wind erosion or water erosion , and improve the soil structure to a certain extent , but it cannot change soil conditions like a loosening tiller .

Figure 2 *cutted Root and slot in soil .*

Conclusions Ddesigned a kind of rotaty root-cutter which was used to breaking soil hard layer and cutting off Leylus-chinensis roots to promote its develop , in this way ,the eteriorated grassland could be improved .The cutter could shut off Leylus-chinensis roots completely ,however make a small destruction to the pasture soil and vegetation .

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Distributed overgrazing : a key cause of grassland degradation in Inner Mongolia

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Key words : degradation , overgrazing , distribution , Household Production Responsibility System , Inner Mongolia

Introduction The common perception that overgrazing is the main reason for grassland degradation in China , is based on a simple formulaic statement that total livestock population exceeds the carrying capacity of grassland (SEPA , 2001) . However , the actual distribution of livestock has been consistently overlooked .

Materials and methods Our case study site of Baiyintala Village (*Gacha*) , is located in the low-yielding desert grasslands of northwestern Xilingol Prefecture , Inner Mongolia . Interviews were conducted with 28 herders , or one third households in this village , covering topics such as grassland utilization , availability of water resources and methods to combat drought .

Results Whereas quantitative overgrazing , simply emphasizes that total livestock numbers exceed grassland carrying capacity on a large spatial-temporal scale (e .g . at the province or country , or for one year or longer) regardless of how these livestock are actually distributed within the grassland , distributed overgrazing describes overgrazing where the livestock population exceeds grassland carrying capacity at a smaller spatial-temporal scale (e .g . a natural village or *hot* , or for one season or longer) and results from change in abiotic factors , such as precipitation or the system of sedentary animal husbandry linked to Household Production Responsibility System (HPRS) . There are five factors leading to distributed overgrazing : (a) an uneven livestock distribution among different households' grassland under HPRS (Figure 1) ; (b) increased impact of livestock resulting in trampling caused by shortage of drinking water and grassland (the red line replaces the green line under HPRS in Figure 2) ; (c) imbalanced grassland use caused by a simple livestock structure ; (d) over-trampling on fixed routes for water on every herder's grassland ; and (d) overuse in drought when livestock cannot be moved under HPRS constraints .

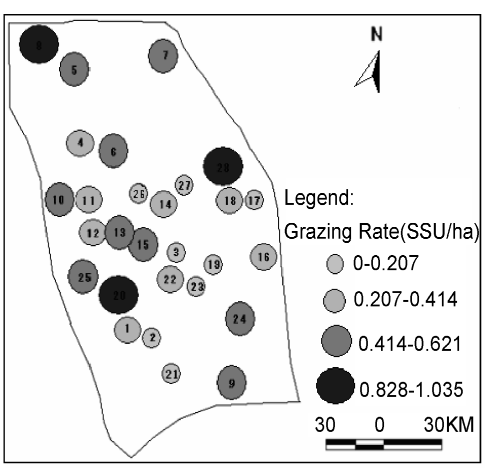

Figure 1 *Livestock distribution of 28 sampled herders' households in Baiyintala in 2006 .*

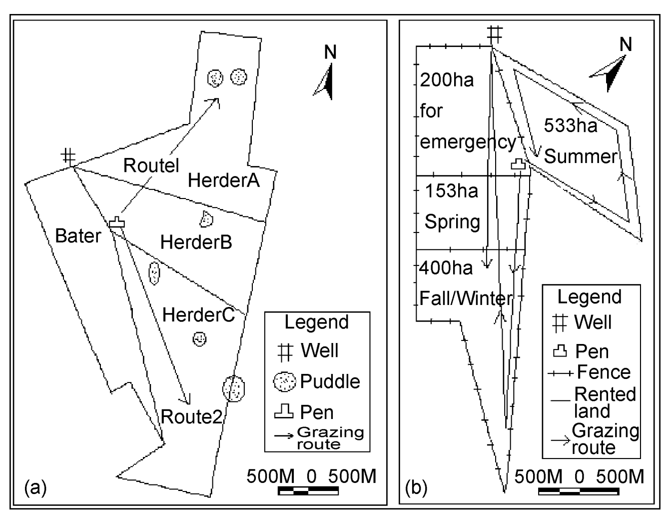

Figure 2 *Multiplied grazing routes caused by HPRS implementation .*
Note : (a) is hot before HPRS and (b) is Bater's grassland use under HPRS .

Conclusions Investigation of grassland use in the case study site indicates distributed overgrazing needs to be added to the current explanation for grassland degradation which merely emphasizes total livestock population . The change in livestock distribution under the HPRS has played an important role in grassland degradation .

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Seedling recruitment in steppe communities

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Key words : seedling ; density ; seasonal dynamics ; vegetative recruitment ; steppe communities

Introduction Seedlings are central to population maintenance , community structure and succession . The conditions of seedling growth can play an important role in local-scale species richness and productivity (Zeiter et al ., 2006) . Relatively few studies have addressed seedling-recruitment in semiarid grassland ecosystems of Inner Mongolia . The dynamics of seedling recruitment after different types of disturbance is unclear for many species in this region . The aim of the present study was to evaluate the seasonal dynamics of seedlings in typical steppe communities .

Materials and methods Three perennial graminoid species from the steppe community of Inner Mongolia were selected for population and seedling studies . The experimental site was located in an area of flat terrain in the southern part of Duolun County , Inner Mongolia . Treatment included mowing and grazing . This experiment was started in Mid-May , and extended to early October . To facilitate seedling monitoring , eight 25cm 25cm quadrates were sampled in each of 5 replicated subplots .

Result and discussions Seedling densities of all species showed an increasing trend during the growth period . Seasonal seedling dynamics of S . krylovii was similar to that of the Gramineae , which account for majority of the seedlings .

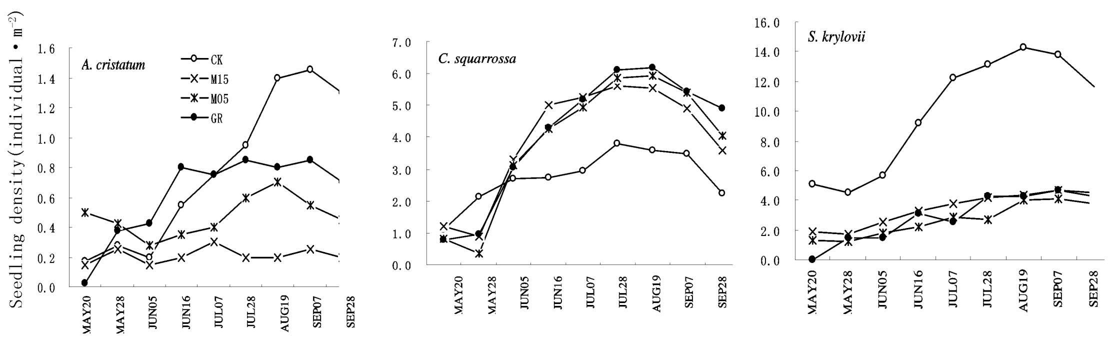

Figure *Seasonal dynamics of seedling dendity .*

In a comparison of all three species , the pattern of relative seedling density was S . krylovii > C . squarrossa > A .cristatum ($P < 0.05$) under control conditions , but under both grazing and mowing treatments the rank order was C . squarrossa > S . krylovii > A . cristatum ($P < 0.05$) . Mowing disturbance results in a reduction of reproductive parts , especially for late-flowering plants . This land use practice , therefore , can induce seed limitations for a species normally producing a sufficient amount of seeds (Overbeck et al ., 2003) . The species in this experiment , however , all had later reproductive phenology . The tall-growing species- S . krylovii lost a larger proportion of biomass than the smaller plants when mowed .

Conclusions From the standpoint of seedling density , S . krylovii accounted for the majority of all seedlings present in the study plots . It's trend of seedling recruitment , however , was similar to that of the other species . In this typical steppe community , seedlings , especially of the dominant species , played a vital role in population recruitment .

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The cause of grassland desertification and its managing strategies in Inner Mongolia , P .R . China (Session :A6)

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Key words : Grassland desertification , Human activities , Managing strategies , Inner Mongolia

Introduction Over 35% of pasture land has degraded or desertified in Inner Mongolia in the past 50 years (Erdenijab , 1996) and the degrading rate is much faster (~12%) in some area such as Qigen Gacha , Ongnuud Banner , and Inner Mongolia in recent years . The cause of grassland degradation and desertification was investigated and analyzed in the paper .

Materials and methods We surveyed changes of human population , livestock number , pastureland , living style , etc . in Inner Mongolia and specifically in Qigen Gacha , Ongnuud Banner Inner Mongolia , China . Data was recorded and analyzed . The satellite images of Horqin desert of Inner Mongolia were obtained by China Remote-Sensing Satellite Ground Station on 11 August 1987 and 24 July 2004 with 30m spatial resolution .

Results A case study in Qigen Gacha , Ongnuud Banner , Inner Mongolia showed that human population , livestock number , open land for cultivation increased , and the usable grassland decrease over time (Table 1) . It is the case in whole Inner Mongolia , China . Human population in Inner Mongolia increased dramatically from 2 million in 1947 to 24 million in 2004 (Table 1) . With the increasing human population in the region , open land for cultivation increased about 800 times in 1995 compared to that in 1957 in Inner Mongolia [Table 2 ; Erdenijab (1996) & Heilig (1997)] . Due to grassland desertification , fresh water including lakes and rivers are disappearing (Figure 1) .

Table 1 *Changes of Population , Livestock , and Grassland in Qigen Gacha , Ongnuud Banner in Inner Mongolia over time .*

Year	Population	Livestock	Grassland (*mu*)	Open Land (*mu*)
1947	220(2M)*	1040	100 ,000	0
1980	585	5100	85 ,000	3000
2004	800(24M)*	9700	60 ,400	15000

* Number in braokets represent human population in Inner Mongolia ; M :million

Table 2 *Open land for cultivation in Inner Mongolia over time[From Erdenijab(1996) & Heilig(1997)] .*

Year	1957	1961	1976	1985	1995
Open land 1000 ha	10	500	920	6834	7612

Conclusion We conclude that grassland degradation in Inner Mongolia is caused by human activities including : 1 . A large increase in human population ; 2 . Opening land and cultivation ; 3 . Cutting trees and grasses for fuel (Data not shown) ; 4 . Increase in livestock number (10% in Qigen Gacha , Inner Mongolia by 2004) ; 5 . Changing the herding style (from nomadic to semi-nomadic to settled , without rotation) ; 6 . Rodent and insect infestation (Data not shown) . Based on these causes and comparison to the grassland management strategies in the USA , we believe that recovering the plant diversity and reforestation in the deserted area is the only way to control grassland desertification and prevent further grassland degradation in the area . It is obvious that controlling the situation is a long-term battle requiring a comprehensive effort . This will require establishing a world-wide net-work and getting more international support for controlling the environmental disaster" in Inner Mongolia , P . R . China .

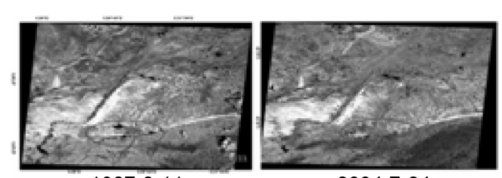

Figure 1 *Satellite images of grassland desertification in Horqin , Inner Mongolia for 18 years .*

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Effects of slope and defoliation intensity on the effectiveness of desert wheatgrass for reduced runoff and soil erosion under simulated rainfall

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Key words: runoff, sediment, desert wheatgrass, defoliation, sloping lands

Introduction In order to protect reservoir from non-point source pollution, one of the best management practices is to restore the sloping farmlands to grasslands in the areas surrounding the reservoir. Desert wheatgrass (*Agropyron desertotrum* (Fisch.) Schult.) is notable for its drought resistance and strong ability to stabilize soils and reduce erosion due to the deep penetration of root system and easy establishment. The objective of this study was to evaluate the effects of slope and defoliation intensity on the effectiveness of desert wheatgrass for runoff and sediment reduction.

Materials and methods The experiment was a split-plot with a randomized complete block design. Slope 30% vs. 15% were the two main plots and ground cover types (bare ground, desert wheatgrass defoliated at 6 cm stubble height, and desert wheatgrass defoliated at 12 cm stubble height) as the subplots (1.5 m wide by 4.6 m long) in each block with 3 replicates. The desert wheatgrass was established in the fall of 2005 and defoliated whenever it entered the heading period in 2006 and 2007 and the accumulated forage yield was summarized. In 2006 (the desert wheatgrass got full growth from last defoliation) and in 2007 (the desert wheatgrass was just harvested), two separate simulated rainfalls at a rate of 55 mm h^{-1} for 20 min were applied to the plots on consecutive date; the former represented dry soil condition (Dry Run) and the latter represented wet soil condition (Wet Run). Data were analyzed using SAS 8.02 PROC ANOVA procedure.

Results No significant effect of stubble height was detected on the accumulated forage yield, but 15% slop produced more than 30% slope (data not shown). In the simulated rainfall experiments, 30% slope produced higher runoff and sediment than 15% slope in Dry Run in 2006 and only higher sediment in Wet Run in 2006 and Dry Run in 2007 (Table 1). Plot of 12 cm stubble defoliation produced significantly lower runoff than plot of 6cm stubble defoliation and bareground and least sediment, although the difference was not significant vs. 6cm stubble defoliation plot.

Table 1 *Effects of slope and ground cover type on the runoff and sediment loss in dry run and wet run in 2006 & 2007.*

		2006				2007			
		Dry run		Wet run		Dry run		Wet run	
		Runoff	Sediment	Runoff	Sediment	Runoff	Sediment	Runoff	Sediment
		mm	Mg ha^{-1}	mm	Mg ha^{-1}	mm	Mg ha^{-1}	mm	Mg ha^{-1}
Slope	15%	1.44^{b}	0.65^{b}	3.65^{a}	1.68^{b}	2.63^{a}	1.16^{b}	7.36^{a}	3.47^{a}
	30%	2.09^{a}	2.03^{a}	4.63^{a}	3.63^{a}	3.16^{a}	2.82^{a}	7.52^{a}	4.49^{a}
Cover type	Bare	1.86^{a}	3.67^{a}	5.35^{a}	6.69^{a}	3.67^{a}	5.06^{a}	9.45^{a}	10.56^{a}
	6cm	2.08^{a}	0.23^{b}	4.66^{a}	0.44^{b}	3.01^{ab}	0.56^{b}	7.36^{b}	0.86^{b}
	12cm	1.35^{b}	0.12^{b}	2.42^{b}	0.23^{b}	2.00^{b}	0.35^{b}	5.51^{c}	0.53^{b}

Note: means with different letters in same column within group of slope or cover type are significantly different at 0.05 level.

Conclusions When using desert wheatgrass as vegetative materials for restoration of sloping lands, 12 cm-stubble defoliation could be a reliable management practice for its good performance in both soil and water conservation and forage production.

Acknowledgements This study was funded by the New Star Projects of Beijing Municipal Sci. & Tech. Commission.

Restoring the biodiversity of the Roggeveld-Renosterveld: evaluation, multiplication and establishment of indigenous plant species on old agricultural fields

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Key words: restoration, old agricultural fields, biodiversity, indigenous species

Introduction The Hantam-Roggeveld in the Northern Cape Province of South Africa, which stretches over 300 km^2 was identified by Succulent Karoo Ecosystem Programme (SKEP) as a priority area for conservation. Priorities include multiplication of seed indigenous to the Roggeveld to improve and restore biodiversity. The botanical biodiversity of the area has in the past been negatively impacted by crop production resulting in huge areas which now lay fallow and exposed to erosion due to poor vegetation cover. The objectives of this project are to increase our understanding and knowledge of six key plant species found in the Roggeveld and their use in rangeland restoration, as well as to create awareness among the local farmers on the necessity to actively restore and manage old agricultural fields. Wild rye (*Secale africanum*) is a very palatable forage plant and endemic to the Hantam-Roggeveld. It has become critically endangered due to poor livestock management practices. It now occurs in very small populations on only two farms within the area and is the flagship species for this project.

Materials and methods Farms representing three different areas in the Tanqua-Roggeveld area where wild rye grass was common in earlier years, namely the Hantam, Roggeveld and Klein-Roggeveld, were selected as study sites. Seed of six key species *Secale africanum* (grass), *Eriocephalus africanus* (dwarf shrub), *Felicia filifolia* (dwarf shrub), *Ehrharta calycina* (grass), *Chaetobromus dregeanus* (grass) and *Polhillia involucratum* (dwarf shrub) underwent germination trials to determine viability and potential for restoration projects. Survival of these species was tested on old agricultural fields with a spilt-plot design with three block replications. The treatments are broadcasting of seeds, planting of seeds and the use of plugs.

Results and discussion *Not yet available*

Conclusions Preliminary results from the six-monthly counts on *Secale africanum* have indicated that seeding on ripped old fields is the most successful and cost effective way of re-introducing this species.

Influence of exclosure year on community structure and species diversity on typical steppe

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Key words: typical steppe, seasonal exclosure, community structure, species diversity

Introduction Exclosure is the most common method for the restoration of degraded grassland, but in China complete exclosure of livestock from grassland is often difficult because of the poor economic status of pastoral areas. One of the measures to resolve conflict is seasonal exclosure (Katoh, 1998). In this study, we investigated the influence of years of seasonal exclosure on typical steppe grassland to provide guidance for grassland management.

Materials and methods The study was done in Taipusi banner on typical steppe, Inner Mongolian Plateau (41°35′ to 42°10′ N, 114°51′ to 115°49′ E), a semi-arid continent climate, average annual precipitation 407 mm, average temperature 1.6℃ and chestnut soil. Four previously severely degraded ecological sites, based on historical documents and investigation, were chosen, where different exclosure periods applied (0, 5, 14 and 25 years of summer exclosure for hay cuts). A field survey done in August 2007 (10-20, 0.5m×0.5m, random quadrats per site) recorded all species in each quadrat, measuring total coverage and the height, coverage, density and yield of each species. Richness, evenness and diversity indices were calculated.

Results With increased periods of exclosure, coverage reached a maximum after year 14, the year that density reached a maximum, though density then declined. Community yield and height continued to increase up to year 25 (Figure 1). Plant species diversity (Margalef index Ma, Shannon-Weaver index H) initially increased then remained relatively constant after year 5. The transformation tendency of evenness (Pielou index, Epi) showed little change. The community changed from *Potentilla acaulis*+*Artemisia frigida*+*Stipa krylovii* to *Leymus chinensis*+*Cleistogenes squarrosa*+*Serratula centauroides*.

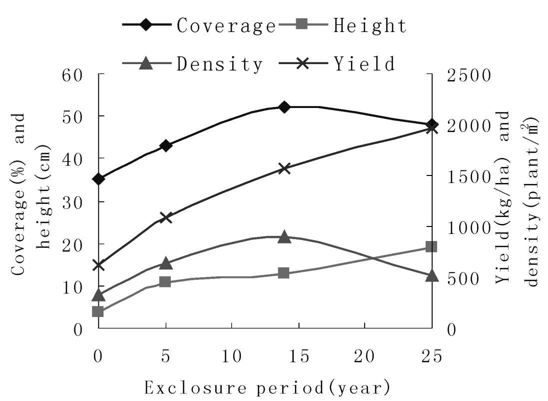

Figure 1 *Community structure and yield in different exclosure period.*

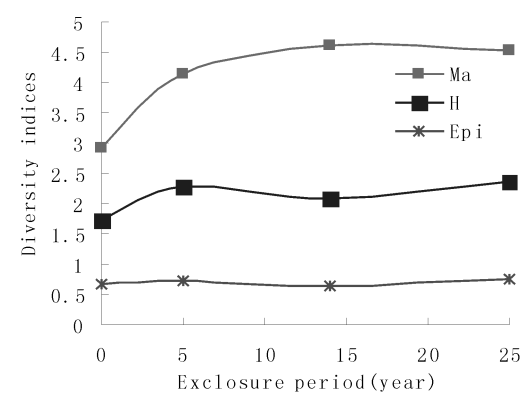

Figure 2 *Diversity index in different exclosure period.*

Conclusion Summer exclosure for hay production then grazing through the rest of the year did enable the grassland to recover to some extent. Fourteen years of seasonal exclosure appears a reasonable compromise, though the decline in density between years 14 and 25 warrants further study and maybe a change in management.

Reference

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Determination of intensity and socio-economic natural resources degradation factors in Iran territory

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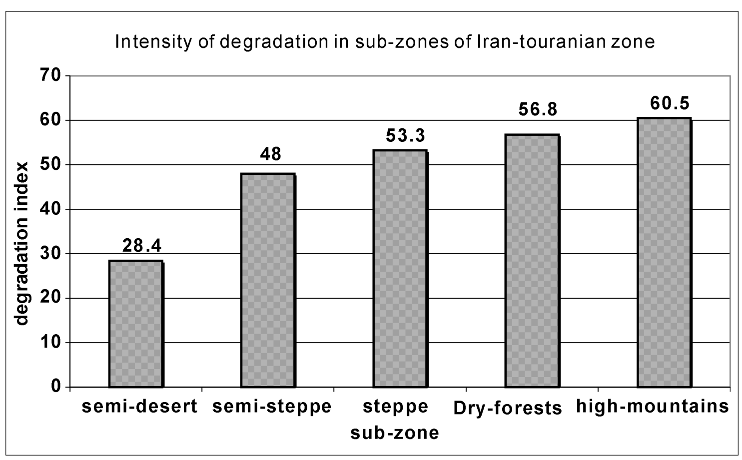
Key words: socio-economic factors-natural resources-degradation-climatic zones

Introduction The most important problem of natural resources of Iran is degradation, in recent decades (N. Ansari *et al*. 2007). The objective of this research was to determine the degradation intensity and socio-economic factors that lead to this situation.

Material and methods In 11 selected provinces, distributed in 3 main zones of Hanry Pabbot's climatic zones of Iran, 131 sample areas were chosen. In these sample areas questionaires were completed and analyzed for 487village and nomad settlements, 1847 families and 504 experts.

Results Degradation intensity showed an increasing trend, from the semi-desert zone toward semi-steppe, steppe, dry forests and high mountains sub zones of Iran-touranian zone.



Moreover, 19 socio-economic factors were the most important and effective factors related to natural resources degradation in Iran. These factors were divided into three groups including animal and animal husbandry, cutting and harvesting and land use changes. Stakeholders suggested animal and animal husbandry accounted for 47.2%, cutting and harvesting 16.9% and land use changing 35.9% natural resource degradation. In contrast, experts suggested 43.3% was due to animals and animal husbandry, 24.3% to cutting and harvesting, and 32.4% to land use changes. Mean of these two sources indicated that the most effective group in natural resources degradation was animal and animal husbandry with 45.9%. Cutting and harvesting group with 33.5% was second and land use changes was third with 20.6% is.

Conclusion The most important factor in natural resources degradation is the animal and animal husbandry group, which includes increases in livestock and herder numbers, premature grazing, over grazing and competition between stakeholders. So, in the natural resources policy making, animal husbandry must be the basis for decision making by the government.

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Restoration of vegetation and soil nutrients on the northern area of Loess Plateau

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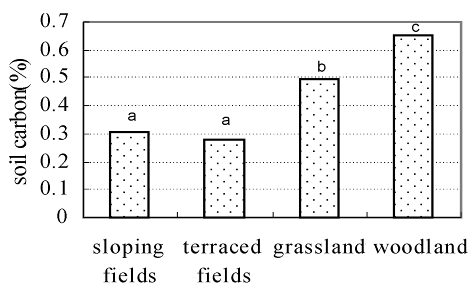
Key words : Restoration of Vegetation ,soil nutrient ,Land-use type ,Loess Plateau

Introduction Severe loss of soil and water quality has occurred on the northern area of the Loess Plateau . Past research showed that 80% of the mud and sand streamed into the Yellow river came from the northern area of the Loess plateau , and most of the mud and sand came from sloping fields (Wei , T .X . 2002) . Since the grain-for-green policy was implemented , not only has the expansion of sloping fields been controlled , but also the restoration of vegetation was facilitated . So far , most research has reported on the effect of returning sloping fields into woodlands and grasslands on water and soil conservation , but little research has been conducted on vegetation restoration and soil nutrients . In this research , Shenmu County in Shanxi province , located in the north of Loess Plateau , was chosen as the survey area . We analyzed the effect of returning sloping fields into woodlands and grasslands on restoration of vegetation and soil nutrients . The research results are expected to supply a scientific basis for ecosystem restoration .

Materials and methods Four land-use types were chosen in the Liu-dao-gou test-site on shenmu , in the summer of 2004 and 2005 . Sixty quadrats of 25 m^2 were set on grassland , and 20 quadrats of 25 m^2 were set on three other land-use types . In the grassland , survey we measured species composition , the coverage and plant height . In the woodland , we measured the tree height , the mean annual growth and the tree diameter . The total soil nitrogen and carbon were measured on four land-use types .



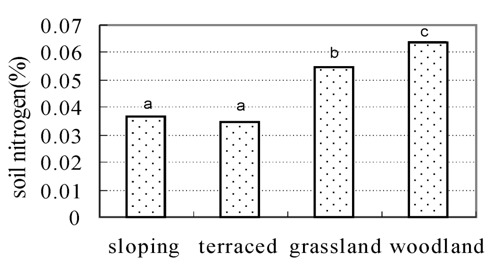


Figure 1 *Change of soil carbon , soil nitrogen among four land-use types(Different alphabet indicates a significant) .*

Results Thirty four species occurred in the grassland area . Among these species , the occurrence frequency of *Stipa bungeana* , *Lespedeza davurica* , *Cleistogenes squarrosa* and *Artemisia scoparia* were more than 80% . The total carbon and nitrogen contents in sloping fields and terraced fields were very low , 0 .3% and 0 .03% , respectively . In grassland , the corresponding contents were 0 .5% and 0 .05% . Whereas the total carbon and nitrogen contents in woodland were highest , 0 .6% and 0 . 06% , respectively (Figure 1) .

Conclusions This survey area a temperate steppe zone , is characterized by vegetation such as *Stipa bungeana* and *Lespedeza davurica* etc . which is favored by a warm environment . The representative vegetation has been restored gradually over 20 years of returning sloping fields into grassland . However , in some areas vegetation degradation occurred . Returning sloping fields into woodland plays a significant role in restoration of soil nutrients . The content of total carbon and nitrogen in woodlands increased two times more than that in a sloping field during 20 years .

Reference

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The preliminary investigation on grassland secondary desertification caused by a dry lake bed — take a Er-shute Lake in Dong Wu Danner as an example

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Key words: dry lake bed, grassland secondary desertification

Introduction Rivers and lakes play very important roles in a grassland eco-system. Many of them are inland rivers and lakes, and the drying and shrinking of a lake can directly influence the eco-system. In this paper, we analyzed the ecological impact of a dry lake to gain insight into the process of grassland secondary desertification

Materials and methods The A Er-xiaote Lake (37°32′N, 105°02′E) is located in Men Dou Communalize which belongs to Dong Wu-zhumuqing Banner in Xi Lin-guole Alliance. The lake is an inland lake typical to semi-arid grasslands. Four areas (the central area of lake (A), lake margin (B), secondary desertification areas (C), the original vegetation area (D)) were measured. The adjacent areas were artificially separated into zones along a transect from the center of the lake to the northwest. Soil samples were collected at three experimental points in every zone. Each sample was divided into three layers (0-10 cm, 10-20 cm, 20-30cm) and brought to the laboratory for analysis.

Results Through analyzing sediment (soil) particle size, we found that the content of particle (particle size > 0.05 mm), increased at first and then deceased from the lake center to the outside, which was in contrast to the distribution of the smaller particles (particle size < 0.001mm). The analysis showed the horizontal distributions of conductivity, salinity, and pH was significantly correlated with conductivity and salinity. The pH declined from the lake center to outside, and it increased with depth in the secondary desertification areas and the border of lake. Sulfate was the main water-soluble salts contained in sediment. SO_4^{2-}, Cl^-, Na^+, K^+, Mg^{2+}, Ca^{2+} concentrations declined from the lake center to the outside, with a low peak in the secondary desertification areas. The concentrations of other ions were not significantly affected.

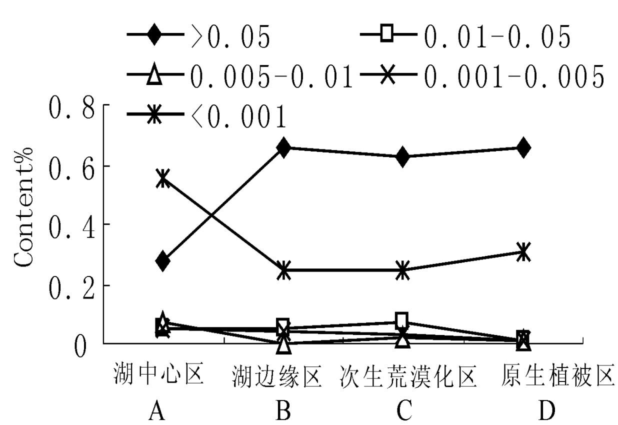

Figure 1 *horizontal distribution of mechanical composition.*

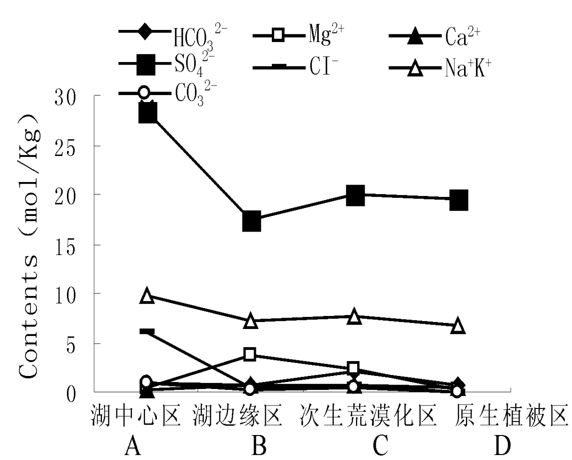

Figure 2 *horizontal distribution of eight ions.*

Conclusions (1) An abundance of sand materials on the lake bed could create sandstorms and bury vegetation and increase desertification on some areas. (2) With the action of small winds, alkali dust devils could form. The alkali leached into the soil with rainwater could be the cause of salinization-alkalization. (3) With the level of wind erosion increasing, the fine sand was blown off and the coarse sand remained on the lake bed, and this could affect the pattern of desertification and change terrain, such as lake bed drop and lake shape. Grassland secondary desertification was accelerated.

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The effects of range enclosure on vegetation composition and density in upland grasslands of Iran

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Introduction Livestock and plants are in a constant interaction at range ecosystems. Overgrazing pressure due to the increment of human population cause a significant reduction in plant growth vigor, reproduction ability and poor establishment of valuable plants which lead to plant composition change and lower density of class I category range plants (Brand and Goetz, 1986, and Warren et al. 1986).

Materials and methods The experiment was conduced in Hanna rangeland in Isfahan province, central par of Iran. The non-grazed range site was closed to grazing for 25 years. The data collection was carried out for two years (2004 and 2005) in the closed and opened range sites. Plant density, vegetation cover, floristic list of plant composition of class I (palatable plant), II (moderate palatable) and III (non palatable) plants were colleted in two dominant vegetation types both in grazed and non-grazed sites by proper number of quadrates (Wayne and Stubbendieck, 1986).

Results and discussions There was a significant difference between the class I plant density in grazed and non-grazed range sites (Table 1). Enclosure of range land enhanced the population and density of class I range plants which was due to providing a better opportunity for reproduction and establishment of those species in non-grazed range sites. In grazed areas the class II range plant had a better opportunity because of grazing pressure to develop and increase their population. In a similar experiment by Warren et al (1986) in range sites grazed by cattle, 13 important range species decreased in density after five years.

Table1 *Vegetation Cover Rate in Non-grazed and Grazed Areas.*

Palatability Class	Vegetation Cover in Non-grazed (%)	Vegetation Cover in Grazed (%)	T- value
I	56.9	21.2**	25.21
II	12	10.8NS	5.76
III	3.4	20.6**	42.1

** Significant difference ($p<0.01$) NS = no significant difference ($p<0.01$)

The result in Table 2 showed that the enclosure was significant enhanced the total biomass cover. The percent of vegetation cover of class I in grazed treatment compared to class III was significantly reduced which could be explained by heavy grazing, soil humus destruction due to water erosion, livestock trampling and lock of seed resources for natural re-vegetation. Passera and Boresta (1996) in their experiment conducted in Argentina concluded that the reproduction of palatable perennial grass plants in plots closed to grazing was much faster them these grazed.

Table 2 *Analysis of variance for Vegetation Cover Rate in on-grazed and Grazed Areas.*

Palatability Class	df	SS	MS	F
Vegetation Cover	1	6903.1	6903.1	78.18**
Error between samples	70	6180.8	88.3	-
Sum	71	13083.9	-	-

** Significant difference ($p<0.01$)

The results of the present experiment support the positive effect of range site exclusion on vegetation development in semi-arid rangelands of Iran.

Wheat production management in Uzbekistan : current status and perspectives

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Key words : wheat production , salinity , animal feed

Introduction Sustainable crop production is the basic approach for agriculture in the 21^{st} century . After independence big changes occurred in the cropping systems of Uzbekistan . They are associated with both development of food security policy of the independent state and transition to market economy . With the growth rates of population in Uzbekistan (2 .4 percent per year) by 2010 it will reach around 35 million (presently 23-24 million) . This will sharply raise the demand in foodstuffs that requires significantly increasing the production of agricultural crops and livestock . In this regard , increasing wheat production is the most important objective of the agricultural research in this area . Because it is not only used as grain it is also used for animal feeding . Most of the arable area of the country suffers from elevated salinity to a various degree .

Crop production One of the most essential factors of developing the grain industry is to put into production highly productive grain varieties , resistant to diseases , unfavourable climatic conditions , and soil salinity as well as moisture deficit . The active development of plant biotechnology in the Republic of Uzbekistan allowed us for the first time to begin biotechnological research on wheat . Taking into account that the same varieties and crops in various soil-reclamation conditions display themselves differently , improvement of salt-resistance could be achieved through : creating salt-resistant wheat varieties , for of strong-saline regions of Uzbekistan ; selecting grain and leguminous crops in saline soils considering their biological adaptation through different regions of the republic ; creating and rapidly putting in operation advanced , pollution-free , and highly efficient industrial technology for cultivation of agricultural crops for various salinization degrees of soils . .

Laws and current conditions The Republic of Uzbekistan's Act of Achievements of breeding (August 30 , 1996) was approved for the purposes of regulating relations in the field of legal protection and usage of achievements of selection . Development of scientific research within priority state programs (basic , applied scientific and technical grants and grants for innovations) is in the course of The Center of Science and Technology of Uzbekistan . The high-yielding , disease- , drought- , and salt-tolerant varieties have been introduced and the principles of seed farming and agro-techniques have been developed .

Perspective and conclusion Implementing the conservation agriculture practices , scientifically proved crop rotation , would allow two yields of cereals and leguminous cultivars per year . Other need include the following :
-Complex study of the international nurseries and defining the initial materials for breeding of wheat production .
-Extending the scientific work in creation of new early maturing and ultra early maturing varieties
-developing the structure of seed production for cereal crops , providing the farms with elite and super elite seeds .
-Implementing the most rational crop rotations and their placement on the best preceding crops taking into account soil characteristics .
-Using the integrated management of protecting the plants from diseases , pests and weeds .
-Further development and widely introduction of biotechnology , agro-eco technology , and informational technology in the field of grain and farm production development .
-Organic inclusion of agrarian science into the training process of agricultural staff , integration of higher education , agrarian science and production .

Amelioration of natural grasslands in the high ranges of Kerala , India

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Key words : renovated—TDM (tons dry matter)—defoliation—plant introduction—growth rhythm

Introduction Improper natural grassland management in Kerala , India adversely affected its productivity . Problem orientated trials were taken to enhance productivity .

Materials and methods Grassland vegetation was botanically analysed in $5m^2$ plots (4 sub samples) .
Nitrogen effect on grassland was studied using a random block design with 4 replications . Nitrogen was applied at 0 , 40 , 80 or 120 kg/ha as Urea and in two split doses . Gross plot size was $25m^2$, net $5m^2$. Fodder samples were chemically analysed .
Growth rhythm studies were conducted for one year in 52 plots ($1m^2$ each) through weekly harvests . 1 .5 TDM/ha was fixed as the utilizable defoliation stage . Grasslands renovated through plant introduction with improved species like Setaria anceps , Chloris gayana , Brachiara ruziziensis , Macrotyloma axillare , and Desmodium uncinatum and D . intortum . Weeding was accomplished by cutting and light burning . Seed mixture was broadcast . Two methods of covering seed were teste , stirred the soil surface by hand rakeing or trampling by light weight cattle . First light grazing occurred 70-90 days after seeding followed by a weed cut . Plots were top dressed nitrogen at 40kg/ha . No statistically laid out trials , only observational studies .

Results The results identified palatable species of 8 grasses and 1 dicot . Economic optimum drymatter production was 35 .75 TDM/ha with 40kg nitrogen/ha .
Growth rhythm revealed possibility of 5 grazing defoliations with average production 22 .9 kg DM/day in 365 days and 35 .1kilo dm /day in a growing period of 238 days .
Renovated pasture yielded 7 .5 TDM/ha .(30% legumes on dry weight basis) .

Table 1 *Fodder yield in TDM/ha at different levels of nitrogen .*

Years	Nitrogen (Kg/ha)				
	0	40	80	120	160
1967	3 .58	4 .56	5 .70	6 .38	8 .48
1968	3 .16	5 .10	7 .08	8 .30	8 .66
1969	3 .20	5 .34	7 .54	7 .82	9 .56
1970	5 .36	6 .02	7 .26	7 .44	7 .70
mean	3 .82	5 .25	6 .89	7 .48	8 .60
Mean increase in DM Per Kg of N applied (in Kg of DM) .		35 .75	38 .37	30 .50	29 .87

Table2 *Growth analysis of natural grassland at Mattupatti .*

No .of cuts	Date of harvest	No . of growth days	Yield of DM(T/Ha)	Average Production of DM(Kg/day)
1	13-06-69	49	1 .92	39 .2
2	08-08-69	56	1 .82	32 .5
3	26-09-69	49	1 .58	32 .2
4	31-10-69	35	1 .48	42 .3
5	19-12-69	49	1 .56	31 .8
Average for the production period in the year		238	8 .36	35 .1
Average for the year (365 days)		365	8 .36	22 .9

N :P :K applied : 200 :100 : 200 Kg .ha .

Conclusion By scientific management , drymatter production and quality was enhanced . (production 3TDM/ha to 9.56 TDM/ha) plant introduction resulted 7 .5 TDM/ha per year of production .

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The characteristic of Mg Alkali soil developed in Tu Mo Chuan Plain

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Keywords :magnesium soloneization ,soda salinization , alkali soildevelopment stage , Tu Mo Chuan Plain , cation exchange consequent succession

Introduction Tu Mo Chuan Plain is one of the saline soil areas in Inner Mongolia . With the area enlarged continuously by unreasonable irrigation saline soil ,the sodic solonetz's formation , occurrence and distribution has been systematicly researched by the predecessors (Yu Renpei ,1964 ;Hao Zhenxiang ,1993) ,but the issues of magnesium soil have not been published .

Materials and methods Three profile are selected . Profile 1 is located in DaHeiHe cattle farm . The parent material is alluvial deposit . It belongs to the type of salic profile . The plant cover is of the type of halophytic meadow .Profile 2 is located 500m south of San Qingying village in Tuo Ke Tuo . Profile 3 is located in the southeast of Genbao Village of Ba Bai Xiang about 500m .It belongs to the type of desalting prohile . The plant cover is the type of steppe . Research methods :(1) determination of Exchangeable base Salt-leaching : First , Salt-leaching : weigh the particle of desiccated soil 5 .0000g($<$0 .25mm) ,then use 85% ethanol for centrifugation washing once , and then use 95% ethanol to wash by several times until there is no Cl^- . Second , extract : wash water-soluble salt , then use 1N NH_4OAc of pH9 .3 . Extract Ca and Mg with EDTA complexing titrimetric method ;Measure K and Na with flamc photometry .(6400A) (2) The measure of soluble salt :make the soil : water of 1 :1 . Titrate CO_3^{2-} 、HCO_3^- with double indicator ;Titrate Cl^- with $AgNO_3$;Titrate SO_4^{2-} with EDTA complexing titrimetric ;Titrate K^+ 、Na^+ with flamc photometry ;Titrate Ca^{2+} 、Mg^{2+} with EDTA complexing titrimetric .(3) Determination of the pH with the acidimeter .(PHS-3D) .

Results From the Profile1 ,it shows that the soluble salt aggregates in the epipedon and the subsurface horizon .In the epipedon , Na^+ takes more than 95% of the whole soluble salt . The content of Mg is the highest in the subsoil and the content of Ca is the highest in the substratum . pH is very high in the epipedon . In the epipedon and subsurface horizon ,the degree of alkalization is very high . With the depth increasing , exchangeable magnesium aggregates obviously . From the Profile2 ,it shows that the content of water-soluble salt is a little in the surface ,but it increases in the subsoil and substratum .In the subsurface horizon , sodium salt takes absolute advantage in the whole profile . The contents of exchangeable calcium and magnesium are high in the epipedon . With the depth increasing ,Na increases .From the Profile3 ,it shows that in the epipedon of the profile , the content of Mg is high . In the subsoil , Na is very much . The content of exchangeable magnesium is also very much in this profile .The horizon of high Na percent saturation appearce under the Mg accumulation horizon .

Conclusions Magnesium alkali-affected soil appears both in the process of salification and desalting , In the process of salification , sodic soloneization accompnished with magnesium soloneization . In the surface of the profile the content of Na is high .Mg take the advantage under the horizon of Na . In the process of desalting , The horizon of Mg aggregates upon the horizon of Na . With gradually desalting ,Mg is instead by Ca ,then form the normal soil .

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Forming mechanism and classification standard of "Black-Soil-Type" degraded grassland in Yangtze and Yellow River headwater region of Qinghai-Tibetan plateau

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Key words: alpine meadow, "Black-Soil-Type" degraded grassland, distribution, forming mechanism

Introduction Alpine meadow comprises a principal part of natural ecosystems, accounting for 90% of the grassland area in Yangtze and Yellow River (YYR). However, an unreasonable stocking rate and grazing system, and the effect of increasing population, global climate change and natural disaster on alpine meadow ecosystems, grassland has resulted in over half being degraded to different degrees. This has seriously threatened the existence of herds and hindered sustainable development of animal husbandry. This report explores the effects of rodents, overgrazing, and climate change on degraded grassland.

Materials and methods There are 16 counties and 1 township in the YYR source region (31°32′～36°16′N, 89°24′～102°15′E, 3500m～4500m). The climate is dominated by Southeast monsoon and high pressure of Siberia. The average air temperature is -5.4℃～4.1℃. Average annual precipitation is 274.6mm～746.9 mm, above 50% of which falls in the short summer growing season from June to August. According to grassland type and approximate distributing area of "black-soil beach" degraded grassland, 120 sample areas of field investigation and 92 training sample areas of remote sensing were surveyed and inspected in 16 counties and one township. Evaluation indices and classification of degraded grassland follows (Table 1).

Table 1 *Evaluation indices and classification of degraded grassland.*

Degraded ranks	Original vegetation coverage	Ration of palatable forage (%)	Degraded indication plants(%)	0～10cm Content of organic matter(%)	0～10cm Ratio of grass vs soil
Ⅰ Original vegetation(OV)	>90	>75	<10	>15	<20
Ⅱ Light degradation(LD)	75～90	55～75	10～30	15～10	20～35
Ⅲ Moderate degradation(MD)	55～75	35～55	30～50	10～7	35～50
Ⅳ Heavy degradation(HD)	45～55	20～35	50～75	7～5	50～75
Ⅴ Extremely heavy degradation (black soil beach)(ED)	<45	<20	>75	<5	>75

Results With the aggravation of degradation, the community quantitative values show a declining trend. No. of species, diversity index and evenness index reached the maximum in MD grassland, the minimum in ED grassland, and the percentage of aboveground biomass for high quality forage reduced abruptly. The similarity index was maximum between OV, LD and MD grassland, and then between LD and MD; Overstocking has reached to 10^7 sheep units; *Ochotona curzoniae* pest is not a primary reason of grassland degradation. Grassland degradation can lead to changes of physics characteristics and nutrition factors of soil. With the increase of stocking rates, the average content of organic matter, organic carbon, total N, total P trend decreases, and contents of available N appear changing trend of "S" curve. The increase of average annual air temperature over fifty years was 0.16℃/10a in YYR source region, which is much larger than 0.04℃/10a in other region of China.

Conclusions The formation of the "Black-Soil-Type" degraded grassland ecosystem is a result of a range of factors including human activity. According to the different degraded ranks, relevant measures of rehabilitation should be adopted, and the lighter the degraded degree, the earlier and quicker rehabilitation occurrs. Restoration of degraded grassland ecosystems has commonly two paths: one is natural restoration and the other is rehabilitation or reclamation by human factors. The lightly and moderately degraded grassland ecosystem can bereversed. Therefore, by fencing closure, weeding, fertilizing, using rodenticide, decreasing stocking rate, optimizing population structure by stocked and slaughter ages, they can be rehabilitated. As for extremely degraded grassland, they no longer can be utilized and the condition cannot be reversed. Therefore, only building artificial and semi-artificial grassland through furrow, scarification and replanting can we restore these heavily degraded systems.

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Seed protein variability and abiotic stress in naturalised Italian ryegrass (*Lolium multiflorum* Lam .)

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Abstract : Electrophoretic (SDS-PAGE) analysis of seed proteins was employed to reveal genetic variability in naturalized populations of Lolium multiflorum from unmanaged land in a region of the Province of Buenos Aires located in the Flooding Pampas of Argentina . The populations came from the following four site types , defined according to the species composition of the plant communities found at each : (i) a community designated loam' that was the least edaphologically and topographically limiting ; (ii) half-loam' that presented intermediate limitations of drainage and alkalinity ; (iii) alkaline lowland' that presented the most severe limits of alkalinity ; and (iv) humid lowland that only presented hydro-morphological limits . SDS-PAGE applied to samples obtained from each population revealed multiple banding patterns that could be divided into six electrophoretic zones , A to F . Individual bands were further sub-classified as follows : A1 , A2 , A3 , B1 , B2 , B3 , B4 , B5 , C1 , C2 , C3 , C4 , C5 , D1 , E1 , E2 y F1 . The banding patterns of each population sample were compared , once the minimum sample size required to represent the variability of the each population was derived by the Method of Pielou . In some comparisons , discrimination between populations could be made by observing only one band ; for example , band C1 discriminated alkaline lowland' from humid lowland' and band C4 half-loam' from alkaline lowland' . In other comparisons , it was necessary to observe several bands simultaneously . By this means , all the six pair-wise comparisons between the four populations provided sufficient information for discrimination to be made . If the divergence between populations is related to the conditions found at each topographical site , these populations may comprise a useful source of genetic variability for stress tolerance and might offer the potential for the development of new cultivars adapted to local conditions . We believe this to be the first report of the use of this methodology to characterise and distinguish natural populations of L . multiflorum found in different topographical positions in the grasslands of the region under study .

Key words : electrophoresis ; method of Pielou ; alkaline lowland ; humid lowland ; topographical position ; grassland

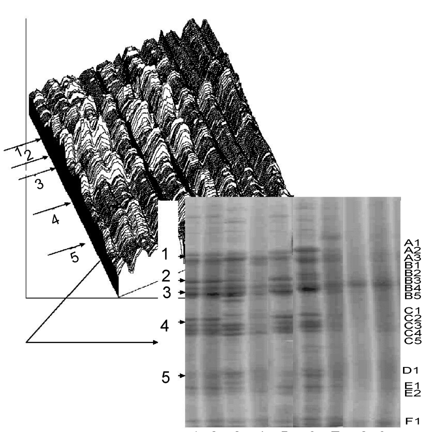

Figure 1 *Example gel of observed protein profiles . Lanes 1-3 : standard cultivar Nui ; Lane 4 : half-loam ; Lanes 5-6 : loam ; Lanes 7-8 : alkaline lowland ; Lanes 9 : humid lowland . Arrows indicate the reference bands of cultivar Nui , originally designated in cultivar Dalita (ISTA , 1992) , while the lines on the right hand side represent the range of bands covered by each denominated zone A to F (modified classification of Galussi et al ., 1997) . Included is a plot produced by the programme Scion Image , where each trace corresponds to a gel lane and shows the peak area and relative position of each band .*

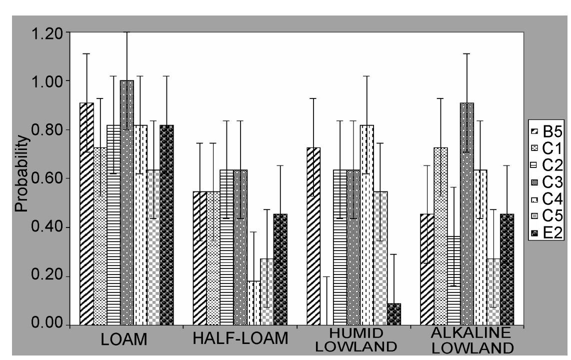

Figure 2 *Frequency profile for the bands significant in differentiating populations from distinct topographical positions ($t < 0.5\%$) .*

The improvement of degraded permanent grasslands by grazing in the NE Romania

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Key words: grasslands, fertilization, degraded, production, *Festuca*

Introduction The permanent grasslands from northeastern Romania, situated on soils with low natural fertility, are weakly productive and have an improper flower composition. The resulted fodder is of low quality. The main means for improving these grasslands consist in adjusting soil fertility, changing the dominance in the vegetal canopy and their good management. The paper presents the influence of organic and mineral fertilization on degraded permanent grasslands of *Festuca valesiaca* L. from the Moldavian forest steppe, during 2006-2007.

Materials and methods In this paper, we present the results obtained in the trial set up at Ezareni, at the height of 107 m, on 18-20% slope. The year 2007 was very dry at Ezareni – Iasi, and the climatic conditions were unfavourable to the good development of vegetation on grasslands. The experimental factors were: V_1-Unfertilized control; V_2-10 t ha^{-1} cattle manure applied every year $+N_{50}P_{36}$; V_3-10 t ha^{-1} manure applied every year $+N_{50}+_{50}P_{72}$; V_4-20 t ha^{-1} cattle manure applied every 2 years $+N_{50}P_{36}$; V_5-20 t ha^{-1} cattle manure applied every 3 years $+N_{50}+_{50}P_{72}$; V_6-30 t ha^{-1} cattle manure applied every 3 years $+N_{50}P_{36}$; V_7-30 t ha^{-1} cattle manure applied every 3 years $+N_{50}+_{50}P_{72}$; V_8-40 t ha^{-1} cattle manure applied every 3 years $+N_{50}P_{36}$; V_9-40 t ha^{-1} cattle manure applied every 3 years $+N_{50}+_{50}P_{72}$. The harvesting was done at the period of ear formation in dominant grasses, and yields were expressed in dry matter (DM). The changes found in the structure of canopy were determined through the gravimetrical and planimetrical methods.

Results Data presented in Table 1 showed that fertilization had a positive influence on yield, according to applied rates and combinations. The mean yields were between 2.16 and 2.34 t/ha DM, in variants fertilized with 10 t ha^{-1} cattle manure, applied every year on the background of $N_{50}P_{36}$ or $N_{50}+_{50}P_{72}$, between 2.24 and 2.48 t/ha DM in variants fertilized with 20 t ha^{-1} cattle manure, applied every year on the background of $N_{50}P_{36}$ or $N_{50}+_{50}P_{72}$, 2.52-2.68 t/ha DM in variants fertilized with 30 t ha^{-1} cattle manure, applied every year on the background of $N_{50}P_{36}$ or $N_{50}+_{50}P_{72}$, and between 2.78 and 3.42 t/ha DM in variants fertilized with 40 t ha^{-1} cattle manure, applied every year on the background of $N_{50}P_{36}$ or $N_{50}+_{50}P_{72}$. The highest yields were obtained in the variants at which 10, 20, 30, 40 t/ha of manure were applied every year, every 2 or 3 years, together with $N_{50}+_{50}P_{72}$. The fertilization has led to the improvement of the botanical structure, by increasing the participation percentage of legumes, at the same variants of fertilization, and slightly diminishing the percentage of other plants (Figure 1).

Table 1 *Influence of fertilization on DM yield (t ha^{-1})*

Fertilization variant	Production of DM yield (t ha^{-1}) 2006-2007
V_1	1.45
V_2	2.16^{*}
V_3	2.34^{**}
V_4	2.24^{**}
V_5	2.48^{***}
V_6	2.52^{***}
V_7	2.68^{***}
V_8	2.78^{***}
V_9	3.42^{***}

$^{*}=P\leq 0.05$; $^{**}=P\leq 0.01$; $^{***}=P\leq 0.001$;

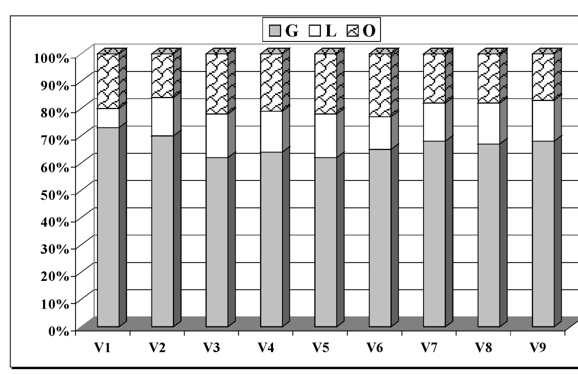

Figure 1 *Influence of fertilization on canopy structure (%).*

Conclusions The permanent grasslands of *Festuca valesiaca* L. from Romania react very well to the fertilization, which may be an important measure of recovering permanent grasslands, and promoting, at the same time, the concept of organic agriculture. The best results of production, but also of improving the flower structure were obtained in variants where different rates of manure were applied every year, every 2 or 3 years, together with maximum nitrogen rates.

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Restoring rain use efficiency to an incised upland valley system in Namibia using filters and Ecosystem Management Understanding (EMU) principles

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Key words: Base levels, BIOTA, EMU, gully erosion, restoration

Introduction Proactive management to avoid degradation is a worthy ideal for rangelands. However, managing the legacy of historic degradation is equally important and therefore requires an assessment of resource allocation between avoiding new degradation and repairing problems from the past. Quite clearly, avoiding future degradation should be a priority, but the benefits of repairing key productive landscapes should not be overlooked. Using principles within the Ecosystem Management Understanding (EMU) Process, and with the local farmers encouragement, we developed a trial restoration project of an upland fertile valley system in the Auas-Oanob Conservancy. The EMU approach emphasises catchment ecology and the identification of geomorphic base levels that determine patterns of soil moisture balance (Tinley 1982) and hence productivity, diversity and general ecological health. This approach is in stark contrast to the symptoms-band-aid" approach that appears to predominate. Our approach veiws rangelands as ecosystems controlled principally by base levels, which when incised, initiate cascading headward gully erosion and landscape leaking (Pringle *et al*. 2006). This project falls under the Biodiversity Transect Analysis in Africa (BIOTA) program.

Materials and methods The site is on Farm Lichtenstein-sud (21.01°S, 17.89°E) on sandy loam in the Highland Savanna of Namibia, with a mean annual rainfall of roughly 300mm. A gully system, with a slope of about 1:70, was treated with filters made of branches cut selectively from *Acacia mellifera* that was growing in dense stands nearby. The branches were packed at strategic locations to slow down flowing water and trap some sediment, while allowing excess water to pass through. At some locations the branches were woven with wire and tied to nearby trees. If there was no appropriate tree nearby, a steel post was hammered in to tie the wire to. Ten of the treated features are compared with ten similar features in other unfiltered gully systems. The sampled features were measured, by landscape function analysis (LFA), with transects running across rills or gullies. The measured features consist of four gully confluences and six rills per gully system. Half of the measured features were fenced to exclude cattle, both at the treated gully system and the unfiltered systems. The restoration work along roughly 2km of rills and gullies took about 100 person days to complete and used up 30 steel posts of 0.9m length and about 900m of fencing wire.

Results The filters are waiting for rain, therefore no follow-up results are available yet to compare with the baseline.

Figure 1 *Branches of* A. mellifera *packed in a gully head to form a filter.*

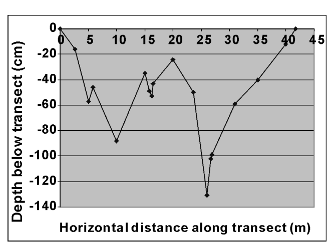

Figure 2 *e.g. of cross section base-line above confluence of two gullies.*

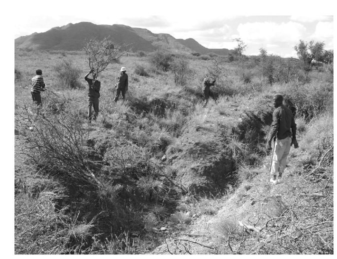

Figure 3 *Water becomes violent at a confluence, needing strong filters.*

Conclusions It is too early to determine effectiveness of the filters. If the current rainy season is poor, then the filters may rot before they function in a subsequent rainy season. Such restoration work is not only risky, but costly. It must form part of a broader strategy, coordinated with neighbouring farmers, aimed at catchment level management to restore hydrological functioning that can then allow improved grazing management to become effective. While the location and management of infrastructure, and ecologically-based grazing management are also critical in maintaining remaining ecological and resource integrity, to accept historic degradation as an intractable reality is demoralising. We (and farmers) also recognise values other than gross margins in allocating resources and assessing performance.

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Biogeocenotechnology of restoration and increase of efficiency for degraded pasture ecosystems in Arid regions of central Asia and Russia

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Key words : degraded pastures , halophytes , xerohalophytes

Introduction The vegetation of natural pastures in Central Asia and Russia has a very important specific feature - ability to annually cycle and self-reproduce phytomass . Being an essential component of the biosphere it determines not only forage capacity of pastures , but also quality of the man's natural environment in arid territories and genetic diversity of flora and fauna . Here a great amount of carbon dioxide is fixed for long periods in the subsurface sphere of arid ecosystems (roots , organic matter of soil) . However , lack of necessary agricultural and ecological knowledge , poor management , destructive utilization of pastures , destruction of shrubs and semishrubs - all these negative factors are the causes of reduced biodiversity , decreased productivity , and degradation of pastures . For restoration of biodiversity and productivity of degraded pastures and saline lands , the best candidates appeared to be halophytes .

Materials and methods In the period from 1975 to 2000 mobilization and collection of genetic resources were conducted within a wide zone in arid regions of Turkmenistan , Uzbekistan , Kyrgyzia Republics of and also in southern regions of Russia (the Astrakhan , Volgograd , Saratov , Samara , Rostov Provinces , the Stavropol Territory , the Republic of Daghestan , and the Republic of Kalmykia) . In development of a technology of phytoreclamation of degraded pastures and saline soils the following species and varieties of halophytes selected in the course of introduction-selection efforts were used : *Haloxylon aphyllum* , *Salsola paletzkiana* , *S . richteri* , *Aellenia subaphylla* , *Eurotia* ceratoides , *Calligonum* spp . , *Ephedra strobilacea* , *Kochia prostrata* , *Salsola orientalis* , *Camphorosma lessingii* , *Artemisia turanica* , *Artemisia halophila* , *Poa bulbosa* , *Gamantus gamocarpus* (, *Climacoptera lanata* , *Halimocnemis villosa* and other pasture plants . Tests of the mentioned species were conducted in the Republic of Uzbekistan in piedmont semidesert (Nashanksy station) , in the sagebrush-ephemeral desert (Karnabsky station) and in the Southwestern Kyzylkums (Ayakagitinsky station) and in Russia (Solezaimischensky station) .

Results and discussions For selection of the most environmentally stable , highly productive species of forage halophytes 300 species of plants from the flora were tested . Integrated investigations conducted in the last 25 years made it possible to utilize resources- and energy-saving technologies for ecological restoration of biodiversity and productivity of degraded pasture ecosystems and secondary saline soils . The proposed technology of phytoreclamation of degraded lands is based on the following fundamental biogeocenotic principles (Shamsutdinov , 1996 ; Shamsutdinov & Ibragimov , 1983 ; Shamsutdinov & Shamsutdinov , 2002) : 1) compliance of an ecological-cenotic structure of created pasture ecosystems with the zonal type of natural biogeocenotic structures ; 2) utilization in design of adaptive ecosystems of various types of zonally typical dominant halophyte species belonging to the violent and patient types of a strategy ; 3) differentiation of ecological niches on the basis of seasonal , strata , succession , fluctuation and functional mutual supplementation of zonally typical dominant species in the course of formal of nodal communities . What ???These biogeocenotic principles make a theoretical basis for phytoreclamation of degraded lands . In the course of phytoreclamation it is possible to design various types of pastures with optimal productivity , structural and functional organization , and stability . Designs of such pasture ecosystems contain polydominant communities consisting of halophyte shrubs , semishrubs , xerohalophylic perennial and annual grasses (on the basis of a seed bank) .

Conclusions Germ populations of halophytes collected during expeditions provided a basis for the Central Asian genofund numbering 70 species and 5000 samples and the Caspian genofund in Russia including 50 species and 1200 samples . Environmentally oriented biogeotechnology of reclamation is realized by creation of spring-summer and autumn-winter perennial self-restoration pasture ecosystems in place of degraded lands .

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Desertification reasons , endangering and tendency in China's land

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Desertification in China has spread about 26 220 000 km^2 ,most of them in western of China . The type , size and endanger lever of the desertification in arid , semi-arid areas of western of China are the most concentrated and serious .

Key words : Desertification , Reasons , Endangering , Tendency , China

Reasons of desertification formation The rapid growth of population and the laggard management is the internal driving force of expanding desertification : The requirement of food , fuel and other fundamental sub'sistence increase with the population growth , which give land raised pressure . The population exceeded the capacity of the ecological environment and excessive exploit the resources lead to environmental degradation . It is the rapid population growth and laggard production management , causing the unreasonable development and utilization of resources , deteriorate the ecological environment , accelerating and expanding the desertification .

Humanity unreasonable use of resources speed up desertification Overcharging cultivating : Lack of protect cultivation after reclaim , the soil erosion by wind or buried by sand , the yield sharp declined , the people had to give up farming , on the one hand the land abandoned became sandy , on the other hand there are new grassland or fixed land reclaimed , fall into a vicious circulation .
Overcharging grazing : Use meadows without maintain , the productivity of natural grassland is low , with the increase of population and interests of market-driven , the people increasing livestock blindly , leading to the serious overloading of pasture , the herdsman even contest , fight each other for pasture .
Overcharging Woodcutter : Because of fuel shortage , peasants and herdsmen use natural plants and animals manure as fuel .
Overcharging pluck : The peasants and herdsmen in order to increase their incomes , unplanned , uncontrolled plucking medical weed and so on . In doing this , they shovel out lawns and excavators hole , severely damaging the grasslands , and greatly accelerated the erosion desertification process .
Abuse of water resources : In desert areas ,the performance of abuse of water resources is the lack of surface water planning and arrangements in the upper , middle and lower stage , exploitation of underground water excessively , the irrigation use too much water .
Indiscriminate mining : Because of people pay little attention to ecological and environmental protection when people development and mining roads , towns and other fundamental construction , often lead to the occurrence of desertification .

Desertification endangering Farmland , grassland degradation , the reducing of utilizable land areas , the agricultural and domestic productivity decline .
Dynamic Community recession , a reduction in biodiversity .
Silting the channel and river bed , buried , pressed and blocking roads , damaged traffic , water conservancy facilities .
Sandstorms frequent occurrence , deterioration of the ecological environment , ecological disaster increase .

Tendency of desertification After half a century , the Work to Combat Desertification in China achieved great achievements , but the situation is still very serious by the status and development trend . Despite the parts had improved , but the integration is still expanding , the speed desertification expanding is acceleration , in 1950s the speed is annual 1560 km^2 ,in 1970's it is 2100 km^2 , the current speed is 2460 km^2 . The desert oasis edge , grassland farming-pastoral areas and agricultural development zone is most serious , some potential desertification of land is gradually evolving to real desertification land .

Eco-politics of rangeland management in the Hindu Kush-Himalayan Region : articulating ecology into food sovereignty , environmental security , development and peace for a sustainable world

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Introduction Rangelands are the uncultivated areas or abandoned cultivated areas and occasionally fallow lands that harbour natural or seeded/ planted vegetation of herbaceous and woody species and that serve as habitats of a variety of wild animals , support domesticated animals , provide unique products and ecosystem services especially vital for the livelihoods of livestock-dependent communities (Singh 2007) . Rangelands make approximately 70 percent of the world's total area (Zhaoli 2004) . The current dismal state of the Hindu Kush-Himalayan (HKH) Region – in many areas full of chaos , turmoil and instability – could be transformed into a state springing hope , peace and development . Ecologically sound natural resource management is a precondition to maintain essential ecological integrity of any system , which is of critical value serving as the strongest foundation for the sustainability of the natural resources and systems on the living planet . Ecological integrity actually is the real substance of human happiness .

Materials and methods Matter for this paper has been largely based on the eco-philosophy the author has been brooding over for sometime . Eco-philosophy , from which emerges the eco-politics , could be a strong foundation for the reclamation of mountain rangelands shared by the countries of the HKH Region through co-management promoting mutual cooperation . Additionally , this would be instrumental in dispelling tension and restoring lasting peace vital for food sovereignty , environmental security and sustainable development in the HKH Region .

Results and discussion

Ecology as a Culture of Peace Ecological integration of all the ecosystems and biomes of the Earth is the most essential condition of the very sustainability of life on the planet . Peace on Earth emanates from the condition of the ecosystems that serve humanity with life-sustaining foods , life-supporting products and life-stimulating services . Ecology is the culture of peace . Ecological well being in the Region would ensure economic well-being of the livestock-dependent communities who form majority in the mountains .

Biological Corridors : A Concept Co-management of the rangelands in the HKH Region , as also proposed by Zhaoli (2004) , should be regarded not only essential but an imperative for restoring ecological balance and promoting peace and sustainable development in the Region . Rangeland ecosystems could be transformed into biological corridors linking the unique biodiversity-laden habitats between two or amongst many countries in the Himalayan Region .

Eco-politics Concept The eco-politics can induce the member nations of the HKH Region to undertake co-management of their natural resources in the border areas and share tangible benefits to be accrued through ecological affluence . Intangible benefits that would infuse sustainability in the land-based production and livelihood systems will come the natural way . Resource conservation-based eco-politics , rather than the resource degradation-oriented conventional geopolitics , would give healing touch to the wounded mountains and their long-suffering people .

Conclusions Eco-politics with meaningful fusion of ecology and politics that can guarantee unity and integrity would articulate into the welfare of the people and all living beings and the nourishing systems on Earth . Food sovereignty , environmental security , development and peace achievable though pragmatic eco-politics would be exemplary for other ecological regions of the world – a path towards acquiring a happy and sustainable world .

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Maintaining grassland biodiversity while controlling the shrub *Rhus glabra*

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Key words: Biodiversity, smooth sumac, *Rhus glabra*, herbicides

Introduction In the United States of America, the tallgrass prairie is a fragmented, threatened ecosystem. Few areas remain intact and many of those are degraded by increasing densities of woody plants. Historically, the resprouting shrub smooth sumac (*Rhus glabra* L.) was a minor species (Weaver and Clements, 1938) kept at low densities and restricted to ravines by a disturbance regime of fire and grazing. These and other processes are limited and some occur no longer (Steinauer and Collins 1996). Therefore, these plants increase rapidly and form dense thickets threatening productivity and biodiversity of the prairies (Tunnell et al. 2006). We tested the use of herbicides and fire to control smooth sumac with the goal of maintaining native forb biodiversity.

Materials and methods The experiment was conducted at Nine Mile Prairie (40°51′N, 96°51′W; 97 ha), a tallgrass prairie remnant 14 km west of Lincoln, Nebraska USA. Annual precipitation averages 718 mm, with a majority occurring from April to October. The dominant soil was Pawnee clay loam (fine, montmorillonitic, mesic Aquic Argiudoll). The study was a randomized complete block with 13 herbicide treatments and one control per block. Three blocks were located in both the burned and non-burned areas. Prescribed burns were conducted in May and herbicide treatments in June. Broadcast spray-applied herbicide treatments per ha were 1.06 and 2.13 kg ae 2,4-D LV Ester; 0.15 kg ae Picloram + 0.56 kg ae 2,4-D LV Ester; 0.20 kg ae Picloram + 0.84 kg ae 2,4-D LV Ester; 1.12 and 2.24 kg ae Triclopyr; 1.26 kg ae Triclopyr + 0.42 kg ae Clopyralid; and 0.56 kg ae Picloram. Wick-applied herbicide treatments per ha were 1.40 kg ae 2,4-D Amine; 0.2 kg ae Picloram + 0.74 kg ae 2,4-D Amine; 1.48 kg ae Triclopyr; 1.11 kg ae Glyphosate; and 0.74 kg ae Picloram. For two years following treatment, live smooth sumac stem densities were counted within a 3 x 7 m quadrat in each plot in mid-September, and forb frequencies were determined in late August using multiple placements of a 0.5 by 0.5 m quadrat. A mixed model analysis of variance was used to assess treatment differences. We focused on the most abundant forbs and the shrub leadplant (*Amorpha canescens* Pursh) because it is an important indicator species of a high quality tallgrass prairie plant community (Stubbendieck and Conard 1989).

Results and discussion Pretreatment stem densities of smooth sumac were not significantly different across all treatments ($P = 0.9170$). No interactions between herbicide and burning were detected, but the main effects of herbicide treatment and burning were significant. Smooth sumac stem density in burned plots (0.27 stems/$m^2 \pm 0.06$) was greater than stem densities on non-burned plots (0.14 stems/$m^2 \pm 0.04$). Stem densities were significantly reduced compared to the control ($P = 0.0001$), regardless of the herbicides used or the application method. Forb frequencies varied by treatment. Where 2,4-D, Picloram + 2,4-D, and glyphosate were applied with a wick, forb frequencies two growing seasons after treatment were not different from the control. Forb species richness for the wick treatments was consistently greater than for the spray treatments. Frequencies of leadplant where herbicides were applied with a wick were four times greater than when herbicides were applied as a broadcast spray.

Conclusions Prescribed burning is not an effective control measure for smooth sumac. While most herbicide treatments greatly reduced smooth sumac, the broadcast spray application resulted in decreases in forbs and leadplant. Wick application effectively controlled smooth sumac and prevented decreases in forb frequencies.

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Heavy metal Pb stress on germination and growth of 5 clover varieties

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Key words : clover , variety , heavy metal Pb , germination , growth

Introduction There are more than 360 species of clover all over the world . Cultispecies such as *Trifolium repens* , *Trifolium pratense* and etc . were widely used nowadays . Clover was not only used as forage , but also used as green manures (Carmela Bahiyyih et al ., 2005) . As the problem of heavy metals contaminating soil is more and more seriously , the plant growth characteristics with heavy metals stress were studied by more and more people . This paper describes the germination and growth of 5 clover varieties with heavy metals Pb stress .

Materials and methods The germination experiment treatments applied were : 5 concentrations of Pb (0mg/kg , 200mg/kg , 600mg/kg , 1000mg/kg , 1200 mg/kg) as the form of $C_4H_6O_4Pb$ solution was used to water the seeds when the papers run short of water . The seeds , packed in paper , were stored in the greenhouse(28℃ average temperature) . Every paper consisted of 100 seeds . Results were recorded 10 days after planting . In the pot-cultured experiment , more than 10 clover seeds , packed in a pot , were stored in the greenhouse . The mixture of 4 kg soil and 45 g manures were put into a pot to feed the seeds . 5 seedlings were remained in every pot when the clover sprouted and grew well . 5 different concentrations of Pb as former were used to water the soil when the clover was in its branching stage . Leaf area(determined with a CI-202 leaf-area meter) , plant height and overground biomass(fresh weight) was recorded when clover was in its early flowering stage . All the experiment was arranged in randomized blocks with 3 replications .

Results Clover's germination rate , radicle length , leaf area , plant height and overground biomass were reduced by the increasing of concentration of heavy metal Pb . Different clover varieties had variable germination rate and a downward trend in germination rate of 5 clover varieties(Figure 1) . The seedling radicle length , leaf area , plant height and overground biomass when concentrations of Pb was 1000mg/kg and 1200 mg/kg were significantly lower than it was when concentration of Pb was 0mg/kg(Figure 1) .

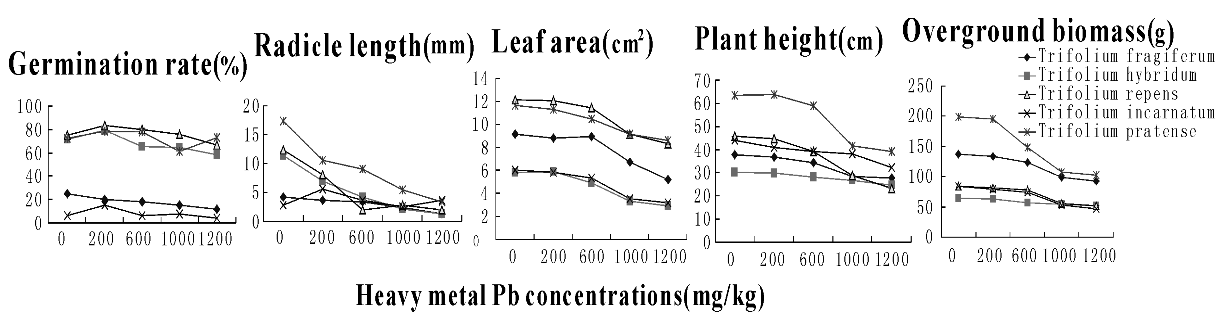

Figure 1 *Effect of heavy metal Pb stress on germination and growth characteristics of 5 clover varieties .*

Conclusions Heavy metal Pb stress has a strong influence on the germination and growth characteristics of 5 clover varieties . Varietal differences in clover with heavy metal Pb stress . The germination of *Trifolium incarnatum* affected little by heavy metal Pb stress (Figure 1) . Low level heavy metal Pb concentrations have little influence on the germination and growth characteristics of 5 clover varieties . But a significant downward trend in radicle length , leaf area , plant height and overground biomass was made by the increasing of heavy metal Pb concentrations .

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Restoration of degraded Mongolian rangeland by overseeding techniques ?

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Key words : pasture degradation, overgrazing, overseeding, seedling, germination

Introduction Large areas of Mongolian rangeland pastures are heavily degraded, mainly due to overgrazing. A main problem of severe degradation is the loss of key grass species (Sasaki *et al*. 2007) resulting in a strongly impaired capacity for self rehabilitation (Darhiihuu *et al*. 2008). Thus, we applied different overseeding techniques to test whether they are successful to reintroduce plant species into degraded rangeland of Mongolia.

Materials and methods At three sites representing three ecological zones (mountain steppe, forest steppe and steppe) overseeding experiments were carried out during three years. The most costly technique was sowing in rows where the seeds were covered with 1-2 cm of soil. Other techniques were broadcasting, broadcasting followed by animal trampling, broadcasting followed by harrowing, broadcasting followed by litter cover. Two mixtures of grass (*Agropyron cristatum*, *Stipa krylovii*, *Bromus inermis*, *Elymus dahuricus*, *E. sibiricus*) and the legume (*Medicago varia*) species were overseeded. At ten days intervals the number of seedlings of grasses and *Medicago* were counted throughout the whole growing season. The results are presented for the overseeding technique sowing in rows and the best of the other techniques. The experimental design was a completely randomized block design with 4 replicates.

Results and discussion Despite the dry climatic conditions with annual precipitation of 200 to 350 mm yr^{-1}, seeds were able to germinate at all three sites (Table 1). In all sites and all years the overseeding technique sowing in rows reached the highest number of seedlings and the highest maximal germination rate ($P < 0.0001$). The second best overseeding technique changed among sites and years, without a clear pattern. Likewise there was no trend whether *Medicago varia* or the grasses reached higher numbers of seedlings.

Due to high death rates during the growing season, generally no survivors were left before winter (Table 1). One exception occurred at the mountain site with the highest precipitation and the coolest temperatures. But even at this site survivors were observed only in one out of three years. The lack of success of overseeding demonstrates how extremely difficult (re) introduction of species into plant communities is under the environmental conditions of Mongolia. In addition we found that severe degradation strongly impaired the capacity for resilience of Mongolian rangeland plant communities (Darhiihuu *et al*. 2008).

Table 1 *Success of overseeding techniques in terms of highest seedling number, highest germination rate, highest death rate and survivors before winter for* Medicago varia *(Med.) and grasses averaged over the three years.*
(SEM : standard error of mean; n = 24 (4 replicates × 2 seed mixtures × 3 years).

Site	Overseeding technique	Highest seedling number (m^{-2})		Highest germination rate (m^{-2} $10days^{-1}$)		Highest death rate (m^{-2} $10days^{-1}$)		Seedling number before winter (m^{-2})	
		Med.	Grass	Med.	Grass	Med.	Grass	Med.	Grass
Mountain	Sown in row	36	18	25	11	24	6.1	1.6	3.6
steppe	Best other treatment	16	2.3	16	2.3	13	1.2	0.5	0.3
Forest	Sown in row	60	0	59	0	39	0	0	0
steppe	Best other treatment	28	0	28	0	15	0	0	0
Steppe	Sown in row	23	55	30	22	21	11	0	0
	Best other treatment	3.9	17	12	7	9	3.5	0	0
SEM		2.8	2.8	2.0	1.0	1.6	0.9	0.2	0.4

Conclusions Under the given environmental conditions restoration of severely degraded rangeland is, if ever possible, extremely difficult.

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Can replacing native grasslands with agronomic species improve the above-ground productivity on the Mixed Prairie in Canada ?

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Key words : *Agropyron cristatum* , *Psathyrostachys juncea* , establishment period

Introduction The relative benefits of introducing forage species to the Northern Great Plains has been examined in well publicized studies with contradictory conclusions . In most cases the research was conducted in trials that were confounded by time of establishment or where the treatments could not be randomized and consequently lacked independence . Therefore , we initiated a study to re-examine the relative productivity between commonly introduced species and native Mixed Prairie communities on the Northern Great Plains .

Materials and methods We examined the above-ground primary production (ANPP) and harvested biomass from *Agropyron cristatum* (L .) Gaertn ., *Psathyrostachys juncea* (Fisch .) Nevski and *Triticum aestivum* L . in comparison with the native community in a randomized complete block design with 4 blocks and 5 treatments over 12 or 13 years from establishment . The study was repeated on two sites having either a Brown or Dark Brown Chernozemic soil in southern Alberta , Canada . Average annual precipitation at the sites was 348 and 377 mm , respectively . The native community was represented by a control ($native_{cont}$) and a harvested treatment ($native_{harv}$) . We examined the ANPP and harvested biomass of the introduced species and the $native_{harv}$ in three , 4/5-yr periods at each site .

Results and discussion With the exception of *P . juncea* on the Brown Chernozemic (BC) site , the seeded treatments were relatively more productive in the establishment period than in subsequent periods (Table 1) . Following establishment , *A . cristatum* produced similar yields as $native_{harv}$ on the Dark Brown Chernozemic (DBC) site but about 1 .8 times more on the BC site . *P . juncea* generally produced less ($P < 0.05$) or similar ($P > 0.05$) yields as $native_{harv}$ while *T . aestivum* produced more ($P < 0.05$) . The study confirms the relative ANPP advantage of *A . cristatum* to native on the BC site but not on the DBC site . *T . aestivum* was the most productive on both sites and its ANPP advantage to the native appeared sustainable . Our study does not support unconditionally the previous claims of improved productivity from introduced grasses (Smoliak 1968 , Kilcher and Looman 1983) since their relative performance was affected by species , time since establishment and by site . Production comparisons of introduced species with native communities must consider their previous management . Furthermore , the relative productivity of native grasslands is strongly influenced by their defoliation regime . Therefore , production comparisons of introduced species with native communities must consider their previous management .

Table 1 *Above-ground net primary production of native communities and monocultures of seeded introduced species during three periods since establishment at two sites on previously unbroken land . The effect of period , treatment , and its interaction on ANPP are significant ($P < 0.05$) for each site) .*

Period (years)	Native		Introduced		
	Nat_{cont}	Nat_{harv}	*A . crist .*	*P . junc .*	*T . aest .*
	Dark Brown Chernozemic (1994 to 2006)				
	ANPP (g m^{-2})				
1 to 4	178b[1]	154ab	291c	123a	338d
5 to 8	178b	139b	138b	87a	164b
9 to 13	306c	259b	301bc	190a	538d
Mean	221	184	243 .1	133	346
	Brown Chernozemic (1995 to 2006)				
	ANPP (g m^{-2})				
1 to 4	64a	75ab	265c	93b	476d
5 to 8	124a	91a	205b	134a	224b
9 to 12	178b	129a	178b	120a	207b
Mean	123	98	216	116	269

[1] a-d Means followed by a common letter within row are not different ($P > 0.05$) .

Conclusions The belief that seeding native grassland with introduced species would increase forage production is not supported by this study . *A . cristatum* , probably the most productive of the perennial forage grasses that were introduced to the Mixed Prairie , yielded greater ANPP in the more xeric community represented by the BC site but demonstrated little advantage on the more mesic community of the DBC site .

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Seedling recruitment of alpine grassland under different disturbance in the Headwaters of Yangtze and Yellow Rivers on Tibetan Plateau

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Key words: alpine meadow, seedling recruitment, degradation, Qinghai-Tibetan Plateau

Introduction Concern is growing about grassland degradation. Seedling recruitment is important in grassland succession (Welling and Laine, 2002). The objective of this study was to clarify the relative contribution of seedling recruitment patterns to the alpine grassland community with levels of degradation.

Material and methods The study was conducted at Guoluo Prefecture, Qinghai Province (33°43′ - 35°16′N, 98°48′ - 100°55′E), located in the middle of the Qinghai - Tibetan Plateau at an average altitude of over 4000 m. The vegetation is typical alpine meadow. The experiment was conducted during the June to August of 2007 by field investigation fixed samples. In our study, three sampling plots (30m×50m) per degradation level and five quadrats (50cm×50cm) per each plot were set up. We selected four samples by different degraded levels: Normal undegraded meadow (ND), Lightly degraded meadow (LD), Medium degraded meadow (MD) and Heavily degraded meadow (HD) (Ma *et al*. 2002). The ND meadow is the alpine meadow that has enclosure and forbid grazing, and the other three degraded meadow are free-grazing alpine meadow. The seedlings were identified if it is seedling from seed or asexual reproduction by research methods of Welling and Laine (2002). The data were statistically analyzed using ANOVA with SPSS version 12.0 packages.

Results At all four levels, the clonal-seedlings showed significantly larger contribution to grassland regeneration than seed-seedlings. Our results show that with increasing degradation, the total seedlings recruitment showed a decreasing contribution to grassland regeneration. The habitats degradation had a significant impact ($P<0.001$) on natural seedling recruitment in grassland. The regeneration by natural seedling recruitment was more effective under ND than other degraded meadows. With the increase of degradation, the total seedlings and clonal-seedlings recruitment showed a degressive contribution to grassland regeneration. But, the seed-seedlings recruitment presented an increase with the degradation (HD> MD> LD) (Figure 1).

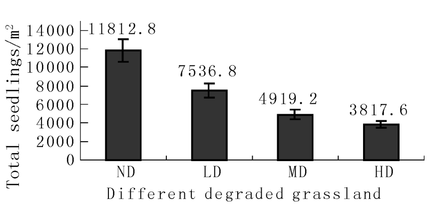

Figure 1 *Total seedling numbers (± SE) per square meter under four degraded-level alpine grasslands.*

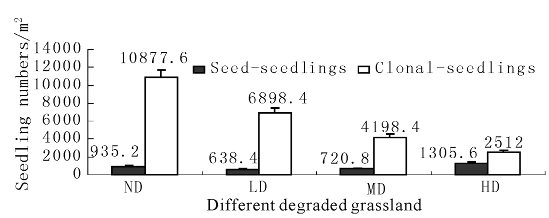

Figure 2 *Seed-seedling and clonal-seedling numbers (± SE) per square meter under four degraded-level alpine grasslands.*

Conclusions Results suggest that habitats fragmentations because of degradation have significant negative effect on successful seedling recruitment. Additionally, clonal-seedlings play a more important role than seed-seedlings in structuring grassland community under all conditions.

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Soil restoration in the Songnen plain : A case study of degraded grassland after being fenced for five years

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Key words : degraded grassland , soil nutrients , fencing , soil restoration

Introduction Fencing is a simple and feasible method for restoring degraded grassland in the Songnen plain of northeast China (Li *et al* , 1995) . After grazing was banned within the fenced area , grassland ecosystems began a semi-natural and self-restoring process . The aim of this study is to clarify the restoration of the soil nutrient status in the degraded grassland after being fenced for five years .

Study site and methods The study site was in the southern Songnen plain in Xinhua County (E122°55 .413′ , N44°34 .052′) . The climate is temperate semi-arid , with semi-humid continental monsoons in the area . The annual average temperature is 5 .1℃ and annual rainfall is 450mm . The soil types are mostly meadow soil and saline-alkaline soil . A fence 1hm^2 in size had been built in the extreme grazing area in August 2001 . Grazing was banned thoroughly within this fenced area , but the outside was still open for grazing . After being fenced for five years , the dominant species inside the fence were *Leymus chinensis* , *Calamagrostis epigejos* and *Artemisia scoparia* , while the dominant species outside was only annual *Chloris virgata* .

Soil sampling points were randomly selected inside and outside the fence in August 2006 . The soil core digging method was to dig three layers at each point , i .e . 0～10cm , 10～20cm , 20～30cm . Twelve points were sampled inside the fence and six points outside . The conventional methods were used to analyze the soil nutrients (Nanjing Institute of Soil Science CAS , 1978) . The analysis components included total nitrogen (TN) , nitrate-nitrogen (NON) , total phosphorus (TP) , available phosphorus (AP) , total potassium (TK) , and available potassium (AK) . Independent Sample T test was used to analyze significant differences between the inside and outside areas of the fence at same soil layers .

Results The difference in AK in the 0～10cm layer and the difference in TP in the 10～20cm layer between the inside and outside areas were significant (Table 1) , but the other soil nutrient indices at the same layers inside and outside the fence were not significantly different . Inside the fence , the vertical distribution of nutrient indices showed a decreasing gradient rule from the surface to the deep layers , whereas outside the fence NON and TK were lower in the 0～10 cm layer and higher in the 10～20cm layer , with the content decreasing further in the 20～30cm layer . In the 0～10 cm layer , both NON and TK inside the fence were higher than the outside , and the other soil indices from inside the fence were lower those from the outside .

Table 1 *Comparison of soil nutrients between the same layers inside and outside the fence (Means ± SD) .*

Layers(cm)	Fence	TN(%)	NON(mg/kg)	TP(%)	AP(mg/kg)	TK(%)	AK(mg/kg)
0-10	Inside	0 .13±0 .02	0 .081±0 .004	0 .025±0 .008	2 .96±0 .72	1 .89±0 .31	190 .84±29 .89 ^{a}
	Outside	0 .20±0 .15	0 .078±0 .003	0 .032±0 .009	3 .17±0 .85	1 .80±0 .51	246 .84±63 .85
10-20	Inside	0 .12±0 .02	0 .080±0 .006	0 .022±0 .007^A	2 .11±0 .19	1 .68±0 .29	157 .22±20 .23
	Outside	0 .11±0 .02	0 .082±0 .006	0 .032±0 .004	2 .41±0 .68	1 .87±0 .22	184 .22±43 .25
20-30	Inside	0 .08±0 .05	0 .077±0 .004	0 .021±0 .006	1 .94±0 .28	1 .64±0 .34	160 .02±19 .59
	Outside	0 .07±0 .02	0 .081±0 .005	0 .023±0 .008	2 .00±0 .51	1 .77±0 .55	163 .38±12 .76

a : *t* test result $|t| = 2.577$, $p = 0.02$. A : *t* test result $|t| = 2.970$, $p = 0.009$.

Conclusions NON and TK increased in the surface layer (0～10cm) after fencing for five years in the Songnen degraded grassland , while all other indices did not change significantly . The soil nutrients of the fenced grassland showed a clear vertical distribution rule , i .e . decreasing from the surface to the deep soil layers . Surface soil may be more sensitive to the effect of fencing and the banning of grazing . We conclude that the restoration of soil nutrients is a slow process .

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Changes of vegetation in the sandy desertification process of grassland in Yanchi, Ningxia

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Key words: vegetation, sandy desertification, perennials, therophytes, psammophyte shrubs

Introduction Yanchi county, locates at the southwest fringe of Mu Us sandy land, and is an ecotone comprising sandy land through to desert steppe and to steppe. Over the recent decades, Yanchi has suffered severe sandy desertification. The distinct vegetation conditions between sandy grasslands at different desertification levels have resulted from a considerable difference in intensity of wind erosion. The objective of this study is to explore the changes of vegetation characteristics among different desertification degrees.

Materials and methods For quantitative field sampling, three 110km-long parallel transects running from inner steppe to mobile-sand dunes were established according to vegetation distributing image of Yanchi county. The sampling plots were arranged at 2km intervals along each transect. In each plots, plant density, frequency, coverage and height for each species were recorded and the importance value for each species were calculated through relative density, relative coverage, relative height and relative frequency using the method described by Ren (1998) from July to August at the peak of crop standing.

Results A total of 64 plant species were recorded. At the potential desertification land (PD), the dominant plants were *Stipa bungeana* and *Lespedeza potaninii*. At the light desertification land (LD), *Lespedeza potaninii* was most frequently found. At the medium desertification land (MD), *Leymus secalinus* and *Echinopsilon divaricatum* were frequently found. At the severe desertification lands (SD), the dominant plant was *Salsola pestifer*. At extreme desertification land (ED), floristic composition is dominated by psammophyte shrubs such as *Salix psammophylla*, *Artemisia sphaeracephala*.

Table 1 *Patterns and dynamics of plant life form composition for different desertification categories.*

Desertification categories	Total species number	Perennials		Therophytes		Shrubs or semi-scrubs	
		Species number	Dominance (%)	Species number	Dominance (%)	Species number	Dominance (%)
PD	23	17	87.33	6	12.67	0	0
LD	49	34	67.71	15	32.29	0	0
MD	28	19	62.69	9	37.31	0	0
SD	28	13	43.63	14	55.94	1	0.43
ED	17	3	19.97	8	22.94	6	57.09

Conclusions With sandy desertification aggravating, the steppe species lost their former competitive advantages and gradually gave place to arid and sand tolerant perennial species and therophytes and eventually to psammophyte annuals and shrubs. Therefore, the steppe dominant species became subdominant component in light and medium desertification lands and dropped out or even faded out in severe and extreme desertification lands.

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Study on ecological restoration to degenerated *Leymus Chinensis* rasture

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Key words : Degenerated *Leymus Chinensis* pasture , Improvement , Ecological recovery , Community succession , Biomass

Introduction *Leymus Chinensis* pasture spreads in north China widely and Productivity is higher than other tape of pasture . Recent years its ecological environment gets worse and productivity decreases obviously due to human disturbing and comprehensive effect of natural factors . The techniques for rejuvenating degenerated *Leymus Chinensis* pasture in Dongwu Country were studied . A useful kind of method for ecological recovery and norm of community succession was found .

Results 1 . The soil available nutrient of improving field was higher than the CK , but content of organic matter was lower than the CK . That due to the increase of soil microorganism activity and made the accumulated organic matter decomposed rapidly . 2 .The natural height of leaf layer of *Leymus chinensis* on improving field was average increased 9 ㎝ , raised 30% ; The growth strength dry matter was average increased 810 g/hm^2 .t , raised 5 .3 times . The density and coverage got a great improvement there were 262 strains of *Leymus chinensis* per square meter and it was 193 strains more than the CK , therefore , the density and coverage raised 2 .8 and 2 .4 times respectively . 3 .The total production of improving field was 127 .15% higher than the CK , and the biomass of *Leymus chinensis* was 511 .36% more than the CK , so the effect of boosting production was significant Through the significance test , the difference of total production was not significant , but no significant difference was observed in *Leymus chinensis* at the second year of improvement . The other years the difference of both *Leymus chinensis* and total production was extremely significant . 4 . Grassland improvement loosed the soil , improved the extension strength of underground rhizome of *Leymus chinensis* , increased the biomass of underground root system , and enhanced the ability of nutrient uptake and vegetative propagation . 5 .The content of crude protein in *Leymus chinensis* on improving field raised 1 . 1% , the quantity of various nutritional components in unit area was increased 3 .5～4 .8 times . As far as the nutritional value was considered , 1 hm^2 was equal to 14 .6 hm^2 control grassland .

Conclusions 1 . The improvement showed complex active effect on ecological environment improving : Improve soil fertility and structure . 2 .It could take 10 years as one cycle to rejuvenate the plants , improve grassland production , and make the forage stable , high quality and yield .3 .It could not keep high production forever through just one time improvement , and there would be degradation succession few years later , so it needs incessant renewal . 4 . The appropriate period of improvement should be limited during mid-July and mid-August . If too early , the annual or biennial weeds would appear in the grassland and affect the development of rhizome of high-quality forages ; if too late , the weeds seed mature and made the plant community complex to affect the quality of grassland . 5 . The grassland which was being rejuvenation for 2 or 3 years , only could do cutting grassland but not pasture in order to guarantee normal development and propagation of rhizomatous forages .

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Analysis on the rangeland degenerate gradient of Bayanbulak

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Key words: degenerate gradient; rangeland degeneration; dominant; overloaded; primal synusia

Introduction The Bayanbulak rangeland, located in the southern slope Tianshan mountain in Hejing County, Xinjiang, is 2400～3800 m above sea level. It is a perch and close mountain basin, with a total area of 13998 km^2 (Xu Peng, 1993). It is not only the important animal husbandry production base, but also the important water source of Kaidu River. However, influenced by global climate warming, unreasonable use and the overloaded herds, a series of ecological questions appeared such as rangeland degeneration, soil desertification, weeds spreading and so on.

Research methods The study takes the degenerate gradient rangeland as the sample and the plant community characteristic should be consistent with obvious and general or light degeneration. The study was initiated from 5 to 15 of August in 2005, determined the coverage, height, density, abundance and yield of the plant community. The sample area is $1m^2$, and each degenerated rank replicates 5 times.

According to $SDR_2 = (C' + Y')/2$ (C' is relative coverage, Y' is relative weight), the study can calculate the degree of dominance of each investigated sample, define the dominant species, companion species, and confirm the different degenerated gradient.

Results and discussion *Stipa purpurea* and *Festuca kryloviana* are the primary dominant and subdominant species in Bayanbulak, the dominance is 0.6～0.7 and 0.3～0.6, respectively. As the result of the growing degeneration, the dominance of these two plants drops from 0.6 to 0.2, even to zero. But the dominance of those plants like *Astragalus alpinus* and *Leymus ovatus* which have a bad palatability and are suitable to grow in the sandy soil increase from 0.3 to 0.6, even forms the sole community. In the mild, moderate and serious degenerated rangeland, the ground biomass are 1500～2250, 750～1500 and 750kg/hm^2; the proportions which *S. purpurea* occupies are above 85%, 65% and below 50%; the dominance are 0.6～0.7, 0.3～0.6 and below 0.3, respectively. Mild degenerated rangeland: The primal synusia of community has not got obvious change, but the fine grass yield reduces. The dominance of *S. purpurea* is above 0.6, and the total coverage is above 50%. Moderate degenerated rangeland: the herbage synusia becomes constructive species, the percentage of participating increases to 70% above; the fine grass steps down for the associated synusia, the percentage of participating falls to 30% below. The primal vegetation is replaced by other inferior herbages; as a result the fine grass proportion drops. The dominance of *S. purpurea* is 0.3～0.6, and the total coverage is 30～50%. Serious degeneration rangeland: The typical characteristics are soil desertification, basification, and surface exposition. The percentage of participating is smaller than 50%; inferior herbages become the dominant synusia. The dominance of *S. purpurea* is below 0.3, the total coverage is below 30%.

Conclusions (1) Taking *S. purpurea* as the dominant species, with the consideration of the total coverage, Bayanbulak rangeland may be divided into the mild, the moderate and the serious degeneration. (2) degeneration area of Bayanbulak rangeland reaches as high as 291400 ha, accounts for the total area 64.38%, in which the serious degeneration takes 91867 ha, accounts for 20.3%, Moderate degenerated is 96698 ha, 21.36% and Mild degenerated covers 102835 ha, 22.72%.

Besides climatic factor, the main reasons for the degeneration of Bayanbulak rangeland are the unreasonable herds system and the overloaded domestic animal. Regarding rangeland degeneration, some countermeasure should be proposed initially: for the serious degenerated, herd is forbidden; for the moderate degenerated, herd should be adjusted of seasonal variations and be rotational grazing; for the mild degenerated, herd should be in the delimited area with rotational grazing.

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Effects of desertification on C and N contents and storages in Horqin sandy grassland , northern China

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Key words : desertification ; carbon and nitrogen ; content and storage ; sandy grassland ; northern China

Introduction Sandy grasslands are widespread in northern China , where desertification of grassland is very common because of overgrazing and wind erosion . However , very little is known about the effects of desertification on grassland C and N contents and storages in this region .

Materials and methods A field experiment was conducted in the Horqin sandy grassland during 2003 to 2004 , where degree of desertification gradients could be utilized to evaluate C and N contents and storages in plant , litter , and soil components relative to the degree of desertification .

Results The results showed that that (1) land desertification could result in significant decreases in soil carbon and nitrogen contents , but the decrease of carbon and nitrogen contents in the plant and litter was not significant in the desertification processes ; (2) the carbon and nitrogen storages decreased significantly with increase of grassland desertification degrees ; the carbon and nitrogen storages lost by the desertification reached up to 107 .53Mt and 9. 97Mt in Horqin Sand Land during the last one century , and the average amounts lost per unit area were 3 .6 kg/m^2 and 0 .3 kg/m^2 ; (3) the 92-96% carbon storage and 96-97% of the nitrogen lost by desertification came from soil organic C and total N ; the carbon and nitrogen storages lost in plants and litter accounted only for 3-7% and 2-3% of total lost carbon and nitrogen storage ; (4) most of the carbon and nitrogen in the grassland are lost in early stages of the desertification process (in the light and moderate desertified stages) , the amount of carbon and nitrogen lost was less in later desertification stages (in the heavy and severe stages) ; (5) the loss of soil organic C and N storages results mainly from decrease of nutrients-rich soil fine particles eroded by wind . The decrease of plant and litter carbon and nitrogen storages results mainly from loss of soil potential productivity .

Effect of anthropogenic disturbances on plant functional groups diversity, composition and ecosystem stability of meadow in Kanasi Reserve

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Key words: anthropogenic disturbances, plant functional groups composition, plant functional groups diversity, ecosystem stability, Kanasi Reserve

Introduction Human-driven grassland ecosystem degradation has highlight questions about how the number and composition of plant functional groups in a grassland ecosystem influence its functioning (Tilman D. et al., 2006). Although biodiversity and composition are now known to affect grassland ecosystem productivity (Tilman D. et al., 1997), their effects on stability are debated.

Methods Here we present the dependence of the temporal stability of ecosystem and functional groups (shrubs and half shrub, perennial bunch grasses, perennial rhizome grasses, sedges, forbs, legumes, annuals and biennials) on plant diversity in a short-term meadow experiment that divided into four disturbance intensities (light, moderate, heavy and over) and established 100 plots. Ecosystem stability is defined as S = standard deviation of aboveground biomass within each plot/mean aboveground biomass. Functional groups dominance is defined as D = (relative height + relative density + relative coverage + relative biomass)/4. We determined functional groups diversity and ecosystem stability with the use of 2 years (2006-2007) of data collected annually on plant species, individual height, density, coverage and aboveground biomass within each plot (0.5m × 0.5m). The regression of aboveground biomass on functional groups diversity was analyzed with the use of *repeated measures MANOVA*.

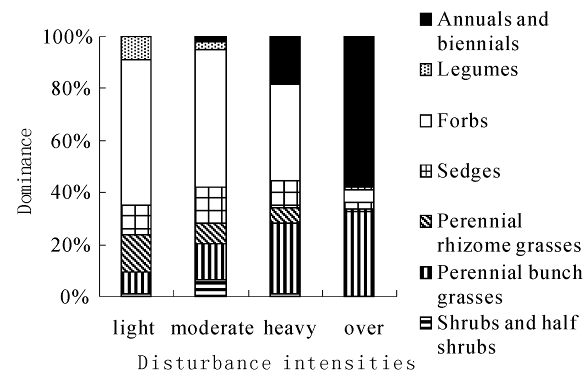

Figure 1 *Changes of functional groups dominance under four disturbance intensities.*

Results and discussions The dominance of perennial bunch grasses, annuals and biennials increased with increasing disturbance intensities, on the contrary, perennial rhizome grasses, forbs and legumes decreased (Figure 1). The results showed that perennial bunch grasses, annuals and biennials have greater endurance and resilience to disturbance, whereas perennial rhizome grasses and legumes have more sensitivity. The treatments of light and moderate disturbance intensities had lower standard deviation (lower risks) for a given mean biomass (return) (Figure 2). The results showed that lower disturbance intensity leads to less ecosystem productivity fluctuation and greater ecosystem stability.

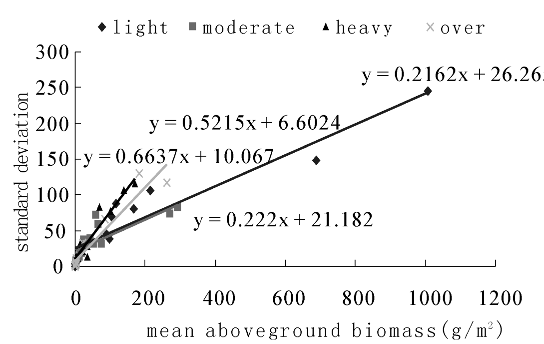

Figure 2 *Effects of disturbance intensities on ecosystem stability.*

Conclusions Perennial bunch grasses, annuals and biennials have greater endurance and resilience to disturbance and they can adapt to more intense disturbed habitat. Whereas perennial rhizome grasses and legumes have more sensitivity to disturbance and they can adapt well to equable" habitat. The greater ecosystem stability of lower disturbance intensity plots resulted from their having lower standard deviation. In total, on average across the two years of measurement, ecosystem stability was significantly dependent on the changes of functional groups composition and diversity under different disturbance intensities.

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The influences of coal mining collapse on the saturation conductivity of soil In Maowusu sandy land

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Key words: Coal mining collapse, Saturation conductivity, Maowusu sandy land

Introduction The saturated conductivity is an important character for soil properties, which is a significant water power parameter for soil water movement to research. The saturated conductivity is a function for texture, weightiness and hole distributing character of soil, the hole distributing character of which has had a great affect on the saturated conductivity.

Materials and methods Three sampling area were selected, which were no-collapse area, one - year area and two-year collapse area. The soil samplings were collected from 3 areas in Maowusu sand land. Twenty-seven soil samplings were sampled from each site in three different depths by the 100ml loop sword. The sampled soil samplings were prepared to measure the saturated conductivity by water-pressure change method. The results were discussed on the change in different depth and different areas. The measured data were compared with the soil hole. The saturated conductivity and hole of soil were analyzed by using SPSS 11.0 to generate correlation coefficient. The variety is analyzed by ANOVA method.

Results There were great correlation in between the saturated conductivity and hole of soil, the correlate coefficient is amount to 0.83 ($P<0.05$). The saturated conductivity of soil is 0.0082cm/s in no-collapse area, 0.0089cm/s in one - year area, 0.0102cm/s in two-year collapse area. The influence is the greatest in 50 centimeter, the smallest in 10 centimeter. Comparison with no-collapse area, collapse area was added evidently in 50 centimeter and 30 centimeter. Three areas nearly vary in 10 centimeter. In one - year area and two-year collapse area the saturated conductivity were respectively greater 12.0% and 33.9% than that of no-collapse area in 50 centimeter, 10.2% and 32.4% in 30 centimeter.

Table 1 *The saturated conductivity of diversity sampling site.*

Conductivity	Repeating sampling1	Repeating sampling2	Repeating sampling3	Average
no-collapse area	0.0078	0.0080	0.0087	0.0082
one - year area	0.0088	0.0098	0.0080	0.0089
two-year collapse area	0.0117	0.0083	0.0106	0.0102

Conclusions Coal Mining Subsidence added the ventilate dank hole quantity. Granule substance with rainfall is moved so that soil hole is enlarged. Comparison with no-collapse area, the saturated conductivity of soil in each layer is added in collapse areas, which is greater in deep layer than in shallow layer.

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Discussion the signification of Chinese grassland reclamation reasons in the historical period

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Key words: grassland, history, reclamation

Introduction There are about 400 million hectares grassland in China, which accounts for more than 40% of the land area. Grassland is not only the production base of the animal husbandry, but also the ecological environment protection. According to some relative reports: 90% of grassland in China has problems of degradation, desertification, salinization, and erosion in different degree which is mainly caused by reclamation. The ecological impacts on several large-scale reclamations in the past have not recovered yet. Therefore, this article combining the current situation of Chinese grassland, concluding historical mistakes, taking history as a mirror, reasonably developing and utilizing grassland, managing it scientifically, correctly adjust the relationship among population, resources and environment, let the dream of sustainable harmonious development between human and nature to be true.

Methods This article aimed at reclamation of Chinese grassland in the historical period, concerning fields such as history, geography, Grassland science, and so on. Therefore, this article uses the method of historical research, based on abundant work on collection and looking up references, analyze and compare the direct or indirect information and material, via summarizing and interpreting to educe the research results. The references include books and magazines on geography, history, nomads, Grassland science, agricultural history, farming and so on.

Conclusions according to the compare between the analysis of the history of reclamation of Chinese grassland and situation of reclamation after the foundation of PRC, it can be concluded:
(1) After the emergence of human activities, there was a close relationship between China grassland and human activities has close links. With population growth and social development, human started reclaiming the prairies. Since then, human beings evolved developing the grassland from relying on the grassland. The reclamation of grassland has caused the adverse impact to grassland and ecology. This impact is still unable to resume.
(2) Though out several large-scaled reclamations in Chinese history, the reasons of reclamation can be summarized as: ① migration for the supplement of the army mainly during Qin, Han, and Ming dynasties; ② for the shortage of food caused by the increasing population mainly during Tang and Qing dynasties; ③ for gaining economical benefits mainly during Public of China.
(3) Though the compare between history and nowadays, it can be found that solving the problem of food shortage and gaining the economical benefits as the two main reasons for the reclamation are very meaningful. Now we realize that reclamation can only currently solve the food shortage but not for a long term, instead it would make the ecological and environmental problems worse. Therefore, we should draw lessons from history, protect grassland, develop grassland rationally, manage grassland scientifically, handle the interaction of population, resources, and environments correctly, and realize the harmony between human beings and nature.

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Effects of the artificial grassland reconstruction on the soil nutrients and enzyme activity in the degraded red soil

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Key words: artificial grassland, reconstruction, soil nutrients content, soil enzyme activity, degraded red soil

Introduction It is an important stratagem of solving the conflict between short supply of food and lack of arable land to reconstruction the artificial grassland in the subtropical hill regions in southern China (Ouyang *et al*. 2007). And planting forage in the degraded ecosystem also help to accelerate the establishment of environment, especially have the good effects of increasing the soil nutrients content and the enzyme activity.

Materials and methods The site was on a hill pasture in Jiangxi agricultural university, north of Nanchang, China (116°0'E, 28°22'N, altitude 61.2m, gradient 15°). The soil was red soil. Treatments were: (Ⅰ) Natural grassland, with the natural vegetation of *Imperata cylindrica*, *Miscanthus sinensis* etc.; (Ⅱ) Pure pasture of *Lespedeza cuneata* and (Ⅲ) Pure pasture of *Paspalum wettsteinii*. In sown pastures 1250kg/hm^2 of lime and 22500kg/hm^2 of stable manure were applying before establishing the pasture. In June of the next year, the pH value, total nitrogen (TN), phosphorus (TP) and potassium (TK), and the activities of catalase, acid phgatase and urease in different soil layer were determination.

Results The results were in Table 1. In three grasslands the soil nutrient content (except TK) and the enzyme activity generally decreased with soil depth. In the established artificial grasslands, the soil pH rose, the soil nutrient content (except TK) and the enzyme activity in all soil layers were increased. These effects of treatment Ⅲ were better than treatment Ⅱ (except TN). These effects in the upper soil depth were more distinct than those in the lower soil depth.

Table 1 *Effects of constructing artificial grassland on soil nutrients and enzyme activity (cm, g · kg^{-1}, mg · kg^{-1}).*

	Soil layer	pH	TN	TP	TK	catalase	acid phgatase	urease
Ⅰ	0～5	5.27±0.23^{B}	0.65±0.11^{C}	0.54±0.02^{C}	11.93±0.13^{AB}	18.72±3.29^{Bc}	0.31±0.07^{Cc}	0.56±0.05^{Aa}
	5～10		0.43±0.05^{D}	0.66±0.05^{C}	12.34±0.22^{A}	6.07±2.11^{De}	0.16±0.02^{Ee}	0.38±0.07^{Bc}
	10～20		0.30±0.03^{E}	0.34±0.03^{D}	10.62±0.08^{B}	3.11±0.97^{Fg}	0.05±0.01^{Ff}	0.25±0.01^{CDe}
	20～30		0.27±0.04^{E}	0.33±0.05^{D}	12.81±0.27^{AB}	2.00±1.84^{Gh}	0.05±0.01^{Ff}	0.23±0.01^{Df}
Ⅱ	0～5	6.13±0.19^{A}	1.35±0.27^{A}	1.25±0.04^{AB}	9.96±0.16^{C}	24.81±3.37^{Aa}	0.36±0.04^{BCb}	0.57±0.06^{Aa}
	5～10		0.90±0.09^{B}	0.73±0.02^{C}	9.30±0.20^{C}	17.12±3.06^{Bc}	0.40±0.02^{Bb}	0.50±0.03^{Ab}
	10～20		0.50±0.06^{CD}	0.34±0.01^{D}	11.12±0.24^{B}	4.63±1.68^{Ef}	0.24±0.02^{Dd}	0.26±0.01^{CDe}
	20～30		0.43±0.21^{D}	0.34±0.01^{D}	10.31±0.29^{B}	3.37±0.41^{Fg}	0.05±0.01^{Ff}	0.26±0.01^{CDe}
Ⅲ	0～5	6.34±0.04^{A}	1.08±0.39^{B}	1.57±0.04^{A}	13.70±0.16^{A}	26.01±2.99^{Aa}	0.51±0.06^{Aa}	0.61±0.07^{Aa}
	5～10		0.84±0.17^{B}	1.18±0.05^{B}	10.58±0.08^{BC}	21.46±2.03^{Ab}	0.37±0.02^{Bb}	0.52±0.04^{Ab}
	10～20		0.40±0.03^{D}	0.39±0.01^{D}	12.91±0.15^{AB}	7.66±1.54^{Cd}	0.17±0.01^{Ee}	0.30±0.01^{Cd}
	20～30		0.29±0.03^{E}	0.30±0.01^{D}	11.51±0.06^{AB}	4.06±1.78^{Ef}	0.06±0.00^{Ff}	0.27±0.01^{CDde}

Discussion Reconstructing artificial grassland could increase soil nutrients content and enzyme activity through planting herbage and managing grassland. Which also enhance the differences of the vertical distribution of soil fertilizer in different soil depth. The effect of planting grass was better than planting legume in short times.

Reference

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Research on classification criteria of Heitutan (black soil beach) degraded grassland in Sanjiangyuan region

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Key words: Heitutan degraded grassland, classification criteria, alpine meadow, Qinghai-Tibet Plateau, Sanjiangyuan region

The severe problems of ecosystem environment in Sanjiangyuan, in which was the source of Yangzi, Yellow and Lan-Cang-jiang River in southern Qinghai of China, were extensively attracted by lots of researchers around the world, especially problems of Heitutan degraded grassland. To restore Heitutan degraded grassland on alpine meadow, the research of classification criteria of Heitutan (black soil beach) degraded grassland in Sanjiangyuan was conducted in this paper. The sites were located in Sanjiangyuan region, in which was part of Qinghai-Tibet Plateau. The Heitutan degraded grassland was formed by human activities, overgrazing, rodents and so on conditions, it was not a normal type. Its species composition, community structure, biodiversity, biological productivity, soil and micro-environment, and other aspects of the degraded grassland system have obviously changed compared with its original state of equilibrium or evolutionary succession in the natural system. Therefore, the indicators selected were not consideration climate factor, only selected the vegetation cover, a stone cover aboveground, advantages of four kinds of economic groups, edible forage ratio, the effective numbers and the average numbers of rodent holes, the average rate of rodent destruction, soil thickness, number of layers and slope, and elevation, as a total of 14 kinds of indicators of the degraded grassland for cluster analysis. Test plots were located in the seven counties of Sanjiangyuan areas, total of 45 plots. In each plot, the 14 indicators were determined, which above mentioned.

Using hierarchical cluster analysis of statistical software SPSS 11.50 to cluster, the cluster method adopted between-groups linkage. The coefficient of the distance adopted squared Euclidean distance. The scope of the changes in each index was relative larger, therefore, data standardization choice Range (-1, 1), and the graphics output using Dendrogram in the process of clustering.

According to key indicators of all degraded grassland, the classification criteria of Heitutan degraded grassland were sorted out from 45 plots in Sanjiangyuan (Table 1).

Table 1 *The classification criteria of Heitutan degraded grassland in Sanjiangyuan.*

Heitutan degraded grassland		The average number of hole (per/ha)	Dominance poisonous weeds	The proportion of edible plants (%)	Stone coverage aboveground (%)	Vegetation coverage (%)	Cyperaceae dominance
Original type		0-400	0-20	70-100	0-10	80-100	30-50
Middle		400-1000	20-30	50-70	10-30	60-80	20-30
Severe		1000-4000	30-50	40-25	30-50	80-60	10-20
Extreme		>4000	>50	0-25	>50	0-50	0-10
Beach	Middle	<1000	<30	>55	<15	<30	>20
	Severe	1000-4000	30-50	25-55	15-50	30-80	10-20
	Extreme	>4000	>50	<25	>50	>80	0-10
Slope	Middle	<1000	<30	>55	<30	<30	>20
	Severe	1000-4000	30-50	25-55	30-50	30-80	10-20
	Extreme	>4000	>50	<25	>50	>80	0-10

Note: the beach slope: 0^0-7^0, slope gradient: 7^0-21^0.

Through cluster analysis methods, the classification criteria of Heitutan degraded grassland in Sanjiangyuan were researched. There are different classification criteria in different degraded grassland. From primary grassland to extreme degraded grassland, the numbers of grassland classification were 3, 12, 8 and 4 separately, because of community competition. This was showed that primary grassland and extreme degraded grassland type were both less number types than middle and severe degraded grassland, in which the community competition were of intensity. The Heitutan degraded grassland could be divided two kinds of ecological types, which were beach and slope. Each ecological type could be divided into middle, severe and extreme degraded grassland type. The classification indicators of Heitutan degraded grassland included the average numbers of rodent holes, dominance poisonous weeds, the proportion of edible plants, stone coverage aboveground, vegetation coverage, and Cyperaceae dominance. Community types of extreme Heitutan degraded grassland were quite simple and their communities tend to stability. The change of degraded types of that was relative less, but in middle and severe degraded type, grassland vegetation was not stable, community competition was intense, and its community structure was complex, especially the middle degraded type. The management measures of all kinds of degraded grassland were proposed.

Population dynamics of soil microorganisms in deteriorate grassland in West Region of China

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Key words: soil microorganisms, population dynamics, nitrogen bacteria group, deteriorate grassland, habitat

Introduction Animal husbandry is the most important sector of West Region of Chinese economy, and it accounts, for example, 45.36% and 50.06% of total agricultural output value in Inner Mongolia and Sichuan province respectively (CAYEB, 2006). In recent years, sustained overgrazing and rodent s destruction are responsible for more than 50% degradation of grassland in western China, which causes serious social and economical problems in the region. To prevent deteriorate, intensive multidisciplinary researches have been performed. However, there is little documented information on microorganisms population changes in the region though it is well known that soil microorganisms play an important and vital role in grassland ecosystem. The objectives of present study focused on enumerating and detecting different groups of microorganisms population dynamics in the region.

Materials and methods The study was carried out at Tianzhu alpine grassland experiment station (37°11'-37°13' N, 102°29'-102°33'E) of Gansu agriculture university, northeastern of Tibet plateau in China. Soil samples were collected (0-40cm in depth) and treated as described by Xu and Zhang (1986) at three sites (Table 1) in June, August and October in 2003 and 2004 respectively. The number of soil microorganisms (fungi, actinomycete and bacteria) and nitrogen bacteria group (ammonifying bacteria, nitrobacteria, diazotroph and denitrobacteria) were enumerated by plate colony count or MPN method (Xu and Zhang, 1986).

Table 1 *Basic condition of sample sites.*

Sample site	Vegetation	Soil						
	Main species	CO	HE	pH	WC	OM	TN	TP
Rodent hill	*Microula sikkimensis*, *Elsholtzia ciliate*, *Polygonum viviparum*, *Oxytropis* spp., *Potentilla chinensis*	37	33	8.0	19.80	10.91	0.50	0.043
Unfenced grassland	*Kobresia bellardi*, *Carex* spp., *Iris chinensis*, *P. viviparum*, *O.* spp., *Stellera chamaejasme*, *P. chinensis*	41	22	8.0	18.41	10.83	0.45	0.042
Fenced grassland	*K. bellardii*, *C.* spp., *O.* spp., *Stipa capillata*, *P. viviparum*, *P. fruticosa*, *P. chinensis*, *Cyperus* spp.	82	41	7.8	24.42	12.22	0.64	0.058

CO: coverage (%); HE: height (cm); WC, OM, TN and TP means percentage of water content, organic matter, total N and total P respectively. Rodent hill: original vegetation damaged; Unfenced grassland: nearby animal road, tight soil.

Results and discussion The number of soil microorganisms and nitrogen bacteria group in serious degradation grassland (unfenced grassland and Rodent hill) were much less than those in slight degradation ones (Fenced grassland) (Table 2), and their distribution tendency with temporal change showed Low (June)-high (Aug.)-lower (Oct.)" pattern except fungi showing high (June)-Low (Aug.)-lower (Oct.)" pattern in plant growth period (Figure not shown). Moreover, predominant species of fungi, *Aspergillus*, *Rhizopus*, *Penicillium* and *Mucor*, were similar while their numbers varied with habitat (fenced grassland was higher than the other two habitats, data not shown). This was due to vegetation and soil condition significant difference in three habitats (Table 1). The number of microorganisms in this study was distinctly low compared to those obtained by Zhao (Zhao *et al*, 1984, the same method and sites) because of grassland deteriorated. The results clearly illustrated the important decline of soil microbial population associated with the deterioration of grassland. Therefore, it is very important to take soil microorganisms into account when utilization and management grassland.

Table 2 *The number of soil microorganisms and nitrogen bacteria group in different habitats* $\times 10^4$/*g dry soil.*

Habitat	Fungi	Actino-mycetes	Bacteria	Ammonifying bacteria	Nitrobacteria	Diazotroph	Denitro-bacteria
Rodent hill	0.30^a	170^b	807^b	804^b	0.18^b	5.03^b	1.02^b
Unfenced grassland	0.22^b	155^b	580^c	518^c	0.11^b	4.12^c	0.97^b
Fenced grassland	0.32^a	255^a	1302^a	1170^a	0.53^a	6.16^a	2.13^a

The data in the table is an average of 2003 and 2004; Letters different mean significant level ($P<0.05$)

Conclusion The number, as well as distribution, of soil microorganisms and nitrogen bacteria group varied greatly with habitat, it was much higher in slight degradation grassland and summer than in serious degradation grassland, autumn and spring.

Indicators and characteristics of degenerated grassland in China

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Key words : grassland degradation , index of degeneration , degradation hazards

There are more than 400 million hm^2 of grasslands in China , and more than 80% are in various degrees of degradation . Degredation of China s grassland ecosystem contributes to productivity constraints . Grassland degradation is the deterioration of structural characteristics , material recycling , energy flow and other characteristics of grassland ecosystems , that is , the biological communityand the physical environment required for their survival .

Grassland degradation diagnosis Ren Ji-zhou academician proposed a three threshold value" , that is , a health threshold value , a warning threshold value , and an unhealthy threshold value based on soil stability and nutritive value and energy flow distribution mechanism for restoring three indicators . He established a scale for evaluation of grassland health and function , and pointed out that it is the grassland degradation process which leads from the threshold value for healthy grasslands to the threshold value for collapsed systems . Finding the line between the two thresholds from the threshold for health to the unhealthy threshold , is the key for determining whether grassland degradation is occurring(Hu Tian-ming . 2001) .

Degraded grassland classification and evaluation indicators Grassland degradation is a process , that is , it occurs over a period of time from initial decline to extreme degradation of the grassland . The degree of degredation can be divided into four stages : mild , moderate , severe and extreme . Indicators of these stages include plant species composition , dominant plant cover , litter , plant biomass , wildlife species composition and condition , soil conditions , etc . . .These indicators and their status play an important role in theoretical study and practical applications(Shi Zhi-Cheng . 2001 ,Liu Wei , Qi-Ji Wang , et al . 1999) .

Degradation causes Over-grazing is the main reason for grassland degradation . Under natural conditions the unit area of grassland can only maintain a certain number of livestock . If frequent , unrestricted excessive grazing by livestock occurs , adequate regrowth will not occur . There is no time to accumulate organic matter , production decreases , and dwarf shrubs become more common . In addition , good forage , those species preferred by livestock , are most affected by overgrazing , while toxic species are favored Over the long-term xcessive livestock trampling increases soil compaction , resulting in lower permeability , increased flooding , and further deterioration of soil properties . In grasslands , many other human impacts also lead to degradation(Zhou Hua-kun . 2002 , Hu Tian-ming . 2001) .

Grassland degradation hazards Grassland degradation simplifies plant communities and soil properties deteriorate ,with the result that grassland structure and composition undergo great changes . Subustantially reduced productivity and potential stocking levels are not the only impacts of degredation , biodiversity loss is also a major concern . Studies show that with grassland degradation , species richness and evenness are greatly reduced (Li , Jiang . 2002) . And as degradation continues , soil physical , chemical and biological characteristics are adversely impacted . Nutrients and physical properties decline and plant growth is further restricted . Soil water-retention capacity is also decreased , thus affecting the environment , and leading to ecological decline and potential natural disasters(Li , Yong-hong , Chen Zhong . 1999) .

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Quantitative analysis on different degeneration stage of meadow steppe in Hulunbeier, Inner Mongolia

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Key words: systematic cluster; range site; degeneration stage; threshold

Introduction Range condition in North America have been using for half a century, this method as well as some grassland monitoring methods manual are mainly based on the changes in plant species composition of succession to stage or stages of degradation, it can reflect years interference (eg, grazing) the results, but certain methods are important as an indicator species, and neglected the role of other plant species, it can only choose the neglect of other important species of plant species were discussed this issue.

Materials and methods Use the same range site, to settlements for the Centre to set up three line, and each line every 50 m based on a sample point, three line of a total of 240 samples. Each sample around random set five of the $20 \times 50\text{cm}^2$ quadrat, a total of 1,200 quadrat, the quadrat of all plant species within the projector coverage, and many of the biomass (dry weight). The calculation dominance of all plant species, will be the corresponding quadrat the average get an average of 80 data and the use of fuzzy systems SAS8.0 cluster analysis method.

Results According Demirmen (1972) indicated that the principle of Class identified, found two adjacent points of the close coefficient big jumps, the average coefficient two adjacent points is a threshold value, with the actual situation of the grassland, grassland can be of Class three (fig1, 2: Ⅰ、Ⅱ、Ⅲ、and ⅰ、ⅱ、ⅲ).

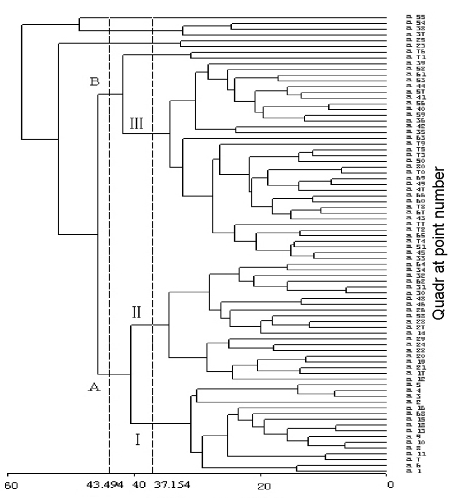

Figure 1 *The dendrogram of cluster analysis by summed dominance ratio of seven main species.*

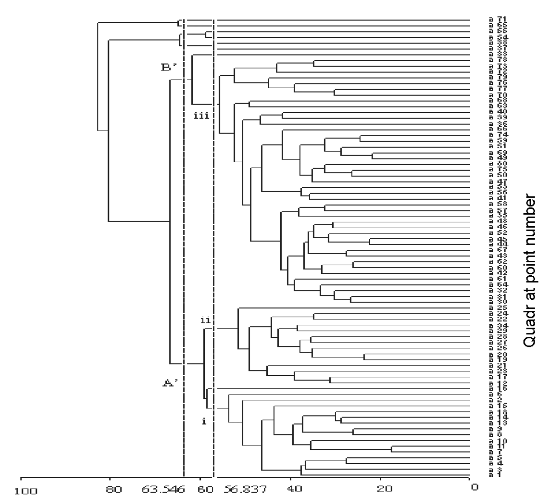

Figure 2 *The dendrogram of cluster analysis by summed dominance ratio of all species.*

(A、B、Ⅰ、Ⅱ、Ⅲ、A'、B'、ⅰ、ⅱ、ⅲ indicated the mark of different distance coefficient)

Conclusion Although indicators different, but the results of the same cluster. Use of all plant species cluster, the threshold value of 56.837 for the three class, threshold coefficient span the distance smaller, larger than 37.154 of threshold value at the same time use the main plant species cluster, these showed that the use of all Clustering of plant species than the main species to the effect of clustering poor, but the amount of information to include the whole, the mosaic kind of small points, sample points of the relationship more clear. This may be other non- dominant species added to the trend of the degradation of the dominant plant species and occupation.

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Influence of composition ratio of herbage and shrub on roadside vegetation characteristics along Bi-Tong Highway

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Key word: Slope protection, vegetation restoration, shrub and herbage mixture, community diversity

Introduction Highway plays important role in promoting the development of Chinese economy (Forman R, 2002). With the increase of Highway in China, great attentions have been paid on the eco-environmental issues caused by slope cut and plant clearance including soil and water erosion, habitat loss, air pollution etc. This study was conducted to address the influence of re-vegetation of shrub and herbage mixtures on vegetation community including species composition, distribution pattern, community diversity etc. The findings of this study can be used as reference for restoring the roadside vegetations destroyed by highway construction in the similar geographical areas.

Materials and methods This study was conducted along the roadside of Bi-Tong Highway in Tongbai County (N32°23′, E113°28′), which is in a transition zone between subtropical and temperate. The yellow soil in the sample site is very poor in terms of fertility. The native vegetation is broadleaf forestry, which degraded seriously due to long-history human activity. The characteristics of road vegetation along roadside including species composition, plant cover, plant density and species diversity were sampled in 3 repeated 5m×5m quadrats. The collected dada were statistically analyzed by using software of SPSS 15.0.

Results The results show that *Leguminosae*, *Gramineae* and *Compositae* dominated the plant community and play important roles in the re-vegetated plots. The density, coverage, height and biomass of re-vegetated communities increased gradually with the increased density of planted herbages. The highest value presented when the seeding rate of herbage reached 700 plant · m^{-2}. The species richness (Margalef index), plant diversity (Shannon-Wiener index) and Pidou evenness index tended to increase with species density at the beginning, but decreased when the seeding rate of herbage was over 500 plant · m^{-2}. With the increase of seeding rate of herbage, the species similarity between planted communities and naturally restored communities decreased first and increased thereafter. This indicates that the type not density of the species planted plays important role in community composition. 500 plant · m^{-2} of seeding rate of herbage is appropriate to prohibit the ruderal from invading into restoration plots, to promote plant coverage and increase the similarities of planted community to naturally restored communities.

Conclusion The configuration of plants in the re-vegetation is helpful to boost the progressive succession of plant community. The moderate seeding rate of herbage can increase the community diversity index.

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Grasslands/Rangelands Resources and Ecology

——Water Resources in Grasslands/ Rangelands

Rangeland management and hydrology

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Key points : Rangeland improvements have included techniques to manipulate the hydrologic cycle on rangelands . Grazing practices have been designed to minimize soil erosion and maximize water use by plants .

Key words : Runoff , erosion , infiltration rate , watershed , water harvesting , grazing management , range improvement techniques

An early range saying was , It takes more than the twinkle in a bull's eye to produce cattle on the western range ." This referred to the western U .S .A .but probably applied to most rangelands of the world . Indeed the entire rangeland ecosystem needs to be understood to raise cattle and the many other rangeland products and services . An important part of rangeland ecosystems is the hydrologic cycle as water is the fluid of all life . This paper examines the historical perspective of rangeland developments and improvements as they relate to the hydrologic cycle with most emphasis being a North American perspective .

Early hydrology research

Hydrology has its roots as a science with ancient civilizations . There is evidence of canals , aqueducts and irrigation infrastructure that existed about 3 ,500 BC . The phoenicians constructed rock-wall terraces to hold the soil after they cut the Lebanon cedar forests . Vitruvius , centuries later , believed in the pluvial origin of springs and Palissy (1510-1590) stated categorically that rainfall was the only source of springs and rivers . In the 17th century , Pierre Perrault and Edmé Mariotte of France and Edmund Halley of Great Britain undertook hydrological research of modern scientific type so that they may well be regarded as the founders of hydrology . The 18th century saw the beginnings of systematic river flow measurements on several continents . In the 19th century , William Smith in England connected geology with groundwater , and Darcy laid the foundation of groundwater theory . Enormous advances in hydrology were made during the 20th century , especially in conservation ; irrigation ; flood control ; remote sensing ; and ground , surface , and atmospheric modeling . Scientific advances continue into the 21st century .

Early range research

In contrast , range science is less than 100 years old , originating during the 1930's as a discipline offering university degrees . The need for systematic methods of rangeland assessment first became apparent when Jared Smith was sent by the U .S . Botanical Survey in 1895 to study the causes of the deterioration of western U .S .A .rangelands that had been widely reported in the late 1880s . Many range research methods and techniques have been developed at a rapid rate since the 1930's . The first textbook in hydrology was Nathaniel Beardmore's *Manual of Hydrology* published in 1862 . The first textbook called *Range Research-Basic Problems and Techniques* was published a hundred years later in 1962 .

Bringing hydrology and range research together

Hydrology and range science came together following flooding from overgrazed alpine areas of the Wasatch Mountain in Utah , USA . Research led to changing the kind and number of livestock using the watersheds . Hence , runoff and erosion studies began on rangelands in the U .S .A .before those on croplands (Columbia , Missouri in 1917) and forestlands (Wagon Wheel Gap in Colorado in 1910) and at locations farther west . Grazing studies in relation to watershed management , initiated in 1920 on the Tonto National Forest in Arizona U .S .A . , helped lay the foundation for recognition of the value of such studies in western watershed management . Studies on erosion and flood problems in California included consideration of grazing of rangelands .

When considering the many hydrologic-related perturbations that may be applied to the various combinations of plants , soils , and climates , it is obvious that the hundreds of publications on rangeland watershed management are really insignificant in describing the effects of upland treatments on water yields , sediment yields , and dissolved solids in runoff .On rangelands , treatment effects over many years are difficult to separate from the effects of natural climatic fluctuations during the same years .Both watershed and plot studies are required to provide this information .Watershed studies on most rangelands are characteristically long term .If two gauged watersheds are being compared , twenty-five to thirty runoff events are often needed for calibration before one watershed is treated .These twenty-five to thirty runoff events may not occur for many years .Gauging equipment is quite expensive . Homogeneous watersheds are often difficult to locate for pairing . Finding three or four homogeneous watersheds is often impossible—therefore , small , unreplicated samples are often used .After several more years of evaluating treatment effects , too few publications usually came from these large , long-term investments ; thus , plot studies have been very popular in the past 50 years for evaluating watershed variables .

One of the pioneers of small rangeland watershed plot studies was Frank Rauzi in the 1950s in the northern Great Plains of the U .S .A . Simulated rainfall was applied to small plots to measure infiltration rates and sediment yield in various plant-soil complexes under various management schemes .This type of research had been conducted by other researchers since the 1930s , but Rauzi applied the techniques widely under numerous conditions .His publications are referenced in most of the Literature Cited Sections" of infiltration publications today .

Post-world war II range improvement practices

Since World War II , rangeland watershed research and application have had a two facet approach .Cheap energy allowed drastic mechanical range improvement practices to be applied to vast areas of western rangeland .A principal goal of many of these practices was increased infiltration rates , which reduced runoff and erosion .These continued until 1973 , when increased energy prices allowed these practices to be used only on rangelands with high potential for forage response or special areas , such as mine tailings or highways and roadways .Range improvement practices since 1973 have had to depend on favorable responses coming during an extended period of time .This has also been an experimental period , with many modeling and prediction efforts and with many environmental concerns being voiced . Watershed researchers have found that hydrologic condition is generally correlated with range condition and seral stage .As a range site experienced plant succession from parent material through the stages of soil development to climax , the infiltration rates increased and sediment production decreased . A retrogressive influence caused an opposite reaction .Many grasslands and savannas were historically depleted of woody shrubs and trees by the occasional occurrence of wildfires .This so-called pyric disclimax condition was interrupted by overgrazing by livestock and by a very successful century-long fire prevention program .This resulted in vast areas of rangeland becoming infested with shrubs and trees , which produced a decrease in forage production .It was also found that infiltration rates increased and erosion and sediment production decreased directly under the shrub or tree in an area influenced by the plant′s crown .In the interspaces between plants , the understory disappeared from overgrazing and competition from the shrubs and trees .Unless the soils were very sandy , the interspaces became highly erosive , which led to rapid retrogression in seral change . Therefore , the range improvement practices that were used to kill brush and trees such as rootplowing and chaining , also improved hydrologic condition—if a successful stands of forage plants were established .

Several range improvement practices were used solely to increase infiltration of the surface water .Contour trenching was used from the beginning of the 20th century through the 1960s .The trenches were most often built in alpine areas above the timber line and were 1 to 2 meters deep .The objective was to contain all water and sediment on-site .Costs were very high and had to be justified by the benefits to downstream wildlife and human inhabitants , through changes in quantity , quality and regimen control of runoff and ground flow .Rarely did the trenches increase forage production on-site because less productive soil from the subhorizons was piled on top of the topsoil during construction . Contour furrows were made extensively on rangelands prior to the increased energy prices of 1973 .The furrows were 1 .5 meters apart , 20 to 30 centimeters deep , and 50 to 75 centimeters wide .The capacity of the furrows exceeded 50 mm of precipitation , with an expected life effectiveness of about 10 years . However , a rather questionable benefit-cost ratio was derived .

Pitting on rangelands consists of forming with a notched disc on plows small basins that are commonly 1 to 2 m long , 20 to 30 cm wide , and 10 to 20 cm deep .Another type of pitter has a series of spike teeth on a rotary drum .The teeth punch holes in the soil surface that are narrow and about 22 cm deep , spaced about 1 m apart .The spike tooth pitters have generally failed , while the disc pitters have been used in the Great Plains of the U .S .A .for increased production of established plants and in the southwestern U .S .A .for establishment of grass seedlings . A technique related to pitting is a land imprinter that consists of a steel drum with angle irons welded to it that imprints a variety of geometric patterns on the soil surface . Infiltration increases with a reduction in runoff and evaporation , while water is routed to the plant roots .

Ripping to a depth of 1 m is used to break compacted soil profile layers that inhibit soil moisture penetration and root development .A large energy-consuming bulldozer is required .Results have been quite variable . For untreated soils in New Mexico , U .S .A .surface runoff was as high as 89 percent of storm rainfall ; annual erosion , as high as 4 ,640 kg per hectare . Ripping reduced runoff 96 percent and erosion 85 percent in the first year after treatment .Three years after treatment , the reductions amounted to 85 percent for runoff and 31 percent for erosion .

Waterspreading on rangeland involved diverting water from stream channels and distributing it over nearby flood plains or valley floor with a dam and a series of dikes .It can also involve the spreading of runoff water and decreasing its velocity to maximize infiltration before the water reaches a channel .Operation is mostly automatic whenever sudden , torrential storms result in overland flows .These systems of water conservation are often in conflict with water laws .Many of these systems have been very elaborate in the past , combining spreading dikes , respreading dikes , contour furrows , gully plugs , and check dams .A more recent dike arrangement consists of a series of crescent or horseshoe-shaped dikes with water spilling around the ends .Dikes are located such that water from one dike spills into another dike downslope .The freeboard was only 30 cm high and easily and quickly constructed with a motorized road grader .Soil moisture was increased from 15 to 40 percent in the top 60 cm of soil .

Specialized water harvesting techniques

A specialized area of rangeland watershed research and development since World War II has been water harvesting .This process involves collecting and storing water from land that has been treated to increase runoff .Many examples of water harvesting techniques have been used by ranchers , municipalities , and federal agencies for watering domestic livestock , municipal purposes , and wildlife .These developments have been given various names including guzzlers , trick tanks , paved drainage basins , catchment basins , and rain traps .Nearly all designs have a water-collection area or apron , a storage tank , and a watering trough .Size varies from a few square meters to thousands of hectares .The small designs are used for watering small animals such as upland game birds .An example of water harvesting for a municipality is the city of San Angelo , Texas , U .S . A .which depends on surface runoff to supply municipal needs .Large reservoirs were constructed adjacent to the city ; but in the mid 1970s they were nearly empty from drought .City officials inquired about techniques to increase runoff from the collection area that was covered by a mesquite (*Prosopis* sp .-short grass community .Controlling the brush increased runoff and decreased evapotranspiration rates . Grazing the shortgrass increased the runoff but fecal material , at some level of concentration , would be added to the runoff . If overgrazing occurred , excessive sediment was suspended in the runoff .The problem was at least temporarily solved by brush control and an end of the drought . Other methods of water harvesting include : water collection form naturally impermeable areas such as slick rocks ; treating the soil with chemicals so that they become impermeable ; and covering porous soils with corrugated roofing , plastic sheets , aluminum sheets , or heavy roofing materials .Although initial costs and maintenance demands are great , water harvesting may be the only practical method of developing water in certain areas .In many areas , these techniques do not require water rights .They may be less expensive than hauling water and at the same time minimize energy demands and water pollution problems .

Hydrologic implications of grazing management

The hydrologic effects of ungulate grazing were first considered in the 1970's . Grazing schemes use one to several herds in one to many pastures or paddocks were being tried and investigated in many areas . At the 1st International Rangeland Congress in Denver , Colorado , USA in 1978 , Alan Savory introduced his grazing methods that often consisted of many paddocks (up to 50) , one herd , and very short grazing periods in each paddock (1-3 days) . Extensive research followed in many countries including the United States , Mexico , Australia , and Pakistan . Some general statements can be made from this research concerning domestic and wild ungulates as their presence relates to water in the ecosystem . Grazing reduces plant cover and volume , and plant species respond differently to grazing . Some plant species have little resistance to grazing while others have great resistance , and still others are stimulated by grazing . The number of plant species that are stimulated by grazing is not near as great as claims by advocates in the 1970's . Some plant species with little resistance to grazing may become more resistant with subsequent generations . And some species such as blue grama (*Bouteloua gracilis*) may have a bunchgrass form under moderate to no grazing , but change to a sodgrass with lower production under heavy grazing which results in more runoff and erosion . Reduced plant cover and volume result in decreased interception of precipitation and decreased transpiration by plants . Decreased plant cover and volume also result in decreased organic matter additions to soil , which affects soil structure and porosity . Additionally , water infiltration rates decrease , and runoff and erosion increase . Increased runoff and erosion lead to loss of sustainability after about 50% utilization of the present year's plant growth .

Hoof action (often called trampling) by ungulates also reduces plant cover and volume with the same effects on the hydrology as grazing . Trampling has been touted as a great beneficiary to soils by causing the same beneficial effects as mechanical plowing . In reality , trampling increases surface roughness when the soils are wet resulting in decreased runoff and erosion . Trampling decreases soils roughness when soils are dry resulting in increased runoff and erosion . Unfortunately , most arid and semi-arid rangelands are usually dry . Trampling also affects soil configuration known as trails . When they are found up and down slopes , runoff and erosion increase . When they are found across slopes , runoff and erosion decrease . Trampling decreases bulk density and porosity which results in increased runoff and erosion . Fortunately , annual increases in bulk density are often mitigated by cold-weather freeze-and-thaw conditions . So what are the benefits of trampling other than increasing roughness in wet soils ? In loose sandy soils , trampling can increase bulk densities which results in increased water holding capacity . This allows water access to plants that may be increased from a day to several days , which is enough for considerably more plant growth . Trampling can also control soil-dwelling animals such as rodents whose exposed mounds result in high erosion rates . A study in Colorado , USA showed that pocket gophers may add up to 12 .5 metric tons ha^{-1} yr^{-1} of sediment to streams . A diagram showing how rangeland management practices affect plant and rock cover ; plant volume ; and animal grazing , trampling , and burrowing , which ultimately affect runoff and erosion is shown in Figure 1 .

The benefits of dung and urine added to soil surfaces have been known for millennia . Since the early days of environmental awareness , there has been concern of dung being washed by runoff into streams . Because of its nature to solidify shortly after deposit , dung is not readily washed into streams by runoff unless it is deposited onto bare ground that is connected to a runoff system or the defecating animal is in the stream . Fisheries in watershed of low fertility may benefit from accelerated erosion and elevated nutrient levels .

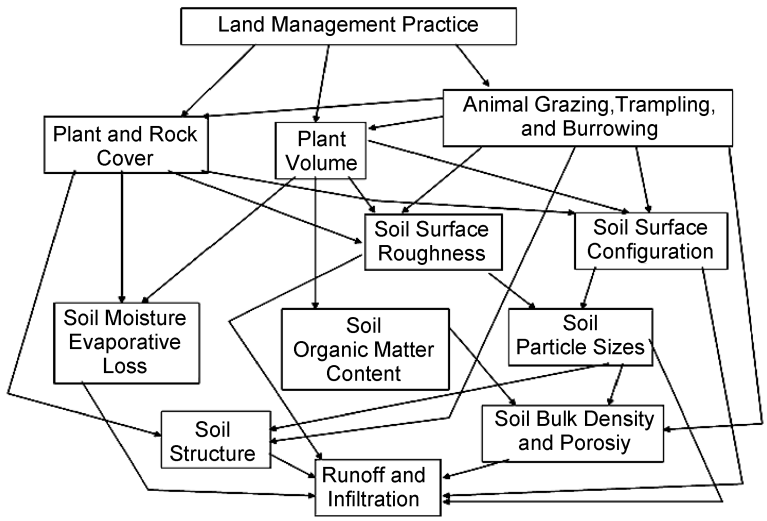

Figure 1 *Diagram showing how land management practices affect runoff and infiltration .*

It is also noted that it is easy to fence out livestock . It is difficult to fence out wildlife , so the total number of ungulates may not change from fencing out livestock . Stocking rates that result in 0% to around 50% utilization of the current year's plant growth are usually sustainable . Stocking rates that are much greater than 50% utilization of plants are rarely sustainable from a hydrologic point of view .This applies to grazing schemes that use all the forage in a pasture or paddock , even if they rest it for long periods of time following grazing .

Generally , those grazing schemes that improve vegetation conditions also improve soil and hydrologic conditions . It is possible to increase forage without damaging other rangeland uses . It is not known how to do this in all areas of the world .

Conclusions

From a hydrologic point of view , most rangelands can be sustainably grazed by livestock and other ungulates . Grazing levels and rotation schemes need to be tailored to each individual ranch or pasture . Past abuses can be mitigated with numerous mechanical and biological techniques beyond grazing manipulation . Affordability and time constraints challenge range managers to be creative and use various techniques to achieve long-range goals . Hydrologic considerations should not be overlooked , and many management practices can be used in reaching those goals .

Grassland and water resources : recent trends and future challenges in temperate zones

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Key points : Three main components of the terrestrial hydrological cycle are taken into account in this paper : soil , groundwaters and streams , linked by various transfers , such as drainage , throughflow and runoff .

The main result of this literature review is to point out the major positive effects of grassland on all the water quality criteria , with two local problems : nitrate and microbiological parameters . In a short second part , we develop a challenge for the grassland researcher community : to contribute to the international agronomists efforts to improve our water resource quality . To conclude , we propose some research questions for the future .

Key words : water quality , runoff , water infiltration , grassland management , farmer practices

Introduction As focused by Briggs and Courtney (1989) the high yields characteristic of modern , intensive farming systems in temperate areas reflect man s ability to modify the agro-ecosystem in such a way to remove or diminish natural limitations upon productivity , and to provide a more favourable environment to crop growth . We agree with this research on productivity as an effect desired by many farmers in Europe and helped by our Common Agricultural Policy . On the other hand , we propose to explain that farmer practices involved in these modern farming systems have major impacts on hydrological processes (Benoît , 1994) .

In this trend , the grasslands have a particular position , some of them are very intensive , but some of them have for a long time been managed on an extensive way . The geography of the grasslands is also very clear in temperate zones : extensive grasslands are located in mountains (i .e . Alps , Pyrénées , Vosges , Jura , Central Massive , Scotland , Norway , north of Sweden , Schwarzwald , Carpathians , Tatars , . . .) and Mediterranean zones (i .e . east of Spain , centre and south of Italy , south of France , Greece) , intensive in Atlantic zones (Netherlands , Denmark , England , Brittany) and a mix of them in central Europe (Rhine and Danube basins) .

This paper fouses on the relationships between the diversity of grassland management and the main fluxes of water in this terrestrial hydrological cycle (soil , groundwaters and streams , linked by various transfers , such as drainage , throughflow and runoff) , and will confirm recent reseraches on grassland advantages in environment management (C .F .E . Topp , and al ., 2007) .

Grassland in the hydrological cycle
For the terrestrial hydrological cycle , Briggs and Courtney (1989) identify :
— four main components : soil , groundwaters , streams and seas ,
— four main transfers : drainage , throughflow , runoff and seepage .

This cycle is vulnerable to the effects of agriculture , and , for us , in particular , through the impact of grassland management practices upon the transfer mechanism of water and the associated chemical and biological elements .

The focus is on two main management practices : (i) proportion and location of grassland in the landscape , (ii) farming practices on grassland . These practices interact with interception and infiltration (as inputs of water) and evapotranspiration , drainage and runoff (as outputs of water) . This hydrological cycle is a topic point when we try to take into account the global changes and the agriculture adaptations to climate changes , where grassland are central .

Effect of grassland on infiltration As the works of Holtan and Kirkpatrick show , infiltration rates on grassland are generally higher than those on arable land (Briggs and Courtney , 1989) . Nevertheless , marked variations occur in grassland soils due , in particular , to differences in sward age , composition and grazing intensity . In general , infiltration capacity increases as the pasture gets older due to the accumulation of organic material at the surface and the development of an extensive root system and of a stable soil structure . Different types of grass also have different effects , partly because of the way in which they affect soil structure , but also because of their varied resistance to animal trampling (Gifford and Hawkins , 1978) .

The most important factor controlling infiltration capacity in grassland is grazing intensity . Reviewing the hydrological effects of grazing , Gifford and Hawkins (1978) concluded that light-moderate grazing may reduce infiltration capacities by about 25% compared with ungrazed pasture , while under heavy grazing infiltration capacities fall about 50 % . Briggs (1978) , for example , comparing infiltration capacities in different areas of a single pasture on clay soils , showed that in the most heavily trampled areas infiltration rates were zero , whereas in the least trampled areas the infiltration capacity was 7 .6 cm h^{-1} . Similarly , Selby (1972) noted that in New Zealand , grazing may cause severe compaction , which reduces infiltration capacity , promotes surface runoff and encourages soil erosion.

Effect of grassland on the soil moisture budget Farming does not affect the total quantity of water held in the soil in the long term, but it does affect the pattern of retention throughout the year. Thus Keuren *et al*. (1979) found that summer-grazed pastures had higher rates of evapotranspiration than winter-grazed plots but less surface runoff and subsurface outflow.

The lack of knowledge about the grassland situation has to be reduced by new researches focused on grassland management and soil moisture budget evolution in the global changes context (IPCC, 2007).

Effect of grassland on overland flow and surface runoff Overland flow refers to the movement of water across the soil surface either in the form of thin sheets of water (sheetwash) or as concentrated flow in rills and gullies. Horton (1933) described what has become known as Hortonian or infiltration excess overland flow. Overland flow occurs in two situations: (i) when rainfall intensities are greater than the infiltration capacities of the soil and (ii) when local saturation of the soil in footslope or channel-side areas is created by lateral movement downslope.

Flow velocity is an important parameter in relation to runoff because it affects the time taken by water to enter the permanent stream network, and thus the response time (flashiness) of the stream system. As written by Briggs and Courtney (1989), for rainfall interception, infiltration capacity, surface roughness and surface moisture retention, grasslands have a very positive effect.

In the temperate zones, the first wave of major researches began around the 1930 s. Early research about the effects of cropping systems and grassland on overland flow in the USA has been summarised by Glymph and Holtan (1969). Recent European works are focused on the excellent effects of grassland on runoff. Chisi and Zanchi (1981) recorded the effects of different cropping, cultivation and grassland with or without drainage, on runoff and soil loss from silty clay soils in the Vicarello area near Pisa. In each situation, overland flow and soil loss from grass are less that from arable land. A grass sward provides a more or less continuous vegetation cover which intercepts rainfall and impedes any overland flow which does occur. The improved rooting and organic matter accumulation, with the high worm activity as showed earlier by Darwin (1881), in grassland soils also means that infiltration capacities tend to be higher than in arable soils.

In the same way, Souchère *et al*. (2003b) show the effectiveness of grassland location in a watershed to reduce soil loss. Using simulations with STREAM model in a Normandy watershed (Bourville), they evaluated the increase in soil loss after the ploughing of 17% of grassland surfaces by the farmers: the overland flow increased by 75% and the soil loss by 85%. To improve the situation, they simulated the effect of a 1% increase of grassland located in strategic places: the runoff volume will decrease by 48%.

Nevertheless, soil structural damage caused by trampling or vegetation removal due to over-grazing may allow overland flow to take place, and in some cases serious losses may be initiated. Costin (1979) illustrates these effects by comparing plots under a range of grazing regimes, from moderate to heavy stocking, in New South Wales, Australia. Higher grazing intensities resulted in lower vegetation cover and higher rates of overland flow and soil loss. Similarly, the effects of herbicides used to control rangeland weeds has been shown by Richarson and Bovey (1979).

So, grassland strips and optimal grassland location in the landscape are the best strategic options to reduce the overland flow and soil losses in temperate zones. So, a general plan for an ecological infrastructure based on grassland is now to be built at the European scale for next C.A.P.

Effect of grassland on water quality

Nitrate For many authors (Briggs and Courtney, 1989; Manion, 1995; Benoît *et al*., 1995), grassland has a better effect on water quality and water resources than crops.

Under cut grassland, nitrate leaching is very low when fertilizers are applied in accord with the level of yield, until N fertiliser rates of around 400 kg N ha^{-1}. A number of recent works allows us to conclude that water quality is good in respect to nitrate under cut grassland in Europe (Ball and Ryden, 1984; Baraclough *et al*., 1984; Decau and Salette, 1994; Dowdell and Webster, 1980; Garwood *et al*., 1986; Jordan, 1989; Simon, 1995).

Without fertiliser or with low levels (less than 100 kg N ha^{-1} y^{-1}), no significant nitrate leaching is measured and a low level of nitrate leaching until 250 kg N ha^{-1} y^{-1}. For a 400 kg N ha^{-1} y^{-1} fertilisation rate, the nitrate leaching is lower if the fertilisers are concentrated in spring and summer than when they are spread throughout the year. In this case, autumn fertilisers and soil mineralisation induced an available N amount higher than the plant needs for N. Above 400 kg N ha^{-1} y^{-1}, nitrate leaching increases rapidly.

The relationship between nitrate leaching and nitrogen fertilizer level has been investigated for grazed grassland composed of pure grass stands in a large range of pedological and climatic contexts in temperate zones (UK, France, Netherlands, New-Zealand) (Farrugia and Simon, 1994; Lançon, 1978a; Lançon, 1978b; Ledgard, 1989; Lantingua *et al*., 1987; Macduff *et al*., 1989; Owens *et al*., 1994; Peyraud *et al*., 1995; Richards and Wolton, 1976; Ryden, 1983; Ryden *et al*., 1984; Scholefield *et al*., 1988; Scholefield *et al*., 1991; Sherwood and Ryan, 1990; Simon, 1995; Steele *et al*., 1984).

Comparing with the response curve for cut grassland, the nitrate leaching for grazed pasture is higher. It stays in a moderate level if nitrogen fertilisation rate is low (less than 200 kg ha^{-1} y^{-1}). Then, it is very variable and able to reach very high levels if fertilisation rate is higher than 300 kg N ha^{-1} y^{-1}. This high variability between experiments shows that nitrogen fertilisation is not the single factor responsible for nitrate leaching. Stocking rate is a more synthetic index and gives a better explanation of nitrate leaching.

Any farmer practice which induces a decrease in stocking rate on the pasture decreases the variability in nitrate leaching. But, hay or silage harvesting on a grassland field also decreases the number of grazing days and consequently the nitrate leaching. The main factor influencing nitrate leaching in grazed pastures is the stocking rate.

Pesticides In our research of papers on water quality, we did not find a paper detecting pesticide contamination under grassland. This fact is central for the future of water resources in temperate zones because herbicide, fungicide, and pesticide contaminations are increasing very rapidly in surface and groundwaters. So, the location of grassland in watersheds is a major solution for water managers to decrease such water contaminations (Benoît *et al*., 1995; Mignolet and Benoît, 1999).

Microbiological parameters A more critical point are bacteria, virus and parasite contaminations of water from cattle. A large number of papers recently pointed to this source of water contamination (Vallet, 1994; Brewer, 1997; Crane *et al*., 1983; Larsen *et al*., 1994; Marinova, 1995; Moore *et al*., 1983; Moore *et al*., 1989; Sherer *et al*., 1992). Two main management problems are identified by these works: the animal trampling in the small rivers during drinking, and the direct contamination by liquid effluents from buildings or during the spreading of slurry along the streams. New parasites are developing, as Guardia for example.

On the other hand, we find few papers dealing with the effects of water quality on herd health, but they seem very important (Meijer *et al*., 1999). This feedback effect of water contamination on animal production is a deficiency in our research topics.

How to increase the positive effects of grassland on water resources? The presented results indicate a new position for grassland: their capability to protect water resources and to protect soil from erosion. So, a general trend for the area of grassland to decrease should stop in order to benefit European society. Three challenges for the future are presented:

How to increase the surfaces of grassland? During the last thirty years, there has been a global trend to decrease grassland area through three factors: becoming cropland by ploughing of productive grassland, becoming forest by plantation and becoming urban zones by building.

Now, there is a new challenge to inverse this trend and to increase the grassland surfaces. But, a lot of difficulties have been identified: (i) in Europe, the CAP subsidies induced an increase in crops through high level of subsidies, (ii) industrial cheese factories favoured the use of more maize in dairy cow feeding, (iii) the efficiency of work and the level of investments induced the increase of maize in dairy cows farms (Gall A. Le. *et al*., 1997; Mignolet and Benoît, 1999; Mignolet *et al*., 1997; Mignolet *et al*., 1999; Mignolet et al, 2004). And, we can add that the image of modernity, including our own influence as researchers often gave a qualitative advantage to maize in livestock farming systems.

Only two main arguments are developed to increase the grassland surfaces: (i) for high quality cheeses it is beneficial and sometimes a legal obligation to use grassland, (ii) for water resource protection, grassland should be a major way in Europe (Brouwer and Hellegers, 1996; Oenema *et al*., 1998; Pflimlin and Madeline, 1995).

Where to localise grassland? A major challenge for water resource protection is to locate grassland in sensitive areas for water resources protection. The present proposal is to locate new surfaces of grassland on (grass) strips in valleys, seen as a network of water corridors. This should produce important effects through improving water quality and reducing water runoff (Souchère *et al*., 2003a). So, we have to deal with farmer decision processes.

What is more, understanding individual decisions made by farmers confronted by uncertain situations raises numerous difficulties (Brossier, 1989). The rational nature subtending the farmer's decisions appears to be part of complex process of adaptation to the environment in a situation where information is lacking and where rationality itself is limited (Simon, 1975). This process in fact belongs to an apprenticeship in which the farmer refers not only to the production factors in his possession but also to the family context in which he finds himself, his different objectives, the history of the farm, and the perception each farmer has of the advantages and disadvantages of his system and environment (Benoît *et al*., 1988), (Bonneviale *et al*., 1989), (Dent et McGregor, 1994). It is based on the supposition that the decisions made by farmers are consistent: given their situation and objectives, farmers have reasons for doing what they do" (Brossier, 1989). The work thus consists in discovering these reasons, by basing ourselves on the observation of how farmers manage their farms in reality (Brossier *et al*., 1989). So, what is the perception of grassland in their territory by farmers, is the topic question.

How to build a new image of grassland?

Firstly, we have to know the current images of grassland for the people, mainly for farmers and public decidors. But, as scientists, we also have an influence on this image of grassland: how can we improve the image of grassland through our work? This paper is one of a large number of contributions in this way. But, are we able to give enough arguments, for example in Europe, to change the level of C.A.P. subsidies, and to re-build this common basis for the future of agriculture?

Conclusion

What are the challenges for researchers in the future?

We identified the main favourable effects of grassland on water resources: runoff decreasing, no pesticide contamination, global protection against high nitrate content if moderate stocking rates are used on grazed pasture. But, some new researches have to be developed. In the future, we propose to focus on the following main research questions to improve our knowledge on grassland and water resources:

a. Increasing knowledge on grassland location The evolution of grassland surfaces and the location of these evolutions have to be known and to be related to water data bases. We propose to IGF-and IRF to manage a deal with the Land Use and Cover Changes research programme: Global Land Project (Lambin *et al*., 1999; Lambin *et al*., 2003; Mannion, 1995; Velkamp and Fresco, 1997). All over the world, the grassland areas are one of the major cover in term of challenges for the future (Girard and Benoît, 1990; Girard *et al*., 1990; Benoît *et al*., 1993; Lambin *et al*., 1999; Mignolet et al, 2004). A scenario for future is to re-build a network of grassland along all the rivers. This global grassland corridor network could be a major contribution of grassland for sustainable development.

b. Modelling of farmers choices The question we want to focus is: how to preserve grasslands, where are they maintained? In an other formulation: what are the good reasons for a farmer to keep or to increase grassland? Surveys, economical studies, modelling of farmer s meaning are the main methods to evaluate the possible future of grassland (Le Ber and Benoît, 1998; Le Ber and al., 2006).

c. Increasing knowledge on grassland interests for water resources by two main trends of research *Developing a common organisation for Observational Research*. As we showed above, we need more coordinated data basis to help us to build our research hypothesis. Often, it is very difficult to compare data on an European scale. Three main trends shape this challenge:

— the common development of measuring and monitoring of water quality (field and watershed scales);
— the generalisation of measuring and monitoring of animal health (quality of drinking water for animals, monitoring of parasites);
— the improvement of measuring and monitoring of animal products.

The future of researches in these fields seams to be linked to the developments in Observational Study Methodologies (measuring, surveying, monitoring, statistical analysis, building of common conceptual framework). A very useful initiative could be to initiate a International Network of Experimental Stations: Grassland effects on natural resources . IGF and IRF could be the boosters of this initiative.

Building a common grassland management typology. If we want to compare our results in Europe, the description of grassland management in a multi-criteria typology is a necessity. Until now some of us have precise results on water quantities and qualities (the norms and the laboratory analyses are standardised), but we have large difficulties even in temperate zones to compare an Irish cow pasture with a Lorraine one in a same grassland management typology. A future common challenge could be to build together a European grassland management typology.

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Water fluxes in the Xilin river catchment , Inner Mongolia , at different scales

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Key words : hydrological modeling , catchment hydrology , steppe grasslands , overgrazing

Introduction Degradation of grasslands caused by overgrazing can heavily influence hydrological processes and can thus have a strong impact on other ecosystem functions .Within the work of the Research Unit MAGIM Matter fluxes in grasslands of Inner Mongolia as influenced by stocking rate" the hydrology of the Xilin river catchment in the continental Inner Mongolian steppe is examined from plot scale to catchment scale with the aim to characterize the crucial hydrological processes in this area and to point out how overgrazing and grassland degradation alters them .

Materials and methods On the plot scale experiments were carried out to examine soil physical properties and to quantify soil moisture following a geostatistical sampling scheme .Eddy covariance was used to record water fluxes on the site scale .On the regional scale research focuses on catchment hydrology by nested catchment sampling .At this scale various techniques are applied .Discharge measurements were carried out in different parts of the Xilin river .Mean residence time (MRT) of waters in the relevant hydrological compartments will be determined by sampling of 2H and 18O isotopes in precipitation , groundwater and surface waters .End member mixing analysis (EMMA) is used to interpret the geographic source of stream water by determining the characteristic composition of its solutes .Furthermore groundwater monitoring of wells throughout the whole catchment and in a measuring field site is used for chemical analysis of the groundwater and for quantifying the role of the groundwater in catchment hydrology .Experiments and investigations were carried out on specifically set up experimental plots , representing various grazing intensities , as well as in pristine areas throughout the whole catchment .Process oriented modelling is applied on all scales in order to increase process understanding as well as to develop scenarios of possible water budget changes .

Results For soil physical properties a strong effect of grazing could be shown due to increased mechanical stress under higher grazing .In terms of soil moisture a slight trend indicating decreasing soil moisture contents could be detected while the grazing intensity was increasing .The total amounts of soil water content differed only little .Also in the case of evapotranspiration no pronounced differences between areas of different grazing intensities could be found .We conclude that clear differences exist in terms of the processes that are involved in the partitioning of water fluxes , i .e .interception , transpiration , evaporation and infiltration .On sites of a higher grazing intensity the vegetation density decreases , thus the evaporation gains more importance compared with transpiration .These field observations could be successfully simulated using field scale deterministic modelling approaches .Hydrological investigations on the catchment scale revealed that discharge is not only generated by precipitation and surface runoff but must be the product of various processes in which precipitation stored as snow , snow drift and the lateral flow on frozen soil layers towards the river might play an important role .First uncalibrated simulations utilizing a catchment scale model show that especially spring snow melt as well as peak flows in summer are biased compared to observational data from the Xilinhot gauging station .Nevertheless , the model captures the overall winter and summer characteristics .The preliminary results suggest that adjustments in the snow subroutines as well as changes in surface properties are needed .The results also underscore the importance of further precipitation observations throughout the catchment to better capture the spatial variation in the meteorological input .

Acknowledgement We are grateful to the Deutsche Forschungsgemeinschaft (DFG) for their generous funding of the research unit MAGIM" .

Mobilisation and Transport of Sediments, Colloids and Phosphorus from Intensively Managed Grasslands

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Key words: Suspended Solids, Colloids, Total Phosphorus

Introduction Soil erosion can cause serious ecological degradation when suspended solids (SS) and sorbed contaminants are delivered into surface waters. As such soil erosion is a process which needs to be controlled if we are to meet water quality guidelines and good ecological status in surface waters. The effective control of soil erosion and the delivery of SS into surface waters requires a holistic understanding of the land-uses that are susceptible to erosion and the land-management factors that influence soil erosion and the mobilisation and transport of SS. However, a review of the soil erosion literature in the UK reveals that almost all of this research relates to erosion on arable land or upland areas, with a generally implicit assumption that intensively managed lowland grassland does not erode and therefore does not present a threat in terms of sediment-related water quality problems.

Materials and methods This paper presents results from 3 years of environment-based experiments and monitoring at a range of scales, from small plots (0.2 m^2), to field-scale lysimeters (1 ha), up to a headwater catchment (48 ha). The rates of erosion and yields of sediment, colloids and phosphorus (P) from intensively managed grasslands are discussed and compared in relation to that from arable land and international water quality guidelines. Furthermore, the influence of two common, but currently poorly understood, land management options are also examined; (1) subsurface drainage, and (2) stocking density.

Results Results show that 1-ha grassland fields can yield up to 15 kg of SS in response to rainfall events lasting less than 24 hours. These yields of SS are within the ranges of those recorded on arable land, a land-use considered to be more susceptible to erosion. The concentrations of SS and P in runoff from 1-ha intensively managed grasslands are ecologically significant; frequently exceeding international water quality guidelines such as those of the European Union's Freshwater Fisheries Directive and the United States Environmental Protection Agency's ecoregional nutrient criteria. The presence of subsurface drainage attenuates hydrological response to rainfall events, relieving saturation and reducing the occurrence of saturation-excess overland flow, resulting in reduced yields of SS and P by up to 40%. Evidence from the plot scale experiments suggests that increasing stocking density tends to cause an increase in the soil bulk density and a reduction in the vegetation cover, leading to a faster hydrological response and higher concentrations and yields of both SS and P.

Conclusions Evidence presented in this paper suggests that contrary to the popular assumption, intensively managed grasslands do erode and do present a significant threat to water quality in terms of sediment-related water quality issues. Land-management within intensively managed grasslands has massive potential to influence the mobilisation and transport of sediment, colloids and phosphorus, and the overall rate of erosion from these environments.

Assess physical functioning of riparian systems with an eye toward management

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Key words: Interdisciplinary, hydrology, geomorphology, biology, objectives

Introduction Riparian systems, where aquatic ecosystems transition to terrestrial uplands, focus land uses and hydrologic processes into compact areas. To avoid problems of floods downstream and low flows in dry times, water must be kept on the land longer with riparian proper functioning condition (PFC) (e g., Prichard et al., 1998). PFC occurs when adequate vegetation, landform, and coarse woody debris is present to: dissipate stream (or wave) energy from high flows (winds) reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve floodwater retention and ground-water recharge; develop root masses that stabilize banks against cutting action; and develop diverse physical habitats for fish, wildlife, and biodiversity. PFC enables restoration to later seral stages if desired. For each unique area, it is based on the local potential, the highest ecological status that an area can attain, or the capability, the highest it can attain given political, social, or economic constraints. Grazing is not a constraint because livestock or wildlife can be managed to encourage PFC.

Methods PFC assessment uses an interdisciplinary team that understands local watershed hydrology, especially the range and frequency of flows; soils and fluvial geomorphology in relation to deposition and saturation; and biology about habitats needed for local riparian plants, fish, and wildlife. The team discusses potential and/or capability for the lotic stream reach or lentic wetland and then uses a 17 (20) -attribute checklist about hydrology, vegetation, and erosion/deposition to assess the physical functionality of the system. They record notes about at least all improper attributes to develop an understanding of PFC issues. Using the definition, they rate it as PFC, functional-at-risk (trend up, down, or not apparent), nonfunctional, or unknown. Unacceptable conditions outside the control of management are noted, but emphasis on the seventeen (20) attributes often points directly to possible objectives for management. Creeks and Communities" is collaboration among all watershed (catchment) landowners, users, managers, and advocates.

Results and discussion Because all disciplines and agencies work together using the PFC process, an interdisciplinary understanding helps people communicate well. The user-friendly approach helps connect professionals with lay citizens and focuses discussion on important at-risk areas. There, specific attributes can be addressed through management of land and water uses such as grazing or water storage for irrigation, and on catchment features such as vegetation, roads, trails, and floodplains. With some training, ranchers and environmentalists can agree about what they see and designate attributes to be monitored as objectives.

Conclusions The value of PFC is an upward spiral that leads to better conditions for downstream flood prevention and base flows after aquifer recharge. With water and soil for forage, fish, wildlife, and riparian-dependent biodiversity, communities become more beautiful, sustainable, and productive. Putting the focus on physical functionality helps people work together to make the riparian system produce what they all value. This avoids the sense that riparian area management is for other" people. Once riparian areas function properly, they continue to improve. Much resiliency comes from soaking up the water to grow plants that slow the water of future floods and hold soils while retaining nutrients. PFC assures the proper relationship among soil, water, and nutrients thus providing more and better habitats for fish, wildlife, livestock, and people. Proper functioning riparian areas provide a foundation for restoration or other resource objectives.

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Modelling native pasture hydrology at the catchment scale

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Key words : modelling , native pastures , CAT , Native Pasture Model

Introduction Australian native pastures , like many around the world have undergone botanical transition since the introduction of agriculture . This has resulted in a shift in the landscape water balance increasing recharge to groundwater systems , rising water tables and the salinisation of waterways and soils .The enhancement of native perennial grass species is the most likely method for improving the water balance in the high rainfall , topographically difficult grazing landscapes of south-eastern Australia .Studies into the hydrology of native species and their communities have shown that increased water use is possible though this varies with species attributes (Hughes *et al* . 2006) . To examine the impact of native perennial species within a catchment landscape the 1-dimensional Native Pasture Model (NPM) was developed to be incorporated into the 3-dimensional catchment and groundwater model the Catchment Analysis Tool (CAT) .

Material and methods The NPM was developed to simulate the growth and water use of two native species *Bothriochloa macra* (C_4) and *Austrodanthonia* spp .(C_3) .The NPM was validated against treatments for an experiment conducted at Wagga Wagga NSW for green leaf area index (GLAI) and soil water deficit (SWD) . The NPM was then incorporated into CAT and applied to the Bet Bet catchment (64 ,432 Ha) , a high priority catchment in central Victoria . Water balance , stream flow and salt output data was then predicted over a 44 year period .

Results Modelled data simulated experimental data well showing a relative root mean square error (RRMSE) of 12.8% GLAI ($r^2 = 0.68$) and 24 .1% SWD ($r^2 = 0.91$) for *Austrodanthonia* spp and a RRMSE of 15 .8% GLAI ($r^2 = 0.82$) and 22 .8% SWD ($r^2 = 0.91$) for *B .macra* (Figures 1 and 2) . When modelled in CAT , water balance differences between species were evident with 3 .6 mm more run-off and 12 .8 mm less recharge to groundwater (Table 1) by *B .macra* . It also resulted in 391ML of additional stream flow and 6304t less salt out of the catchment for *B .macra* .

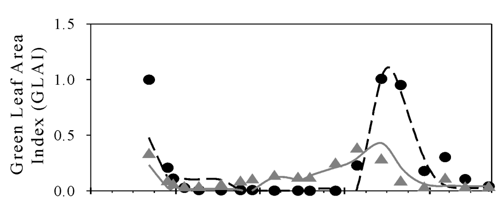

Figure 1 *Measured (scatter) and modelled (lines) GLAI for Austrodanthonia spp . (grey) and B .macra (black) .*

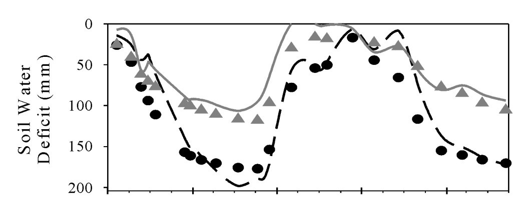

Figure 2 *Measured (scatter) and modelled (lines) SWD for Austrodanthonia spp . (grey) and B .macra (black) .*

Table 1 *Water balance of Bothriochloa macra and Austrodanthonia spp . using the NPM in CAT when applied to the Bet Bet catchment (Area = 64 ,432 Ha) .*

	Bothriochloa macra	*Austrodanthonia* spp .
Rainfall	557 .2	557 .2
Runoff	16 .4	12 .8
Soil evaporation	175 .1	149 .7
Transpiration	315 .4	327 .1
Evapotranspiration	490 .5	476 .8
Subsurface flow	12 .1	16 .2
Recharge	38 .9	51 .7
Stream flow (ML)	17902	18292
Salt output (t)	20677	26981

Conclusion Accurate prediction of the impact of botanical change on landscape hydrology is important for natural resource management . The NPM is unique in its ability to simulate Australian native species at both the plot and catchment scale . Further parameterisation of native species and the adoption of factors associated with botanical change within the model will enable modelling of dynamic temperate grassland landscapes .

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P and N content of surface and subsurface water flows in limestone soil

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Key words: overland, interflow and drainage water flow nutrient content

Introduction Pathways for P & n transport from soil to water bodies include overland flow, interflow and vertical flow. While a distinction can be drawn between infiltration excess and saturation excess overland flow, in practice they can be difficult separate. Likewise, interflow, which describe the lateral movement of water that has infiltrated the soil, but has not drained to groundwater, may emerge down slope and become indistinguishable from inter and overland flow. Ground water may also rise to the surface in places and merge with overland flow. Water moving by these pathways acquires nutrient by physical detachment of soil particles and by dissolution of soluble constituents. Field experiments in Ireland investigation the mobilisation of soil and fertilizer nutrients and their transport in water have usually been conducted on sites with imperfectly or poorly drained soils (Tunney et al., 2005). The overland flow is not significant on the well-drained soils that are most intensively farmed in Ireland. However, since infiltration is influenced by land-use that can affect soil hydraulic conductivity though compaction and structure breakdown, naturally well-drained soils may be more susceptible to overland flow than their genesis would suggest. In the work describes here simple equipment was used to operationally distinguished between overland flow, interflow and vertical flow, with frequencies of occurrence of these flows recorded and water samples representing them collected and chemically analysed for dissolved reactive P and Nitrate.

Materials and methods Collectors were installed in five stations located at 1m altitudinal intervals (71-76m OD) on N-S transect in the Hill Field (grass land) at UCD Research Farm. Overland flow was collected from miniplots hydrologically isolates using 40cm diameter PVC rings, 10cm deep, embedded to a depth of 5cm, with a connection to collected at low point of the ring. Interflow was collected in stoppered, wide mouthed plastic bottles (2000cm^3) that had been at placed in holes excavated to their depth and diameter. The bottled were preformed around the top 10cm of their circumferences. Drainage water was collected by suction using Teflon soil water samplers (station 1-5) installed at varying depths. All water samples were filtered through 0.45-μm Millipore filter immediately after collection and subsequently analysed for dissolved reactive phosphate (DRP) colorimetrically by ascopbic acid ammonium Molybdate method and nitrate by ion chromatography.

Results and discussion The soil of the Hill Field grads from being a Grey Brown Podzolic at higher elevation to a Gley in its bottom side corner, with drainage transition from good to imperfect. Between November 2004 and April 2006, overland flow was recorded and sampled on 21 occasions, while interflow was recorded on 26 occasions. Suction samples were collected, at different depths, through the monitoring. The range of values for dissolved reactive P and nitrate in the various water samples as shown in the Tables Below.

Table 1 *Dissolved reactive P (Mg.ml^{-1}).*

Type of flow	Depth (cm)	Range	Mean
Overland	0	0.14-2.67	0.969
Interflow	0-10	0.00-3.40	0.509
	25	0.00-0.17	0.015
Drainage	65	0.00-0.10	0.002
	85	0.00-0.01	0.002

Table 2 *Nitrate concentration (Mg.ml^{-1}).*

Type of flow	Depth (cm)	Range	Mean
Overland	0	1.4-96.3	32
Interflow	0-10	0.8-1215	76
	25	0.0-1128	243
Drainage	65	0.0-3313	238
	85	0.0-701	167

Conclusion Episodes of overland flow and interflow occurred even though the site is located in the lowest rainfall in Ireland and the most of the field land covered by well-drained soil. Water samples of different origin showed marked differences in their dissolved reactive P and nitrate contents, where DRP relatively high in overland and interflow samples, the nitrate was high in drainage samples.

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Integration of IKONOS data in assessing the dynamics of the range ecosystems of the Manzla watershed (Tangier, Morocco)

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Key words : Brushland (matorral), range ecosystems, trend (dynamics), high spatial resolution, western Rif

Key points The sustainable and participatory management of sylvo-pastoral ecosystems of the Rif's mountains require a precise analysis of the profile of the natural resources and the evolution of human intervention on the level of the commune and village. The Ikonos image processing enabled us to identify new plant associations and communities and thus to define new range ecological sites resulting from the processes of degradation in a small watershed representative of the Rif mountains (Tangier, Morocco).

Introduction The new orientations and the needs for planning a sustainable development of the Rif's mountains require an exhaustive and precise inventory as well as cartography of the range ecological sites.

Population and the problematic of the pastoral area transformation In the Rif region, the matorral (brushland) represents a stage of degradation and a phase of transition between the clearing from the national forest and its setting in culture to take advantage of a right of ownership. (Mejjati Alami *et al*., 2000).

Objectives The study was carried out within the framework of one program of cartography of land use by remote sensing and its integration in models of study of the dynamics of degradation of the forests and the Rif's brushland, by using the images of the last generation of satellite sensors (SPOT HRV, Landsat TM and Ikonos).

Materials and methods The study area is represented by the Manzla watershed, located at 15 *km* south of Tangier, in the north western part of the Rif's mountains (Morocco). The area is marked by a strong climatic aggressiveness (800 mm/an) (DMN, 2004), eroded soils and strong anthropic pressure. In accordance with the aim of the study, the method of work is founded on the comparison of the land use maps, more particularly delimitation of the unit of matorral, obtained with supervised classification.

Results and discussion

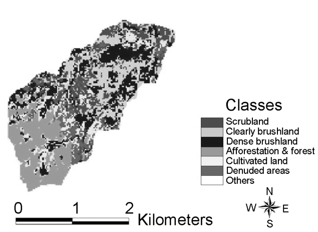

Figure 1 *SPOT HRV image*.

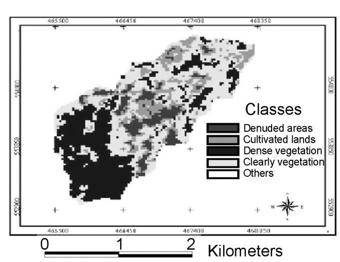

Figure 2 *Landsat TM image*.

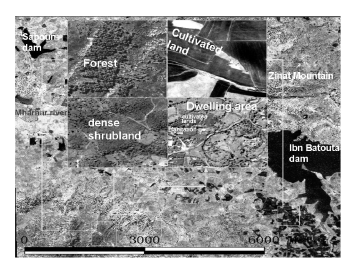

Figure 3 *Ikonos image*.

The precision allowed by Ikonos (figure 3) was exploited for better recognizing and delimiting of all the stages of degradation. The setting in culture was clearly determined on the scale of the plot, thus offering a powerful tool for the follow-up of this process of degradation with strong land implication.

Conclusion This study constitutes the core of a base of rich and up to date information within the framework of one local GIS (with a metric resolution) for the development of rainfed agricultural lands of the Manzla watershed (Tangier).

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Impacts of climate change on regulated and non-regulated water systems in Australia

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Key words: Cooper Creek, QMDB, flows

Introduction The highly regulated system of the Queensland Murray Darling Basin (QMDB) includes the MacIntyre Brook and Dumaresq River. Land-use is irrigated horticulture, dryland and irrigated cropping and grazing. The largely unregulated system of the Cooper Creek drains into Lake Eyre and land-use is primarily grazing. Both systems have valuable natural resources and biodiversity that rely on periodic flooding. This study identified the impact of climate change of water flows in both catchments.

Material and methods From a combination of nine Global Circulation Models (GCM's) and emission scenarios (SRES and IS92a) obtained from the OzClim database (CSIRO, 2001), the driest, wettest and average scenarios were chosen for both catchments. Percentage changes from the base climate (1961-1990) were used to condition rainfall and evaporation for 2030. Rainfall-runoff (Sacramento) and streamflow (IQQM) models for each catchment were run for the base and climate change scenarios (dry, wet, average) to obtain flows at the end-of-system for the MacIntrye Brook and Dumaresq River, and at Currareva (junction of the Thomson and Barcoo Rivers) in the Cooper Creek system.

Results and discussion Based on these scenarios the change in mean annual flow for the MacIntyre Brook ranged from -25% to +9% by 2030, compared to the base period (Table 1). For the Dumaresq River the change in mean annual flow ranged from -25% to +6% by 2030. The dry scenario was associated with a greater risk of lower water allocations and area of crops planted during dry periods.

The change in mean annual flow at Currareva ranged from -7% to +2% by 2030, compared to the base period (Table 1). The average and dry scenarios were associated with a reduced frequency of low daily flows (<1000 ML/d). The impact maybe associated with reduced waterhole persistence and connectivity during periods of drought.

Conclusion The climate change scenarios used here showed that the regulated system had 1) higher reductions in flows for the dry scenario and 2) a wider range of uncertainity in flow projections compared to the unregulated system. If the dry scenario most closely resembles climate in 2030 the loss of water for irrigators and environmental flows in the absence of useful adaptive strategies may reduce agricultural productivity and biodiversity. The resilience of plant and animal life that depend on waterholes during periods of drought may depend on their ability to move to larger and more permanent waterholes. If the wet scenario most closely resembles climate in 2030 slightly higher annual flows may make more water available. The average changes in flows reported here for QMDC correspond closely with the best estimate of climate change in 2030 of 10% reduction in surface water availability (CSIRO 2007).

Table 1 *Percentage change in mean annual stream flow the for dry, average and wet climate change scenarios in* 2030 *compared to the base period of* 1961-1990.

Catchment	Dry scenario	Average scenario	Wet scenario
MacIntyre Brook -QMDB	-25	-9	+9
Dumaresq River -QMDB	-25	-10	+6
Thomson and Barcoo River junction at Currareva	-7	-4	+2

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River restoration and economic development through grassland management : a case study of the James River , South Dakota , U .S .A .

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Key words :Agriculture , Watershed Restoration , Cellulosic Ethanol

Introduction Efforts are currently underway to develop a Watershed Management Plan (WAM) for the James River , South Dakota .The purpose of the WAM is to determine potential actions for flood damage reduction and ecosystem restoration . Agricultural uses predominate in the watershed with the river and its tributaries critically important to the region for drainage , irrigation , recreation , and wildlife habitats . Current economic pressure for corn production has resulted in a 14 million acre increase in corn planted in the U .S . This pressure has caused corn production to shift to marginal lands with high erosion potential .A newly proposed policy by the U .S .Department of Agriculture would allow harvesting of conservation grasslands for the production of biofuels . The purpose of this study was to determine if an economically viable compromise could exist that would allow row-crop agriculture to continue on prime agricultural land and grassland to exist on marginal lands .

Materials and methods The study area is the James River Watershed , which encompasses 36 ,260 square kilometers of South Dakota . To determine the current extent and potential expansion of grassland , marginal land and land use information were analyzed . Marginal land was delineated in a Geographic Information System (GIS) using SSURGO soil survey data . Marginal land was over-laid with 2006 land use data to determine existing and potential grass resources on marginal land . The potential decrease in stormwater runoff , through conversion of cropland to grasslands , was determined using the Soil Conservation Service (SCS) Curve Number (CN) method as described in Chapter 2 of TR-55 (SCS 1986) . The curve number is taken from a table in TR-55 based on the soil type (Hydrologic soil group) and vegetative cover . TR-55 has equations to calculate the runoff depth for a given parcel based on the CN and rainfall depth . Corn and hay prices were calculated by the South Dakota State University Extension Economics+ (SDSUEE) as the average price per bushel or ton during the month of November , 2007 .

Results A total of 10 ,603 square kilometers (25%) of the James River Watershed is marginal land . In 2006 , 6 ,242 square kilometers (59%) of the marginal land was being utilized as grassland while 2 ,642 square kilometers (25%) was cultivated for row crops . Conversion of the cultivated marginal agricultural land to grassland would result in a 10% decrease in stormwater runoff for each converted square kilometer during a typical 10-year storm event . A runoff reduction of 40% , per converted square kilometer , could be realized for a 1-inch rainfall event . In addition to profits from traditional grassland management , potential profit from grass-to-energy production may provide additional economic incentive to convert marginal land to grassland uses . For example , four million tons of grass could be produced on marginal land in the James River Watershed per year . Early estimates for cellulosic ethanol production from native grasses project 80-100 gallons of ethanol can be produced from one ton of grass . Thus , approximately 400 million gallons of ethanol could be produced per year from the 8 ,000 square kilometers of marginal lands . In addition , the 2006 NET rate of return for nonirrigated cropland and grassland in South Dakota was comparable at 4 .2 and 4 .0 percent , respectively (SDSUEE 2007) . Therefore , grassland production of energy crops would become economically viable with a modification of government programs that would allow harvesting of grasses for energy crops and provide a modest subsidy .

Conclusions The conversion of 8 ,000 square kilometers to managed grasslands could provide significant attenuation of flood flows and provide additional economic benefits for producers while providing benefits to water quality , wildlife , and carbon sequestration . These grasslands could provide an important , cost-effective , energy crop alternative that provides greater ecosystem benefits than corn . Changing typical row-crop land practices to those of perpetual grasslands provides a long term , sustainable solution to both reduce flood damages and enhance the environmental and economic opportunities of this important region .

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Gradient analysis of saline groundwater dynamics along spatial transects in the Chaco

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Key words : dryland salinity , groundwater , grassland , bushland , electrical conductivity , soil humidity , Chaco

Introduction The transitional zone between the dry and the semi-humid Chaco is characterized by a high table of saline groundwater .Dryland salinity is commonly observed at the edges of seasonally inundated grasslands in landscape depressions without external runoff (so called water camps) surrounded by native drought deciduous thorn bush .So far , little information had been available on groundwater characteristics (depth and conductivity) as related to soil salinity .

Materials and methods At Campo Maria (22°5′ S lat . 59°3′ W long .) , depth of water table and groundwater conductivity were measured every two weeks for 2 $^1/_2$ years , beginning in July 2002 , using perforated observation tubes installed along two spatial gradients (Glatzle *et al* . 2001) : One from the centre of a water camp across the saline belt at its edge to an adjacent pasture established on previously cleared bushland , the other one from the sown pasture right into the bush .Every September and February soil cores were extracted to 80 cm depth to measure soil humidity and conductivity .

Results and conclusions Depth of water table varied strongly following precipitations at all sites .Infiltrating rain water diluted temporarily the saline groundwater under pasture and produced the necessary hydrostatic pressure to raise the watertable under adjacent bushland , while conductivity under bush remained at a constant high level (Figure 1) .Obviously rain water never infiltrated to the groundwater table under bush .This and low mean soil humidity (Table 1) suggest high transpiration rates and considerable rain water interception by bush (Wiebe 2003) .Sweet runoff water accumulated in the water camp , whereas under the saline belt mean depth of the watertable (115 cm) with medium conductivity was ideal for capillary ascension of saline groundwater , indicated by high average soil humidity (Table 1) .Obviously native chacoan bush fulfils a crucial role in keeping the saline groundwater table at a safe distance from the soil surface .

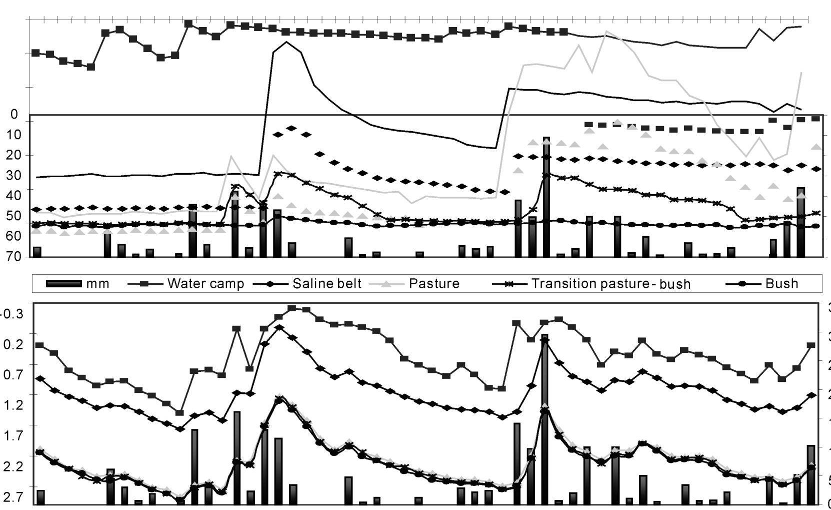

Figure 1 *volution of electrical conductivity (above left : mS/cm) and depth (below left : meters) of groundwater during a 2 $^1/_2$ years measuring period (from July 2002 on) at representative sites : Water camp , saline belt at the edge of the water camp , pasture , transition pasture-bush , and bush . The bars represent rainfall events (both graphs at the right : mm) .*

Table 1 *Mean values of parameters measured over 2 $^1/_2$ years .*

Site	Soil surface a .s .l .(m)	Water-table a .s .l .(m)	Depth of water-table (cm)	Groundw .conduct . (mS/cm)	Soil humid . (%)
Water camp	109 .6	109 .02	58	5 .6	15 .0
Saline belt	110 .0	108 .85	115	31 .5	11 .7
Pasture	111 .1	108 .77	229	40 .1	9 .5
Transition Past .-Bush	111 .1	108 .73	233	45 .9	8 .5
Bush	111 .1	108 .70	236	53 .8	8 .5
Mean	110 .6	108 .80	174	35 .4	10 .6

Impacts of grazing management on cattle distribution and non-point source pollution from pastures in the central United States

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Key words: grazing, cattle behavior, water quality, GPS

Introduction There are concerns that cattle tend to congregate in riparian areas which are highly susceptible to environmental damage, resulting in impaired water quality from stream bank erosion and manure deposition (CAST, 2002). Few studies have evaluated the effects of grazing management on water quality in the humid Midwestern region of the USA. Climate, topography, forage species, and management practices may influence animal behavior, as it relates to use of riparian areas and the subsequent impacts of grazing on stream bank erosion and water quality. The objective of the current study was to evaluate the effects of grazing management, the availability of off-stream water sources, and micro-climate on the temporal/spatial distribution of cattle in pastures with streams.

Materials and methods Six 12.1-ha cool-season grass pastures, each bisected by a 196 meter stream segment, were grouped into 2 blocks and assigned one of three grazing management treatments. Treatments included: continuous stocking with unrestricted stream access, continuous stocking with stream access restricted to a 4.9-meter wide crushed rock crossing, and 5-paddock rotational stocking with one paddock in the riparian zone. Each pasture was stocked with 15 fall-calving Angus cows from mid-May through mid-October in 2005, 2006, and 2007.

Cattle distribution patterns were monitored by visual observation and with GPS collars (AgTraX^{tm}-BlueSky Telemetry, Aberfeldy, Scotland). During visual observations, cattle distribution patterns and activity were monitored from 0600 to 1800 hours on two consecutive days from May through September of 2005 through 2007. One cow per pasture was fitted with a GPS collar for 2 weeks per month from May through September in 2006 and 2007. Collars recorded cattle position every 10 minutes 24 hours per day. The effects of off-stream water on cattle distribution was evaluated by providing access to off-stream water to cows during the second week in which cows were fitter with GPS collars in May, July, and September. Off-stream waters were located a minimum distance of 220 meters from the stream on both sides of the stream. Cattle location was defined as within stream, 0 to 34 meters from the stream, 34 to 68 meters from the stream, and greater than 68 meters from the stream.

Results and discussion Based on both visual observation and GPS collar data, cattle managed by continuous stocking with unrestricted stream access spent a greater ($P<0.05$) proportion of time in and within 34 meters of the stream than did cattle managed by continuous stocking with restricted stream access or rotational stocking. Cattle in unrestricted stream access pastures spent an average of 6.1% of the time within the stream and an additional 15.7% of the time within 34 meters of the stream over the 3 grazing seasons, based on visual observation data. Cattle managed by rotational stocking spent 0.3 and 3.5% of the time in and within 34 meters of the stream, respectively, while cattle managed by continuous stocking with restricted stream access spent 1.2 and 0.8% of the time in or within 34 meters of the stream, respectively, based on visual observation. The proportions of time cattle spent in or within 34 meters of the stream estimated by GPS collars were 1.2 and 10.6% in pastures managed by unrestricted stream access. The difference between visual observation and GPS collar data is likely caused by the visual observations being conducted during daylight hours only, while GPS collar data is collected 24 hours per day. With warmer temperatures during daylight hours, cattle are more likely to congregate near the stream in an attempt to regulate body temperature.

In 2006, the presence of an off-stream water source decreased ($P<0.05$) the proportion of time cattle spent within the stream by approximately half when cattle had unrestricted stream access. A similar effect was not observed in 2007, possibly because of differences in the presence of natural off-stream water sources associated with precipitation between the two years.

At higher ambient temperatures, cattle distribution patterns within pastures were altered as cattle attempted to regulate body temperatures. At ambient temperatures above 27℃, the proportion of time cattle spent within 34 meters of the stream increased ($R^2=0.85$) when cattle were managed by continuous stocking with unrestricted stream access.

Conclusions The amount of time cattle spend in or near pasture streams may be reduced with improved grazing management that alter cattle behavior; this alteration in cattle distribution may result in positive water quality impacts.

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Can grazing species be used to manipulate the amount of nitrogen leaching to groundwater ?

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Key words : grazing , cattle , sheep , deer , nitrogen leaching

Introduction Regulatory limits on nitrogen (N) leaching from farmed land in the Lake Taupo catchment in New Zealand make the identification of effective N leaching mitigation strategies for land owners imperative.More N has been shown to leach from cattle than from sheep urine patches due to the greater volume of urine as well as the greater rate of N deposited in cattle urine patches (Williams and Haynes, 1994).A field-scale study was undertaken to examine the potential for using different grazing species to reduce the amount of N leaching from grazed land.

Materials and methods The trial site was located on a highly porous pumice soil in the Lake Taupo catchment in New Zealand. In October 2003 a 4-year old ryegrass/cocksfoot/white clover pasture was divided into 9 (0.5 ha) paddocks, and young (5-18 month old) sheep, cattle and deer treatments were assigned to the paddocks in a randomised complete block design.The paddocks were rotationally grazed by their assigned species when a target herbage mass was reached (2500 kg DM/ha), and animals were removed when a target residual herbage mass was attained (1000 kg DM/ha).The aim was to achieve identical grazing pressure by all three species on a stock unit (SU) equivalence (based on annual feed intake).

Pre and post-grazing herbage mass was estimated by a rising plate meter calibrated each season for each animal species to obtain an estimate of dry matter intake (DMI). Herbage on offer was analysed for N concentration by NIR to allow estimation of N intake (NI).Animal grazing days were recorded at each grazing event and expressed as stock unit grazing days (SUGD).From May 2004 until February 2007, 40 ceramic cup samplers per paddock, placed 60 cm below the soil surface in a stratified random pattern, were used to sample soil solution for nitrate-N (NO_3-N) and ammonium-N (NH_4-N) concentration.The soil solution was sampled after each interval of approximately 60 mm of drainage as determined by a water balance model.

Results and discussion Mean rainfall for the 3 years of leaching measurements was 1584 mm/yr with the calculated drainage below 60cm averaging 951 mm/yr.Whilst the amount of NO_3-N and NH_4-N leaching below 60 cm differed significantly between years ($p < 0.001$), there was no significant difference in the amounts of either N form that was leached between the three species of grazing animal overall, or in any of the three years.

Table 1 *Three-year mean annual dry matter and N intake, SUGD, and mineral N leached (2004-2007).*

Treatment	DM Intake (kg DM/ha.yr)	N Intake (kg N/ha.yr)	SUGD (days/yr)	NO_3-N leached (log.kg NO_3-N/ha.yr)	NH_4-N leached (kg NH_4-N/ha.yr)	Mineral N leached (kg) per kg N intake (%)	Mineral N leached per SUGD (gmN/SUGD)
Cattle	7218	267	7307 a	8.17 (36.6)[1]	2.9	12.3 a	5.5 a
Deer	7620	284	8602 b	7.59 (25.1)	2.9	7.5 b	3.4 b
Sheep	8628	320	10588 c	7.79 (25.9)	2.8	7.5 b	2.9 b
probability	ns	ns	<0.001	ns	ns	<0.05	<0.01
$LSD_{0.05}$			699	0.89		3.0	1.5

[1] Values in brackets are arithmetic means (kg NO_3-N/ha.yr).

Although there was no significant difference in the amount of mineral N leached between the three species, nor in the amount of DMI or NI apparently consumed, the number of stock units required to harvest the herbage on offer was significantly greater for sheep and deer than for cattle.Despite attempting to achieve identical grazing pressure on a SU equivalent basis, it became increasingly difficult to maintain sufficient control of pasture growth in doing so.More SU equivalents of sheep and deer than cattle were required to harvest the available herbage, especially in the late spring and summer period.This resulted in more SUGD's needed per ha to maintain adequate control for sheep and deer pastures than for cattle pastures. The amount of mineral N leached was less per sheep and deer SUGD than per cattle SUGD (Table 1).However, the number of SUGD's required to harvest that herbage meant that the amount of total mineral N leached per SUGD and per kg N intake was significantly different between the three species.

This study gives valuable information on N leaching in this catchment and provides new data to assist in calculating the potential to mitigate N leaching losses using different grazing species.However, the extent of the potential reduction in N leaching through the use of different grazing species must be based on a whole-farm system analysis.

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Digitaria eriantha under water deficiency

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Key words: water use efficiency, forage quality, *in vitro* dry matter digestibility, neutral detergent fiber, nitrogen.

Research on dryland pastures in the semiarid regions of Argentina has concentrated mainly on aspects such as potential production related to quantity and quality as well as fertilization requirements. But since soil water is the most limiting environmental factor that affects plant production in these areas, the water use efficiency and the quality of the pasture under water limited conditions should be considered. Even if water stress is the most important physical limitation to plant yield there are contradictory results about its effect on nutritive value.

Digitaria eriantha is a highly palatable perennial C4 grass which can be grown in most of the semiarid areas of Argentina. It has the potential to become one of the most widely pasture grass in those areas. The climate during its growing season is characterized by considerable fluctuations of rainfall. Water stress effects on *D. eriantha* quality has not been studied.

The purpose of this study was to determine the effect of moisture regimes on yield, water use efficiency and quality of *D. eriantha*.

This study was conducted at the greenhouse and the experimental field of the Universidad Nacional del Sur at Bahía Blanca (38°44′S 62°15′W). The soil was a typical ustipsament with a petrocalcic layer and a loamy-sand texture. *D. eriantha* cv. Irene was used.

There were three treatments at the field: 1) no irrigation, 2) irrigated every 7 days, and 3) irrigated every 14 days.

A randomized complete block design was used.

Plots were 5.0×2.8 m and there were 6 replicaes for each treatment.

There were also 3 treatments in the greenhouse: a) 100%, 2) 75% and 3) 50% field capacity.

Forage was dried at 65°C, weighed and ground for chemical analysis. Nitrogen was determined by the semimicro-Kjeldahl method (Bremmer, 1996) and then multiplied by 6.25 to obtain crude protein (CP), phosphorus concentration was obtained by Murphy and Riley (1962).

In vitro dry matter digestibility was determined by Terry and Tilley (1964), neutral and acid detergent fiber and lignin by Van Soest *et al* (1991).

There was a good correlation between yield and the availability of soil water. The production of *D. eriantha* with 75 and 50% of field capacity was reduced 81 and 56% compared to treatment of 100% of field capacity. The water use efficiency was 6.38 kg ha^{-1} mm^{-1}.

Water stress had a smaller effect on forage quality than on growth. Drought reduced the seasonal decline in digstibility (IVDMD) by reducing the rate of increase in acid detergent fiber and lignin compared to non-stressed plantas. This can be due to a delay in plant growth.

Water deficit decreased the rate of seasonal decline in nitrogen content, may be by a decrease in leaf senescense, but there was a reduction of phospohours concentration.

The response of plants to water stress depends on the time of the stress. Most of the effects on forage quality were positive, may be due to a delay in maturity caused by water stress. At later times the stress accelerate the maturation.

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Influence of recycled water irrigation on Triticale nutrient absorption

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Key words: Recycled water, Irrigation, Nutrient, Root, Biomass

Introduction As our population increases, so does the strain on our nation's potable water supply. In the arid and semi-arid zones of North China, the quantity of water resource per person is less than 700 cubic meters per year. Reuse of treated municipal wastewater for irrigation reduces the use of potable groundwater for agricultural irrigation. Triticale is the dominant forage type in China and the shortage of water resources is the limiting element influencing its production. Since recycled water is a valuable substitute water resource for forage irrigation, the influence of recycled water irrigation on the growth and nutrient absorption of Triticale was studied in potted plants.

Table 1 *Water quality of recycled water for the experiment.*

Water	N(mg/kg)	P (mg/kg)	K(mg/kg)	Ca (mg/kg)	Mg(mg/kg)	pH
RW	15.07	0.7350	14.40	78.70	30.10	7.460
NW	3.080	0.02700	4.960	52.40	18.20	7.780

Methods Recycled water (RW) was derived from Zhuozhou sewage disposal plant, while nutrient water (NW) was tap water supplied N, P, K, Ca, Mg such that the content of NW was the same as RW (Table 1). Two water types (RW and NW) were used to irrigate Triticale, with 15 replicates.

Table 2 *Effects of recycled water irrigation on root activity of Triticale ($TTC mg \cdot g^{-1}$ root drymatter h^{-1}).*

Date	May.4	May.14	May.24	Jun.4	Jun.14
NW	0.93	0.52	0.74	0.39	0.68
RW	1.11	0.59	0.84	0.44	0.70

Results and discussions The results showed that the type of applied water had a significant effect on Triticale biomass, with the highest biomass found with RW (Figure 1). RW significantly increased the root activity of Triticale in comparison to NW (Table 2). No effect of water type on the N, P, K, Ca and Mg absorption of Triticale shoot was evidenced (Table 3).
Meng (1999) and Qi et al. (2003) indicated that sewage could increase the yield of crop by studying the effect of sewage irrigation on wheat, summer millet and summer corn. This study confirmed that recycled water irrigation could increase the yield of Triticale significantly, and indicated that the influence of irrigation water type on the N, P, K, Ca, Mg content of Triticale were not significant.

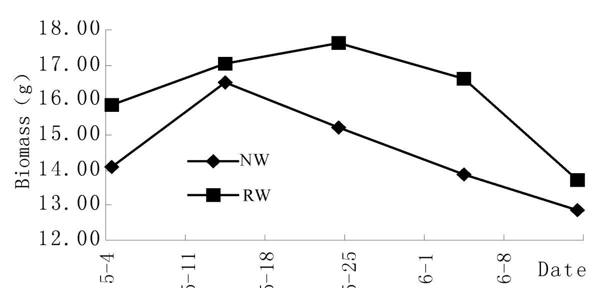

Figure 1 *Effects of recycled water irrigation on biomass of Triticale.*

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Table 3 *Effect of the different irrigation water quality on N, P, K, Ca and Mg absorption of Triticale shoot (mg/kg).*

Date	Water	N	P	K	Ca	Mg
May.14	NW	1.137a	0.206a	2.669a	0.676a	0.152a
	RW	1.080a	0.189a	2.687a	0.696a	0.157a
May.24	NW	1.183a	0.185a	2.649a	0.875a	0.182a
	RW	1.128a	0.194a	2.701a	0.929a	0.184a
Jun.4	NW	1.557a	0.236a	2.586a	1.017a	0.191a
	RW	1.438a	0.242a	2.602a	0.926a	0.191a
Jun.14	NW	1.439a	0.219a	2.648b	1.180a	0.220a
	RW	1.486a	0.225a	2.886a	1.203a	0.228a

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Studies on characteristics of soil moisture of *Stipa bungeana* typical steppe under different land disturbances in hilly area of Loess Plateau

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Key words: Soil Moisture Changes, Moisture Balance, Land Disturbances, Typic Steppe, Hilly Area of Loess Plateau

Introduction Soil Moisture is influenced by rainfall and also by land use (Gerd *et al*., 2003; Basica *et al*., 2001). We examined how ungrazed rangeland and areas manipulated by parallel ditches and fish-scale pits compare with respect to restoration effects in areas of *Stipa bungeana* typical steppe in an arid hilly area of Loess Plateau in Ningxia. These treatments enhanced utilization of water resource, however, there is potential danger that previous water resource distribution and water utilization balance could be disrupted. Therefore, it was helpful for ecosystem management to study characteristics of soil moisture with respect to these treatments.

Materials and methods The area of investigation is located in Renwan village of Pengyang county in Ningxia (35°50′N, 106°39′E). The regional climate is continental, with average annual rainfall of 440mm and evaporation capacity of 1360.6mm. (1) Sampling sites. Three treatments including ungrazed grassland (BU), parallel ditches (PD) and fish-scale pits (FP) in three sloping positions were selected as sampling sites. Three sloping positions involved upgrades (UG, altitude was 1565m), mesoslopes (MS, altitude was 1536m) and downgrades (DG, altitude was 1516m). These three measures have been carried out for 5 years and the vegetation in sampling sites presented no differences. The predominant plant species was *S. bungeana*. (2) Moisture measurements. Soil moisture in the depth of 0-200cm was measured once every ten-days between March and December in 2006 by drying method. Meanwhile, we designed runoff experimental plot and surveyed runoff collected by parallel ditches after raining.

Results The soil moisture content was most in parallel ditches (Figure 1), was more in fish-scale pits, was least in ungrazed grasslands with the change of time ($p<0.01$). The difference of soil moisture content among them was more evident in rainy days. The order of soil moisture content in ungrazed grasslands from highest to lowest was downgrades, mesoslopes and upgrades ($p<0.01$). The order of soil moisture content in fish-scale pits and parallel ditches from highest to lowest wholly was mesoslopes, downgrades and upgrades ($p<0.05$), but it had no difference between upgrades and downgrades ($p>0.05$). Soil moisture content variation in depth of 0-40cm was biggest in ungrazed grasslands, bigger in fish-scale pits, and smallest in parallel ditches, but variation in depth of 40-200cm was biggest in fish-scale pits (Tab.1). Except rainy season, soil moisture in depth of 0-130cm in parallel ditches and ungrazed grasslands were in negative balance in most of the year (Tab.2). Soil moisture in parallel ditches was easier to become negative balance than that in ungrazed grasslands when rainfalls and runoffs were less. Surplus of soil moisture in parallel ditches was higher than that in ungrazed grasslands only when parallel ditches intercepted more runoffs.

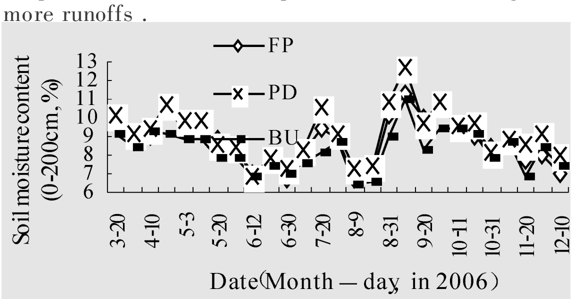

Figure 1 *Seasonal changes of soil moisture content under three measures.*

Table 1 *Statistic eigenvalue about soil moisture contents of different depth soil under three measures.*

Items	Depth (cm)	FP	PD	BU
Standard deviation	0-40	2.84	2.80	2.87
	40-100	1.56	1.47	1.33
	100-200	0.75	0.76	0.53
Coefficient of variation (%)	0-40	28.17	26.53	29.18
	40-100	18.49	16.85	17.18
	100-200	9.59	9.13	7.18

Table 2 *Balance of soil moisture under Bu or PD measures (0-130cm).*

Date	Measures	Changes of soil moisture (mm)	Rainfall (mm)	Runoff or runoff being intercepted (mm)	Moisture loss (mm)	Water balance
March to Jun.	BU	-33.49	80.81	0	114.30	-33.24
	PD	-46.68	88.60	0	135.28	-46.86
Jul. to Sep.	BU	30.01	199.84	13.46	156.37	29.78
	PD	50.69	219.10	53.83	222.24	52.13
Oct to Dec.	BU	-27.72	26.64	0	54.36	-27.71
	PD	-36.54	31.40	0	67.94	-36.49
March to Dec.	BU	-31.20	307.29	13.46	325.03	-32.21
	PD	-32.53	339.10	53.83	425.46	-31.52

Conclusions Based on seasonal changes and balance of soil moisture under three measures, we conclude that PD and FP could improve soil moisture content in arid hilly area of Loess Plateau, especially in rainy days. However, soil moisture in PD is easier to become negative balance than that in BU when rainfalls and runoffs are less.

Maximising water yield with indigenous tall grassland/rangeland on New Zealand uplands and trade-offs with alternative land uses

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Key words : Water yield, Indigenous grassland/rangeland, Land use, New Zealand

Introduction Water is an essential ecosystem service that is under increasing pressure worldwide. Successful resource management requires accurate information on water yields from important source areas in relation to alternative land uses and vegetation types. Upper watersheds/catchments usually have the greatest potential for water production in New Zealand, regardless of where water is being extracted.

Methods Non-weighing lysimeters, containing indigenous tall tussock grassland or several types of alternative cover in a series of studies in SE New Zealand uplands (500-2000 m) have been supplemented with a range of other methods. These include two paired catchment studies, a weighing lysimeter and a stable isotope study (Mark and Dickinson 2008).

Results and discussion Water yields from indigenous tall tussock grassland/rangeland have been consistently higher at upland (> 500 m) sites than from any of several alternate cover types tested, even bare soil. Such yields are mostly 60-65% of the 1300-1400 mm of annual precipitation, regardless of the methodology, but reached 80% in lysimeters on a highly fog-prone upland at 870 m. There is general agreement that the high yields from the indigenous tall bunch grassland/rangeland are associated with low evapo-transpiration from the dominant grass cover but the role of fog remains contentious. However, the stable isotope ($\delta^{18}O$ and δD) analyses of fog-, rain-and ground-water from three upland sites have indicated a subequal contribution from fog and rain. One long-term paired-catchment study has shown a steady reduction (up to 41% after 22 years) in water yield from an afforested (exotic *Pinus radiata*) catchment compared to that from an adjacent one of indigenous grassland. The second such study compared water yield following burning of the grassland/rangeland and revealed some reduction during the first three post-burn summers; up to 32% in the second year, consistent with results from an earlier lysimeter study.

Conclusions The tall tussock grass life form and its leaf morphology/anatomy/physiology (fog deposition plus low transpiration) appears to be the differentiating factors. Maintaining dominance of such tussock grass cover is highly desirable for water production purposes, especially in upland supply catchments. Trade-offs between forestry for wood production/carbon sequestration versus water production should be carefully evaluated with fully integrated land use planning, particularly in such important catchments (Mark & Dickinson 2008).

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Growth and water use of perennial ryegrass and tall fescue under different irrigation treatments

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Key words: *Lolium perenne*, *Festuca arundinacea*, water use efficiency, drought, yield

Introduction New Zealand pastures are predominantly perennial ryegrass (*Lolium perenne* L.), which is susceptible to drought. Tall fescue (*Festuca arundinacea* Shreb.) has been shown to be more drought tolerant (Garwood et al., 1979). To quantify drought stress effects and determine irrigation requirements of these two grasses, we carried out an experiment in a rainshelter where rainfall was excluded from trial plots otherwise exposed to normal weather (Martin et al., 1990).

Materials and methods Grasslands Samson′perennial ryegrass and Grasslands Advance′tall fescue were sown in the rainshelter on 11 November 2004 in a randomised block design, with 2 replicates and 6 irrigation treatments: (1) full irrigation weekly, adding the weekly Penman potential evapotranspiration each time; irrigated (2) 2 weeks in every 3, (3) every 2 weeks, and (4) every 4 weeks with the same amount of water as (1) that week; (5) no irrigation from 1 August to 8 January to harvest than as (1); and (6) irrigation as (1) to 4 December then no irrigation to 12 March than as (4). Each 5 m×3 m plot had its own trickle irrigation supply, and each treatment was mown down to 5 cm every time the pasture mass reached 2,500 kg/ha. Data reported here were collected from 1 August 2006 to 31 July 2007.

Results Tall fescue produced 16% more dry matter, but only used 6 % more water than perennial ryegrass (Table 1). Treatments (1) and (2) had highest yields, but also highest water use. Treatments (2)-(5) had the highest water use efficiency. Yields decreased at around 12 kg/mm of maximum potential soil moisture deficit (MPSMD) (French & Legg 1971) experienced by the pasture through the year (Figure 1), but tall fescue produced higher yields for a given MPSMD than perennial ryegrass.

Table 1 *Fescue and Ryegrass dry matter production (t/ha), water use (mm) and kg DM/mm water used.*

Species	DM (t/ha)	WU (mm)	DM/mm WU
Ryegrass	12.9	727	18.5
Fescue	15.0	769	19.9
LSD(5%)	0.89	25.2	1.83
Tmt 1	17.4	1142	15.3
2	15.9	824	19.3
3	15.4	706	21.8
4	10.3	524	20.0
5	12.8	565	22.7
6	11.8	727	16.3
LSD(5%)	1.54	43.7	3.17

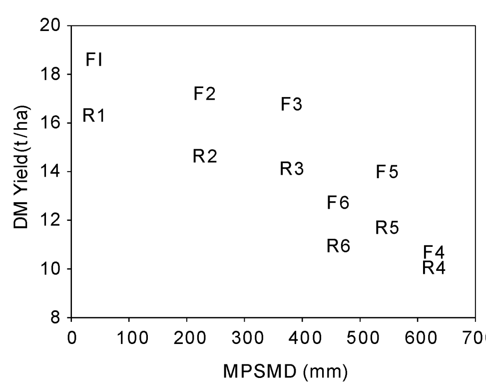

Figure 1 *Total pasture dry matter yield v. MPSMD.*
F Fescue, R ryegrass. Numbers are irrigation treatments.

Conclusions Tall fescue produced more dry matter, and more dry matter/mm of water used, than perennial ryegrass. Water stress at any time reduced both ryegrass and fescue pasture yields by about 12 kg./mm MPSMD, but autumn stress appeared to reduce production more than spring stress. Reducing the highest water use by nearly 40% only reduced yield by 11%.

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Study of meadow brome planting on soil and water conservation

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Keywords : meadow brome , slope , soil erosion modulus , surface runoff , soil and water conservation

Introduction China has one of the most serious soil erosion problems in the world .At present , vegetation is the most effective factor preventing soil erosion (Cerda 1999) .Grass coverage on slopes is key (Wang Pingqing ,2005) .Therefore , with brome grass as test material , a runoff experimental plot was built on 25 ° slope land in Yanqing county , and the effect and mechanism of brome grass on soil and water conservation was studied .This work verifies scientific theory and demonstrates technical solutions for effective control of soil erosion and rational use of grasses in northern China .

Materials and methods Test materials were brome grass (*Bromus riparius*) which came from Canada .Runoff experimental plots were built on 25° slopes .There were two treatments with Brome-growing areas and bare areas (CK) , and three replications , totalling six runoff plots in the same slope .The test field was oriented north to south , and the area of each runoff plots was 2m × 3m .The plots were separated by asphalt felt paper , buried underground 30 cm , above the ground 20 cm , then we set gullies and an outlet pond at the base and sewed grass seed on May 18 , 2006 along contour lines , spaced 15 cm .After each rain , we measured the depth of the barrels and calculated the total runoff volume of the slope , then took sampling by whole profile sampler , after filtering , dried the sediment in 1 -2BS-electric under 105℃ until the weight was constant .

Results The surface runoff and soil erosion modulus were important indicators of the slope erosion strength .The test results of 25° slope runoff experimental plot in Yanqing in 2006 showed that (Table 1) , the effect of lawn Brome planting for erosion control was significant , the surface runoff and soil erosion modulus of CK were 44331 .87 m^3/km^2 .a and 7423 .56 t/km^2 .a .The runoff and soil erosion modulus of Brome grass covered were less than the CK , only 14233 .19m^3/km^2 .a and 57 .82 t/km^2 .a .

Table 1 *The runoff and soil erosion modulus of different treatments .*

treatment	surface runoff m^3/km^2 .a	soil erosion modulus (t/km^2 .a)	capability of water conservation(%)	Capability of soil conservation(%)
CK	44331 .87a	7423 .56a	-	-
Bromus riparius	14233 .19b	57 .82b	67 .8	99 .3

Note : different letters in same row mean significantly under 0 .05 level

Conclusions Brome grass planting played an important part in soil erosion control on 25° slope land in Yanqing .The runoff and soil erosion modulus of Brome grass planting area were 14233 .19 m^3/km^2 .a and 57 .82 t/km^2 .a respectively .The capabilities of water and soil conservation were 67 .8% and 99 .3% .

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Water use indices of tropical perennial grasses in a temperate environment

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Key words: meadow brome, slope, soil erosion modulus, surface runoff, soil and water conservation, tropical grass, soil water, water use efficiency

Introduction The North-West Slopes of New South Wales (NSW) is classed as a temperate environment, but it has warm to hot summers and a summer dominant rainfall distribution. This environment may suit perennial grasses that have C4 photosynthetic growth, such as tropical perennial grasses, because their pattern of seasonal growth is well matched to rainfall distribution. While some endemic perennial grasses are C4, their water use index tends to be low (e.g. 3.6-4.9 kg DM/ha.mm, Murphy 2002). As demand for increased production efficiency per unit of rainfall is promoted by the livestock industry to satisfy sustainability requirements, improved estimates of efficiency are required to better evaluate options for producers.

Materials and methods An experimental site was established on a red chromosol on the North-West Slopes of NSW (31°16′S, 150°52′E, 490 m alt., 671 mm AAR) to compare the water use index of some introduced and endemic perennial grasses. Four treatments of three tropical species (*Digitaria eriantha* cv. Premier; *Chloris gayana* cv. Katambora; *Bothriochloa bladii* cv. Swann) and a mix of native species (*Austrodanthonia bipartita* cv. Bunderra; *B. macra*; *Dicanthium sericeum*; *C. truncata*) were randomly allocated to plots (6×9 m) across three replicates. Treatments were established in December 2005 by seeding at a rate of 2 kg/ha of germinable seed into a prepared bed at a depth of 10 mm. Treatments were allowed to establish and set seed during summer 2005-06 before water use indices were estimated in 2006-07. A calibrated neutron moisture meter was used to measure profile volumetric soil water content of each plot, to a maximum depth of 1.7 m, at sowing and thereafter at 3-week intervals. Herbage mass (kg DM/ha) was estimated at 6-week intervals from 20 September 2006 to 31 May 2007 using a comparative yield method (Haydock and Shaw 1975). Plots were mown to a height of 0.1 m after each assessment. A water use index (kg DM/ha.mm) was calculated for each 6-week interval by dividing herbage mass by the sum of rainfall received (mm) and soil drying created by the grasses (mm) and values were accumulated for the season.

Results and discussion Native perennial grasses showed less soil drying (39 mm) compared with the tropical grasses (119-149 mm, Table 1). Premier accumulated the highest herbage mass of all species (16,157 kg DM/ha), and the native grasses the least (2,689 kg DM/ha, Table 1). Similarly, Premier (32.4 kg DM/ha.mm) had the highest efficiency compared with all other species (Table 1). Water use indices for the tropical grasses were 2 to 5 times greater than for the native grasses (Table 1). Such indices provide a framework to compare the production performance of a range of grasses under controlled conditions. These results are for the first season of production after grasses were established, indicating their potential. Further measurements will be taken in later seasons as the grasses mature.

Table 1 *Rainfall, soil drying, herbage mass and water use index data for* 2006-07.

Species	Rainfall (mm)	Soil drying (mm)	Herbage mass (kg DM/ha)	Water use index (kg DM/ha.mm)
Premier	364	137a	16,157a	32.4a
Katambora	364	149a	11,516b	22.3b
Swann	364	119a	6,893c	13.7c
Native grasses	364	39b	2,689d	6.5d
LSD ($P<0.05$)	-	40	3,460	6.6

Conclusions In the temperate environment of the North-West Slopes of NSW, three introduced tropical grasses had higher water use indices in the first season of production after establishment compared with a mix of endemic native grasses, indicating that the tropical species can achieve high levels of efficiency in this environment.

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Level of water stress substantially affects productivity and water use efficiency of 30 forages used by the Australia dairy Industry

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Key words : water use efficiency , forages , dairy

Introduction The recent droughts in Australia have highlighted to the Dairy Industry the importance of irrigation water . Fodder production for the dairy industry is the second largest user of irrigation water in Australia . There are numerous species which can be used as a source of fodder , although basic information on seasonal and annual water use , and nutrient characteristics are lacking for some forages .

Methods A field experiment was conducted on a brown dermosol at the University of Sydney , Camden (34°3′S , 150°39′E) , over three years to evaluate the dry matter yield (DMY) , water use efficiency (WUE) and nutrient content , of 30 forages under optimum and two levels of deficit irrigation .A neutron probe was used to determine irrigation scheduling requirements , as well as water extraction down the soil profile .At a 30mm soil water deficit , the optimum treatment was refilled to field capacity (100%) , while the two water deficit treatments received 33% and 66% , respectively , of the water applied to the optimum treatment .Each forage was harvested at the optimum stage of growth for determination of DMY and quality .Fertilizer was applied to replace nutrients removed at each harvest , except for legumes where no nitrogen was applied .Seasonal WUE was calculated by dividing dry matter produced , by the sum of rainfall , irrigation and change in soil moisture content .

Results and discussion Annual DMY ranged from 8 to 31t DM/ha , with maize (*Zea mays*) having the highest yield .The perennial grasses , tall fescue (*Festuca arundinacea*) , perennial ryegrass (*Lolium perenne*) , prairie grass (*Bromus wildenowii*) and kikuyu (*Pennisetum clandestinum*) had the next highest yields in the range of 27 to 28t DM/ha (Neal *et al* ., 2005) .During the summer , the DMY from maize was over four times that of perennial ryegrass or white clover (*Trifolium repens*) and WUE was almost three times higher (Figure 1) .While there was a significant decrease in dry matter production for all forages under deficit irrigation , WUE was not significantly affected for maize , kikuyu and lucerne (*Medicago sativa*) (Figure 1) , as the decrease in yield was directly proportional to water used . This highlights the need to select the correct forage species when a deficit irrigation strategy is likely .

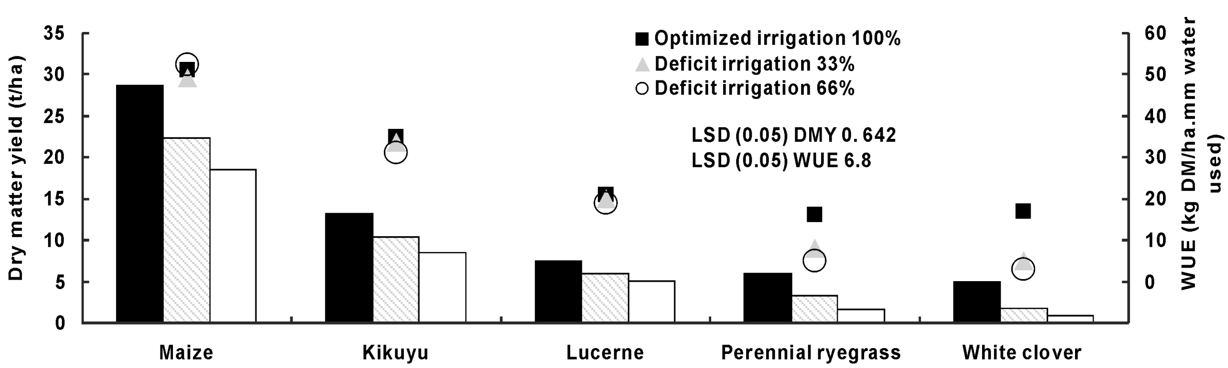

Figure 1 *Dry matter production (t/ha) (columns) and water use efficiency (kg DM/ha .mm water used) (symbols) of five selected forages*

Conclusions In the extremes of climate experienced in Australia , there is no single forage which provides an abundance of feed of sufficient quality throughout the year for dairy cows , and which is also WUE .Depending on rainfall , irrigation capacity and livestock requirements , a number of different forages can be used to fill the feed budget . Substantial savings in water can be achieved if the right species is selected for a particular season .However , in summer there is a tradeoff between WUE and nutritive value , with C4 forages (kikuyu , maize) generally having a lower nutritive value .

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The economic and phosphorus-related effects of precision feeding and forage management in North Cameroon

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Key words : Phosphorus , Precision Feeding , Forage Management

Background Structural best management practices have been implemented throughout the north province of Cameroon in an effort to reduce phosphorus (P) losses to the reservoir .Yet long-term water quality control efforts within north Cameroon are hindered by continuous P build-up in the soils resulting from dairy farm P imports exceeding exports .Addressing the P imbalance problems and maintaining economic viability of the farms requires a system-level redesign of farm management .One possible innovative strategy , precision feed management (PFM) , reduces soil-P build-up by limiting feed and fertilizer purchases , and increasing high-quality homegrown forage production .

Methods This study applied the integrated farm system model (IFSM) to two dairy farms in north Cameroon to quantify the benefits of a PFM farm planning strategy in controlling P imbalance problems , and maintaining farm profitability and reducing off-farm P losses .

Results The IFSM accurately simulated the 2 farms based on farm data supplied by farm planners ; these scenarios were used as the baseline conditions .The IFSM simulations of more accurate feeding of P (based on P required in animal diets) integrated with increased productivity of grass-forage and increased proportion of forage in the diet reduced the P imbalance of one farm from 5 .3 to 0 .5 kg/ ha and from 9 .6 to 0 .0 kg/ha for the second farm .For both farms , soluble P lost to the environment was reduced by 18% .Feed supplement purchases declined by 7 .5 kg/cow per year for dietary mineral P , and by 1 .04 and 1 .29 t/cow per year for protein concentrates through adoption of the PFM system .Moreover , when a land management practice of converting corn to grass was coupled with the precision feeding of P and improved forage management , IFSM predicted reductions of 5 .8 and 9 .3 kg/ha of converted land sediment-bound P in erosion loss each year .

Conclusions The model predicted slight purchase increases in corn grain to offset reductions in corn silage production and feeding rates , but no appreciable change in the farm P balance due to land conversion .The model-based studies conducted on a farm-by-farm basis complement farm planning efforts in exploring innovative farming systems .Moreover , the results set a benchmark for potential benefits of PFM strategies , economically and environmentally .

Modelling deficit irrigation strategies for dairy regions of Australia

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Key words: Irrigation, efficiency, perennial ryegrass, dairy

Introduction The seasonal differences between daily rainfall and evapotranspiration in temperate regions of Australia emphasises the reliance on irrigation to support pasture growth in these regions (Rawnsley *et al*., 2007). Water scarcity and or increase costs are placing significant demands on irrigators to improve their return for each mm of water applied. This modelling study examines deficit irrigation strategies to provide recommendations for farmers to improve irrigation use efficiency.

Materials and methods Monthly pasture cuts of perennial ryegrass (*Lolium perenne* L.) were simulated using the biophysical pasture model DairyMod (Johnson *et al*., 2003) at two sites; Elliott (northwest Tasmania; 41°06′S, 145°46′E), and Kerang (northern 0, 10, 15, 20, 25, 30, 35 or 40 mm of irrigation was applied. Simulations were run for 46 years (1960-2006), with median data for the last 40 years presented.

Results and discussion The marginal irrigation water use index (marginal pasture production due to irrigation/irrigation water applied (kg DM/mm); MIWUI) increased with decreasing irrigation application depths at both sites, indicating that a deficit irrigation strategy can increase the amount of pasture grown per mm of applied water (Table 1). A higher MIWUI for these perennial ryegrass pastures was found in the cool temperate climate of Tasmania than in the warmer climate of northern Victoria. The MIWUI for each irrigation application depth in Tasmania was substantially greater than 10.0 kg DM/mm, a figure that is often quoted as industry average. In contrast, in northern Victoria the MIWUI was below 10.0 kg DM/mm for each irrigation application depth, indicating that climate significantly influences the response of perennial ryegrass to irrigation.

Table 1 *The median annual perennial ryegrass pasture yield, irrigation water applied and MIWUI from differing irrigation application depths in Tasmania and northern Victoria over forty years (1967-2006).*

	Elliott (Tasmania)			Kerang (Northern Victoria)		
Application depth	Yield (t DM/ha)	Irrigation applied (mm)	MIWUI (kg DM/mm)	Yield (t DM/ha)	Irrigation applied (mm)	MIWUI (kg DM/mm)
0 mm	15.4	0.0	n.a	4.2	0.0	n.a
10 mm	20.9	130.0	41.6	7.1	370.0	7.8
15 mm	23.7	195.0	39.5	9.4	555.0	8.6
20 mm	25.3	260.0	35.5	9.9	740.0	6.3
25 mm	25.3	325.0	28.6	9.8	925.0	5.0
30 mm	25.3	390.0	23.7	9.8	1110.0	4.2
35 mm	25.3	455.0	20.3	9.8	1295.0	3.6
40 mm	25.3	520.0	17.7	9.8	1480.0	3.1

Conclusions The results of this study indicate that a deficit irrigation strategy can significantly improve the return of pasture grown for each mm of water applied. In addition, the use of irrigation water in warmer climatic regions to grow perennial ryegrass is potentially unsustainable due to the high level of water required and the low (< 10.0 kg DM/mm) marginal response to these applications.

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Water quality in terms of metals during flooding in two ecosystems of the Conchos Watershed, Mexico : rangeland-forest and urban areas

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Key words : water quality, rangeland, pollution, metals, Chihuahua

Introduction Water from the Conchos River is essential for about 1 million inhabitants of the State of Chihuahua-Mexico and economically fundamental for three irrigation districts of the state covering about 64,000 km^2 . Moreover, the Conchos River is the main water supplier to the lower Rio Grande/Rio Bravo (TNRCC, 1994) that serves as the natural boundary between Mexico and the United States of America ; the river water is mainly utilized by Texas' producers .The water of the Conchos river flows throughout the whole Conchos basin that contains two main hydrologic and climatological environments ; the upper zone about 2,700 m above sea level (masl) used as rangeland and forest production and the lower zone about 720-1,500 masl where the main urban areas are located and where water joins the Rio Grande/Rio Bravo water .The objective was to measure heavy metal contamination in the Conchos river considering two main environments : rangeland-forest use (pine communities and short grass-brush land communities), and lower zone (urban areas) .

Materials and methods Four locations were selected in the Conchos River to obtain water samples .Water samples were collected during 2004 and 2005 on a bi-monthly basis ; therefore, 12 samples were obtained in each location .As, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, V, Se, Zn Tl and Li were determined using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) Perkin Elmer 2100 .For statistical analysis two points represented the rangeland-forest community (Satevo river (S) and Zaragoza river (Z)) and two points represented the urban area (Chuviscar (CH) and Ojinaga (O)) .An Analysis of Variance (ANOVA) was performed to determine year, month, and community differences (zone) using a 0.05 level of significance .

Results and discussion Mn level was different for year and zone (Figure 1) while As concentration was different for year, season and zone (Figure 2) .With respect to other elements, Cr was not different .Pb was significant for zone, Zn for year, V for year and season, Cu for year and season and Fe for season .The elements Cd, Co, Mo, Ni, Sb, Se, Tl and Li were not significantly different with respect to year, season, and zone and their concentration was inconsistent .It was noted that, in general, the rangeland-forest environment contained lower levels of the metals tested .

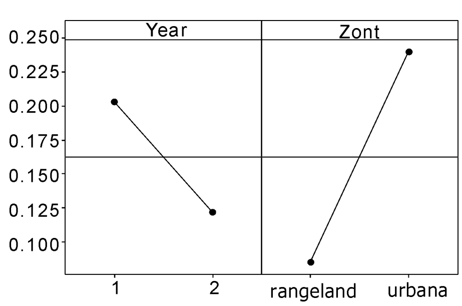

Figure 1 *Mn levels for year and zone in the Río Conchos .*

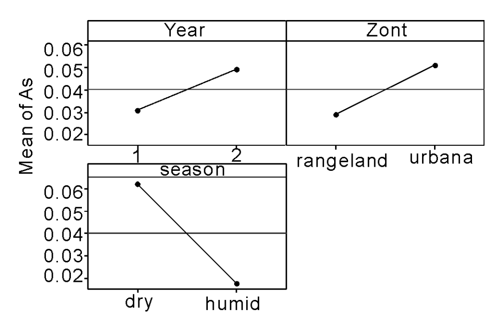

Figure 2 *Levels of As considering year, season and zone .*

Conclusions The rangeland-forest ecosystem in the upper region of the Conchos watershed produced water with low levels of metals in contrast with the lower ecosystem .It is expected that this difference is due to anthropogenic activities .

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Investigation of effects of water spreading on improvement of Iran's Rangelands

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Key words : water spreading , Iran's Rangelands , arid and semi-arid regions , water resources

Introduction Area of rangelands of Iran is estimated at about 90 million ha (54% of Iran total area) .These rangelands have the richest flora in the world and more than 6000 species of plants .

Materials and methods Eleven water spreading (W .S) projects from total 36 W .S stations available in Iran , were selected (these eleven stations have suitable distribution across Iran , so results can be approximately representative of the total conditions of Iran) .For evaluating their efficiency and effects on range improvement , data from before and after doing W .S , informal reports and field surveys in these stations were collected and analyzed .These stations are , 1-Gareh Baygan , 2-Jajram , 3-Khuzestan , 4-Varamin , 5-Poldasht , 6-sabzevar , 7-Gonabat-kalat , 8-Sahrin-ghare , 9-Ab-barike-bam , 10-Sefid rood , and 11-Ghoshe damghan .These are located in the Center , the West , the East , the North East , the North West and the South West of Iran .

Results The results can be classified following 3 issues
The effects of W .S on quantitative and qualitative varieties of vegetation cover In Gareh Baygan investigation of data before and after doing W .S , shows that vegetation cover changed from 20% to 34 .07% , the area of poor rangelands around the station have decreased from 7500 ha to 2352 ha .Production of *Salsola tomentosa* has increased about 60% , forage production changed from 101 kg/ha has became 501 and 825 kg/ha , range capacity changed from 0 .07 animal units /year to 0 .34 and 0 .56 animal units /year , range condition changed from very poor to average and good and range trend from down ward to upward (Nejabat 1999) .

The effects of W .S on soil properties In the Sefid Rood results of soil analysis show that after W .S saturation percent was increasing , electrical conductivity was decreasing , and pH content was increasing .W .S decreases the amount of property damage caused by floods , feeds the underground aquifer and improves the farming soil and physical properties of soil .

Bio-Ecological effects of W .S In Gonabat-kalat due to improvement of plant coverage after W .S , a very appropriate food has been provided for the animals , so the animals have come to the area and this improves animal production .
The results of W .S in Gareh Baygan shows that there is reduced mobility and migration of people in the range lands in which there were problems such as shortage of appropriate water and forage for animals .

Conclusions Iran is located in arid and semi arid of the world with mean annual rainfall of ca .240 mm and irregular spatial and temporal distribution .In such conditions rangelands are the primary sources of water for different uses , so different methods of water harvesting such as W .S can be applied to improve water recourses of rangelands .Many rangelands of Iran are suitable for W .S and this technique improves conditions of ground water , soil , vegetation cover , and forage production of rangelands . Results of this study show the positive effects of W .S on rangelands .The experiences of Iran in this case can be employed in the other countries with similar conditions to Iran .

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Dynamics of post-wildfire wind erosion of soil in semiarid rangelands , Idaho , USA

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Key words : aeolian transport , wind erosion , wildfire , semiarid , rangelands

Introduction Post-wildfire soil erosion by wind is an important but unstudied ecological process in cold desert , semiarid shrub steppe . In particular , the post-fire dynamics of soil erodibility are not well understood . We examined threshold wind speed during saltation events as a measure of erodibility for three months following a late-summer wildfire in southeastern Idaho , USA rangelands during 2007 . Our objective was to describe variability and controls of erodibility throughout the first few months following fire , into the beginning of the winter period .

Materials and methods We measured the fraction of time saltation was detected (saltation activity) , the minimum wind speed required to initiate saltation (threshold) , air temperature (temperature) and percent relative humidity (rH) for five-minute intervals , and soil volumetric water content from 0-15 cm depth (water) for 6 hour intervals , at a burned and an unburned site . We determined and analyzed daily means of threshold , water , temperature and rH during saltation events at one burned site .

Results and discussion Little saltation activity was detected and threshold could not be assessed at the unburned site . Threshold increased during the course of the study at the burned site (Figure a) , suggesting that erodibility was highest immediately following fire and decreased throughout fall . Water , temperature , and rH (Figure b , c , d) were moderately-strongly correlated with threshold (Pearson's correlation = 0 .70 , -0 .68 , 0 .76 , respectively , all $p < 0.00$) . A multiple regression model with rH and water as predictors explained substantial variability in threshold (threshold = 6 .92 * 0 .02 rH * 0 .10 water , $r^2 = 0.75$, p-values < 0.00) .

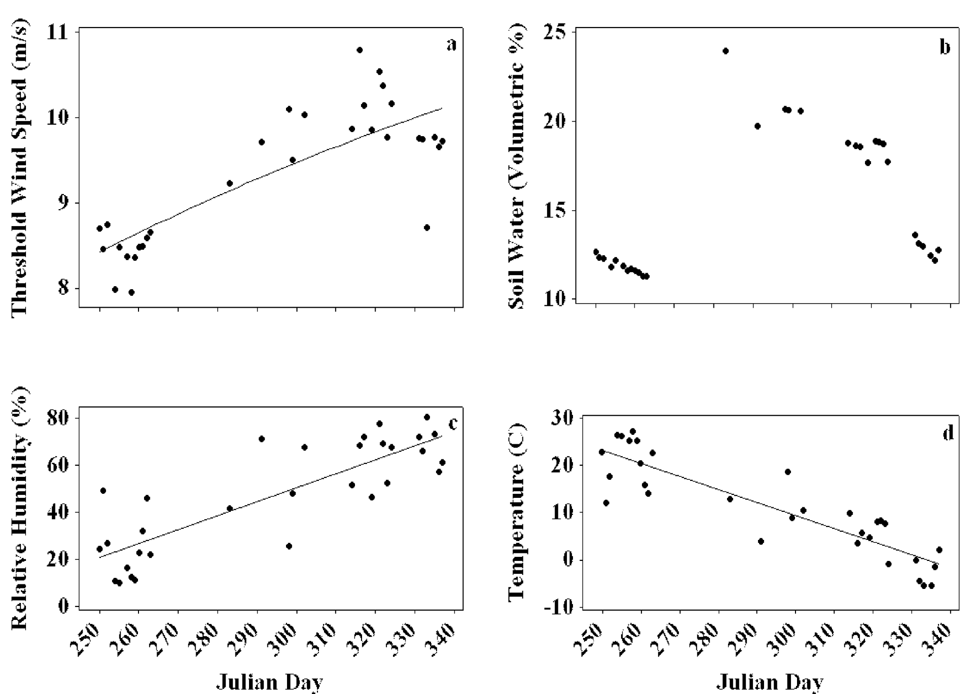

Figure 1 *Daily mean threshold , soil water content , rH , and air temperature for erosion events occurring after summer wildfire .*

Conclusions Preliminary findings from this study suggest that wildfire has the potential to increase wind erosion susceptibility in the semiarid rangeland environment we studied .Erodibility , as measured by daily mean threshold wind speed , appeared to be highest in the weeks immediately following fire .Both subsurface hydrology and boundary layer atmospheric conditions appear to be major controls on the dynamics of post-wildfire wind erosion .

Effect of artificial grassland on soil and water conservation in Beijing

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Key words : barren lands , meadow brome , artificial grassland , soil and water conservation , Beijing

Introduction There are severe soil erosion and water loss problems that are exacerbated by livestock production around Beijing . Drought-resistant and barren-tolerant perennial grass is a good forage that promotes soil and water conservation (Adekalu et al ., 2007) .The main objective of this study was to reduce soil erosion and water loss on barren lands in Beijing by planting perennial grass in different areas .

Materials and methods The experiment was conducted with in Yanqing , Miyun , and Changping in Beijing .Their soil textural classifications were sandy loam , sand clay loam and clay loam .Rainfalls were 393 .5mm , 579 .7mm and 613. 7mm .Treatments were imposed in a randomized complete block design with three replicates .There were one CK (control) that was a barren slope and one treatment that was artificial grassland sowed in autumn with meadow brome (*Bromus riparius*) in one experimental area .Surface runoff and soil erosion was observed on plots in 2006 , and grass height , cover and biomass of artificial grassland were measured with three replicates in the August .

Results and discussion Ground covers and biomasses of artificial grasslands in Miyun and Changping were over 97% and 5321kg/hm^2 , and higher ($p<0.01$) than those in Yanqing .This was due mainly to rainfall and soil textural classification (Table 1) . Meanwhile , soil erosion and water loss of artificial grassland was lower significantly ($p<0.01$) than that in CK in every experiment area .Amounts of surface runoff and soil erosion of artificial grasslands were only 3090 .3 t/km^2 and 2 .6 t/km^2 in Changping in 2006 , and the effect of soil and water conservation was highest there , 98 .22% and 99 .99% .This site had clay loam soil and high ground cover of grassland (Table 2) .

Table 1 *Artificial grassland background of three areas in Beijing in 2006 .*

Areas	Overground biomass(kg/hm2)	Ground cover (%)	Grass height (cm)
Yanqing	4867 .7b	85 .3b	36 .2a
Miyun	5569 .3a	97 .7a	38 .7a
Changping	5321 .9a	97 .9a	39 .9a

Note : Different letters of each column in an area are significant differences at 0 .01 level ($p<0.01$) .* AG indicated artificial grassland .

Table 2 *Yearly amount of surface runoff and soil erosion of three areas in Beijing in 2006 .*

Areas	Treat-ments	amount of surface runoff (t/km^2)	Soil erosion (t/km^2)	water conservation (%)	soil conservation (%)
Yanqing	CK	44331 .9a	7423 .6a	—	—
	AG*	14233 .2b	57 .8b	67 .89	99 .22
Miyun	CK	182979 .5a	3591 .1a	—	—
	AG	14110 .3b	8 .1b	92 .29	99 .77
Changping	CK	173909 .9a	25806 .7a	—	—
	AG	3090 .3b	2 .6b	98 .22	99 .99

Conclusions Surface runoff and soil erosion in barren fields was decreased effectively by planting drought-resistant and barren-tolerant perennial grass .Ground biomass and cover increased , and vegetation restored rapidly after grass planting .This benefited livestock and had positive effects on soil and water conservation in Beijing .

Reference

Adekalu K .O . , Olorunfemi L .A . , Osunbitan J .A . , 2007 .Grass mulching effect on infiltration , surface runoff and soil loss of three agricultural soils in Nigeria . *Bioresource Technology* 98 : 912-917 .

The surface water and soil quality by the year-long staying management in Jeseniky region

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Key words : wintering, surface water, soil

Introduction The common cattle keeping is with winter staying in the stable in Czech Republic, because there is not forage on the pastures. The new use of year-long cattle keeping on pastures has economic benefits, but elevates risk of increased concentrations of phosphorus, potassium and ammonia compounds percolating into the water table. The aim of paper is to appraise the influence of year-long cattle staying on pasture for soils and surface water quality.

Materials and methods Two localities were monitored during 2004-2007 period: 1-wintering with the shelter, 2-wintering without the shelter (where wintering place was moved every year). The water samples were taken from the upper (*U*) reaches of streams (above the pasture) and from the lower (*L*) ones in two-months interval (the water was sampled 20-times in total). The indicators: N-NO_2^-, N-NO_3^-, N-NH_4^+ and P. The soil is sandy-loam, subunit luvi-cambisols. It was sampled directly at the cattle wintering place (highest animal concentration) and from the adjacent pasture (check sampling) from depth of 0.02-0.30 m and 0.30-0.60 m in April and in October (the soil was sampled 7-times). The soil samples were analysed for content of inorganic nitrogen (N_{in}) and available nutrients (P, K, Ca) by Mehlich III method. The results were evaluated by statistical software SPSS for Windows v.13.0.

Results and discussion The streams were not contaminated by nitrate and nitrite. The limit of ammonia nitrogen for surface water is 0.5 mg.l^{-1}, it exceeded acceptable pollution limits during the 2004-2005 period, also in the upper reaches of streams. The highest concentration was in August (1*U* 0.89, 1*L* 1.23, 2*U* 0.91, 2*L* 1.02 mg.l^{-1}) and October 2004 (1*U* 0.69, 1*L* 0.91, 2*U* 0.75, 2*L* 0.85 mg.l^{-1}). From December 2005 to August 2007 N-NH_4^+ content was under the pollution limit. Pollution by phosphorus (0.15 mg.l^{-1}) exceeded limits five times on locality 1 under the wintering place and twice on locality 2 (at the both samplings places). The pollution on locality 1 was proved from September 2006, which could be caused by the high phosphorus concentration in soil (Rzonca *et al.*, 2006) and its transport. From this point of view non-shelter wintering that is moved every year is better for surface water quality. The values of nutrient content in soils are in Table 1. In wintering place was tendency to increase of nitrogen content in 0.30-0.60m layer against the pasture (control). The cattle staying on wintering place had significant influence on increase of phosphorus content in 0.02-0.30m layer and of potassium in the both layers. The content of potassium was significantly higher on locality 1 than on 2 in 0.02-0.30m layer. The content of calcium showed a tendency to decrease in 0.02-0.30m layer and it was significantly lower in 0.30-0.60m layer in wintering place against the pasture.

Table 1 *The nutrient content in soil (mean of year 2004-2007).*

Locality	Utilization	Depth [m]	N_{in} [mg.kg^{-1}]	P [mg.kg^{-1}]	K [mg.kg^{-1}]	Ca [mg.kg^{-1}]
1	pasture	0.02-0.30	7.80	37	218	2163
		0.30-0.60	5.20	18	126	1733
	wintering place	0.02-0.30	24.48	164	1191	1543
		0.30-0.60	15.16	132	395	959
2	pasture	0.02-0.30	14.24	50	181	2177
		0.30-0.60	9.97	29	141	1822
	wintering place	0.02-0.30	26.54	57	533	1752
		0.30-0.60	14.03	29	262	1095
ANOVA (F-ratio)	Locality	0.02-0.30	0.26	2.49	6.63$^+$	0.09
	Utilization		2.14	4.34$^+$	22.46^{++}	3.87
	Season		3.70	1.85	0.23	0.10
	Locality	0.30-0.60	0.01	0.96	1.25	0.45
	Utilization		3.20	1.29	8.29^{++}	13.45^{++}
	Season		6.16$^+$	1.79	1.64	0.27

$^+$ $P>95$ $^{++}$ $P>99$

Conclusions The year-long cattle keeping could contaminate surface water by phosphorus and ammonia nitrogen, but changing the wintering place every year and following the proper farming routines (high bedding, regeneration of grass turf in the spring) can eliminate the risk. The year-long cattle keeping has proved an impact on the increase of potassium and phosphorus content and the decrease of calcium content in the soil of winter place.

Acknowledgements The work was supported by Ministry of Education CR No. LA 327 and No. MSM 2678846201.

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Grazing management processes and strategies for Riparian Wetland areas

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Key words : Grazing management, riparian-wetland areas, livestock, adaptive management

Introduction In arid rangelands, cattle often focus grazing near riparian areas. Excess intensity or duration of grazing generally leaves inadequate riparian vegetation to stabilize stream banks against the cutting action of flowing water. Woody plants may lose diverse age structure needed for maintaining channel form or fish habitat. An excessively eroding channel may incise or entrench forming a gully that accelerates erosion. An incised stream does not access (flood) its floodplain so flood waters can not recharge an aquifer. Water rushes downstream in the wet season or during storm events, increasing downstream impacts rather than soaking into upstream floodplain soil and aquifers where it could have supported vegetation, dry-season flows, forage, and habitat.

Methods A technical reference *Grazing Management Processes and Strategies for Riparian Wetland Areas* (Wyman et al 2006) was developed to assist livestock operators and land managers in developing successful riparian-wetland grazing management strategies across a wide array of land types. Because of the complexity of riparian-wetland areas and issues, this technical reference does not set forth a formula or rules for identifying the type of grazing strategy best suited for an area. Rather, it provides information to help livestock managers collaborate to design appropriate grazing strategies for soil, vegetation, water, wildlife, and livestock needs.

Results and discussion Basic topics covered in this technical reference include riparian-wetland area attributes and processes, riparian resource assessments and inventories, development of resource management objectives, management strategy factors, grazing treatments, and collaborative monitoring. Alternatives to passive continuous grazing, employing rest or deferment from grazing when appropriate, and considering the associated uplands and the entire water catchment and its resources helps them when developing a grazing management strategy. Examples of tools, techniques, treatments, and success stories are provided. The reference is intended to provide the background and information needed for management of riparian area resources while maintaining the economic viability of the grazing enterprise. It ensures that everyone involved clearly understands riparian function and management objectives, and understand how they can benefit from proper management and improved riparian conditions. Flexibility in the grazing management plan accommodates changes in weather and what is learned from monitoring information, in a timely manner.

Conclusions It is important to manage grazing so that water loving plants grow vigorously and retain the structure needed to dissipate the energy of high flows post-grazing to permit natural stream function. Consequently, it is important to consider the entire water catchment and its resources when developing a grazing management strategy. A successful grazing management strategy meets the needs of the operator, livestock, wildlife, and upland and riparian resources. Monitoring how well the strategy meets these needs and adapting as necessary perpetuates success.

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Analysis of infiltration and surface runoff in River Njoro watershed using a rainfall simulator

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Key words : runoff plots , rainfall simulator , infiltration , runoff

Introduction Land use influence on hydrology has generated interest worldwide , especially in developing countries , where forest areas have been converted to other land uses including , agriculture and grazing .Hydrological changes in River Njoro watershed have been attributed to deforestation , intensive cultivation and overgrazing .These changes have led to increase of surface runoff and reduction of infiltration .The objective of the study was to assess the effect of land use treatment on infiltration and surface runoff using a rainfall simulator and runoff plots .

Materials and methods The study area is in Njoro , Kenya .The catchment is bound by (0°15′S , 0° 25′S , 35° 50′E , 36° 05'E) . Soils in the region are Ultisols and Entisols .The mean annual rainfall is 939 .3 mm .The assessment was done on runoff plots . The plot dimension was 0 .4 m by 0 .25 m giving a plot size of 0 .1m^2 .There were 5 landuse treatments set in a randomized complete block design with 3 sites (replicates) .Rainfall was applied at an average rate of 10mm/h for 3 minutes on three plots using the Kamphorst rainfall simulator (Kamphorst , 1987) .Surface runoff and infiltration from the 15 plots of the different landuses were measured .Soil characteristics including antecedent moisture conditions , organic matter , bulk density , soil texture and soil pH from soil samples of 0-10 cm depth were measured at each site .Data was analyzed using ANOVA and treatment means separated using Duncan's Multiple Range Test (Steel and Torrie , 1980) .

Results and discussions Table 1 below shows infiltration and surface runoff from every land use area and other soil properties . Runoff was high in grazing , agricultural and deforested area than the other sites .(please clarify the preceding statement) Surface runoff was high in grazing land (23 .78mm) , while the indigenous forest recorded the lowest runoff (0 mm) .Statistical analysis reveal that there were significant differences between grazing land use and other land use areas except agriculture ($p < 0.05$) .Significant differences also exist between agriculture and the deforested land use areas , plantation forest and indigenous forest .There were significant differences in infiltration between indigenous forest and all the other land use areas .There were also significant differences between plantation forest and the other land use areas .However there was no significant difference in infiltration between agriculture and grazing land use types .Indigenous forest recorded the highest infiltration value (43 .5mm/h) whereas grazing land use recorded the lowest mean value (20 .2mm/h) .

Table 1 *Mean surface runoff , infiltration and soil properties in five land use types in the River Njoro watershed .*

Landuse	Bulk density g/cm^3	Organic matter	% moisture	Soil pH	Soil texture	Mean surface Runoff (mm)	Mean infiltration (mm/h)
Agriculture	0 .85	5 .7	23 .47	6 .2	Clay loam	18 .74	25 .4
Grazing	1 .05	5 .0	22 .41	5 .9	Clay loam	23 .78	20 .2
Plantation forest	0 .95	6 .2	23 .52	6 .4	Clay loam	6 .99	37
Deforested	0 .78	10 .1	29 .2	5 .8	Sandy clay loam	17 .72	26 .2
Indigenous forest	0 .74	9 .4	24 .7	6 .2	Sandy clay loam	0 .31	43 .5

Conclusions High infiltration and low runoff was recorded in indigenous and plantation forest land use areas .This was due to high vegetation and litter cover and their associated properties .Areas characterized by intense interference of surface cover conditions like agriculture and grazing recorded low infiltration and high runoff .The reduction of runoff and increase in infiltration is effective where there is vegetation and litter cover .These findings have implications for hydrological modeling in the River Njoro watershed .More studies on infiltration and runoff using other methods are needed .

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Distribution and sustainable utilization of water resources in Inner Mongolia pastoral area

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Key words: pastoral area, grassland, water resources, sustainable development

Introduction The total area of grassland is 827,000 km^2 in Inner Mongolia, but the gross water resources are 19.935 billion m^3. The utilization of water resources do not correspond with the development and protecting of grassland because of asymmetry in distribution, illogical scheme and low ratio in utilization of water resources. So it is very important to enhance the management and improve the scheme in using water resources, and then we could advance some good plans to meet the expectation of economy and society.

Distribution and utilization of water resources The grassland is very vast in Inner Mongolia, variability of land form is complicated. Annual variety of precipitation is very large, and the distributing of water resources is very asymmetric because of precipitation, geographical location and temperature etc. Water resources are much uncoordinated with the distribution of population and grassland. Until 2005, the total water consumption is 3.231 billion m^3, 1.127 billion m^3 of them are the surface water and 2.104 billion m^3 of them are the groundwater.

Sustainable utilization schemes of water resources At present, the emphases in using water resources are how to protect the water resources successfully and the logical scheme in Inner Mongolia. As the central methods in protecting ecosystem, some water saving irrigated grassland were cultured, and some natural grassland were enclosed, the feed is prohibited or stocked in turn in these regions. For the purpose of protecting ecosystem and developing irrigated grassland, we should give some regards to the matters, (1) implementing the law of water resources, adjusting prices of water; (2) Adhere to the principles of water for grass, grass for livestock", making overall plans in using water resources for production, living and ecosystem; (3) Adhere to the principle of reasonable development and logical schemes", pay equal attention to water saving and water development; (4) Developing efficient and water-saving forage grassland, improving the ratio in use of water resources; (5) improving the rebuilding and management in surface water irrigation district; (6) logical plans in using the underground water resources.

Epilogue With the development of irrigation works in pastoral area, the conflict between water resources and grassland will be serious more and more, logical schemes plans in using water resources will become one of very important factors in protecting ecosystem and sustainable development in pastoral area.

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Yield and quality of Italian ryegrass as affected by supplemental irrigation

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Key words : productivity , nutritive value , Italian ryegrass , irrigation

Introduction To achieve the highest yields , ryegrass requires watering when rainfall is not enough to cover its needs .Biannual varieties might be able to extend the growth period as compared to the annual , but this needs to be tested in the field .

Material and methods A study was conducted in 2005/06 applying the following treatments : rainfed , and irrigation up to 25% , 50% and 100% of soil water holding capacity .Two varieties were tested , one annual (Pollanum) and the other biannual (Lipo) .A sprinkler irrigation system was used .Planting date was October 17 . After harvests , 50 kg/ha of nitrogen were applied .

Results and discussion Water application increased dry matter yield values (Figure 1) , as compared to the rainfed treatments . Irrigated annual ryegrass (Pollanum) tended to be higher yielding than the biannual , especially at the 25% treatment .Under rained conditions , Lipo showed better results .For Pollanum , Lourenço e Palma (2001) reported higher values as well as Jung and Shaffer (1992) for Lipo .The results for crude protein and digestible dry matter content are presented in Table 1 .

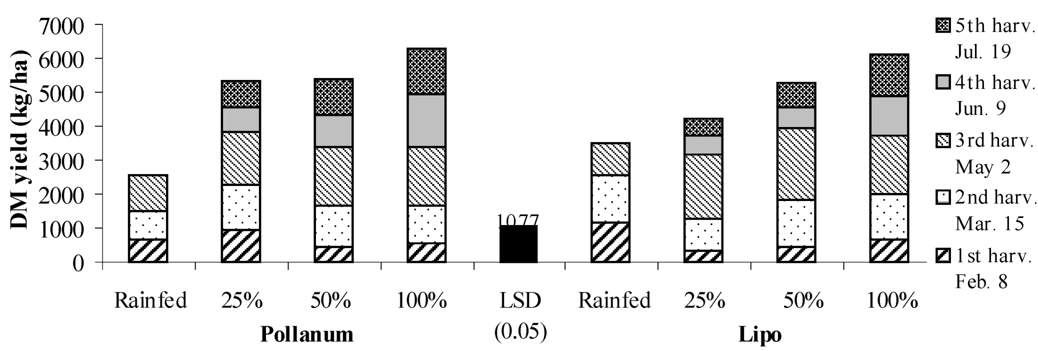

Figure 1 *Total dry matter yield by ryegrass variety and watering regime .*

Table 1 *Crude protein (CP) and dry matter digestibility (DMD) by harvest and irrigation treatment .*

Harvests	Crude protein (g kg^{-1})				Digestible dry matter (g kg^{-1})			
	25%	50%	100%	Mean	25%	50%	100%	Mean
1st	17 .5	14 .5	12 .4	14 .8	837 .6	835 .0	833 .5	835 .4
2nd	18 .3	18 .1	18 .8	18 .4	812 .4	813 .1	808 .3	811 .3
3rd	15 .1	14 .5	15 .3	15 .0	740 .5	767 .3	897 .1	801 .6
4th	14 .4	13 .9	15 .1	14 .5	538 .3	562 .8	619 .0	573 .3
5th	11 .6	13 .0	11 .9	12 .2	514 .3	532 .6	585 .5	544 .1
Mean	15 .4	14 .8	14 .8	15 .0	668 .6	702 .2	748 .7	713 .1

LSD (0 .05) for CP : irrigation treatment × harvest = 1 .3 ; for DMD : irrigation treatment = 45 .4 , harvest = 46 .8

Conclusions The results showed that under rainfed conditions , the biannual variety Lipo achieved greater yields .Under irrigation treatments , the Pollanum variety showed better water use efficiency especially at the 25% treatment .The forage produced in this study was good , even though a decrease in crude protein was noticed after the second harvest , and in dry matter digestibility after the third .

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Modeling the impact of grazing on water budgets

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Key words : grazing intensity , soil property , modeling , water budget , Inner Mongolia grassland

Introduction Land management is important for heat and water transfer by altering plant and soil functions .It is essential to quantify and predict management effects on these processes in order to assess their consequences for plant production and the environment .Many studies have focused on the effects of land management on soil hydraulic properties .However , few studies have dealt with the consequences of these practices on water budgets , especially in the semi-arid grassland .In this paper , *in situ* measurements of hydro-meteorological and energy elements from the project MAGIM" (*Matter fluxes in grasslands of Inner Mongolia as influenced by stocking rate*) were used to parameterise the hydrological model HYDRUS-1D (Šimůnek et al ., 1998) to simulate water fluxes as a function of grazing intensity .

Materials and methods This study was performed on long-term experimental sites of Inner Mongolia Grassland Ecosystem Research Station (IMGERS , 43°37′50″N , 116°42′18″E) .Four plots with different grazing intensities were investigated .Two plots were protected from grazing since 1979 (UG 79 , 24 ha) and 1999 (UG 99 , 35 ha) .The other two plots were grazed : one was grazed only during winter time with 0 .5 sheep units (ewe and lamb) ha^{-1} yr^{-1} (WG , 40 ha) and the other was heavily grazed with 2 sheep units ha^{-1} yr^{-1} (HG , 100 ha) during the whole year .In each plot , soil moisture was measured by Theta-probes in three soil depths at 5 , 20 and 40 cm .The automatic micrometeorological stations recorded the precipitation and other weather variables .To determine the root length density , root samples were taken up to 100 cm depth .In addition , undisturbed soil samples were taken at four depths of 4～8 , 18～22 , 30～34 and 40～44 cm to determine the water retention characteristics and hydraulic conductivity .Modeling of soil water flow was performed with HYDRUS-1D for a growing period of 153 d from 1st May to 30th September , 2004-2006 .The initial condition was set based on measured water contents .An atmospheric boundary condition and free drainage condition was imposed at the soil surface and bottom boundary of the flow domain , respectively .

Results In general , the simulated water contents agree well with the measurements in all four plots .This is exemplified by the treatment UG 79 during the growing period in 2006 (Figure 1) .The increases in water content at 5 cm and 20 cm depth after rainfall were predicted reasonably well .However , the model underestimated the water contents at 40 cm depth .After model calibration and validation , water household components for the four plots were calculated (Table 1) .In comparison with the two ungrazed sites , winter grazing did not show clear effects on the water household components , while heavy grazing remarkably decreased soil water storage by 25% ～45% , interception by 50% ～55% and transpiration by 20% ～30% , and increased evaporation by 25% ～40% , runoff by 100% ～300% and drainage by 100% ～200% .

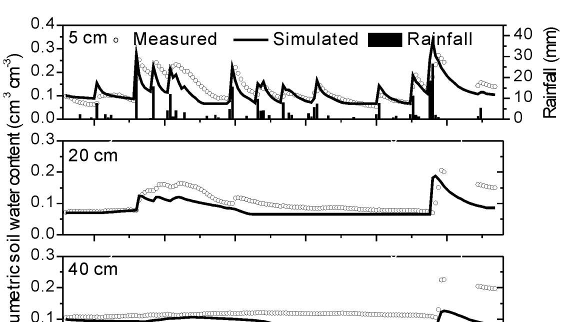

Figure 1 *Comparison of simulated and measured soil moisture in UG 79 during the growing period in 2006 .*

Table 1 *Water household components during the growing periods in 2004-2006 simulated with Hydrus-1D (in mm ; P : Precipitation ,I :Interception ,T :transpiration ,E :Evaporation , S :Water storage change ,D :Drainage ,and R :Runoff) .*

Year	Treatment	I	T	E	S	D	R	errors
2004	UG79	16.3	171.0	106.0	-23.6	1.1	1.7	2.5
	UG99	15.2	166.0	113.2	-20.1	3.2	1.6	-4.1
(P=275	WG	14.7	154.0	115.3	-18.0	4.0	4.1	0.9
mm)	HG	7.1	131.2	141.8	-21.1	6.5	5.5	4.0
2005	UG79	14.8	90.4	73.8	-29.5	1.3	0.3	-4.1
	UG99	14.4	82.4	75.6	-23.4	1.7	0.2	-3.9
(P=147	WG	13.2	79.7	86.1	-29.2	1.3	0.2	-4.3
mm)	HG	6.6	65.3	104.6	-33.6	5.7	0.4	-2.0
2006	UG79	18.3	131.4	110.8	-19.5	1.8	1.0	-1.8
	UG99	17.4	117.5	109.3	-3.3	1.5	0.7	-1.1
(P=242	WG	16.3	103.6	116.2	5.9	0	1.7	-1.7
mm)	HG	8.2	71.9	157.7	1.8	1.0	5.1	-3.7

Conclusions HYDRUS-1D model revealed the impact of grazing on water budgets .We conclude that intense grazing increased soil evaporation and reduced plant available water , consequently reduced grassland productivity .

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Research on the remote sensing monitoring ecological environmental changes in Hulun Lake Area

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Key words: Hulun Lake, remote sensing monitoring, area, vegetation index, EOS/MODIS

Introduction Hulun Lake is the biggest natural lake in Inner Mongolia Autonomous Region, its water area is the key factor for sustaining Hulunbeier grassland safety. As a way to determine the ecological changes of Hulun Lake, the Satellites and Remoter Sensing Monitoring Centre of Inner Mongolia Meteorological Bureau has monitored the Hulun Lake and surrounding area since 1999 by using NOAA and EOS/MODIS satellites.

Materials and methods Remote sensing images and data: The monitoring NDVI data are free, are provided by NOAA/AVHRR and can be downloaded from USGS/ EROS data centre in America. Its space resolving rate is 1 km^2, timing resolving rate is one month, and timing sequence is 2002-2005. The MVC method (Maximum Value Composites) was used, which eliminates partial interference from clouds and atmosphere. The area of Hulun Lake from 1999-2005 is calculated by using EOS/MODIS satellite channel 2 to make 250 meter single channel sphere projections and also using rectangle and polygon function of MODIS satellite image software, and drawing a closing curve along the lake and calculated the area (the lake area data of 1999 is calculated by NOAA satellite data.).

Results and discussion The monitoring results on changing of Hulun Lake area: The area of Hulun Lake in 1999 was 2370 km^2, it is the largest area on record. However, the area is fluctuating, decreasing year by year. The area in August 2005 was only 1885 km^2. The comparison result of lake area in satellite image data shows the Hulun lake joined with new Dalai lake in 1999 (Figure 1). However, from the remote sensing image data in 2005 (Figure 2), we can clearly see that the dissociated new Dalai Lake had already dried up. It shows the trends of declining Hulun Lake water. The monitoring result on vegetation changes around Hulun Lake: As figures 3 and 4 show, by comparing statistical data of unitary vegetation grading index around Hulun Lake in 2002 and 2005, the area of grade 1～6 vegetation index (NDVI) was 9799 km^2 and 31463 km^2, respectively and the area of grade 7～H vegetation index was 36024km^2 and 14349 km^2 in 2002 and 2005, respectively. It tells us that from 2002 to 2005, the ecological environment has degraded to some extent, with a decrease of good vegetation density and increase of degraded pasture area.

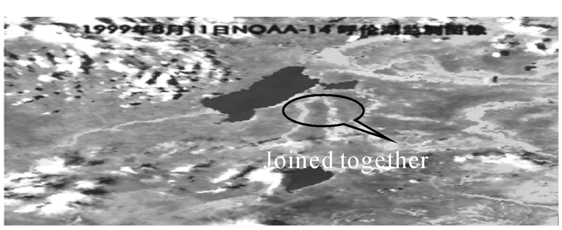

Figure 1 *The NOAA-14 monitoring image of Hulun Lake in August 1999.*

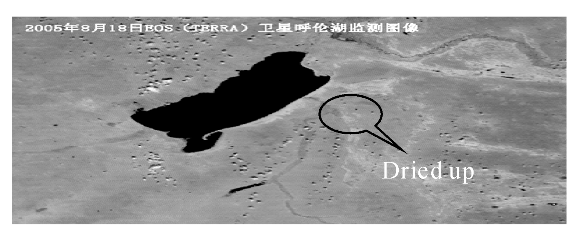

Figure 2 *TERRA satellite monitoring image of Hulun Lkae in August 2005.*

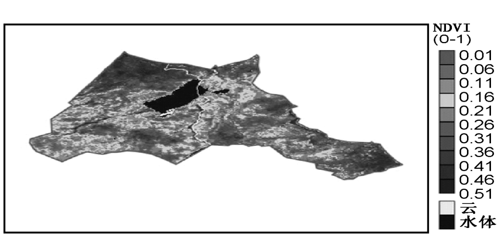

Figure3 *Vegetation index around Hulun Lake in August 2002.*

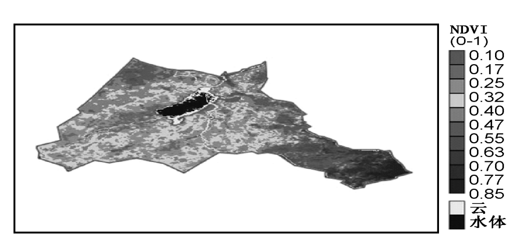

Figure4 *Vegetation index around Hulun Lake in August 2005.*

Conclusions Comparison of remote sensing images and data of Hulun Lake, show the Hulun Lake area has decreased and surrounding lake vegetation has deteriorated severely.

Effects of single irrigation on yield and WUE of siberian wildrye grass in agro-pastoral transition zone of China

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Key words: Irrigation; siberian wildrye grass; yield; water use efficiency; agro-pastoral transition zone of China

Introduction The recent studies showed that deficient irrigation increased water use efficiency (WUE) whereas full irrigation decreased it (Waldron et al., 2002). Recent research on the relationship between forage dry matter yield and total evapotranspiration (ET) showed linear and curvilinear relationships (Nielsen et al. 2006). Irrigating in the elongating stage increased the growth of siberian wildrye grass significantly, and forage yield could benefit.

Materials and methods The field experiment was conducted on the Yu'ershan Demonstration Pasture of China Agricultural University in Bashang Plateau in the typical agro-pastoral transition zone of China (116°11′E, 41°45′N, elevation of 1460 m) during 2002-2004. The treatments included: no irrigation (NI), full irrigation (FI) and single irrigation in the key growing stage (KI).

Results Although forage yield of irrigated treatments were much larger than that of NI, differences were not significant between FI and KI (Table 1). WUE could be increased by irrigation and the effect of KI was better than that of FI. It was obvious that water can be used sufficiently in KI. FI with lower WUE would be more costly and waste of water resources. Regression analysis showed that forage yield and WUE were significantly related t ET with quadratic responses (Figure 1), the R^2 was 0.85 and 0.58, respectively.

Conclusions Forage yield of KI reached about 90% of FI with only 30% of the irrigated water. KI was a better irrigation schedule in semiarid areas. The yield response function and the relationship between WUE and total ET were significant and quadratic.

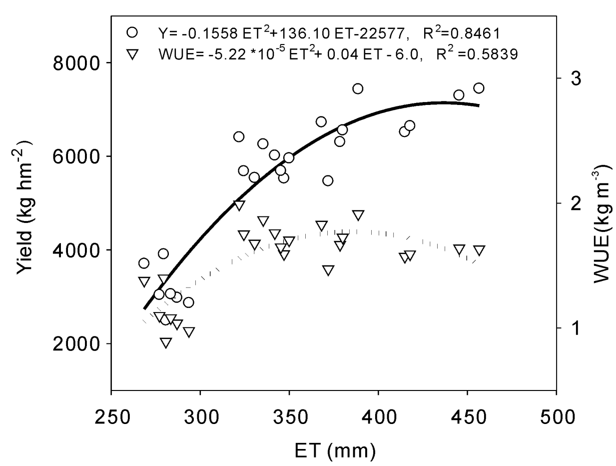

Figure 1 *The yield response function and the relationship between WUE and total ET.*

Table 1 *The evapotranspiration (ET), forage yield and water use efficiency (WUE)* *

Year	T	ET (mm)	Yield (kg ha^{-1})	WUE (kg m^{-3})
2002	NI	288.0±4.2 a	2970.0±77.9 a	1.0±0.0 a
	FI	387.2±20.1 c	6520.0±171.5 c	1.7±0.1 b
	KI	340.5±11.4 b	5725.0±177.8 b	1.7±0.1 b
2003	NI	289.6±6.5 a	2400.0±81.6 a	0.8±0.0 a
	FI	440.0±16.3 c	7133.3±347.2 c	1.6±0.0 b
	KI	333.0±8.3 b	6230.0±160.6 b	1.9±0.1 c
2004	NI	272.8±4.7 a	3553.6±370.3 a	1.3±0.1 a
	FI	380.2±6.9 c	6489.1±803.6 b	1.7±0.2 ab
	KI	343.5±9.9 b	6333.3±775.9 b	1.8±0.2 b

* T: treatment. Values followed by the same letter within a column are not significantly difference at p=0.05.

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The effects of stocking rate and corn gluten supplemental feed on the performance of young beef cows

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Key words : Beef cow , stockpiled forage , corn gluten feed

Aim A winter grazing experiment was conducted to evaluate the effects of stocking rate and corn gluten feed supplementation on forage mass and composition and the BW and BCS of bred 2-yr-old cows grazing stockpiled forage during winter .

Methods Two 12 .2-ha blocks containing Fawn , endophyte-free , tall fescue and red clover were each divided into 4 pastures of 2 .53 or 3 .54 ha .Hay was harvested from the pastures in June and August of 2005 and 2006 , and N was applied at 50 .5 kg/ha at the initiation of stockpiling in August .On October 22 , 2005 , and October 20 , 2006 , twenty-four 30-mo-old Angus-Simmental and Angus cows were allotted by BW and BCS to strip-graze for 147 d at 0 .84 or 1 .19 cow/ha .Eight similar cows were allotted to 2 dry lots and fed tall fescue-red clover hay *ad libitum* .Corn gluten feed was fed to cows in 2 pastures to maintain a mean BCS of 5 (9-point scale) at each stocking rate and in the dry lots (high supplementation level) or when weather prevented grazing (low supplementation level) in the remaining 2 pastures at each stocking rate .

Results Mean concentrations of CP in yr 1 and 2 and IVDMD in yr 2 were greater ($P < 0.10$) in hay than stockpiled forage over the winter .At the end of grazing , cows fed hay in dry lots had greater ($P < 0.05$) BCS in yr 1 and greater ($P < 0.10$) BW in yr 2 than grazing cows .Grazing cows in the high supplementation treatment had greater ($P < 0.10$) BW than cows grazing at the low supplementation level in yr 1 .Cows in the dry lots were fed 2 ,565 and 2 ,158 kg of hay DM/cow .Amounts of corn gluten feed supplemented to cows in yr 1 and 2 were 46 and 60 kg/ cow and did not differ ($P = 0.33$, yr 1 ; $P = 0.50$, yr 2) between cows fed hay or grazing stockpiled forage in either year .

Conclusion Estimated production costs were greater for cows in the dry lots because of hay feeding .

Use of benthic macroinvertebrates as indicators of water quality in River Njoro , Kenya

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Key words : benthic macroinvertebrates , physicochemical parameters , anthropogenic activities , tolerant taxa , impacted sites , effluents

Introduction Unsustainable anthropogenic activities , including intensive agriculture and grazing along River Njoro has resulted in the deterioration of river water quality . The river is the most important source of freshwater for the riparian communities and the Lake Nakuru , a Ramsar site . The study was done in order to determine the water quality in the middle reaches of River Njoro using benthic macroinvertibrates assemblage as an indicator of water quality .

Materials and methods Benthic macroinvertebrates were sampled using a modified Hess sampler , with area of 2 .7dm^2 and 100μm mesh size . Samples were preserved in 10% formalin , and then washed through 250μm and 100μm mesh size sieves . They were sorted out by a stereomicroscope and identified to family level . Physicochemical variables were measured using Jenway Electrochemical analyzer . Three replicates were collected per site on each sampling occasion .Taxa encountered were enumerated , density calculated as individuals per decimeter square (Ind/dm^2) .Species Richness was estimated using the Margalefs Index (Brower et al , 1990) .

Results Species richness showed significant dependence on organic nitrogen ($r^2 = 0.61$) and total phosphorus was negatively correlated to species richness . There was an increasing trend of concentration of nutrients from the upstream sites to the downstream sites . Chironomidae , Oligochaete , *Moina sp* and Cyclopoidae were characteristic of the impacted sites . *Potamon sp* . , *Orthotrichia sp* . , *Ecdyonurus sp* . and *Catenula sp* . were present at the upstream sites but absent from all sites receiving effluents .

Discussion This study shows that seasonality and effluent discharge have a strong influence on the physicochemical and biological characteristics of the middle-reaches of River Njoro .The major sources of nutrients in the River Njoro are the point sources . These have modified the physicochemical characteristics of the river leading to a reduction or exclusion of seemingly intolerant benthic macroinvertebrates and leading to the proliferation of a few tolerant species Chironomidae and Oligochaetae .

Conclusion The close association observed between the physicochemical parameters and the benthic macroinvertebrates imply that the latter can be used to monitor the water quality and in detecting unacceptable impacts .

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The examination of grazing intensity effects on capability of water influence in rangelands soil —a case study : alpine rangelands in north of Iran(Alborz mountains)

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Key words : range ,permeability ,watercycle

Introduction The goal of this research's is knowing the mechanical impacts of livestock trampling under it's weight pressure on reduction of the water influence on rangelands soil and giving an application coefficient which indicate the quantitative relation between the intensity of livestock grazing and the amount of water influence in rangelands soil .

Materials and methods In regions with different intensity of grazing but homogenous and completely resemble in another aspects like : slop ,soil ,vegetation type ,height ,aspect and etc .Three area separated as follow : 1- Reference area 2- Key area ,3- Critical area .The vegetation inventory and sampling performed accidentally by especial plots and then the amount of water influence in soil ,measured by double rings method ,with suitable frequency .The comparisons in second ,ninth ,20th · 50th and 90th minutes after beginning of soil permeability experiment were realized and results recorded .

Results In all of mentioned times the speed of instant and extreme soil permeability in reference area is more than key and critical areas ,for example in 9th minute in reference area the speed of water influence in compare with key area is more than 35 .2% and in compare with critical area it's more than 67 .7 % .The other comparisons has shown in lower tables .

Table 1 *The influence comparison in key reference and critical regions .*

Minutes of influencing	Reference		Key		Critical	
	D	I	D	I	D	I
2	3 .59	5 .9	2 .1	3 .6	0 .78	1 .6
9	8 .2	3	5	1 .9	2 .28	0 .97
20	12 .7	2 .09	7 .9	1 .4	3 .8	0 .73
50	21 .1	1 .38	13 .6	0 .96	6 .8	0 .58
90	29 .1	1 .06	19 .3	0 .75	9 .9	0 .42

Table 2 *The percent of reduction of coefficients in Momentary And accumulative equations .*

	Critical to key	59% reduction
A	Critical to reference	77 .3% reduction
	Key to reference	43 .9% reduction
	Critical to key	55 .7% reduction
B	Critical to reference	73 .5% reduction
	Key to reference	40 .1% reduction

RE% $= \left| \dfrac{Ix_i - Iy_i}{Ix_i} \right| 100^{*}$ RE = Rational error (y range in compare with x range) ,Ix= Instant permeability in considered time in x range ,Iy= Instant permeability in considered time in y range

Conclusion the amount of coefficients of the equations of momentary and accumulative influencing shows a reduction in changing the rangelands from reference to the key and critical situation for the type of plant and the same soil texture by using the received data and formulas for three under experiment regions (reference ,key and critical) .At the result the amount of momentary and accumulative influencing has had a noticeable rational reduction that have been shown in Table 2 .The (A) coefficients undoubtedly have been effected in vegetation that the other factors can focus that such as soil compacting .What is certain is that the factor of vegetation had been the cause of the changing of effecting characteristics alone ,but several factors effect in relation with the vegetation and soil's environment and at the all these factors can effect on the speed of momentary , accumulative and extreme influence .

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Study of effects of irrigation with waste water on growing season of *bromus tecrum*

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Key words : waste water-Heavy metals-Growing season-*Bromus tectrum*

Introduction Because limited sources of water in Iran water outgoing of refinery is used for irrigation purposes In some places . Quality of such these waters and their effects on plants is under doubt .Mahdavi(1) says that concentration of materials in irrigation water even very small amounts , Has an important role in agriculture and drinking . Rahmati measured chrome concentration in treated waste water outgoing of Irandocharkh Industrial unit .results showed that chrome concentrarion in samples is about 15 mg/lit ,while its standard level is 1 mg/lit It can be concluded that that there are probabilities of presence of heavy metal pollutants in iriigation by waste water that may srore in plant body .Additionally effects of using waste water on growing characteristics and forage must be studied .

Materials and methods Sample site is located in downward of refinery of industrial city of Alborz in Qazvin province in Iran ,with area over than 28125 ha .It has piedmont plains with gentle slope that has northern to southern direction .Soil is deep ,fine with calcic horizone .(Calcic cambisols) Dominant species is *Bromus tectrum* that is under grazing by about 400 to 500 livestock dailyThere afre two kinds of land downward of refinery ,farming lands and rangelands ,Animals graze rangelands from late winter to summer and in rest of the year they consume residuals of previous farming season .There are good sources of minerals in waste water so farmers don't need to consume any manure Except to nitrate manure That is consumed 6 bag per hectar (300 kg/ha) .Refined waster water go out of refinery after apllying ordinary methods of refining .Because presence of slope in lands all of waste water will go to downward .

Sampling and data gathering *Bromus tectrum* samples were gathered Three times in growing season using randomized-Systematic method .First time was in vegetative duration in last week of February ,The second was in flowering duration in May and the third time was in seedling stage in june .Main road was selected as base line .plants were cut to height animal grazes using square plot and this procedure was done every 1000 meters ,then samples were moved to rhe lab after drying .Concentration of lead ,zinc and nickel was measured each time .Results were studied by SPSS software(version 12) and ANOVA method was applied for this purpose .Additionally in each plot total amount of plants was gathered and was compared with similar plots in lands near these place without consuming waste water .They were dried and their weight in kg was measured .

Results and discussion Results showed that absorbed amounts of heavy metals in *Bromus tectrum* body is significantly more than its standard levels . Additionally there is significant differences between concentrion of these heavy metals during growing season .From beginning to End of growing season ,concentration of heavy metals decreases .This kind of decrease can be a result of increasing precipitation in last month of winter .It seems that using waste water to irrigation of rangelands doesn't have a bad effect on their growing characteristics .Each Bromus length is quite normal and total volume of plants in each plot is not less than similar plots in lands near this region that don't consume waste water .these lands owners are satisfied Of consuming this kind of water ,they say that their costs for apllying manure Is less than other owners .because they don't have to consume it for their lands .but main problem has located in plant body where hazardous amounts of Heavy metals are … will be directly consumed by animals .

Conclusion As was shown before if pollutant concentration in irrigation water be higher than standard levels its residuals will be stored in plant body and will be consumed by animal directly so it will be seriously hazardous .As materials like heavy metals doesn't decrease during ordinary ways of refining ,It seems that only absolute way to decrease them is biological way .In this method ,enough amounts of some biomasses like fungies and some special kinds of bactries ,sea weeds and even wood residuals are added to waste water after its ordinay refining . .As some heavy metals structure is like metals like Calcium so this biomasses may consume them as their food and destroy themselves .this biological method is so expensive for large scales of waste water so maybe many of managers decides not to apply that .

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Grasslands/Rangelands Resources and Ecology

——Climate Change and Impact on Grasslands/ Rangelands

Carbon stocks and environmental controls of China's grasslands

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Abstract Ecosystem carbon stocks in the northern grasslands play an important role in the global carbon cycles; however, little information on those is available for China's temperate and alpine grasslands. During the last five years from 2001 to 2005, we conducted large-scale field campaigns to investigate biomass carbon stocks and soil organic carbon (SOC) storage for these grasslands. We have collected 978 soil profiles and 1700 biomass plots from 326 sites across the regions (including Qinghai, Tibet, Inner Mongolia, and Xinjiang). Over the whole area with 185×10^4 km^2, the biomass carbon stock was estimated at 536.1 Tg C (1 Tg = 10^{12} g) with a mean biomass density of 41.8 g C m^{-2} for aboveground and 246.0 g C m^{-2} for belowground, and SOC storage in the top 1 meter was estimated at 14.9 Pg C (1 Pg = 10^{15} g), with an average density of 8.0 kg C m^{-2}. Generalized linear model analysis showed that region, climatic variables and soil texture together explained 50% of total variance in biomass and about 70% of that in SOC density. Of the variables examined, water availability explained the largest proportion (~25% and 60%) of the biomass and SOC variation. Our results suggest an important control of water availability on plant production and soil carbon storage in China's grasslands.

Key words: aboveground biomass, alpine grasslands, belowground biomass, soil organic carbon, temperate grasslands.

Terrestrial ecosystems in middle and high latitudes of the Northern Hemisphere have functioned as carbon (C) sinks for atmospheric CO_2 over the past 20 years (Schimel *et al*., 2001), but such evidence mainly comes from forest ecosystems (Fang *et al*., 2001; Myneni *et al*., 2001). Grassland covers nearly 1/3 of China's total territory (Department of Animal Husbandry Veterinary, 1996). Therefore, accurate estimation of C stocks in China's grasslands is critical for precise evaluation of China's terrestrial C cycling and sustainable use of China's grassland resources (Piao *et al*., 2007).

During the past 10 years, biomass C stocks in China's grasslands have been evaluated using the data from resource inventory (Fang *et al*., 1996; Ni, 2004), global biomass database (Ni, 2002), field measurements (Luo *et al*., 2002), and satellite-based statistical model (Piao *et al*., 2007). Similarly, soil organic carbon (SOC) storage in China's grasslands has also been estimated using the data either from China's national soil survey (Fang *et al*., 1996; Wang *et al*., 2003; Wu *et al*., 2003) or global soil database (Ni, 2002). However, large uncertainties still exist in these studies due to the lack of field observations in belowground biomass (Ma *et al*., 2008) and the small number of soil profiles from the Tibetan Plateau and other northwestern regions in the second national soil survey (Yang *et al*., 2007). Overcoming these shortages is the key for the accurate estimation of C storage in China's grasslands.

During the summers (July and August) of 2001-2005, we conducted five-year field sampling campaigns across the grassland regions (including Qinghai, Tibet, Inner Mongolia, and Xinjiang) and collected 1700 biomass plots and 978 soil profiles from 326 sites. Using these data, we estimated biomass and SOC storage in China's grasslands and further analyzed their relationships with environmental factors.

Materials and Methods

Large-scale biomass survey We sampled 326 sites across the grassland regions during the summers (June to August) of 2001-2005 (Figure 1). At each site (10 × 10 m), all plants in five plots (1 × 1 m) were harvested to measure aboveground biomass (AGB). Either three soil pits of 50 × 50 cm or nine soil cores with the diameter of 8 cm at depth intervals of 10 cm to maximum soil depth were sampled to determine belowground biomass (BGB) (For details, see Ma *et al*., 2008). Live roots were distinguished by their color, resiliency and attached fine roots (Vogt and Persson, 1991). Biomass samples were oven-dried at 65℃ to constant mass, and weighed to the nearest 0.1 g. To compare with previous studies, biomass was converted into C content using a conversion factor of 0.45 (Piao *et al*., 2007).

Field soil investigation and laboratory analysis We sampled 978 soil profiles from the 326 sites (i.e. 3 soil profiles at each site) in the grasslands by the five field sampling campaigns (Figure 1). At each sampling site, three soil pits were excavated to collect samples for analyses of physical and chemical properties. For each pit, soil samples were collected at depths of 0-10, 10-20, 20-30, 30-50, 50-70, and 70-100 cm (For details, see Yang *et al*., 2008). Soil samples for C analysis were air-dried, sieved (2 mm mesh), handpicked to remove fine roots, and then ground on a ball mill. Soil organic carbon (SOC) was measured using the wet oxidation method (Nelson and Sommers, 1982). Soil texture in Tibetan soils was determined by a particle size analyzer (Mastersizer 2000, Malvern, UK) after removal of organic matter and calcium carbonates, while that in other soils was derived from a digitized map of soil texture of China (Deng, 1986).

SOC estimation We calculated SOC density for different depth intervals for each soil profile using Eq. 1 (30 and 100 cm).

$$SOCD = \sum_{i=1}^{n} T_i \times BD_i \times SOC_i \times (1 - C_i)/100 \quad (1)$$

where $SOCD$, T_i, BD_i, SOC_i, and C_i are SOC density (kg C m^{-2}), soil thickness (cm), bulk density (g cm^{-3}), soil organic carbon (g kg^{-1}), and volume percentage of the fraction > 2 mm at layer i, respectively.

Climate data and grassland types Mean annual temperature (MAT) and annual precipitation (AP) data at a resolution of 0.1 × 0.1 degrees were complied from the climate database of China during 1970-1999 (Piao *et al*., 2003). Information on the distribution of grassland types was extracted from Vegetation Map of China with a scale of 1 : 1,000,000 (Chinese Academy of Sciences, 2001). Based on China's vegetation classification system, we divided China's northern grasslands into six types: alpine steppe, alpine meadow, desert steppe, typical steppe, meadow steppe, and mountain meadow.

Statistical analysis Regression analyses were conducted to evaluate the relationships between biomass/SOC density and MAT, AP, soil moisture, and soil texture. The general linear model (GLM) was used to assess integrative effects of region (Qinghai-Tibetan Plateau, Inner Mongolia, and Xinjiang), MAT, AP, grassland type, soil moisture, and silt content on biomass and SOC density. All analyses were performed using the software package R (R Development Core Team, 2005).

Results

Regional distribution of biomass and SOC storage Biomass and SOC storage exhibited large differences among different regions (Table 1). The highest biomass and SOC density was observed in Xinjiang (409 g C m^{-2} and 12.1 kg C m^{-2}), while the lowest in Tibet (155.8 g C m^{-2} and 4.8 kg C m^{-2}). The biomass stocks of Qinghai was largest (159.5 Tg), accounting for about 1/3 of the total stocks. Moreover, the contribution of Qinghai (4.8 Pg) to total SOC storage was the largest among the four regions, accounting for about 1/3 of the total storage. Xinjiang stored the lowest biomass and SOC (108.3 Tg and 3.2 Pg), mainly due to its small grassland area. Overall, total biomass and SOC storage in the study area was estimated at 536.1 Tg and 14.9 Pg, with the average density of 289.1 g C m^{-2} and 8.0 kg C m^{-2}, respectively.

Relationships between C density and environmental factors

Biomass in China's grasslands did not show any significant trend with MAT ($P > 0.05$), but significantly increased with AP ($P < 0.05$). Biomass in China's grasslands was positively correlated with moisture ($P < 0.05$). In addition, biomass in alpine grasslands significantly increased with silt content ($P < 0.05$), but that in temperate grasslands did not show any significant trend. SOC density in temperate grasslands significantly decreased with MAT, while that in alpine grasslands showed weak increasing trend with MAT ($P < 0.05$). SOC density in China's grasslands increased with both AP and moisture ($P < 0.05$). Additionally, SOC density in alpine grasslands was positively correlated with silt content ($P < 0.05$), while not in temperate grasslands. GLM analysis showed water availability explained the largest proportion (~25% and 60%) of the biomass and SOC variation (Table 2). Region and grassland type could explain 15%-24% of the variation in biomass and 4% of that in SOC density. Overall, environmental variables could explain about 50% and 69% of the overall variation in biomass and SOC density, respectively.

Discussion

Size of biomass and SOC storage in China's grasslands Our results of biomass density are largely different from earlier estimates (Table 3). AGB in this study was about 30% higher than those estimated by Ni (2004), which was based on the forage field data. In addition, AGB in temperate grasslands was 30% larger and that in alpine grasslands was 10% lower than estimate of Piao et al. (2007), which were derived from a satellite-based statistical model. These discrepancies may be due to the different data source or estimation method (Ma et al., 2008). Moreover, larger difference in BGB (-105%-38.5%) was observed between Piao et al. (2007) and this study, due probably to a large error in the R : S ratios used in the previous studies (Mokany et al., 2006).

SOC density in this study significantly differed from the previous estimates (Table 3). Our values of SOC density were much lower than those estimates based on global SOC database (e.g. Ni, 2002), indicating that the global database is unlikely suitable for investigating detailed soil carbon stocks for a region. Moreover, large differences existed between our estimates and those derived from the national level (e.g. Wu et al., 2003; Yang et al., 2007), possibly due to the small number of soil profiles from the Tibetan Plateau and other northwestern regions in the second national soil survey (Yang et al., 2007).

Effects of environmental factors on biomass and SOC storage The relationship between AGB and precipitation obtained in alpine grasslands was similar with that observed in temperate grasslands. However, precipitation-use efficiency (the slope of the AGB-precipitation relationship) observed in alpine grasslands (0.08 g C m^{-2} mm^{-1}) was lower than that in temperate grasslands (0.23 g C m^{-2} mm^{-1}). The difference may be derived from different growth-limiting factors in temperate and alpine grasslands. AGB in temperate grasslands was strongly influenced by the amount and distribution of precipitation (Sala *et al*., 1988), but in alpine grasslands it was also constrained by low temperature, especially at high precipitation levels (Fang *et al*., 2005; Kato *et al*., 2006).

Significant linear relationships were observed between SOC density and AP ($P < 0.01$) , and between SOC density and soil moisture ($P < 0.01$) . Further , water availability explained the largest proportion (~60%) of the SOC variation . These results suggest that water availability could stimulate plant production and thus contribute to the accumulation of SOC in a water-limiting area (Wynn *et al* ., 2006) . A similar relationship between SOC density and water availability has also been observed in other temperate regions , such as in the Great Plains of the United States (Burke *et al* ., 1989) and Australia (Wynn *et al* ., 2006) , implying that water availability may be a powerful variable for predicting SOC density across broad biogeographic regions .

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Table 1 *Density and storage of biomass and soil organic carbon (SOC) in grasslands for different regions of China. AGB, aboveground biomass; BGB, belowground biomass; TB, total biomass; R: S ratio, root: shoot ratio; AS, alpine steppe; AM, alpine meadow; DS, desert steppe; TS, temperate steppe; MS, mountain steppe; MM, mountain meadow.*

Region	Grassland type	Site/profile	Area /10^4 km^2	Biomass density (g C m^{-2}) AGB	BGB	TB	R: S ratio	Biomass stock (Tg C) AGB	BGB	TB	SOCD (kg C m^{-2}) 0-30cm	0-100cm	SOC stock (Pg C) 0-30 cm	0-100 cm
				Mean/SE	Mean/SE	Mean/SE	Mean/SE	Mean/SE	Mean/SE	Mean/SE	Mean/SE	Mean/SE	Mean/SE	Mean/SE
Qinghai	AS	40/120	14.44	36.8/3.6	189.8/25.3	227.1/28.3	5.1/0.3	5.3/0.5	27.4/3.7	32.8/4.1	4.1/0.4	6.9/0.8	0.6/0.1	1.0/0.1
	AM	32/96	27.57	59.4/5.6	397.5/62.5	459.6/66.6	6.6/0.8	16.4/1.5	109.6/17.2	126.7/18.4	8.9/0.7	13.6/1.6	2.5/0.2	3.8/0.5
	Total	72/216	42.01	51.7	326.1	**379.7**	**5.7**	21.7	137.0	**159.5**	7.4	**11.4**	3.1	**4.8**
Tibet	AS	38/114	49.01	11.3/1.0	71.3/6.9	82.6/7.6	6.9/0.5	5.5/0.5	35.0/3.4	40.5/3.7	2.1/0.1	3.3/0.2	1.0/0.1	1.6/0.1
	AM	25/75	24.17	37.3/3.0	268.5/25.1	304.2/27.2	7.9/0.6	9.0/0.7	64.9/6.1	73.5/6.6	6.6/0.6	8.0/0.7	1.6/0.1	1.9/0.2
	Total	63/189	73.18	19.8	136.5	**155.8**	**7.2**	14.5	99.9	**114.0**	3.6	**4.8**	2.6	**3.5**
Inner Mongolia	DS	39/117	8.91	25.4/2.9	130.2/10.6	154.9/11.7	6.5/0.6	2.3/0.3	11.6/0.9	13.8/1.0	2.5/0.2	4.5/0.4	0.2/0.0	0.4/0.0
	TS	56/168	28.6	59.4/4.0	290.3/22.3	353.4/22.0	6.0/0.6	17.0/1.1	83.0/6.4	101.1/6.3	4.2/0.2	7.5/0.4	1.2/0.1	2.1/0.1
	MS	18/54	6.26	88.5/7.8	538.3/77.9	629.9/80.6	6.2/1.1	5.5/0.5	33.7/4.9	39.4/5.0	7.1/0.6	13.5/1.7	0.4/0.0	0.8/0.1
	Total	113/339	43.77	56.7	293.1	**352.5**	**6.2**	24.8	128.3	**154.3**	4.1	**7.5**	1.8	**3.3**
Xinjiang	DS	32/96	6.15	35.2/3.5	241.6/20.3	280/22.5	7.2/0.6	2.2/0.2	14.9/1.2	17.2/1.4	2.7/0.3	4.8/0.5	0.2/0.0	0.3/0.0
	TS	22/66	11.91	58.7/7.3	376.6/21.5	437.4/25.4	7.2/0.5	7.0/0.9	44.9/2.6	52.1/3.0	5.1/0.6	9.0/1.1	0.6/0.1	1.1/0.1
	MS	8/24	1.08	78.3/12.2	598.5/102.7	690.1/106.6	7.0/1.5	0.8/0.1	6.5/1.1	7.5/1.2	8.7/0.9	14.3/0.8	0.1/0.0	0.2/0.0
	MM	16/48	7.34	87.8/14.2	336.8/32.9	428.8/38.7	4.7/0.7	6.4/1.0	24.7/2.4	31.5/2.8	11.8/0.9	21.9/2.0	0.9/0.1	1.6/0.1
	Total	78/234	26.48	61.9	343.7	**409.0**	**6.6**	16.4	91.0	**108.3**	6.8	**12.1**	1.8	**3.2**
China	**Total**	326/978	185.43	41.7	246.0	**289.1**	**6.4**	77.4	456.2	**536.1**	5.0	**8.0**	9.3	**14.9**

Table 2 *Summary of the results obtained from a general linear model (GLM), showing the integrative effects of region, MAT, AP, grassland type, soil moisture, and soil texture on AGB, BGB, and SOCD in the top 30 cm.*

	df	MS	*F*	*P*	SS%
AGB					
Region	2	9.2	24.7	< 0.01	8.4
MAT	1	8.4	22.5	< 0.01	3.8
AP	1	57.9	155.6	< 0.01	26.4
Moisture	1	6.5	17.6	< 0.01	3.0
Grassland type	4	3.4	9.1	< 0.01	6.2
Silt	1	1.0	2.8	0.096	0.5
BGB					
Region	2	12.6	35.7	< 0.01	14.3
MAT	1	2.5	7.1	< 0.01	1.4
AP	1	41.6	117.5	< 0.01	23.5
Moisture	1	1.0	2.7	0.101	0.5
Grassland type	4	3.8	10.8	< 0.01	8.6
Silt	1	2.5	6.9	< 0.01	1.4
SOC					
Region	2	1.0	5.8	< 0.01	1.2
MAT	1	4.3	25.0	< 0.01	2.7
AP	1	54.8	318.0	< 0.01	34.0
Moisture	1	38.2	221.7	< 0.01	23.7
Grassland type	4	1.0	5.7	< 0.01	2.5
Silt	1	7.7	44.9	< 0.01	4.8

Notes: Biomass and SOC data were $\log_{10}$-transformed before analysis. df: degrees of freedom; MS: mean squares; SS: proportion of variances explained by variable.

Table 3 *Comparison of biomass and soil organic carbon (SOC) density with previous studies. AS: alpine steppe; AM: alpine meadow; DS: desert steppe; TS: temperate steppe; MS: mountain steppe; MM: mountain meadow.*

Grassland type	AGB (g C m^{-2})			BGB (g C m^{-2})		SOCD (kg C m^{-2})			
	This study	Ni *et al*., 2004	Piao *et al*., 2007	This study	Piao *et al*., 2007	This study	Ni *et al*., 2002	Wu *et al*., 2003	Yang *et al*., 2007
AS	24.3	12.8	28.9	132.9	272.8	5.2	17.0	7.5	4.7
AM	49.7	39.7	53.2	351.2	421.0	11.2	18.2	16.7	13.4
DS	29.8	20.5	19.6	182.2	197.6	4.6	8.7	4.8	4.1
TS	59.2	40.0	41.2	319.0	278.4	8.0	12.3	9.5	9.9
MS	85.4	65.9	65.2	557.3	343.0	13.7	11.2	12.9	11.3
MM	87.8	74.2	48.7	336.8	303.4	21.9	18.2	20.0	20.5

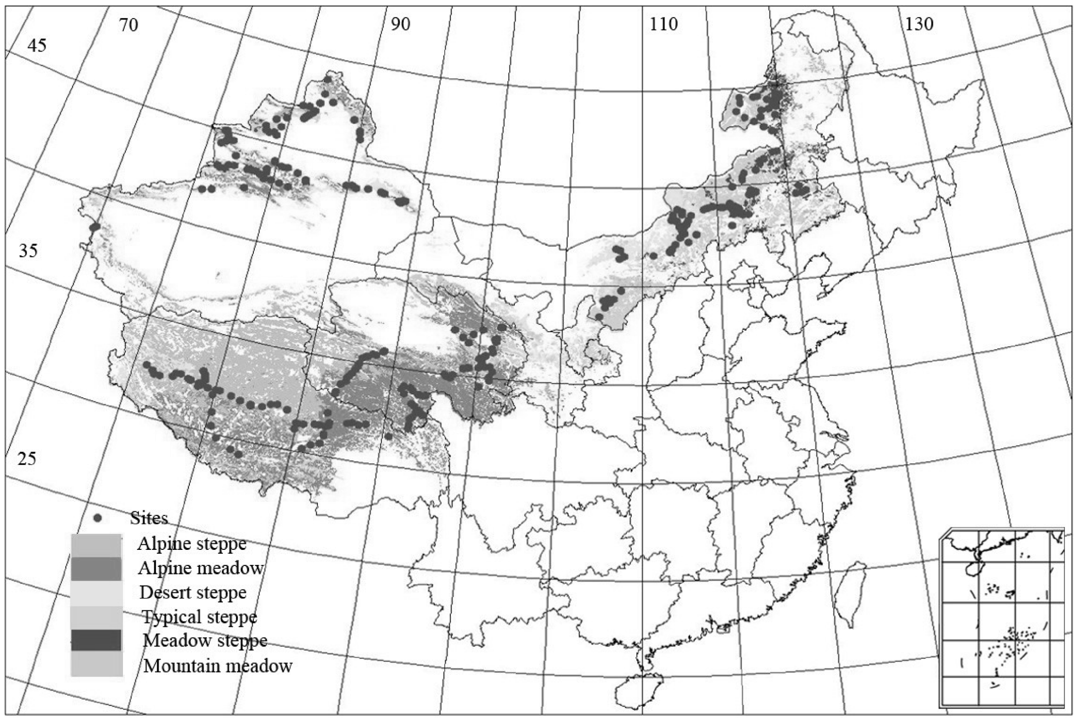

Figure 1 *Locations of 326 sampling sites in China's grasslands at the background of China's vegetation map. The sampling campaigns were conducted during the summers (July and August) of 2001-2005. The distribution of grassland types was derived from the vegetation map of China with a scale of 1:1 000 000 (Chinese Academy of Sciences, 2001).*

The climate change challenge for managed grasslands in New Zealand

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Key points:
1) New Zealand grassland systems were created by humans through land use changes of national proportions. This has brought many economic and social benefits, but at an increasing cost to the environment and people-biodiversity loss, loss of ecosystems integrity, flood damage, soil loss and greenhouse emissions associated with livestock and pasture management.
2) Grassland systems will be affected by changing climate and climate variability. Farming systems will need to be adapted creating systems that are more resilient and able to withstand increased climate variability and extreme events.
3) New Zealand is introducing an emissions trading system to price carbon that seeks to drive behaviour change to reduce emissions and sequester carbon.
4) Complementary research is seeking to develop on-farm solutions that can mitigate greenhouse gases through, rumen processes; genomics for rumen CH_4 production; forage and plant inhibitors for diet manipulation; animal factors; and nitrification inhibitors.
5) The ability to respond to the climate challenge for managed grasslands lies with the people that have to implement these changes-the farmers.

Key words: grassland systems, climate change, land use change, emissions trading system, research programme

Introduction

The climate change challenge for managed grassland systems is twofold. a) to produce food in an increasingly efficient and environmentally sustainable way that minimises greenhouse gas emissions and/or enhances carbon sinks; b) to adapt to an increasingly variable and changing climate with more extreme events. New Zealand has been grappling with these parallel issues through research, new technology implementation with some successes. This paper will outline where New Zealand grassland systems have come from; why New Zealand agriculture greenhouse gas profile is unique for a developed country; what responses have been made and are planned; and how farmers are the key ingredient for making a paradigm shift towards a more sustainable way of managing our land uses and agriculture systems.

Grassland systems impacts and benefits

Where we have come from Managed grassland systems globally have been created by humans, following land use change of global proportions-from forests, wetlands, native grasslands and alpine herb fields. New Zealand is no exception. In only 1000 years, 56% of New Zealand's landscape and ecosystems have been transformed from forests and natural grasslands to the managed grasslands and planted forests of today. Over the last 200 years most of the accessible productive land has been cleared and modified for agriculture, horticulture and human settlements, with resulting loss of habitat and the introduction of pest plants and animals (Ministry for the Environment, 2007a). While 44% of New Zealand land area is still in native vegetation, it is mostly in hill and alpine areas; lowland and wetland habitats are under-represented. However, New Zealand has 32% of its land area both public and private, legally protected for conservation purposes, (Ministry for the Environment, 2007a).

The impacts The land uses have changed over time between planted forests, extensive grazing of sheep to intensive beef and dairy farming and reversion of land and its re-afforestation. These changes have been influenced by settlement patterns, government policies, world markets for the livestock products and climatic conditions. Some of these ongoing changes have resulted in declines in land and soil integrity, increased hill country erosion and flooding, water quality degradation and increased greenhouse gas emissions (GHG) emissions from livestock (methane), soils and excreta (nitrous oxide).

Recent research on carbon (C) sources and sinks from erosion and sedimentation in New Zealand (Baisden et al., 2008), show that New Zealand rivers currently deliver approximately 3+/-1 Tg C y^{-1} to the oceans. Of this, 65% is derived from the most mountainous 9% of NZ land area and 20% is derived from the 2% area of soft rocks with human-induced land cover. The C loss it represents in the terrestrial environment may be negated by C accretion on old erosion scars and it may be considered a C sink as it sits on the ocean shelf. Overall the data suggests New Zealand terrestrial ecosystems are close to net C balance (Tate, et al., 2008), gaining on the hill country and losing C under intensive flat land farming systems. Large uncertainties remain, including C losses/gains from land use change from forests, land use and management effects on soil C and future impacts of bio-fuel and bio-char use.

Greenhouse gases These land use changes have resulted in a steady rise in pastoral agriculture non-CO_2 greenhouse gas emissions-methane and nitrous oxide, at a rate of approximately 1% per annum since 1990 (Ministry for the Environment, 2007b). While New Zealand emissions are only 0.2% of estimated world emissions (Ministry of Agriculture and Forestry, 2006), this represents 4.9 Mt $CO_{2^{-e}}$ growth in emissions since 1990 and is projected to rise by a further 2.3Mt by 2010. New

Zealand's greenhouse gas profile is quite unique amongst developed nations . Half of New Zealand's greenhouse gas emissions comprise non-CO_2 emissions -methane from ruminant animals (one third of total GHG emissions) and nitrous oxide (one sixth of total GHG emissions) from microbial breakdown of animal faecal matter and nitrogen from urine , and inorganic nitrogen fertiliser .

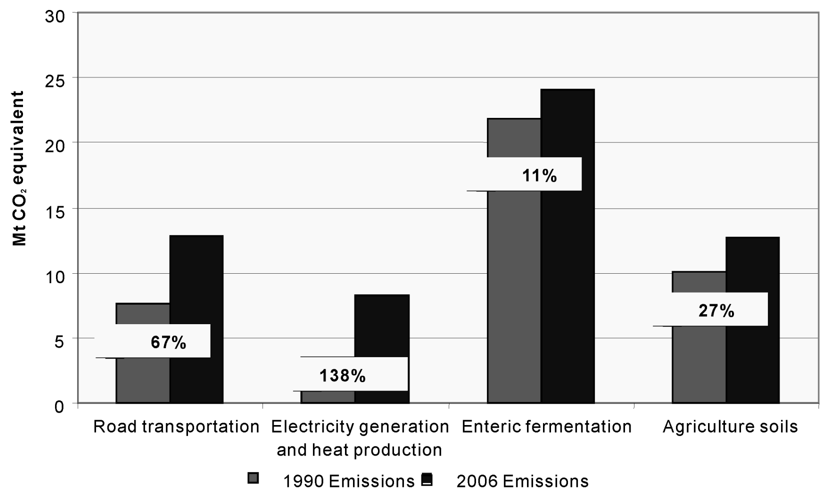

Figure 1 *Growth in New Zealand GHG emissions Source : Ministry for the Environment* , 2008

These increases in emissions have been driven by increases in meat and milk production from each animal (more forage through each animal means more methane and nitrous oxide) , and an increase in nitrogen fertiliser use , driven off rapid growth in world demand for food products and the resulting high commodity prices . (Ministry for the Environment , 2007b) .

However , while the total amount of GHGs emitted from pastoral agriculture has increased since 1990 (dairy has risen 70% , sheep has declined by 18% , (Ministry for the Environment , 2007b ; Ministry of Agriculture and Forestry , 2006)) , the amount emitted per unit of product has declined by 17 .7% and 17 .5% respectively , due to changes in the numbers of animals and animal productivity , (Leslie , et al . , 2008) . Productivity increases are due to new technologies , better feeding and disease management , improved genetics and better pasture and animal management .

The benefits In 2004 , pastoral land use for sheep beef and dairy farming was the largest human land use at around 37% of the total land area of New Zealand . Our economy and social systems have gained from the production from the new grasslands . New Zealand's prosperity has been built from its agricultural heritage . Agricultural exports account for 52% of New Zealand's total exports by value and over the last 15 years have increased their productivity at more than double the rate of the rest of the economy (Sherwin , 2007) . Internationally , New Zealand's agricultural trade is significant-66% of the world lamb trade and 40% of the world's traded milk products come from New Zealand farms (Leslie et al , 2008) .

It has been estimated that 17% of NZ's GDP derives from the top 15 centimetres of our soil (Ministry for the Environment , 2007a) . Our national psyche has been shaped by this economic contribution to the economy . However , that is changing rapidly as increasingly corporate ownership structures , rather than family owned farms , are emerging . The ratio of land price to output price has been rising in New Zealand (sheep and beef currently 14 :1 ; and dairy at 10 :1 , Robobank ,2008) and the family farm and succession to it , is now beyond most individual's ability to pay .

In addition , people's expectations are changing , as we have seen in New Zealand with the growth in eco-tourism . The value of ecosystem services to the New Zealand economy per annum , was estimated at NZ $ 46 billion in 1999 (Patterson and Cole , 1999) . The New Zealand export earnings from tourism are NZ $ 8 .3 billion and rank second to agriculture which is NZ $ 16 .1 billion . Tourism depends largely on the conservation of our natural ecosystems (Ministry for the Environment , 2007a) .

Climate Change

The IPCC (2007) , has reported that there is now observational evidence from all continents and most oceans that many natural systems are being affected by regional climate changes , particularly temperature changes . Furthermore , global assessment of data since 1970 has shown that it is likely that anthropogenic warming has had a discernable influence on many physical and biological processes .

Grasslands and the livestock footprint
Where do grasslands fit into the picture ? Globally , livestock activities contribute 18% of total anthropogenic GHG emissions (including deforestation for grazing land) , which is more than the contribution from transport (FAO , 2006) . Livestock is the single largest anthropogenic user of land globally FAO , (2006) .

Table 1 *Livestock contribution to greenhouse gas emissions .*

CO_2-e	18%	Pasture degradation and land use change
CO_2	9%	Not considering respiration
CH_4	37%	
N_2O	65%	Incl . feed crops

Source : Adapted from FAO , 2006

Climate change effects Climate change effects from the impact of GHG emissions , are threefold-changes in average climate conditions ; changes in the incidence and severity of extreme weather events ; and changes in climate variability . The IPCC (2007) suggests that the most significant impacts of climate change by the end of this century for New Zealand are likely to be an increase of up to fourfold in flood risk in most regions ; a two to fourfold increase in drought risk , especially in eastern regions ; and changing biosecurity risks . The climate changes are projected to affect a large proportion of New Zealand's prime agricultural land for cropping , dairy , sheep farming , viticulture , and market gardening . The IPCC (2007) has also concluded that production from agriculture by 2030 in New Zealand is likely to decline over parts of eastern New Zealand , with initial benefits to agriculture in western and southern areas and close to major rivers , due to a longer growing season , less frost and increased rainfall . However , they consider that there is substantial adaptive capacity , due to a well developed economy and science and technical capability , but considerable constraints to implementation and major challenges from changes in extreme events

Projected impacts on agriculture A recent risk assessment (EcoClimate , 2008) , suggests that for the coming century while there may be little change from the present in total pasture production over New Zealand , there were strong regional variations projected and national production in the driest years may become worse than at present . These will have significance for local agriculture management . These findings are for climate scenarios with a significant increase in west-east rainfall difference across New Zealand .

Likely impacts on agriculture , in addition to the effects of rainfall events , could include ; changes in pasture growth and hence capacity to intensify agriculture in some regions , with opportunities for new pasture species and management systems in others ; changes in pasture composition , with invasion of weeds , pests and diseases increasing biosecurity risks and costs ; changes in water availability , reducing expansion of irrigation for more intensive grazing regimes ; reductions in water availability ; changes in cold hardening in some crops ; significant social and economic impacts on rural communities .

These projections are well outside what New Zealand has already experienced , so any resulting costs are likely to be even greater than what has already been experienced . For comparison , the following figures give an indication of the economic costs of events we already experience that result from mainly natural causes . The February 2004 floods affecting a wide area of central New Zealand had losses estimated at NZ＄107 million to hill-country sheep and beef farms , and NZ＄24 million to cropping . Six thousand people were evacuated , some farms lost 30% of grazing land and 20 ,000 hectares of land was affected by landslips (Ministry of Agriculture and Forestry , 2004a ; 2004b) . The effect of the 2007 drought on sheep and beef farming on the East Coast region of New Zealand was a NZ＄326 million fall in total Value-Added or a 15% decline in the sector contribution to the regions GDP (Ministry of Agriculture and Forestry , 2007)

New Zealand has to date managed the effects of climate events through increased water harvesting , movement of animal feed from areas not affected , the development of drought resistant pasture species and social support through government disaster recovery packages . However , such adaptive management will need to be matched by cuts in GHG emissions by the international community , to reduce the extent and effects of climate change , to avoid the extreme projections at the higher end of the scale .

These projected effects could require significant changes in farm management practices . For example , average dry conditions over a wider area will constrain the ability to import feed . In addition , if changes in climate occur gradually over time , adaptive responses can be made , but if unexpected climate extremes occur more frequently , which the IPCC (2007) projects , then animals and plants may not be able to fully adapt . This presents opportunities for land use changes and costs , if land management practices alone , cannot adapt as a consequences of more frequent extreme events .

The response

The potential consequences necessitate a change in the paradigm governing grasslands management , from one driven primarily by commodity prices , to one that is risk based and takes the full cost of the farming activity into account including environmental externalities . Such an approach will drive mitigation of emissions and adaptation to the effects .

New Zealand has recently embarked on a challenging response to climate change-a market mechanism and related policies (an emissions trading scheme (ETS) and a Sustainable Land Management and Climate Change Plan of Action) . As a Party to the Kyoto Protocol , New Zealand is committed to reducing its emissions to 1990 levels , on average over the period 2008-2012 , or taking responsibility for any excess emissions by purchasing or generating Kyoto-compliant units . New Zealand is taking a constructive role in the negotiations for international commitments beyond 2012 .

Emissions trading system and Plan of Action Legislation is before the New Zealand Parliament to introduce an ETS for all sectors and all greenhouse gases . This will put a price on carbon in the economy and thus take account of the environmental effects of our emissions . There is a staged introduction proposed and a transition for the agriculture sector to enable mitigation technologies and adaptive management to be implemented . Agriculture will enter the ETS in January 2013 .

The ETS will first affect liquid fossil fuels in January 2009 ; stationary energy and industrial process emissions in 2010 and agriculture non-CO_2 emissions in 2013 , with a currently proposed transition period to 2025 before there is full exposure of all agriculture sector emissions to the carbon price , through a free allocation pool equal to 90% of 2005 emissions , when it is brought in to the ETS . This is likely to be phased out progressively by 2025 . The delay in entry of the agriculture sector to the ETS , is in part due to the fact that mitigation solutions for reduction of agriculture emissions are poorly developed compared with other sectors (Ministry for the Environment , 2007c) and to enable cost effective mitigation measures to be developed through investment in research . New Zealand has a Kyoto commitment and an unusually high proportion of its GHG emissions come from agriculture , so it is proposed that agriculture is included in the ETS following the first commitment period of the Protocol . The design for this is underway now .

Research The Pastoral Greenhouse Gas Consortium (PGGRC) is the cornerstone investment by New Zealand in mitigating agricultural GHG emissions . This public private research partnership between the livestock and fertiliser industries and the New Zealand government funds 1 :1 , to understand the animal/soil/atmosphere/water processes , find solutions , develop products , commercialise them and transfer these technologies to the farm after on-farm testing and demonstration . Between 2002-2007 , the consortium invested NZ $ 15million in the following research areas ; rumen processes ; genomics for CH_4 ; forage and plant inhibitors for diet manipulation ; animal factors ; nitrification inhibitors .

The government has recently increased its investment in finding solutions to mitigate agriculture GHG emissions , and on impacts and adaptation to climate change-NZ $ 50 million for research and development and NZ $ 25 million for technology transfer . This also includes an intensive government-funded programme , to better understand , measure and verify GHG emissions from livestock agriculture , and to ensure that any new solutions can be verified for international recognition in our National GHG Inventory , by the UNFCCC , otherwise , New Zealand will not be able to get the credit for the GHG reductions . New Zealand has also established an international research network to better understand GHG emissions from livestock and develop cost-effective and practical means to reduce emissions-the Livestock Emissions and Abatement Research Network (LEARN) *www .lives tock emissions .net*

Early signs of progress from the research are good , especially for nitrous oxide emissions . These were extensively reported at the Greenhouse Gas and Animal Agriculture 2007 Conference , (Special Edition : Australian Journal of Experimental Agriculture , 2008) . For example , nitrification inhibitors can reduce nitrous oxide emissions by up to 21% on an annual basis . However , achieving these reductions relies on farmers using the new products . Nutrient management models like OVERSEER™ have been developed and can estimate nitrous oxide emissions on the farm . Reductions in greenhouse gases from agriculture will only occur when the tools and techniques are designed to be used by the farmers as an integral part of their ongoing farm management practices . People matter .

Historical evidence of behaviour change People respond to price signals and have the capacity to make quite radical changes when conditions change . New Zealand experienced this in 1984 when the government removed agriculture subsidies . At the time , subsidies were approximately 33% of farm income . By 2003 , this had fallen to less than 2% (mostly spent on agricultural research) . The anticipated shift of people off the land did not occur- farmers adapted along with the significant changes to the institutional arrangement governing agriculture (Smith & Montgomery , 2003) . The subsidy removal was tantamount to a price change and saw significant farmer behaviour change .

The change on the ground saw a shift from sheep and beef (the number of commercial sheep and beef farmers fell from 22 ,000 in 1984/85 to 15 ,000 in 2005/06 (Davison , 2006)) , initially to forestry and more recently to dairying and the emergence of a vibrant viticulture industry and a major increase in horticulture . The significant changes were a change in farm size , their distribution, the number of animals (dairy) farmed and the ownership structures. At one level this was a success story-at another, there were significant social impacts to individuals along the agriculture value chain and for whole communities, which lost their infrastructure e.g. schools, postal services. In addition, as world commodity prices have become more favourable for our dairy products, the expansion and intensification of dairying has now brought additional environmental impacts in its wake, greenhouse gas emissions being one of them.

The people It is the farmers who ultimately need to respond to the challenge of climate change and the ETS pricing mechanism. This will be through developing more resilient farm management systems, with adaptive management that can withstand climate variability and extreme events. Land use management in New Zealand has been shown to respond to these challenges in the past. A survey of North Island hill country farmers (Smith, et al., 2007), showed that over the period 1995-99, 50% of farmers had implemented some land use or land management strategy designed to meet changing environmental expectations.

Greenhouse gases can be seen as representing inefficiencies in farm production systems and thus they affect farm profitability, directly through production losses, or indirectly through market pressures for environmental integrity. Examples of industry responses include; a significant reduction in the dairy sector carbon emissions from reduced energy use in the production of dairy products; cropping farmers adjusting their management practices through low tillage systems, reduced energy inputs and efficiency practices through purchase of more energy efficient capital equipment for the farm; the use of standoff pads for cows during wet winter months, when nitrous oxide emissions are likely to be greatest from the soil; tree planting to reduce the effects of rainfall events in erosion-prone areas; changing crop types and planting dates to anticipate changes in season length (Sinner, 2008). The response at the farm-level will be a mixture of mitigation of GHG emissions and adaptive management of farm practices to a number of environmental pressures.

Such initiatives have promoted further development of tools such as OVERSEER™, a model to manage nutrients on the farm which is now being developed to monitor GHG emissions. Landcare Research has developed knowledge about the terrestrial carbon cycle which has enabled piloting of a voluntary carbon trading system for New Zealand landowners to sell carbon credits from regenerating indigenous forests in a pre-Kyoto market. So far, 18,000 tonnes CO_2^{-e} has been traded through the Emissions-Biodiversity Exchange (EBEX21) project. This facility has encouraged some farmers to shift to carbon farming on land that is better suited to regenerating indigenous forest for ecotourism enterprises, while also gaining an income from the carbon credits and plant-based health products. This is adaptive management at work, experience which will inform the climate change response.

A highly consultative process with the agriculture industry is underway at various levels to develop ways of developing farming systems that are resilient and can adapt. The government has set up a Climate Change Leadership Group to oversee the introduction of the ETS and related policies, comprising members from across the sectors and technical experts. There is an Agriculture Sector Peak Group and a Technical Advisory Group of technical and scientific experts in agricultural science and research, to design agriculture entry to the ETS. There is a Research and Innovation and a Technology Transfer Advisory Group designing ways of enhancing and transferring science knowledge and technologies to farmers so they can be adopted as best practice as they are developed. The ETS and the Sustainable Land Management and Climate Change Plan of Action, will facilitate the behavioural changes needed to fulfil the UNFCCC and Kyoto obligations of New Zealand. However, there are no illusions as to its challenging nature. It has never been done before; nor has there been a greater challenge than climate change.

Furthermore, adapting to climate change policy (a carbon price which costs environmental externalities of production), will be as important as adapting to climate change itself. The refocusing of some agriculture enterprises towards the provision of ecosystem services, while utilising other land for high value agricultural production, is one example of land use change triggered by environmental pricing. Recent work (Ministry of Agriculture and Forestry, 2008), indicates that the use of nitrification inhibitors as the ETS is introduced would allow most dairy farmers to improve or maintain their profitability depending on the market price for carbon and milk prices. Land use change is another response. There is approximately 3.2 million hectares of medium and low quality grazing land that could be converted to energy production forests for woody biomass-an area that could supply New Zealand's total projected heat and transport fuels demand (Hall, & Gifford, 2007). These changes and recent deforestation of planted forestry land which is better suited to dairying, is just the beginning of a massive readjustment of land uses that will come as the full price of carbon is felt by the agriculture sector in New Zealand. The hope is that such changes will transition New Zealand to a more sustainable future for people and the environment.

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The impact of climate change on grassland—a modelling approach

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Key words: carbon sequestration, climate change, grass growth, simulation model

Introduction Grassland is the main productive driver of ruminant livestock systems in the UK and is sensitive to climate change. The effects of climate change on grassland systems are potentially complex with the effects on forage yields and quality which may affect the relative suitability of grasses and legumes and their utilisation, and would be difficult to quantitatively identify the impacts with both field and laboratory experiments. Mathematical models are potentially efficient tools for the assessment.

Method A sward growth model linked to the components of soil nitrogen cycling and soil water movement developed by SAC is used to predict the impact of climate change on grassland production utilised for livestock production. Downscaled climate data calculated for three future time-slices (2020s, 2050s and 2080s) under medium-high" emission scenario, was taken from the UKCIP data sources (Hulme *et al*., 2002). Three typical areas each of which represents either beef, or dairy or sheep enterprise in Scotland was selected. Daily climatic data is produced for 50 year periods for the baseline climate and the slices using the Earwig weather generator (Kilsby *et al*., 2006). Cutting managements are used to mimic grazing system. First cutting in a year (equivalent to turnout) occurs when both simulated canopy height and aboveground biomass are greater than pre-defined criteria for various enterprises. Monthly cutting is made afterward until standing biomass on the scheduled date is less than a pre-defined amount.

Simulation results The model is run under three time-slices plus the baseline climate for 50yr each on the selected sites. Simulation results show that average biomass available (Figure 1) and start day of grazing in a year (Figure 2) to different livestock vary under the scenarios of climate change.

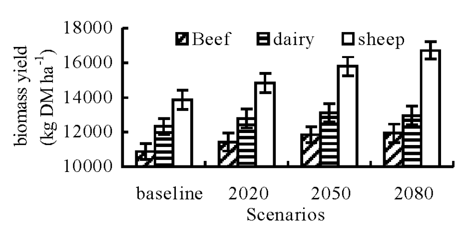

Figure 1 *Average annual biomass removal for various enterprises under different scenarios.*

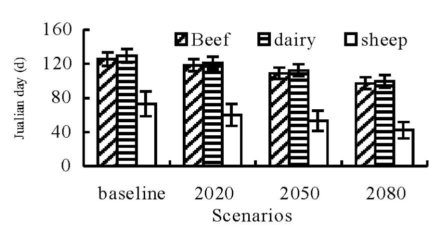

Figure 2 *Average turnout day in a year for various enterprises under different scenarios.*

Discussion Climate change inevitably affects livestock enterprises in the UK. In general, it would produce more biomass from grassland and increase grazing period in a year although the response of grass growth to the changes is different. The preliminary results should be considered as basic input to appraise the wider impacts of climate change on livestock systems.

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Carbon balance in stand of an annual herb at an elevated CO_2 concentration

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Key words : carbon balance , stand , photosynthesis , respiration , elevated CO_2 concentration , *Chenopodium album*

Introduction Global atmospheric CO_2 concentration is predicted to double by the end of the present century (IPCC , 2001) . The influence of increased CO_2 on plant and ecosystem functions has been a major concern in ecology and global change sciences (Long et al ., 2004) . In most studies , elevated CO_2 enhanced canopy photosynthesis . However , the magnitude of the enhancement varies among studies (Nowak et al . 2004) . More recently , Sakai et al . (2006) showed that enhancement of canopy carbon gain by elevated CO_2 is sensitive to the growth stage and leaf nitrogen concentration in the rice stand . However , since most of these studies determined photosynthesis in the stand without destructive harvests , they were not able to fully analyze mechanisms involved in variation in stand carbon balance . Canopy photosynthesis is a function of canopy structure (leaf area index , K , leaf nitrogen distribution etc .) , leaf physiology (photosynthesis , respiration etc .) and environmental factors (irradiance , N availability , temperature etc .) . In the present study , we studied the effect of elevated CO_2 on carbon balance for stands of an annual *Chenopodium album* .

Materials and methods Stands of C . album were established in open top chambers at ambient and elevated CO_2 concentrations (370 and 700 μmol mol^{-1}) in the experimental garden of Tohoku University , Sendai , Japan (38°15′N , 140°52′E) . Plant dry mass growth , photosynthesis and respiration were determined through the growing season . CO_2 exchange of the stand was estimated with a canopy photosynthesis model (Hirose , 2005) . Rates of light-saturated photosynthesis (Pmax) and dark respiration (Rm) of leaves as related with nitrogen content per unit leaf area (Narea) and time-dependent reduction in specific respiration rates (SRR) of stems and roots were incorporated into the model .

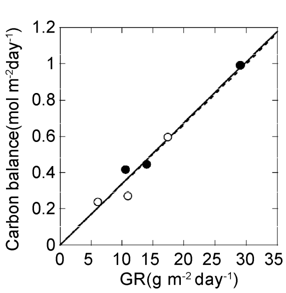

Figure 1 *Comparison of stand carbon balance (canopy photosynthesis minus stems and roots respiration) with mean daily plant growth rates (GR) in C .album stands . Carbon balance is a mean of calculated values for a period between harvests (29 and 41 , 42 and 62 , 63 and 81 DAT) . Open circles , ambient CO_2 (370 μmol mol^{-1}) ; closed circles , elevated CO_2 (700 μmol mol^{-1}) . Solid line represents regression line : $y = 0.034x$, $r = 0.99$. Dotted line indicates equivalence of 1 mol CO_2 with 30 g dry mass .*

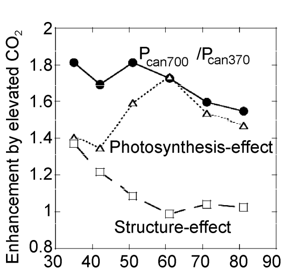

Figure 2 *Enhancement of canopy photosynthesis by elevated CO_2 as a function of DAT (Days after transplanting) . Each data point expresses a mean of canopy photosynthesis . Results of sensitivity analyses (Photosynthesis-effect , triangles , and Structure effect , squares) are also shown .*

Results and conclusions Daily canopy carbon balance , calculated as an integration of leaf photosynthesis minus stem and root respiration , showed a fairly good agreement with dry mass growth determined by harvests (Figure 1) . The enhancement of canopy photosynthesis with elevated CO_2 was 80% at an early stage and decreased to 55% at flowering . Sensitivity analyses suggested that an alteration in leaf photosynthetic traits enhanced canopy photosynthesis by 40-60% throughout the experiment period , whereas altered canopy structure (leaf area index , leaf nitrogen distribution and light gradient in the canopy) contributed to the enhancement at the early stage only (Figure 2) . In early stages when plant size was small , nutrient supply might not be a limiting factor of plant growth , leading to an enhancement of LAI at elevated CO_2 , while in later stages of plant growth , nutrient supply became more limiting and the structural difference might diminish between the two growth CO_2 concentrations . Thus various factors interact to determine the stand carbon balance that is influenced by elevated CO_2 .

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Interactions between defoliation, warming, and drought in a native northern grassland in Alberta, Canada

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Key words: climate change, carbon and nitrogen fluxes, rangeland function, plant community composition

Introduction Canada contains 22 M ha of land dedicated to range and forage production, where the majority of C is produced and stored belowground (Steinaker and Wilson 2005). A healthy rangeland stores equivalent C mass per ha as forested ecosystems, and because this C is primarily belowground, it is at lower risk of release during fires. Consequently, healthy grassland ecosystems may play a significant role in mitigating global climate change. Overgrazing has been documented on up to half of all rangelands in the region, and through a potential decline in root biomass, may reduce soil carbon storage. Coupled with predictions of climate change, these disturbances are likely to further change range health. Improvement of rangeland condition provides direct economic benefits, and because native rangelands store more C than annual croplands, this should also lead to increased C storage, with implications for feedback to climate systems both locally and globally. We however have a relatively poor understanding of how range management practices such as grazing intensity and the predicted future climate (which may become warmer and drier in some regions) interact to affect the function of the native northern temperate grassland ecosystems (Zhou et al. 2006).

Materials and methods We used a randomized complete block design with 5 blocks for a 2 (warming vs. non-warming) x 3 (two intensities of clipping to simulate grazing vs. no clipping) × 2 (drought vs no drought) factorial experiment for the full study which began in spring 2007. The warming treatment was applied using open-top chambers (OTC, 40 cm high and 2 m in diameter) that can increase the near surface air temperature by 2-4℃. As the size of OTCs precluded the use of actual ungulate grazing, simulated grazing was achieved through manual clipping of vegetation in and around (buffer) each plot. Simulated grazing of low and high intensity treatments consisted of clipping to a stubble height of approximately 7.5 m and 2.5 cm, which roughly corresponded to the removal of 30% and 80% of standing current annual biomass. Drought treatments were applied using shelters that intercepted 70% of natural precipitation. In each plot, near surface air temperature, soil temperature and soil moisture content were measured continuously, plant community compositional responses were assessed at peak biomass, soil N availabilities were measured using the Plant Root Simulators (PRS) probes, and fluxes of CO_2 and N_2O were determined using a static gas chamber-gas chromatograph system. Rates of N mineralization were determined using the buried-bag method. Microbial biomass C and N were measured using the fumigation-extraction method. Soil microbial functional diversity and composition were studied using the Biolog and phospholipid fatty acid (PLFA) techniques. A mini-rhizotron was used to estimate belowground primary productivity and carbon flow.

Results Preliminary results from a pilot study conducted in 2006-07 showed that the combined warming by defoliation treatment produced an additional increase in soil (0-5 cm) temperature of about 2 °C relative to all other treatments during August 2006. Soil moisture content exhibited high temporal variability throughout the growing season of 2006 likely reflecting fluctuations in rainfall during this period. Plant community species richness and diversity remained relatively stable throughout the growing season in 2006 and differences among the treatments were relatively minor. Due to warming, rough fescue (*Festuca hallii*) increased in canopy cover, but towards the end of the growing season had fewer tillers. Warming also altered the morphology of many-flowered aster (*Aster falcatus*) and bastard toadflax (*Commandra umbellata*). Few treatment effects were observed for soil microbial biomass C and N, but both parameters had large seasonal variations. In June 2006, the warming treatment resulted in greater ammonification, and defoliation decreased the net nitrification rates, both in the 0-5 cm soil layer. Nitrification was the dominant process in the transformation of organic N to inorganic form in the system. We have so far observed few other significant differences caused by the treatments.

Conclusions These northern temperate fescue grasslands appear rather resilient to changes in the climatic conditions and management practices in the first year of a pilot study. However, we predict that over the longer-term (e.g., up to three years), the grassland ecosystem under study will respond to sustained changes in climate and management treatments in a much more significant way, as changes in plant growth will have cascading effects on ecosystem processes.

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Soil carbon in soils of South Coastal Western Australia under different farm management systems , including Sub-Tropical Perennial Pastures

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Key words : building soil carbon , sustainable land use , perennial pastures

Introduction Soil organic matter consists of all components of the soil that have been derived from biological organisms . Soil organic Carbon is the single largest component , (Garcia ,2004) , and its concentration is the major indicator of soil health , fertility and the long term sustainability of farming practices .

The project was developed in consultation with Australian Soil Carbon Accreditation Scheme and will link in with the South Coast Soil Carbon Monitoring Project . It will contribute towards baseline data that will help to demonstrate-The present and historical rate and levels of Carbon sequestration under mallee and sandplain soils with different management regimes including Kikuyu pastures and Tetraploid rye grasses .

That the most appropriate agricultural systems that will allow positive soil Carbon sequestration are perennial based .
That soil carbon sequestration should be included in emissions trading schemes and the adoption of long term sustainable systems will be facilitated by a direct relationship with financial returns .

Materials and methods GPS defined areas , for long term monitoring , were soil sampled from October to December on 5 properties on the Eastern South Coast of WA . Reference sites were sampled for % Carbon and Bulk density in the 0-110cm soil profile , as perennials such as kikuyu , have root systems that grow over 2m into the soil profile . Further samples were then taken from 0-30cm to obtain data on Bulk density and % Organic Carbon under different regimes . Samples were also taken from non -treatment areas either adjacent annual pastures and /or native vegetation .

The types of management practices and the years under the different systems were recorded . Soil type , water repellency , pH throughout the profile and level of waterlogging or inundation were also determined for soil health . The perennial kikuyu grass pastures were sampled from 0 year ,after 1 year and after 5 years establishment which will indicate an annual sequestration rate . The monitoring of all sites will continue for at least 3 years .

Results and discussion Results for this project have not been determined yet . The data being gathered follow the principals of determining baseline soil Carbon levels as compared to levels when change has been implemented , and following the changes over time . From preliminary work in other areas as well as changes in soils that have been recorded under Kikuyu pastures established for over 20 years , it may be expected that soil C levels will improve over time after Kikuyu and other perennials establish . The results will give a strong indication of what is happening to Soil C under different management regimes , but will need to be followed up with more extensive and long term research .

Conclusions Indications are that under appropriately managed perennial pastures , soil Carbon can develop to a level greater than in other types of plant community . These pasture systems could have a major world role in sequestering Carbon as well improving long term sustainability of agricultural communities both biologically and economically .

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Response of CO_2 emissions to the grazing and enclosure in temperate grassland ecosystem

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Key words : CO_2 flux , grazing , enclosure , Loess plateau , slopeland

Introduction The rangeland on the slopeland of Loess Plateau plays an important role in livestock and ecological protection . The process and main influencing factors of carbon cycle in grassland ecosystem are important in the global change . Many studies mainly focused on the flat regions . The objective of this study was to explore the influence of different management styles on soil CO_2 emission .

Materials and methods The site is on a slope grassland near Huan County , Gansu Province , China (37.1°N , 106.8°E) . The plots were enclosed (in 2001) free grazing grassland , and six terrains : flat , 15° shady and sunny , 30° shady and sunny , 45° shady and sunny slope . The measurement was conducted in August 2006 and August 2007 . CO_2 flux was measured with LI-COR 6400 .

Results There were different impacts of enclosure on the emissions of CO_2 in different years . In 2006 , total CO_2 flux increased due to the increase in the emissions of shady slopes . However , there were little effects on sunny slopes and flat (Figure 1) . This because enclosure increased the belowground biomass , and the major part of soil respiration is root respiration . In 2007 , there was little impact of enclosure on the emissions of CO_2 , but the CO_2 emission in different slopes were different (Figure 2) . Generally , CO_2 flux of steep plots (45°) increased and decreased in gentle plots (15°) . This probably because the soil moisture condition was poor , and the soil temperature was the main influencing factor , and the steep plots were accessible to photosynthetic active solar radiation (PAR) .

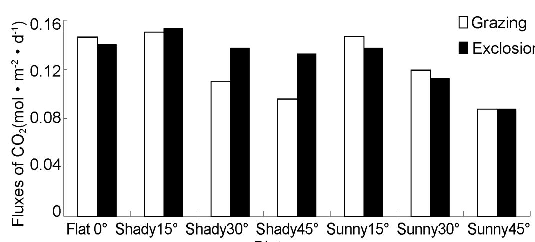

Figure 1 *The emissions of CO_2 under different management styles and terrains (2006) .*

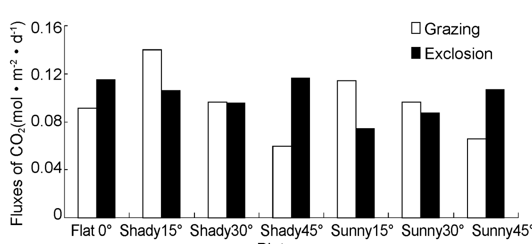

Figure 2 *The emissions of CO_2 under different management styles and terrains (2007) .*

Conclusions Current literature suggests no clear general relationships between grazing management and carbon sequestration (Reeder *et al* ., 2002) . Overall , grazing reduced the total emissions of CO_2 , because grazing removed some biomass of aboveground and litters , also changed the belowground biomass . As the impact of grazing on the grassland is complex . In addition , the breathing gas and eructation of livestock are an important source of greenhouse emissions .

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Carbon exchange from four agro-ecosystems on the Loess Plateau, China

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Keywords: carbon exchange, agro-ecosystem, Loess Plateau

Introduction Soil CO_2 flux to the atmosphere is a significant component of the global C cycle, approximately 10% of the atmospheric CO_2 pool (Jenkinson *et al*., 1991) and the second largest flux between terrestrial ecosystems and the atmosphere (Raich and Tufekcioglu, 2000). The Loess Plateau has one of the more developed agricultural systems in the world and has the longest cropping history in China. The objective of this study was to estimate the amount of carbon sequestration and soil emissions from different agro-ecosystems in the representative areas of the Loess Plateau.

Material and methods The experiment was conducted in 2006 in Huanxian County (37.1°N, 106.8°E, 1650m, 359mm precipitation—mostly in summer, 1993mm evaporation) Gansu province, China. Four agro-ecosystems were compared; rangeland systems, cropping systems (annual crops), sown grassland system (perennial alfalfa) and agroforestry systems (poplar-alfalfa). Above and below-ground plant biomass were measured at the peak of the growing season (August). Soil CO_2 flux was determined in May, August and December with the LI-COR 6400 gas exchange system (LI-COR, Lincoln, NE, U.S.A.).

Results Carbon sequestration in vegetation was significantly higher in the sown grassland system than other agro-ecosystems (Table 1). Cropland had the lowest biomass, 33% lower carbon emissions from the soil surface and 8.5% higher soil organic carbon content than other systems. There were no significant differences on the carbon emission from the soil surface between rangeland, sown grassland and agroforestry systems.

Table 1 *Carbon sequestration and emissions from four different agro-ecosystems on Loess Plateau (units: t ha^{-1}).*

Production system	Utilisation	Carbon sequested in vegetation (±SE[2])	Carbon emission from soil surface (±SE)	Soil organic carbon (±SE)
Rangeland	Grazing	6.3±0.4 c[1]	3.3±0.3 a	39.3±0.5 b
Sown grassland	Hay production	14.3±1.5 a	3.2±0.3 a	39.1±0.7 b
Cropland	Crop production	4.7±0.7 d	2.2±0.2 b	42.0±0.2 a
Agroforestry	Hay and timber	10.5±0.4 b	3.5±0.3 a	37.7±0.4 b

[1] Value accompanied by different letters differ significantly ($P<0.05$); [2] SE: standard error

Conclusions Increasing plant growth did not result in more soil carbon stored or greater carbon emissions from soils, the additional carbon was sequestered within plant biomass. In cropland there may be reduced soil microbial activity which reduces the breakdown of soil carbon and the rate of carbon emission, or there may be reduced root respiration or these are better soils that store more carbon.

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Impacts and adaptation to climate change in beef production systems in central Queensland

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Key words: GRASP model, pasture growth, cattle

Introduction Trends in Queensland's grazing lands related to climate change, and increases in atmospheric carbon dioxide (CO_2) raise questions about the future productivity of various industries, particularly those on the climatic margins (Howden et al., 1999). Here we investigate the impacts of climate change at Emerald (23°31′S, 148°10′E, mean annual rainfall 648 mm) using a pasture growth model (GRASP) to examine the sensitivity of pasture growth to a range of climate change scenarios and two stocking strategies (constant and responsive).

Materials and methods Climate change scenarios were generated based on output from the CSIRO Mark 3 General Circulation Model. Changes in pasture growth were assessed for 2030. For each climate change projection combinations of higher (H) and lower (L) levels of predicted temperature (T) and rainfall (R) were generated to form four combinations that consisted of T-lower/R-lower (LL), T-lower/R-higher (LH), T-higher/R-lower (HL) and T-higher/R-higher (HH). Constant (based on average annual pasture growth) and responsive (based on the amount of pasture available on the 1st June each year) stocking strategies were used for a native pasture on a light textured soil of average fertility without trees. An average CO_2 enrichment scenario was applied where the base CO_2 level in 1990 was about 355ppm, and in 2030 it was 452ppm.

Results and discussion Variability of annual growth increased under low rainfall scenarios, and particularly under the high temperature/low rainfall scenario (Figure 1). The higher variability of simulated growth between years under low rainfall, compared to 1990 and high rainfall scenarios, was associated with greater under-use of available nitrogen in dry years, more nitrogen build up in the soil and relatively more nitrogen being available for growth in wet years. The risk of less than 1500 kg/ha of annual growth was increased under the low rainfall scenarios. The median growth of pasture was not affected by climate change.

Conclusions The higher variability of annual growth under low rainfall scenarios will make it more difficult to sustainably manage stocking rate. Finding the balance between utilising pastures for animal production and leaving them understocked for recovery will become more difficult and better tools are needed to help pastoralists assess pasture quantity and quality, sustainable stocking rates and recovery times of pastures.

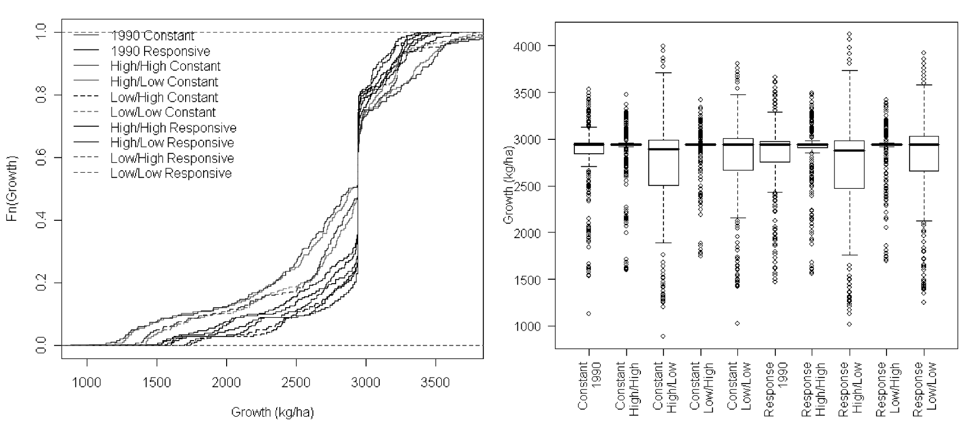

Figure 1 *Growth for 1990 and different climate change scenarios for 2030 using two types of stocking strategy.*

Reference

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A scientific framework for forecasting carbon sequestration in rangelands

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Introduction The uncertainty (higher for more arid areas) of the worth of rangelands for carbon sequestration (CS) can be determined from the vast range of existing and seemingly conflicting scientific work by identifying and assembling the basic components to form pragmatic and comprehensive CS forecasting. For the last 50,000 years people have burned or cleared forests and woodlands to favour large herbivores, and more recently to produce food, lumber, urbanisation, paper and vehicle fuel. The net effect of aerobically decomposing woody matter (e.g. cellulose), whether via direct combustion, burning of fossil fuels or oxidation of soil carbon following erosion is, in chemical terms, the reaction:

$$(n(C_6H_{10}O_5)) + 6nO_2 \longrightarrow 6nCO_2\uparrow + 5nH_2O + energy\ .$$

Vegetation-based CS projects aim to ameliorate our carbon-flux imbalance using 1) the reverse of the above equation (via photosynthesis), and 2) storage of vegetation decay products as soil carbon. Also, existing forests and woodlands *per se* have recently gained more recognition as ideal carbon stores. We examine the potential for CS in the 3.84 Mkm^2 occupied by the rangeland grazing industry in Australia—predominantly shrubland and woodland—i.e. a good candidate for long-term carbon storage. Land degradation (e.g. severe erosion, woody thickening, and accentuation of drought effects) has followed overuse and clearing by the advancing livestock industry for over a century. It also causes increased carbon emissions and decreased biodiversity (e.g. Walker and Steffen, 1993), and animal welfare legislation is inapplicable. Gleeson and Dalley (2006) noticed generally a focus on short-term productivity goals, opposition to environmental concerns, bureaucratic stagnation and paltry adjustments. The economics of climate change may provide impetus for change, e.g. via the Kyoto Protocol which allows for emissions to be offset by trading.

Materials and methods This paper represents a preview of a scientific literature review plus excerpts from fieldwork, and analyses of existing and new datasets including remote sensing and GIS methods—to be published separately. The events constituting carbon emission and sequestration can be simulated using superimposed sigmoidal curves, common in ecological studies. Processing temporal LANDSAT imagery for vegetative cover yields the expanse and magnitude of degradation. The degradation GIS layer combined with layers of biomass and soil carbon permits assignment of sigmoidal curves for each pixel from which regional forecasts are tallied. Uncertainties in measurement arise from unmeasured hydrological carbon and the need for 3D biomass data (e.g. from LIDAR or radar).

Results Some critical requisites for unequivocal results were found to be: allow between 30 and 500 yrs in semi-arid and arid areas for measurable changes in C; use environmentally and edaphically paired sites; accommodate high spatial variability in soil organic carbon (SOC)—positively correlated with woody biomass; record shrub/tree decline and forestry activities; measure SOC to at least root depth—deeper in coarser soils and dryer areas; and notably: percentage changes in carbon stocks elucidate phenomena rather than comparison of absolute values. Estimated C emission rates resulting from current management are 4 to 60 Mt-C.yr^{-1} and for SOC: 0.7% .yr^{-1}-similar in magnitude to those overseas. Estimates of CS for woody thickening are in the order of 0.4 t-C.ha^{-1}.yr^{-1} but its extent remains undetermined. Exclusion of livestock can increase carbon stocks several fold in degraded areas, estimates for CS upon destocking range from 4 to 25 Mt-C.yr^{-1}. We estimate CS at ~1% .yr^{-1}, i.e. 6 Mt-C.yr^{-1}, or ~300 Mt-C over 50 yrs. This value is halved if the Chicago Climate Exchange limit of areas with more than 356 mm rainfall is imposed. An uncertain prognosis for CS arises significantly from: 1) invading buffel grass (*Cenchrus ciliaris*) which can dehydrate shrubs and increase burning, 2) climate change with increased scarcity and intensity of rainfall—inducing more fires and erosion, and 3) population growth.

Conclusions The potential CS of ~300 Mt-C upon destocking is not large compared with our global carbon-flux imbalance but there are corollary benefits such as halting the current rangeland emissions. Uncertainties remain at two levels: 1) precision of the CS values, and 2) achieving the CS by a change in management paradigm.

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Seasonal and diurnal variations of net ecosystem CO_2 exchange over Songnen meadow steppe in northeastern China

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Key words: *Leymus chinensis*, Songnen meadow steppe, eddy covariance, carbon flux, net ecosystem CO_2 exchange

Introduction Carbon dioxide is the key factor to determine the degree of global climate change. In China, the studies on the role of terrestrial ecosystems in the sequestration of carbon have been limited to the typical steppe located in central Mongolia and Inner Mongolia, whereas for the meadow steppe, is still vacant. This paper is the first time to present results of continuous measurements of net ecosystem CO_2 exchange (NEE) above the Songnen meadow steppe in northeastern China using the eddy covariance technique. Our specific objectives were to: (1) to describe the characteristics in variations of net ecosystem CO_2 exchange (NEE) on diurnal and seasonal scales; (2) to quantify the magnitude of a source or sink for atmospheric CO_2.

Materials and methods The measurements were performed in the Pasture Ecology Research Station of Northeast Normal University, which located in Changling, Jilin Province of China (123°44'E, 44°40'N, 167m a.s.l.). To evaluate the carbon sequestration of Songnen meadow steppe, which characterized by a large-scale pattern of meadow and alkali-saline patches, an open-path EC flux measurement tower was established in May 2007 as a member of the US-China Carbon Consortium (USCCC) for a long-term monitoring of turbulent fluxes of CO_2, water vapor and energy (123°30'E, 44°35'N, 171m a.s.l.).

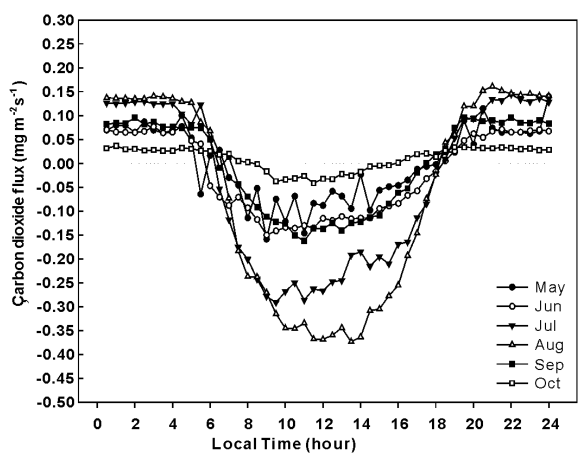

Figure 1 *The monthly-average diurnal variations of CO_2 fluxes over Songnen meadow steppe during the growing season in 2007.*

Results and discussion Apparently in Figure 1, the carbon assimilation was lower in the initial phase of growing season, which caused NEE in the daytime near the size of NEE at night. The rapidly growth of *Leymus chinensis* was respect to rising temperature and soil moisture. From June, NEE in the daytime started to increase and maintained a fairly higher than that at night for a long time until back to balance in September subsequently. An average CO_2 uptake reached a maximum of -0.37 mg CO_2 m^{-2} s^{-1}, which can be seen in August when aboveground biomass peaked and higher than the steppe in Inner Mongolia (-0.29 mg CO_2 m^{-2} s^{-1}, Zhang et al., 2007). The Songnen meadow steppe acted as a net sink of atmospheric CO_2 and sequestered-87.73 g C m^{-2} during the growing season in 2007.

Conclusions The diurnal amplitude of net ecosystem CO_2 exchange (NEE) over Songnen meadow steppe varied substantially within the peak growing season, and there was a marked seasonal trend that NEE was regulated by the temperature and amount of precipitation. Firstly given the importance of Songnen meadow steppe as a terrestrial carbon store and argument concerning its carbon sink strength, this study will help to reduce uncertainties in carbon accounting for eastern Eurasia steppe.

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The influence of simulating warming effect on *Ranunculus brotherusii*

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Key words: *Ranunculus brotherusii*, warming effect, chamber, buds, mortality

Introduction Global warming have becoming a well known fact that is one phenomena of the global changing. Effecting and feedbacking on land ecosystem have been researched by GCET that is becoming the hotspot in climate changing domain (IPCC, 1995, 2001).

Materials and methods Based on the International Tundra Experiment (ITEX) method, we established five different size of chambers as A, B, C, D, E and CK, and examined the simulating warming effects on buds and morality of *Ranunculus brotherusii*.

Results The temperature (surface and underground temperature) increased with the size of the chamber decreasing from CK to chamber A which had the highest temperature of 11.9℃, 11.7℃ (Figure 1, 2). The temperature was lowest in the CK which were 9.4℃, 9.9℃. Compared chamber A with the control, the temperatures increased during 2004 (2.6℃, 2.2℃), 2005 (2.2℃, 2.1℃) and 2006 (2.1℃, 2.0℃). The number of buds of the *Ranunculus brotherusii* was increased with the temperature warming and they were decreased year by year (Figure 3). However, the buds number of the *Ranunculus brotherusii* was decreased with the temperature increasing in the second year and the growth period was shortened (Figure 4). The results proved that the higher temperature was disadvantageous to growth of the *Ranunculus brotherusii* and it would be gradually phasing out if the climate becomes warming and warming.

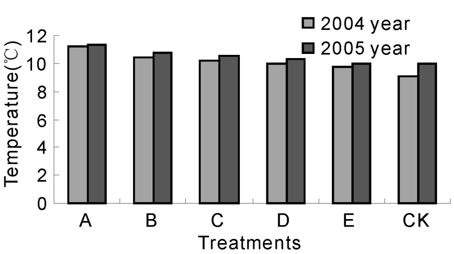

Figure 1 *The variation of the average ground surface temperature in different treatments.*

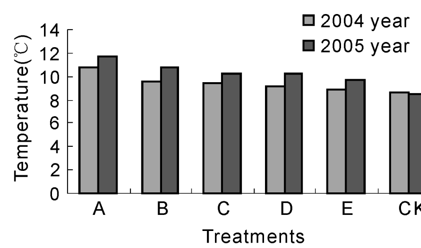

Figure 2 *The variation of the average underground temperature in different treatments.*

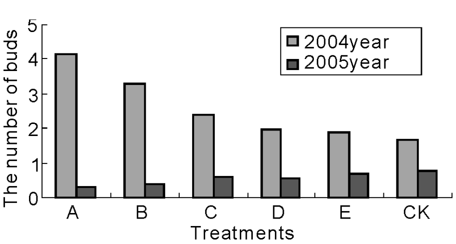

Figure 3 *The variation of bud number in different treatments.*

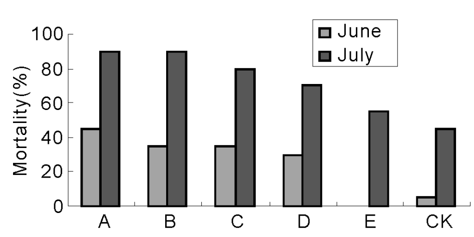

Figure 4 *The variation of mortality in different treatment.*

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Carbon dynamics and mitigation of methane and nitrous oxide emissions in agroecosystems with *Pinus ponderosa* (Dougl . Ex Laws) and native pastures established on degraded volcanic soils in the Chilean Patagonia

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Key words : carbon sequestration , silvopastoral systems , volcanic soils , CO_2 FIX

Introduction During the 1990s , terrestrial ecosystems captured approximately 36% of the total carbon liberated to the atmosphere by combustion of fossil fuels . Consequently , there is a growing interest to study the potential of carbon sequestration in presently non-sustainable agro-ecosystems worldwide , including remote regions such as Patagonia , where large areas of degraded pastures and eroded soils are also encountered , and ranchers face increasing pressures to maintain the cattle-raising productivity of their land . They are encouraged to adopt silvopastoral systems as more sustainable practices that satisfy their socioeconomic necessities and contribute to mitigate atmospheric CO_2 . According to the 3rd IPCC report (2001) , the use of agroforestry systems in degraded lands constitute effective C sinks , especially with the use of perennial pasture and fast growing trees . The objective of this study is to investigate and model the potential to sequester C in an exotic short rotation forest plantation and degraded grasslands of the Chilean Patagonia .

Materials and methods The site was located at 730 m altitude at S 45°25′ W 72°00′ near Coyhaique , Chile . The soil had low bulk density (< 0.9 g cm^{-3}) and high P fixation values (65-89%) . It is classified as medial , amorphic , mesic Typic Hapludands . Treatments were imposed in a randomized complete design with three replicates . Soil samples were analyzed to determine soil organic carbon (SOC) , microbial C and N , and soil respiration (C-CO_2 evolution) . Measured parameters included tree and pasture biomass . Measured SOC values were compared with those predicted by CO_2FIX , previously calibrated to the site conditions . Mean monthly temperature and rainfall during tree growth period , current annual increment of trees , and proportions of C in stems , leaves , branches and roots were used to calibrate the model .

Results Preliminary results show that the contents of SOC are greater than those predicted by the model (Figure 1) , which indicate the need to adjust the soil parameters so that simulations better reflect reality . The unexpected result may be due to the presence of volcanic soils which have distinctive properties including allophanic clays , and higher C contents in surface soil compared to non-volcanic soils . Additionally , soil respiration was highest in the pine plantation (Figure 2) and microbial biomass was highest in the prairie (Figure 3) . Between agroecosystems , soil respiration was not correlated to SOC nor microbial biomass , perhaps due to the larger amount of roots and the presence of mycorrhizae in the plantation . Estimates of CH_4 and N_2O emissions were highest in the prairie . However , pine-based silvopastoral systems would permit addressing cattle-raising and timber production needs and allow for the sequestration of larger amounts of C in above and belowground components of plants and soil of the agroecosystem .

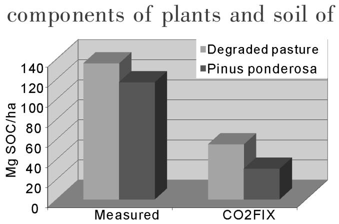

Figure 1 *SOC measured and simulated at 0 to 40 cm depth , Chilean Patagonia .*

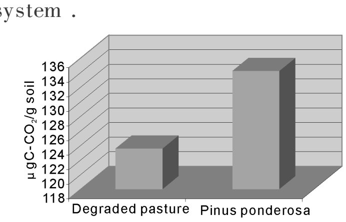

Figure 2 *Mean soil respiration at 0-40 cm depth , Chilean Patagonia .*

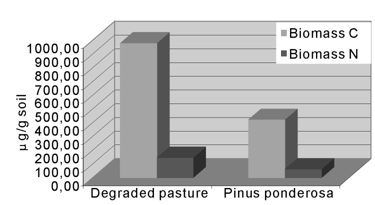

Figure 3 *Mean C and N microbial biomass at 0 to 40 cm depth .*

Conclusions Once the model is recalibrated to soil conditions , it will be used with an adjacent six-year-old pine-based silvopastoral system arranged in strips to estimate total carbon balance , and the results will be used to construct C cycling models . Given the more efficient utilization of site resources and the presence of favorable microclimate , the silvopastoral system will permit a higher annual total biomass production and C capture in comparison with the prairie and the plantation ; also , the presence of highly active aerial and subterranean C cycles will result in a large increase in C capture . The silvopastoral system will have the better potential to mitigate global warming through increased sequestration of greenhouse gases , while also being a more sustainable form of land use in the long term .

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The challenge of managing key supporting ecosystem services in complex land tenure/land use systems—the C cycle in Mexican semiarid grasslands

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Key words : overgrazing , soil carbon , dry land development paradigm

Introduction The grassland biome covers 20% of the arid/semiarid region in Northern Mexico . *Bouteloua gracilis* is a keystone species with respect to providing key ecosystem services of these grasslands . Most grassland occurs on communal land , which lacks sustainable livestock management causing severe plant cover reduction and soil erosion , in turn jeopardizes the cycling of nutrients and water , i .e . critical supporting ecosystem services responsible for the functioning of the natural and human systems of this region . Seventy percent of primary productivity is allocated belowground , thus grassland soils represent significant carbon (C) stores . The C storage is important both in the local context for the functioning of the production systems of subsistence small houshold communities and in the global context for regulating the global climate system . However , little is known on how land use change may have altered the C cycle in semiarid grasslands of Mexico . We examined soil C distribution in different grassland systems along a disturbance gradient caused by land use/cover change . We explore the hypothesis that the provision of ecosystem services in communal land involves complex management decisions that consider both biophysical and socioeconomic factors . We test this hypothesis with the dry land development paradigm (DDP) , a conceptual framework that allows exploring the dynamics of vulnerable socio-ecological systems .

Materials and methods Several grassland types differing in land use history and hence degree of disturbance were selected in this study : *B . gracilis* grasslands with moderate grazing and heavy grazing , grasslands dominated by the African species *Eragrostis curvula* (E) , a shrub encroached savanna-type grassland (S) , a rain-fed corn-crop site (C) , and an abandoned agricultural site (A) . Soil samples were excavated at two depths (0-15 cm , 15-30 cm) at two microsites (beneath plants , interspace) in all grassland sites .

Results and discussion Grasslands with long-term moderate grazing (M) represent the most important soil C pools (> 20t/ha) . However , long-term heavy grazing and plant cover reduction do not seem to significantly decrease soil C pools at least in the top 15 cm . However , land conversion to rain-fed agriculture and the introduction of exotic grasses substantially reduce soil C pools , suggesting that *B . gracilis* contributes with rather recalcitrant compounds to the soil C pool . Turnover rates of dead *B . gracilis* roots are slightly higher in heavily grazed than moderately grazed sites . Hence , historical land cover and use substantially alter soil C pools and fluxes .

Conclusions Effective grazing management of native grassland ecosystem guarantees the provision of C stores as a key ecosystem service . According to the DDP , 70 years of heavy grazing driven by a growing regional livestock market have not pushed yet the system across a biophysical threshold with respect to C storage . However , additional negative effects of overgrazing (soil erosion) on the hydrological cycle may negatively feed back on the C storage potential of the soils .

Climate change and human activity impacts on the net primary production of alpine grassland in northern Tibet , China

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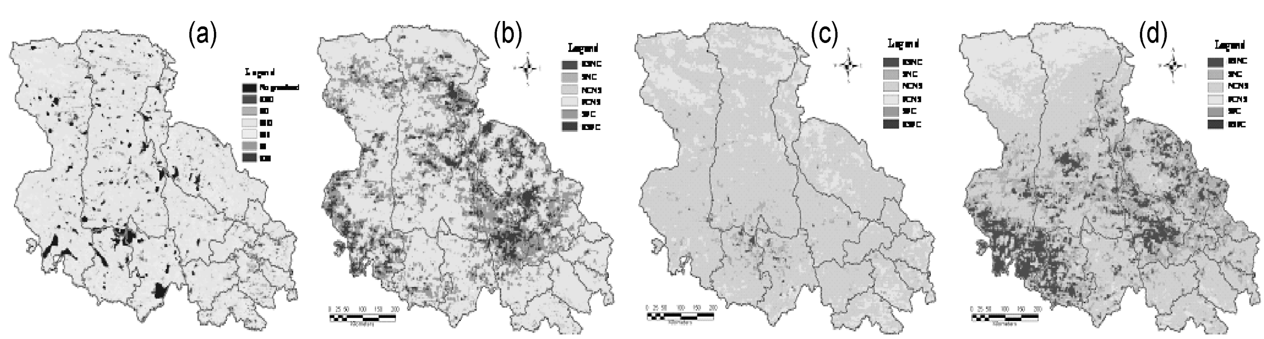
Key words : NPP , climate change , human activity , trends analysis , impact assessment , alpine grassland , northern Tibet

Introduction Northern Tibet region is the headstreams of major rivers , including Yangtze River , Nujiang River , and Lancangjiang River in China (Gao et al , 2005) . Based on the remote sensing data from 1981 to 2004 as well as other related data , spatial trend of alpine grassland net primary production (NPP) and its resonances to climate change and human activity in Northern Tibet were analyzed with the help of geographical information system .

Material and methods Alpine grassland NPP were calculated by the CASA (Carnegie-Ames-Stanford Approach) model and validated by comparing with observational data . Pearson coefficient was used to predict the long term variations of alpine grassland NPP from 1981 to 2004 . A correlative analysis was made to calculate spatial correlation coefficients between alpine grassland NPP and climate change in Northern Tibet . The impacts of human activity intensity was analyzed on alpine grassland NPP based on GIS techniques .

Results The change in alpine grassland in most areas of Northern Tibet was not obvious across roughly 89% of total grassland area ; while the area with marked change only accounts for 11 .4% , with roughly 11 .3% showing decrease and < 0 .1% increase (Figure 1) . In recent years , the precipitation variation in Northern Tibet resulted in an increase of grassland NPP , though solar radiation resulted in decreased grassland NPP . During the period of 1981-2004 , climate factors affected the grassland NPP in Northern Tibet in the following orders : total solar radiation > precipitation > temperature (Figure 1) . The negative effects of local residential areas on the rate of grassland NPP change are smaller than that of roads . In general the intensity of human activity in the region near to road and the residential area are strong and the influence on grassland NPP change tendency are bigger .



(a) Trends of NPP ; (b) NPP and precipitation ; (c) NPP and temperature ; (d) NPP and solar radiation ESD is extremely significant decrease ; SD is significant decrease ; ISD is insignificant decrease ; ISI is insignificant increase ; SI is significant increase ; ESI is extremely significant increase ; ESNC is extremely significant negative correlation ; SNC is significant negative correlation ; NCNS is negative correlation but none significant ; PCNS is positive correlation but none significant ; SPC is significant positive correlation ; ESPC is extremely significant positive correlation

Figure 1 *Trends of grassland NPP and spatial correlation between alpine grassland NPP and annual precipitation , annual mean temperature and annual solar radiation in Northern Tibet .*

Conclusions Most areas in Northern Tibet did not show a significant annual NPP change . The negative effects of local residential areas on the rate of grassland NPP change are smaller than that of roads . During the period of 1981-2004 , climate factors affected the grassland NPP in the following orders : total solar radiation > precipitation > temperature . Generally , the impact of regional climate change on grassland NPP was more negative than positive .

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Effect of increased autumn temperature and CO_2 concentration on frost hardening and winter survival in *Lolium perenne*

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Key words : perennial ryegrass , climate change , CO_2 , frost tolerance , overwintering

Introduction Before 2100 , the average autumn temperature in Norway is expected to increase by 1 .4 to 5 .9 °C (RegClim , 2005) . At the same time , the CO_2 concentration will increase . The aim of the present study was to investigate how a temperature increase during autumn will affect frost hardening , winter survival and spring growth of perennial ryegrass (*Lolium perenne* L .) on a coastal location in Norway , at the present and a future CO_2 level .

Materials and methods The experiment was carried out in open-top chambers at Særheim (58 .76°N , 5 .65°E , 90 m a s l , 8 km from the coast) . Two cultivars of perennial ryegrass (Riikka , Gunne) , were established in June 2005 in 10 l polyethylene bags filled with a fertilized sand-peat mixture , placed side-by side in the chamber . There were 10 plants per bag and 20 bags per m^2 . The ground area of the chambers were 3 .4 × 2 .5 m^2 and they were surrounded by 1 .9 m high transparent plastic foil mounted on wooden frames , which reduced the incoming light by 15% . In eight of the chambers , heaters were included in the air flow in order to increase the air temperature by about 2°C from Aug . to Dec . Eight chambers were supplied with CO_2 gas to increase the CO_2 concentration by about 170 μmol mol^{-1} from June to Dec . There were 4 treatments , each replicated 4 times : Ambient CO_2 /ambient temperature , ambient CO_2 /high temperatur , high CO_2 /ambient temperature and high CO_2 /high temperature . Tillers were counted and tested for frost tolerance (LT50 ; temperature required to kill 50% of the population) (Larsen , 1978) . Spring growth was evaluated by harvesting the total above-ground biomass on 6 June . Data were subjected to ANOVA .

Results Increased CO_2 concentration had no effect on the frost tolerance (Table 1) . Increased autumn temperature , on the other hand reduced the frost tolerance . This effect was evident on 15 Dec . when there was 1℃ difference in LT50 between the treatments . However , the difference levelled out as the winter proceeded . Riikka was more frost tolerant than Gunne . There were no treatment differences in tiller density or spring growth (not shown) , except for a 35% lower ($P < 0.05$) density in Riikka . The average (monthly minimum) temperature for each month from Aug . 2005 to May 2006 in order were 13 .5 (7 .0) , 12 .6 (5 .5) , 5 .8 (0 .9) , 3 .6 (-2 .7) , 1 .5 (-5 .5) , 1 .5 (-3 .4) , 1 .5 (-4 .3) , -0 .4 (-10 .8) , 4 .7 (-1 .0) , and 10 .1 (3 .2) ℃ . The soil was bare , except for a few days of snow cover in Dec . and 3 weeks in Feb/March (maximum depth 10 cm) . Total precipitation was 732 mm from Aug . to Dec . , and 400 mm from Jan . to May . There was no interaction between cultivar , CO_2 and temperature for any parameter .

Table 1 *Frost tolerance (LT50 , ℃) as affected by temperature , CO_2 concentration , and cultivar .*

	Temperature		CO_2		Cultivar			Significanceb		
	Ambient	High	Ambient	High	Riikka	Gunne	SEMa	T	CO	CV
Nov .	-10 .0	-10 .0	-9 .9	-10 .1	-11 .2	-8 .8	0 .40	ns	ns	***
Dec .	-12 .7	-11 .7	-11 .9	-12 .5	-13 .2	-11 .2	0 .30	*	ns	***
March	-10 .5	-10 .7	-10 .4	-10 .7	-10 .8	-10 .3	0 .35	ns	ns	ns

[a]SEM = standard error of the mean ; [b]Statistical significance ; ns , non-significant ; * , $P < 0.05$; *** , $P < 0.001$; T = effect of temperature ; CO = effect of CO_2 ; CV = effect of cultivar . There were no interactions ($P > 0.10$) between T , CO and CV .

Conclusions The predicted increase in CO_2 will have a limited effect on the frost hardening in this coastal environment . A temperature increase of 2 °C in the autumn will delay hardening and reduce the frost tolerance to some extent . However , the best available cultivars will in most cases be frost hardy enough even with this small reduction .

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Effect of grazing and re-establishment of native species on soil organic matter sequestration for the semiarid central grasslands of Canada

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Key words: Carbon sequestration, beef cattle, native species, grazing, biodiversity

Introduction The native mixed grass prairie in North America is estimated to have been reduced to 20 to 30% of its former extent, due to agriculture expansion and urbanization. Aside from the importance that native grasslands play as a repository for biodiversity, wildlife habitat and a grazing resource, the restoration and maintenance of native grasslands can provide an important opportunity to mitigate greenhouse gas concerns through soil organic carbon (SOC) sequestration. Native grasses have more extensive rooting system than tame species, and higher specie richness can result in higher SOC potential (Wedin and Tilman 1996). Objective of this research was to evaluate the impact that grazing and non-grazing treatments and different native mixtures have on SOC sequestration potential in newly established native pastures.

Materials and methods Sixteen pastures (2 ha ea) were randomly set up in a 2×2 factorial design with four replicates: two native mixtures [7 species simple (S) or 14 species complex (C)] and two grazing utilization levels [low (40-50%) and high (60-70%)]. Seeding occurred in the spring of 2001 using a double disk air seeder. Seeding rate for the S and C mixes were 9.5 kg ha^{-1} [25 pure live seeds (PLS) per 0.30 m^2] and 9 kg ha^{-1} (33 PLS per 0.30 m^2), respectively. Cattle grazing were from the end of June to September and in 2002, 2003 and 2004. In each pasture a permanent enclosure (3.6×3.6 m) was used as the non-grazing treatment. In all pastures, SOC samples were taken in the fall of 2000 and 2004. Prior to soil sampling all surface residues in the area were cut and the soil surface flattened. In 2000, soil samples were taken from five different location sites, while in 2004 only three different location sites were used. At each location site, core samples were taken at six micro-sites and at 0-15, 15-30, 30-45 and 45-60 cm. Determination of soil bulk density and sieving the soil sample through a 2-mm wire sieve were done. Representative sub-samples were ground and analyzed for SOC (McConkey et al. 2003). Data was analyzed using the MIXED procedure from SAS Institute, Inc. (2000).

Results and discussion Average annual C sequestration rate on the newly established native pasture was 530 kg ha^{-1} yr^{-1}. In support, a study by Mensah et al. (2003) on dark Brown and Black soils in Saskatchewan compared favourably to our results. Favourable moisture conditions and forage productivity generally occurred for our study, which contributed to the excellent C sequestration potential. A seed mixture x pasture utilization ($P < 0.05$) interaction was observed and orthogonal contrasts were used. The simple+high (S+H) treatment gave the highest ($P < 0.05$) SOC level compared to complex + low (C+L), S+L and C+H and the SOC changes were 3.59, 2.03, 1.47 and 0.94 ± 0.68 Mg C ha^{-1}, respectively. Higher SOC associated with the S+H may be due to more livestock hoof action breaking down and incorporating the standing dead and litter into the soil and enhancing decomposition and reducing loss through oxidation (Schuman et al. 1999). Highest pasture forage production was observed for the S native mix, thus higher SOC levels were not unexpected.

Conclusion Excellent C sequestration rates can be achieved on newly established native pastures on brown soil land previously annually cropped. Pasture forage production and animal stocking rates can affect C sequestration levels.

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Effects of fence on daily variation of CO_2 flux from the soil in Subalpine meadow of Xinjiang

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Key words : fence ,protection ,subalpine meadow ,CO_2 flux ,soil

Introduction The carbon cycle is the important research content of terrestrial ecosystems (GCTE) . Grassland ecosystem as one of the most important type in terrestrial ecosystem accounts for about 25% in total land , and it is one of the ecosystems that have the most obvious response to atmospheric CO_2 increase and global warming .

Material and method The experimental grasslands are the 4 fields in Bayinbuluke Grassland Ecological Station , Xinjiang . They were fenced for 25 years . In order to measure greenhouse gas CO_2 emission , dark enclosed chamber method is used to observe greenhouse gas emission inside and outside the fenced plots . Following formula was used : $F = \triangle m / \triangle t \cdot DV / A = h \cdot D \triangle m / \triangle t$

Where : F=gas flux ($g/m^2 \cdot h$) , V= the volume of observation box , A =soil area surrounded by observation box , D=gas density inside box .

Results and discussion

The flux on daily variation CO_2 emission flux fenced plot By comparative analysis to soil CO_2 flux on the treated grassland for 25 years inside and outside the fence , it can be seen that : CO_2 emission flux inside fence is obviously higher than that outside the fence .

The relationship between CO_2 emission flux and ground temperature In one day , CO_2 emission flux inside and outside are basically fit with daily change of ground temperature at depths of 5cm and 10cm inside and outside the fence , and significantly positive correlation is present between them ; the correlation coefficients inside are 0 .7118 , 0 .6753 , respectively ; correlation coefficients outside fence are 0 .6777 , 0 .6549 , respectively .

Relationship between CO_2 emission flux and soil water potential Correlation analysis between soil CO_2 emission rate and soil moisture showed that soil CO_2 emission rate has an exponential correlation with soil water potential , and correlation coefficient is 0 .6077 outside fence , 0 .4866 inside fence . Correlation coefficient outside fence is higher than that inside fence , which is caused by soil hydrothermal coupling effect difference between inside and outside fence .

The total daily CO_2 emission inside and outside fence The total daily CO_2 emission inside and outside fence is an important indicator to measure if fencing has an improvement on the soil . Total daily CO_2 emission outside fence is 14 .465$g/m^2 \cdot d$, total daily CO_2 emission inside fence is 19 .117 $g/m^2 \cdot d$, 32 .16% more than outside fence . After fencing , soil organic matter has a certain accumulation .

Conclusions Daily variation of CO_2 emission flux of summer soil inside and outside fence has a obvious positive correlation with ground temperature at depth of 5 cm and 10 cm . Daily variation of soil CO_2 emission flux both inside and outside fence has correlation of indices with soil water potential . At the same time , maximum soil CO_2 emission flux occurs when soil water potential is at 29 kpa ~ 35 kpa . The fencing has a promotion role on accumulation of soil organic matter .

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Australian Soil Carbon Accreditation Scheme (ASCAS)

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Key words: soil carbon, validated trading model

Introduction Australia has the highest per capita rate of greenhouse gas emissions in the world. Appropriately managed farmlands could effectively retrieve, store and utilise most of the excess carbon being emitted to the atmosphere, converting a potential hazard into an extremely productive opportunity. Humified organic carbon has many benefits in soils.

The Australian Soil Carbon Accreditation Scheme (ASCAS) rewards landholders for adopting innovative techniques designed to sequester soil carbon. The ASCAS project is a first in the Southern Hemisphere, making Australia a world leader in the recognition of soils as a verifiable carbon sink. Effective carbon management is a key factor for productive farms, revitalised catchments and a greener planet.
The ASCAS project will provide proof of concept that:

i) innovative management practices exist for increasing the level of carbon in agricultural soils
ii) improvements in soil carbon and soil health can be measured
iii) landholders can be financially rewarded for building soil carbon

Materials and methods baseline soil carbon levels in the 0-110cm profile were determined between August and October 2007 within Defined Sequestration Areas (DSAs) located on regeneratively managed broadacre cropping and grazing lands across Australia. In 2008 and 2009 the first Soil Restoration Incentive Payments (SCIPs) will be paid retrospectively for measured, validated soil carbon increases above these baseline levels.

Receipt of Soil Carbon Incentive Payments will be similar to being paid on delivery for livestock or grain, with the bonus being that sequestered carbon remains in soil, conferring multiple landscape health and productivity advantages.

Results and discussion Initial results indicate that soil carbon can build rapidly when farm operations enhance-rather than detract from-the four-step soil-building process of photosynthesis, resynthesis, root exudation and humification (Jones, 2007). The humification step is generally absent from conventional chemically-based (including Zero Till) cropping programs-hence it is difficult for soil carbon to accumulate using standard practice in the Australian environment.

Conclusion The Australian Soil Carbon Accreditation Scheme (ASCAS) will convincingly demonstrate that levels of stable soil carbon in agricultural soils CAN be increased, CAN be measured and CAN be financially rewarded.

Acknowledgement Financial assistance for soil testing has been provided by Fitzroy Basin Association, Northern Agricultural Catchments Council and Rio Tinto Coal Australia. Technical and field assistance from WA Department of Agriculture and Food, Queensland Department of Primary Industries and Queensland Department of Natural Resources and Water are also gratefully acknowledged. Special thanks to Rhonda Willson, Executive Chairman, John While Springs (S) Pte Ltd and Director, Gilgai Australia, for provision of ASCAS Soil Carbon Incentive Payments.

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Mitigation of greenhouse gas emissions by the energy grass ,*Miscanthus* × *giganteus*

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Key words : energy crops , GHG emissions , carbon sequestration , *Miscanthus*

Introduction As a result of the increasing demand for biomass energy crops to replace the fossil fuels oil , gas and coal there has been a renewed interest in identifying suitable energy crops which are close to carbon neutral . Biomass crops not only have the capacity to reduce fossil fuel consumption , but can aid in greenhouse gas (GHG) mitigation by acting as carbon sinks . Hence the construction of a full GHG budget for these crops is of vital importance . Reliable budgets depend on validation from long term growth trials but because of the relatively recent interest in dedicated energy crops these trials are few in number . Clifton Brown *et al* (2007) have recently reported on 16 years of growth trials with the perennial rhizomatous C_4 grass *Miscanthus* × *giganteus* , Life-cycle assessment has been used to synthesise the net environmental impact of energy crop cultivation compared with conventional agricultural land uses , and energy crop combustion compared with fossil fuels , with particular regard to GHG emissions .

Materials and methods A field trial of *Miscanthus* × *giganteus* has been established near Cashel , Co . Tipperary , Ireland (52° 39′N , 07°50′W) since June 1990 . From 1991 to 2005 , yield was determined in late February or early March (average 9 t dry-matter ha^{-1} a^{-1}) . To determine the amount of carbon sequestered to the soil by 2005 , 15 years after planting , one soil core was taken from each of the eight replicate plots and the *Miscanthus* derived organic carbon present in the soil was detected by measuring the change in the ^{13}C stable isotope signal (average 0 .675 t C ha^{-1} a^{-1}) . For details of this procedure see Clifton Brown et al . (2007) . A life-cycle approach was used to quantify the major GHG emission sources associated with the production of useful heat (kWh_{th}) from *Miscanthus* that is harvested and pelleted before combustion (Styles and Jones , 2007 & 2008)-these calculations were updated with Cashel data .

Results Life-cycle GHG emission reductions (average per hectare) possible where *Miscanthus* displaces conventional fuels for electricity generation and heat production , and dominant agricultural land-uses .

	Fuel displaced	Fuel GHG-intensity	Useful energy	Energy GHG reduction		Land-use displaced	Displaced LU emis.	Soil CO_2 seq.	LU GHG reduction
		kg CO_2 eq. kWh^{-1}	kWh a^{-1}	t CO_2 eq. a^{-1}			t CO_2 eq. a^{-1}		
ENERGY DISPLACEMENT	Peat (elec)[a]	1.15	17,472	**19.33**	LAND-USE DISPLACEMENT	Tillage	3.49	4.25	**4.03**
	Oil (heat)[b]	0.331	40,961	**12.54**		Set-aside	0.00	4.25	**2.32**
	Gas (heat)[b]	0.248	40,961	**9.14**		Extensif	0.00	2.48	**0.54**
	Electric (heat)[b]	0.624	40,961	**24.54**		Sheep	3.75	2.48	**4.29**
						Cattle	5.24	2.48	**5.77**
COMBINED ENERGY AND LAND-USE GHG REDUCTION (t CO_2 eq. a^{-1})			MIN	9.68		Dairy	12.07	2.48	12.60
			MAX	37.15					

Conclusions Fuel chain GHG emissions attributable to *Miscanthus* are between 70% and 88% lower than those for oil , gas and electric heating fuel chains , and 86% lower than for the peat-electricity fuel chain . However , long-term soil C sequestration when *Miscanthus* is grown on either grassland or tillage land exceed cultivation emissions , and , along with possible displacement of marginal agricultural production , could result electricity and heat production better than C-neutral . With life-cycle GHG reductions of between 9 .68 and 37 .15 t CO_2 eq . ha^{-1} a^{-1} , energy crop electricity and heat production represent highly efficient land-use options for GHG mitigation .

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Warming-induced decline in ecosystem services is mitigated by plant traits on the Tibetan Plateau

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Key words : climate change , diversity , ecosystem services , Tibetan Plateau , plant traits

Introduction Experimental studies of how global changes and human activities affect plant diversity often focus on broad measures of diversity and discuss the implications of these changes for ecosystem function . We examined how experimental warming and grazing affected species within plant groups of direct importance to Tibetan pastoralists : medicinal plants used by humans and palatable plants consumed by domestic livestock . We posed the following questions : How do experimental warming and grazing affect the number of medicinal and palatable plant species ? Is one plant group relatively more vulnerable to species losses than the other ? Are plant traits associated with particular plant use groups ? If so , do the plant traits mediate the medicinal and palatable plant group responses ?

Materials and methods We established an experiment at four sites within the NE region of the Tibetan Plateau (latitude 37°37′ N , longitude 101°12′E) . We fenced each of the four 30×30m sites within which we laid out 16 plots in a 4×4 matrix . Within each site , we established a complete factorial experimental design where we simulated warming using open top chambers (OTCs) and the defoliation effects of grazing through selective clipping . We characterized the plant species as medicinal or non medicinal and as palatable or non palatable . We also characterized the species according to four plant traits : life history , growth form , rooting depth , and phenology . We examined significant associations between plant groups and plant traits using the Chi-Square statistic . We also examined plant group responses to the treatments using a split-plot , repeated measures ANOVA .

Results Warming resulted in species losses from both the medicinal and palatable plant groups ; however , differential relative vulnerability occurred . With respect to the percent of warming-induced species losses , the overall plant community lost 27% , medicinal plants lost 21% , and non medicinal plants lost 40% species . Percent species losses for both palatable and non palatable species were similar to losses in the overall plant community . Warming increased the proportion of medicinal plants by 0 .06 ; commensurate declines in the proportion of non medicinal plants occurred . The proportion of palatable and non palatable plant species did not change with warming . Most medicinal plants were deep-rooted , while most non medicinal plants were shallow-rooted . Palatable and non palatable plant groups were comprised of both deep and shallow-rooted plant species . The warming-induced percent species loss and proportional changes for deep and shallow-rooted plant species reflected those for the medicinal and non medicinal plant species , respectively .

Discussion The deep-rootedness of medicinal plants resulted in lowered sensitivity to warming , while the shallow-rootedness of non medicinal plants resulted in greater sensitivity to warming ; the variable rooting depth of palatable and non palatable plants resulted in an intermediate response to warming . Some degree of resistance was built into the response of the palatable plant group due to the presence of both deep and shallow-rooted plant species . Predicting the vulnerability of plant groups to human activities can be enhanced by knowledge of plant traits , their response to specific drivers , and their distribution within plant groups . Knowledge of the mechanisms through which a driver operates , and the evolutionary interaction of plants with that driver , will also aid predictions .

Conclusions Plant groups which deliver important provisioning and cultural ecosystem services on the Tibetan Plateau are vulnerable to species losses with warming . These important plant groups are likely to be vulnerable to future warming in this region of the Tibetan Plateau , potentially leading to the reduced well-being of the pastoralists . Future steps to protect ecosystem services furnished by medicinal and palatable plants will be required under the novel stress of a warmer climate . Grazing may be an important tool in maintaining some of these services under future warming .

Climate and grazing interact to control rangeland vegetative characteristics at a regional scale on the Tibetan Plateau

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Key words: climate change, grazing, Tibetan Plateau, biodiversity, biomass

Introduction Rangeland degradation on the Tibetan Plateau is often attributed to overgrazing. However, the effects of on-going climate changes, and their interactions with grazing, are rarely explored. In previous work, we demonstrated that experimental warming decreased plant diversity, plant aboveground production, and resulted in less palatable shrubs replacing more palatable graminoids; these effects were dampened by grazing (Klein et al., 2004 & 2007). Here, we compared the shorter-term, site-scale experimental responses to the longer-term, regional-scale responses.

Materials and methods We sampled four sites along a 700 km transect in Qinghai Province, China on the NE region of the Tibetan Plateau. The sites ranged from 320-560mm of mean annual precipitation and from -3.5℃ to 3.5℃ mean annual temperature. At each site along this transect, we sampled inside fenced areas where large herbivore grazing had been excluded for 40 years and outside of the fenced areas where dormant-season grazing occurred. We measured plant species richness through documenting plant species presence/absence in all plots and measured aboveground peak standing biomass through direct vegetative harvests.

Results Mean annual precipitation, not temperature, was positively associated with aboveground vegetative biomass and species richness across non-grazed and grazed plots. The difference in biomass and richness between the wettest and the driest sites was three times greater in the grazed than in the non-grazed plots. Grazing effects on vegetative properties depended on site precipitation. Grazing decreased at drier sites and increased at wetter sites both biomass and species richness (Figure 1).

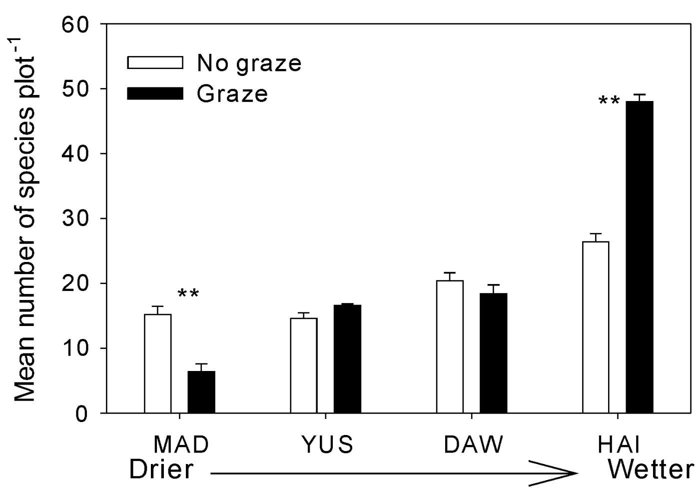

Figure 1 *Grazing effexts on species richness across sites.*

Discussion The positive association between mean annual precipitation and vegetative characteristics is consistent with results from other semi-arid grassland systems. However, the lack of an association between mean annual temperature and vegetative characteristics contradicts the findings from the experimental manipulations. There may be both an ecological and methodological explanation for these opposing results at different scales. Our findings are consistent with previous work which demonstrates the strong role of precipitation in mediating the vegetative response to grazing; however, the observed direction of the response was novel. To develop a comprehensive understanding of grazing effects on plant characteristics, we need to differentiate between dormant versus growing season grazing as the mechanisms driving the responses differ.

Conclusions Both climate and grazing interact to affect the rangelands of the Plateau. While there may be a large, negative response of biomass and richness to climate warming, over the very long-term these properties may recover. However, future changes in precipitation and grazing regimes may have large, non-linear, and persistent effects on vegetation. Grazed systems may be more sensitive to future changes in precipitation than non-grazed systems. Predictions of future precipitation-induced changes in ecosystem properties may underestimate the magnitude of change that will occur in grazed systems.

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Carbon sequestration by grasslands and forests

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Key words: carbon sequestration, grassland, forest, Latin America

Introduction Much R and D funding is invested in forestry development in an endeavour to increase terrestrial C storage. However, it is not generally acknowledged that grasslands, including sown pastures and rangelands, are equally as important for the storage of C as forests (t Mannetje, 2008).

Grasslands Fisher *et al*. (1994) measured soil C storage of 237 t/ha under a 6-year-old *Andropogon gayanus-Stylosanthes capitata* pasture, with about half of it in the 40-100 cm deep soil layer, compared with 186 t/ha under unimproved savanna in Colombia. At another site, the soil under unimproved savanna held 197 t/ha C, compared with 223 t/ha under *Brachiaria humidicola* alone and 268 t/ha under a *B. humidicola-Arachis pintoi* pasture.

Recent research in Colombia and Costa Rica (t Mannetje *et al*., 2008) showed that: 1) Mean soil C stored in native forests and in long-established improved pastures were about the same (157 vs 160 t ha^{-1}). However, mean total C (in soil and above ground biomass) in forest was 40% more than in grasslands (261 vs 162 t ha.) 2) In the humid tropical region of Costa Rica improved pastures and silvopastoral systems had higher soil C sequestration than degraded pasture and native forest, indicating that well managed pastures have an important role in mitigating green house gas emissions.

Forests Forests accumulate C mostly in roots, trunks, leaves and litter. However, once trees are mature and have little or no growth, they will assimilate only as much C as they lose in respiration. Old-growth neo-tropical forests do not accumulate substantial amounts of C in the form of net biomass increases (Clark 2002). Mature trees in temperate forests do not contribute significantly to C sequestration. Current atmospheric C levels limit photosynthesis and growth and thus do not add to C storage. During spring, when deciduous trees develop new leaves, they rely heavily on C reservoirs of sugars, starches and fats, because atmospheric C is insufficient (Hoch *et al*., 2003). Furthermore, limited supplies of other nutrients, particularly N and P, may limit assimilation and growth. Nevertheless, clearing forest leads to a great loss of C in the biomass to the atmosphere, which cannot be replaced by grassland C sequestration in the short term.

Considerable C emissions to the atmosphere take place in forest systems in the humid tropics as a result of decaying litter and decomposing soil organic C and that rivers in humid forested ecosystems, like Amazonia, are C-saturated and add to atmospheric C (Richey *et al*., 2002). Mayorga *et al*. (2005) concluded that Amazonia was, at best, in equilibrium with the atmosphere regarding C, and possibly even added to atmospheric C.

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Non-CO_2 greenhouse gas emissions associated with winter management and farm effluent application in grazed grassland systems in New Zealand

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Key words: Nitrous oxide, methane, stand-off pad, farm effluent, pasture, grazing systems

Introduction In New Zealand, stand-off pads (purpose built, drained loafing space to hold livestock for periods when it is not suitable to have them on pasture) are increasingly used in restricted cattle grazing systems. These stand-off pads are considered to avoid damage to pasture, to minimise soil compaction and to reduce emissions of greenhouse gas nitrous oxide (N_2O) and nitrate leaching during wet periods of the year. However, emissions of N_2O and methane (CH_4) also occur from stand-off pads and from land applied farm effluent collected from stand-off pads. Reducing the emissions from these sources is crucial to the development of successful restricted grazing strategies to reducing their environmental impact. Here we summarise the results of N_2O and CH_4 emissions measured from a stand-off pad and also N_2O emissions from effluent applied to two pastoral soils under contrasting soil moisture conditions.

Materials and methods The stand-off pad was used for holding 21 non-lactating cows for about 18 h per day (following 6 h grazing pasture) for 86-day period between late June and early August when soil was wet. The pad (300 m^2) consisted of screened crushed pine bark and sawdust and an effluent drainage collection system. The effluent from the stand-off pad was applied onto a long-term white clover/ryegrass based pasture on poorly-drained Waikato Te Kowhai silt loam soil during the very dry seasons of 2004 and 2005. The farm effluent was also applied on poorly-drained Tokomaru silt loam soil in the Manawatu region three times between 2003 and 2004. The effluent was applied at N loadings between 16 and 50 kg N ha^{-1} per application. Measurements of N_2O and CH_4 fluxes originating from the stand-off pad were made while it was being used (Luo *et al*. 2008a). N_2O emissions were also measured from the effluent applied and control sites using large numbers of static chambers (Luo *et al*. 2008b).

Results and discussion Nitrous oxide fluxes from the stand-off pad ranged between 0 and 3.0 g N_2O-N day^{-1} and were probably related to the concentrations of water and nitrate in the pad materials. Overall only 54 g of N_2O-N was emitted from the stand-off pad supporting 21 cows for the June-August, 86-day period, representing about 0.01% of the excreta N deposited on the pad. Methane fluxes from the stand-off pad were between 0 and 360 g CH_4-C day^{-1}, and were related to the amount of accumulated dung on the pad surface over time. Methane emissions from the pad during the measurement period were 3.0 kg CH_4-C, and the CH_4 emission value was 2.34 g CH_4/kg excretal C deposited on the pad. Application of effluent to grazed pastures increased N_2O fluxes compared to the control. N_2O emissions from effluent applications were most strongly influenced by soil water-filled pore space (WFPS) and excretal-N inputs through grazing, and ranged from 0.01 to 4.93% of the effluent N (Table 1). N_2O emissions were higher when pastures were grazed and soil WFPS was above field capacity, while emissions were lower when pastures were not grazed and soil WFPS was much below field capacity.

Table 1 *Nitrogen applied through farm effluent and N_2O emissions (Luo et al. 2008b).*

Location	Application time	Soil WFPS (%)	N applied (kg N ha^{-1})	N_2O emitted (kg N_2O-N ha^{-1})	Emission factor (%)
Waikato	Apr 2004	30-53	50.0	0.015	0.03
Waikato	Feb 2005	26-38	50.0	0.004	0.01
Manawatu	Sep 2003	61-90	23.9	0.471	1.97
Manawatu	Jan 2004	69-94	25.2	1.243	4.93
Manawatu	Feb 2004	56-77	18.0	0.449	2.49

Conclusions The use of stand-off pads in New Zealand during winter when soil is wet and strategic application of farm effluent during summer and autumn when soil is dry can significantly reduce N_2O emission from grazed pastures. Delaying effluent-application after grazing events could further reduce N_2O by reducing the levels of surplus mineral-N. Emissions of CH_4 from effluent-application are needed to determine for assessment of effects of using stand-off pads and restricted grazing on total emissions of greenhouse gas from whole" systems.

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Process-based modelling of timothy survival in winter

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Key words: climate change, damage mechanisms, tolerance, physiology, yield

Introduction Timothy (*Phleum pratense*, L.) is the most widely grown sown grass species for silage and hay production in Scandinavia, and is common in many other countries with a cold and maritime climate, like Canada and the Baltic countries. Although timothy is a winter hardy species, every winter some damage is suffered. The two most severe damage mechanisms are frost and ice-encasement followed by anoxia and build-up of toxic compounds in and around the plants. The major tolerance mechanism is hardening, which can be quantified as the LT50 (Lethal Temperature for 50% of the plants in standard testing). Climate change is expected to increase both average winter temperature and weather variability. This may impede the hardening process. The international project WINSUR aims to quantify the associated risks for Norwegian grassland, using both experimentation and process-based modelling.

Materials and methods Our work builds on previous work with the grassland model LINGRA (Schapendonk et al. 1998). We reviewed the literature on timothy (Höglind et al., 2001) and performed simulations with the model showing that tillering dynamics and the formation and loss of leaves from tillers were key knowledge gaps for timothy. This was addressed by experimentation followed by model improvement in these areas (Van Oijen et al. 2005). We now have expanded the model to include simulation of snow and frost dynamics, and damage and tolerance mechanisms.

Results The model was extensively tested for various sites in Southern and Middle Norway. The dynamics of LT50 and total tiller density, showing severe tiller loss during February—April (days 400-500 in the Figure below) showed reasonable correspondence with observations.

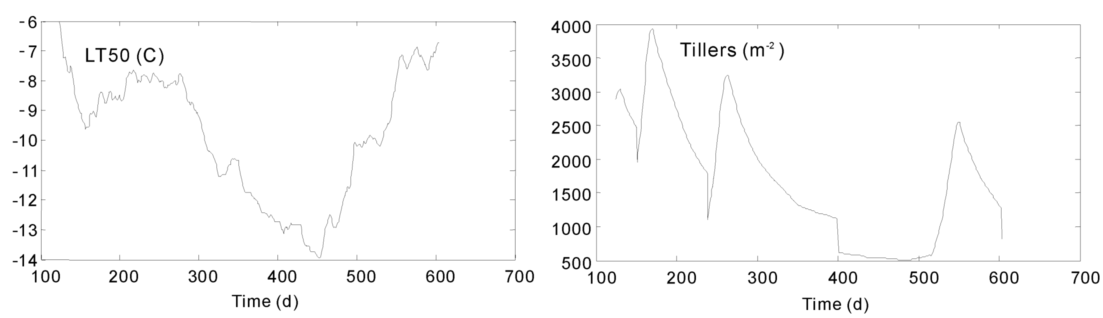

Figure 1 *Simulation of LT50 and Tiller density in Saerheim, Southern Norway during the growing seasons of 2000 and 2001 and the winter in between.*

Conclusions and outlook The process-based timothy model seems to capture the essential dynamics of the grassland system in both summer and winter. Hardening is the key tolerance mechanism, not only against frost but also against ice encasement. Further model development is under way.

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Socio-ecological influences on grazier uptake of seasonal climate forecasts on the rangelands in Australia

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Key words: climate variability, climate change, social science, adoption of new practices, decision-making, social resilience, resource dependency

Introduction Climate variability is the strongest driver of interannual variation in primary and secondary production in the rangelands and savannas and as a consequence has enormous socio-economic impact on rural livelihoods (Ash et al. 2007). Losses during drought periods can be extremely severe. In the face of climate variability, a key challenge facing graziers is to make appropriate management decisions so as to minimise losses in droughts and take advantage of favourable seasons, thus enhancing their resilience (Ash et al 2000). One means of achieving this is through the use of seasonal forecasts. Yet, graziers are slow to uptake the technology. In this study, we aimed to identify the major socio-ecological differences between graziers that are interested or not in the uptake of technology such as seasonal climate forecasts. The potential influences that we focus on include social, economic and environmental resource dependency (Marshall et al. 2007), social resilience (Marshall and Marshall 2007) and perception of change events (Marshall 2007).

Materials and methods One-hundred graziers from the Upper Burdekin catchment in Queensland were interviewed in their homes. Interviews were based on structured surveys that aimed to quantify a grazier's (i) social relationship with the land in terms of attachment to the land and community, family dependency and employability, (ii) economic relationship with the land in terms of financial flexibility and business size, (iii) environmental relationship with the land in terms of current approaches to making decisions in the face of climate uncertainty, (iv) resilience to climate variability in terms of perception of risk, capacity to reorganise, ability to cope and interest in adapting to climate variability, and (iv) perception of seasonal climate forecasts. The relationships between these socio-ecological descriptors of graziers and graziers likely uptake of seasonal climate forecasts were investigated using correlative techniques to assess which factors were most influential in determining forecast uptake.

Results Results suggest that several aspects of a grazier's social, economic and environmental relationship with the land were significantly correlated with the likelihood that seasonal climate forecasts would be incorporated into grazier's decisions. Aspects of social resilience such as the capacity to learn and reorganise were also significantly correlated with uptake. Graziers saw SCF more as means of minimising losses in drought years and maximising opportunities in good years rather than for day-to-day stock handling. In addition, results showed that current scientific information is difficult to follow and the perception of seasonal climate forecasts could be improved in terms of how forecasts are presented, interpreted and valued.

Conclusions Our aim is to increase the adaptability of the grazier-grazing lands system to climate variability. Understanding how graziers prepare for climate variability each year and identifying the factors that influence their preparation can significantly assist in presenting seasonal climate forecasts to the grazing community in a way that ensures that they are interpreted and valued appropriately. In doing so, this research addresses the challenge of assisting graziers to prepare for climate variability through improving the useability of seasonal forecasts.

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Plant productivity responses to rising atmospheric CO_2 and warming in semi-arid grassland in Wyoming, USA

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Key words: aboveground biomass, C_3, C_4, global change, plant species

Introduction There is little information on the responses of native grasslands to combined global change factors. This experiment examines how plant productivity in a northern mixed-grass prairie near Cheyenne, WY, USA responds to combined CO_2 enrichment and warming.

Materials and methods The Prairie Heating and CO_2 Enrichment (PHACE) experiment consists of thirty 3-m diameter circular plots in native semi-arid grassland at the USDA-ARS High Plains Grasslands Research Station, west of Cheyenne, WY, USA. The focus of this presentation is on 20 plots assigned to factorial combinations of two CO_2 and temperature treatments:
ct present [CO_2] & present temp
cT present [CO_2] & warm [+1.5/3.0℃ day/night]
Ct elevated [CO_2] (600 ppm) & present temp
CT elevated [CO_2] & warm,
with five replications. Measurements of aboveground plant biomass (AGB) were determined in late July each year, the time of peak aboveground biomass. Results are presented for two years only, the pre-treatment year of 2005 and in 2007 when treatments had begun.

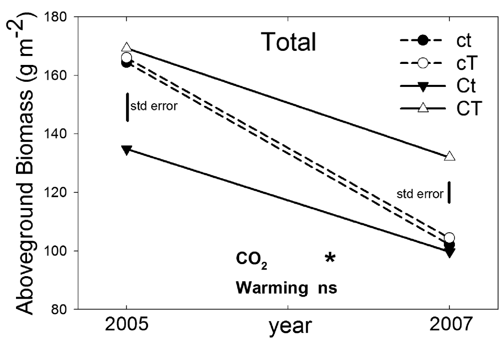

Figure 1 *Peak seasonal aboveground biomass prior to treatments (2005) and as affected by growth at variable CO_2 (C&c) and temperature (T&t) (2007). * indicates treatment significance at $P \leqslant 0.05$ level.*

Results Both total (Figure 1) and functional group (Figure 2) AGB differed in some of the treatment plots prior to initiation of the CO_2 and warming treatments, so statistical tests for treatment effects were performed by evaluating differences in AGB before (2005) and after (2007) treatments had begun. Total AGB declined from 2005 to 2007 (significant year effect), but declined 13.5 g m^{-2} more under present ambient [CO_2] (c), indicating elevated CO_2 (C) enhanced AGB in 2007 (Figure 1). Warming had no effect on total AGB. The C_3 grasses, which dominate this grassland, displayed similar AGB responses to CO_2 and warming as total AGB (Figure 2). However, AGB of C_4 grasses was enhanced in 2007 by both CO_2 (C) and warming (T). Warming (T) increased C_4 productivity more at elevated (C) than at ambient (c) [CO_2].

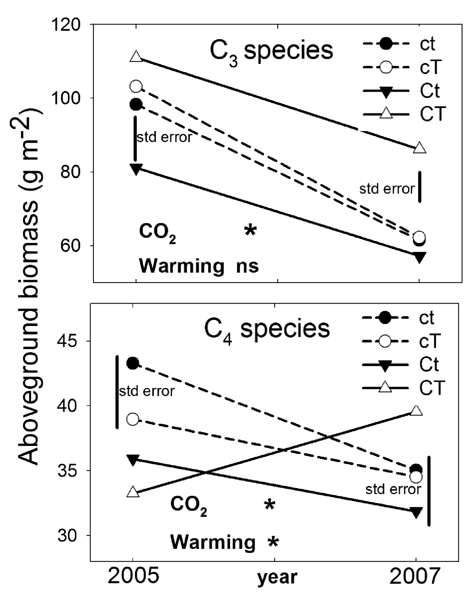

Figure 2 *Peak seasonal aboveground biomass of plant functional groups prior to treatments (2005) and as affected by growth at variable CO_2 (C&c) and temperature (T&t) (2007). * indicates significance at $P \leqslant 0.05$ level.*

Conclusions These preliminary results confirm results of Morgan et al. (2004) that CO_2 enrichment increases plant production in semi-arid grasslands. Further, they suggest combined rising CO_2 and temperature may enhance productivity of warm-season, C_4 grasses.

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Impacts of human interference and climate variability on the grasslands of Kerala

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Key words : shoal grasslands , Kerala , Western Ghats , human interference , climate change

Human interference on the environment and anomalies in climate pose a serious threat to the existence of grasslands in the Western Ghats Mountain in Kerala , southwest part of Peninsular India . In Kerala , shola evergreen grasslands constitute nearly 0 .75 per cent of the total natural forest cover of the state . Protection of the shola grasslands is important in maintaining food and water securities in Kerala and the adjoining state Tamil Nadu . These grasslands find at 1800 metres above the sea level and store large quantities of water on the mountain ranges . Nine months of rainfall , round the year mist and dew makes the grassland area always wet . The grasslands have a very high capacity to retain water and release them gradually . Covered most of the time with mist , 20 per cent of the water they receive is precipitated as dew throughout the year . The stream originating from the grasslands are perennial but with the destruction of the grasslands , they are beginning to dry up . Many of the rivers in Kerala and Tamil Nadu originate from the shola grasslands and were perennial . Introduction of agriculture widely spoit the sholas during the past two centuries . Almost 75% of the 350 km^2 of shola grasslands were lost between 1949 and 1992 in the Nilgiri Biosphere Reserve area alone . Situation is worse in other parts of the Ghats . Newly introduced plantations such as eucalyptus consume excess water and cause severe damage to biodiversity and sustainability of the ecosystem . About a third of the rare species are estimated to be endemic . Several dams in the Ghats also contributed to the destruction of the grasslands . Grasslands face serious challenges from the promotion of hill tourism , increasing trends in population and urbanization and overgrazing . Changes in climate also are a threat to the remaining grasslands . Increase in temperature in certain locations affects the soil moisture condition . It also affects the formation of mist and dew . Increasing seasonality and intensity in rainfall promotes erosion and reduces water availability in non-rainy months . Current conservation and protection measures are inadequate and the implementation mechanism often fails because of the slow government reaction , fragmented organizational structure , misappropriation of funds and so on . This paper is a comprehensive study of the factors affecting the existence of grasslands in the Western Ghats Mountain region of Kerala in changing climate and environments . Suggestions for the efficient control of degradation of the grasslands have been provided , taking into consideration the environmental , social , economic and political situations .

A conceptual model to explain increasing woody biomass in arid and semi-arid regions

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Key words: leaf area index, woody encroachment, climate change, evaporation

Introduction An increase in woody biomass in semi-arid and arid rangelands has been reported from Africa, Australia the Americas. This trend impacts negatively on the ability of rangelands to support livestock. The trend has been attributed to changes in 1) the fire regimes, 2) the type and amount of herbivory, 3) the timing and intensity of climatic factors (e.g. drought) and 4) increased atmospheric carbon dioxide concentrations ($[CO_2]_a$). $[CO_2]_a$ are increasing and simultaneously, pan evaporation rates have been declining and the density of woody biomass has been increasing in arid and semi-arid regions. The rate of CO_2 fixation by leaves increases as the supply of $[CO_2]_a$ to chloroplasts increases. The increase in biomass production is generally larger under xeric than mesic conditions. An increase in photosynthesis and the observed decline in stomatal conductance explains increased water-use efficiency, which, in conjunction with decreased pan evaporation rates, is equivalent to an increased availability of water. We propose that woody thickening could be attributable to the enhanced soil and plant water status. We highlight observations of increased tree water-use-efficiency, reduced global run-off and increased soil moisture as evidence supporting the mechanism.

Materials and methods We explored long-term climate data sets for southern Africa to determine whether site wetness has been increasing. This included analysing records from evaporation pans, rainfall and run-off at these sites. We review evidence of decreased stomatal conductance and resulting increased climate wetness index", and test the three predictions detailed above that increased tree water-use-efficiency, reduced global run-off and enhanced plant water status occur in response to CO_2 enrichment. We explored trends in the leaf area index for areas with a known history of woody biomass increase using the MODIS LAI.

Results Pan evaporation rates have decreased for arid and semi-arid regions of southern Africa and Australia. There is no discernable trend in annual precipitation. The MODIS LAI data confirmed that leaf area index has increased in rangelands experiencing woody encroachment in Australia, South Africa and the USA. Vapour pressure deficit (VPD) has decreased for water-limiting ecosystems of Africa, Australia and the Indian sub-continent (Nemani et al., 2003). There is evidence of global soil moisture increasing (Robock et al., 2005), with a positive soil moisture trend from Jornada LTER. Elevated moisture levels across land-use gradients have been documented in the southern Kalahari.

Conclusions If CO_2 enrichment is reducing stomatal conductance and enhancing soil moisture stores, we predict a more positive plant water status will be observed under CO_2 enriched conditions. As pan evaporation rates have declined, the availability of soil moisture has increased, effectively equivalent to increased rainfall. This, coupled to the increase in N deposition, has increased canopy LAI and hence CO_2 uptake and has resulted in an increased ecosystem-scale woody thickening. Super-imposed on this is the decrease in stomatal conductance resulting from increased atmospheric $[CO_2]a$. The model proposed here has wide-ranging ramifications to policies on afforestation, woody weed control and carbon sequestration.

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The soil organic carbon spatial distribution of degraded grassland with Black Soil Type in the source region of Yellow River

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Key words : soil organic carbon , spatial distribution , degraded grassland with Black Soil Type , soil degraded degree

Introduction Soil carbon storage and its dynamics influence soil fertility and grassland productivity , they are very important indications which reflect soil quality , grassland health and carbon circulation of grassland ecosystem (Doran et al . 1999) . Currently , studies on the degraded grassland with Black Soil Type play an important role on Tibetan Plateau grassland . It is of great significance to the cause and restoration of degraded grassland with Black Soil Type by studying soil organic carbon storage and its spatial distribution .

Materials and methods Soil samples were collected in 0-10 , 10-20 , 20-30cm layers at a total of 30 soil samples from 6 soil profiles in three types and degraded degrees of degraded grassland with Black Soil Type in September , 2006 (Pan 2006) . The soil samples were air-dried , passed through a 2 mm mesh , and homogenized . Soil organic carbon were analyzed by the method of potassium dichromate capacity .

Results Soil organic carbon spatial distribution showed that : (1) Soil organic carbon storage (0-10 cm soil layer) decreased from 7 .05% in lightly degraded grassland to 4 .66% in heavily degraded degree , soil organic carbon storage in 0-10 cm layer was higher than that of 10-20 cm layer and 20-30cm layer , It was very significance for soil organic carbon between 0-10 cm layer and 10-30 cm layer . (2) Soil organic carbon content in bottom type was 6. 57% , 5. 19% in slow-slope type and 4 .68% in steep-slope type (data was average of three soil layers) . Following with the soil layer increasing soil organic carbon reduced , 0-10 cm layer has largest content of soil organic carbon .

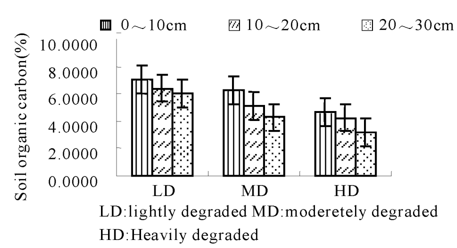

Figure 1 *Soil organic carbon spatial distribution in three degraded degree of black soil type" degraded grassland .*

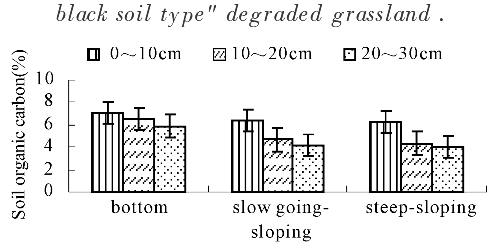

Figure 2 *Soil organic carbon in three types degraded grassland .*

Conclusions Soil organic carbon spatial distribution of degraded grassland with Black Soil Type was that content of soil organic carbon decreased with the increase of soil depth , soil layers and degraded degrees . Bottom type has large carbon and steep-sloping type was least .

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Research on the relationship between climate and plant community in north grassland of China

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Key words: Grassland, climate change, phenology, biodiversity

Introduction Farming-pastoral transitional zone is an important region in Northern China, whatever from its productivity or ecological function. For several decades, overgrazing have made the significant changes of vegetation. The land is being continuous degradation. Although there is lack of historical vegetation cover data, long-term meteorological data has been collected for the past 40-50 years. To explore the dynamic of vegetation which is effect by climate, large area survey, and historical data analysis are used.

Methods Located in agro-pastoral ecotone (41°06′ and 44°08′ Nlatitude, 111°27′ and 118°48′ East longitude, two sites were selected to analyze the phenology from 1985 to 2005, and 7 sites was used to do investigation of grassland biodiversity in two years.

Plant species include *Xanthium mongolicum*, *Plantago asiatica*, *Iris ensata*, *Taraxacum officinale* in Wuchuan County of Inner Mongolia, and *Leymus chinensis*, *Stipa baicalensis*, *Artemisia frigida* and *Heteropappus altaicus* in Xilinhot of Inner Mongolia. A general linear model (GLM) was used to evaluate the grass phenology. Grassland survey was conducted in plant flower season to measure the number of individual plant species and the dry matter, then to calculate the biodiversity.

Results The result showed that the grass phenology, the stages of germination and flowering trended to come early for *Xanthium mongolicum*, *Plantago asiatica*., *Iris ensata*., *Taraxacum officinale* during 1982 to 2005 and growth season was lengthened, because annual mean temperature and winter temperature increased in Wuchuan County of Inner Mongolia. The length of grass growth season is related to accumulative maximum temperature, accumulative mean temperature and annual precipitation. In Xilinhot, the anthesis of *Leymus chinensis* were appeared from the last ten-day of April to the last ten-day of July, but there were only 4 years to appeared anthesis during 20 years. The *Stipa baicalensis* had stronger adaptability, so its anthesis were usually in the middle ten days of August, sometime it appeared early in the last ten-day of July and late in the last ten-day of September. *Artemisia frigida* was of strongest adaptability and the growth stage was not lengthening because of harsh environment. *Heteropappus altaicus* developed normally.

It is important to work on the law of grass growth, development, the temporal and special variance of plant biodiversity on grassland community for adapting to climate change. Based on the observation of grass growth and development and sampling method of field survey, the variation of herbaceous phenology, biomass and biodiversity were analyzed with Marglef richness index (MRI) and Simpson biodiversity index (SBI). These methods can be used to reflect the species richness.

A model of grasses phenology and growth were developed. Grassland sampling and surveying from Middle East to Midwest of Inner Mongolia were taken in July to August of 2006 and 2007 separately. The results showed that biodiversity and biomass of sampling plots were very different between sampling places. Because climate is different, the biomass was higher when precipitation was more or temperature was lower in Inner Mongolia grassland, and the Margalef's biodiversity index decreased when drought index increased.

Conclusions and discussions Phenology period are ahead of time due to the temperature increase, especially the minimum temperature during winter season. The annual growing season has lengthened by 4.5 days over the past 20 years. Grasses development stages are influenced by climate fluctuation. Climate also effect on the biodiversity which increase with more precipitation, and decrease with lower precipitation.

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Initial responses of carbon cycling to elevated CO_2 and warming in native semiarid grassland, Wyoming, USA

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Key words: soil respiration, stable isotopes, mean residence time, temperature sensitivity, fungi:bacteria ratio

Introduction The effect of climate change on carbon (C) cycling, and potential feedbacks to global warming, constitute major uncertainties in prediction of future ecosystem sustainability. Decomposition of soil organic matter (SOM) pools may be stimulated by warming, but additional allocation of C belowground due to elevated atmospheric [CO_2] may offset warming-enhanced losses. Alternatively, warming may reduce SOM decomposition and if soil moisture becomes limiting, but elevated [CO_2] may ameliorate soil moisture conditions in semiarid grasslands. We measured C pools and fluxes to evaluate global change effects on the C cycle at the Prairie Heating and CO_2 Enrichment (PHACE) facility in Wyoming, USA. Microbial community structure and decomposition experiments demonstrated mechanisms driving C cycle changes.

Methods The native grassland at the PHACE site is dominated by C3 grasses (*Pascopyrum smithii* and *Stipa comata*) with important C4 grass (*Bouteloua gracilis*) and sub-shrub components. Within the 3-m diameter treatment rings, elevated [CO_2] is raised to 600 ppm by direct injection in daytime during the growth season, and air temperature is warmed to +1.5/+3°C day/night year-round with ceramic heaters. [CO_2] treatment started in 2006, warming in 2007, and will continue through 2010. Additional irrigation treatments allow estimation of CO_2 interactions mediated by soil moisture.

We measured net ecosystem exchange (NEE) of CO_2, gross primary production (GPP), and ecosystem respiration (Re) using a canopy gas exchange chamber, and soil respiration (Rs) using CO_2 concentration gradients and a closed chamber technique. Stable isotopes indicated the source of CO_2 in soil respiration (labile vs. stable C). Soil samples were collected near peak biomass. Laboratory incubations at 25C were used to determine active and slow SOM pool sizes and mean residence times (MRT). Quantitative PCR was used to assess microbial community structure.

Results and discussion Rates of C cycling were increased by elevated [CO_2], warming and irrigation. Additions of irrigation water immediately stimulated Re, and later GPP, and elevated [CO_2] further enhanced the component C flux rates. During the first year of elevated [CO_2], ecosystem and soil respiration were enhanced more than was GPP, leading to lower net C uptake rates under elevated [CO_2] than ambient conditions. Isotope partitioning will demonstrate the proportion of Rs derived from recent plant inputs vs. older soil organic matter. We speculate that enhanced respiration may be derived from priming (enhanced decomposition) of older SOM by labile C substrates allocated belowground in the elevated [CO_2] treatment.

The ecosystem warming treatment stimulated decomposition in the laboratory experiment, leading to lower MRT of SOM in the 5-15 cm soil depth. If this effect continues in future years, SOM storage rates could decline in a warmer climate. Warming also increased the fungi:bacteria ratio, possibly because fungi are more tolerant of warmer and drier conditions. Stable isotopic composition of microbial CO_2 suggested that warming enhanced the loss of labile C. Interactions between SOM quality and microbial community composition are expected to continue to adjust as global change treatments continue, making long-term predictions uncertain.

Conclusions Responses of C cycling to the first year of elevated CO_2 and warming in native semiarid grassland suggested that C storage in soils could be reduced in a future greenhouse world. If woody plants or grasses with lower litter qualities are favored by elevated CO_2 or warming, as suggested in a companion experiment, reductions in C storage could be offset. We anticipate that our long-term experiment will help reduce uncertainties of climate-C cycle feedbacks associated with soil processes.

Methane yields from grazing livestock : an overview

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Key words : methane , livestock , grazing

Summary Grasslands are chiefly utilised by ruminant and ruminant-like (camelids) livestock species . A unique property of these species is their ability to convert cellulose , hemicellulose and non-protein nitrogen to useful animal products ; which is achieved by the microbial fermentation in their forestomach . Fermentation , however , is associated with production of methane (CH_4) , which not only represents a waste of feed energy , but CH_4 is also a powerful greenhouse gas . Ruminants are the single most important source of CH_4 emission and globally enteric CH_4 emissions from managed grasslands have been estimated to account for 44 Tg/yr (Clark et al . 2005) . There is a convention in international inventory comparisons of expressing enteric CH_4 emission from ruminants as CH_4 yield (% of gross energy intake , GEI) . Here we overview the main factors responsible for CH_4 yield from grazed livestock .

The general underlying mechanisms by which enteric CH_4 yield is determined include the rate and extent of fermentation , the fermentation pattern (type of volatile fatty acids produced) , and the hexose partitioning between fermentation and microbial growth ; which encompass diet , animal and microbial interactions . In grazing systems , the most important factors influencing CH_4 yield include feed intake , animal species , botanical composition and plant maturity , and management interventions . Tropical plant species are not only less digestible than temperate species , but they contain larger amounts of more methanogenic plant constituents (cell walls) than the temperate species . In addition , the livestock species found in tropical environments have evolved physiological , structural and behavioural adaptations to counter environmental stresses and the highly fluctuating feed resources . Prolonged retention in the forestomach of fibrous feeds to extract the maximal amount of energy would appear to be the strategy adopted by species adapted to the feed-scarce tropical environment (Pinares-Patiño et al . 2003) . Thus , it would be expected that CH_4 yield from livestock in tropical environments be higher than in temperate environments .

Calculation of CH_4 yield requires estimations of both feed intake and CH_4 emission . Despite the large research efforts , the estimation of feed intake of grazing animals is still inaccurate ; whereas the SF_6 tracer technology allows reliable estimations of CH_4 emissions , although with high variability . The considerable number of grazing trials involving CH_4 emission measurements conducted during the last decade indicate mean CH_4 yields from cattle and sheep grazing temperate grasslands in the range of 3. 7-7 .5% of GEI (e .g . Pinares-Patiño 2000 ; Machmüller & Clark 2006) , although some studies in the northern hemisphere have reported CH_4 yields for cattle up to 8 .8% of GEI (e .g . McCaughey et al . 1999) ; whereas CH_4 yields for cattle in tropical environments fall in the range 7 .8-11. 9% of GEI (Primavesi et al . 2004) . In temperate environments , mean CH_4 yields for dairy cows are 5 .5% of GEI , whereas non-lactating animals tend to have higher CH_4 yields (e .g . Pinares-Patiño et al . 2007) . In contrast to non-lactating or slow-growing animals , lactating cows have increased feeding drive and therefore higher intakes likely result in shorter retention times of feed and therefore lower fibre digestibility and lower CH_4 yield . It seems that the IPCC (2006) default CH_4 conversion factors are appropriate for livestock in temperate regions , but it likely underestimates CH_4 yields for livestock in tropical regions . Attempts to predict CH_4 emissions from grazing animals have been so far unsuccessful .

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The application of dynamic evaluating models of the meteorological condition effects on natural grassland vegetation in China

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Key words: climate suitability, meteorological condition comparison among years, natural grassland vegetation

Introduction The meteorological elements are the most changeable and important driving factor for grassland ecological environment. It is very important to evaluate meteorological condition effects on natural grassland vegetation. The objective of this study was to establish dynamic evaluating models of meteorological condition affecting natural grassland vegetation to evaluate the climate suitability and better or worse meteorological conditions among years.

Materials and methods The functions of sunlight, temperature, precipitation affecting to grassland vegetation have been setup respectively by utilizing the fuzzy mathematics on the base of ten days data. The comprehensive evaluation model of meteorological factors has been built. The accumulated effects of the meteorological factors on the grassland vegetation in certain period have been reflected by using the integral methods (Qian *et al*. 2007). The climate suitability has been evaluated by using the meteorological condition indices. And better or worse meteorological conditions have been evaluated by comparing meteorological condition indices among years.

Results The methods were applied in China grassland from 2005 to 2007. The climate suitability of grassland vegetation growth was reflected in certain period, the higher meteorological condition index, the more suitable for grassland vegetation growth, such as blue color part in Figure 1. The meteorological condition index differences can also reflect the better or worse meteorological conditions among years for China nature grassland vegetation growth (Figure 2), demonstrated by the grass yield and height observed in nature grassland among years.

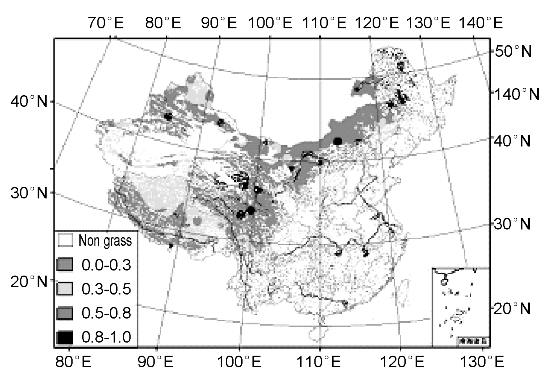

Figure 1 *Climate suitability in July 2006 for natural grassland vegetation in China.*

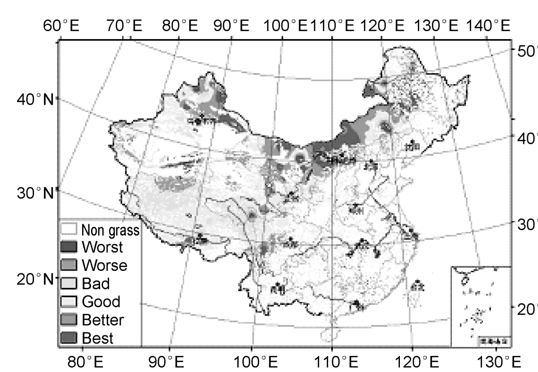

Figure 2 *Meteorological condition indices in July 2006 for natural grassland vegetation in China compared with 2005.*

Conclusions The results of evaluation are satisfied in service. The information is the very important for the government department to make decisions to protect and recover grassland ecological environment.

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Effects of different management on soil organic carbon dynamics in Chinese grassland systems

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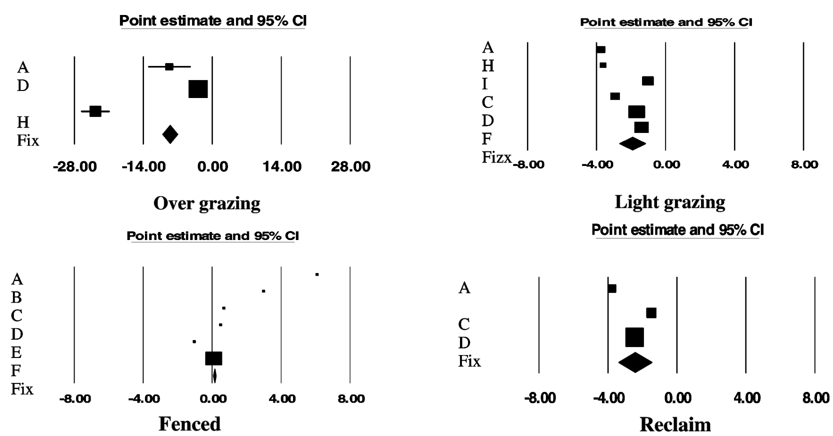
Key words : grazing , reclaim , fenced grassland , soil organic carbon , meta analysis

Introduction The grassland ecosystem is one of the most important land ecosystems in the world . In China grassland area is nearly 400million ha , occupies 41 .7% of the national territory area . Meanwhile it is a large global carbon storage (Cheng et al ., 2000) . Therefore , it is a vital significance to study the effects of the human management on soil organic carbon dynamics in grassland ecosystems .

Materials and methods By reviewing one hundred references and analyzing the change of soil organic carbon under grassland management in long-term experiment , we built the SOC&MANAGEMENT database . Finally , we used meta-analysis to estimate carbon annual change with grassland management in China .



A :alpine meadow B :mountain meadow C :temperate meadow D :temperate steppe E :temperate desert F :temperate desert steppe H :alpine steppe I :shubby grassland

Figure 1 *The annual increase (t C · hm^{-2} · yr^{-1}) of SOC and grassland for types of management in China .*

Results In the Figure 1 , the diamond position and the size have represented the fixed estimate effect and 95% confidence interval . There is a large SOC losses under the over-grazing condition : -8 .677tC · hm^{-2} yr^{-1} while the light grazing and reclamation makes the SOC decreased respectively : -1 .95tC · hm^{-2} yr^{-1} and -2 .455tC · hm^{-2} yr^{-1} . The enclosure management increased the soil organic carbon : 0 .096tC · hm^{-2} yr^{-1} .

Conclusions The soil structure in grassland aggravates unceasingly with the grazing intensity increasing . In addition , massive organic matter expose in the air , which accelerates the decomposition of SOC and reduces the carbon accumulation . But the conversion of grassland into farmland leads the aboveground biomass to move away and reduce the biological carbon transportation into underground . However , the fenced grassland can increase the SOC as it was not affected by the domestic animal or human management .

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Soil-atmosphere exchange and mitigation of nitrous oxide and methane emissions in New Zealand's terrestrial biosphere

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Key words :GHG emissions , grasslands , methane , mitigation , nitrous oxide , NZ-DNDC model

Introduction New Zealand is unique in having a greenhouse-gas-emissions inventory dominated by two non-CO_2 greenhouse gases (GHGs) , CH_4 (36.2%) and N_2O (17.2%) (MfE 2007) . The dominance of these gases in the inventory results from the strong agricultural base of the New Zealand economy and the relatively low levels of heavy industry and vehicular CO_2 emissions per unit land area . Both the net uptake of CH_4 by soils and N_2O emissions from soils are strongly influenced by changes in land use and management . Quantitative information on the fluxes of these two non-CO_2 GHGs is required for a range of land uses and management effects to determine their contributions to the national emissions inventory , and to assess the potential of mitigation options . Here we describe the soil N_2O fluxes and CH_4 uptake and their mitigation strategies for a range of New Zealand land-use and management systems , collated from published and unpublished New Zealand studies .

Materials and methods In situ and farm-scale N_2O and CH_4 fluxes were measured using a large number of chambers in different New Zealand farm systems including ungrazed and dairy- and sheep-grazed pastures (Saggar et al . 2004a , 2007a) . Annual fluxes were estimated by interpolation between the measured flux values and by using a process-based NZ-DNDC model (Saggar et al . 2007b) .

Results Nitrous oxide emissions are highest in dairy-grazed pastures , intermediate in sheep-grazed pastures and lowest in forest , shrubland and ungrazed pasture soils . N deposited in the form of animal urine and dung and N applied as fertiliser , are the principal sources of N_2O production . Although nitrification inhibitors have showed some promise in reducing N_2O emissions from grazed pasture systems , their efficacy as an integral part of farm management has yet to be tested . In contrast to N_2O emissions , soil CH_4 uptake was highest for a New Zealand Beech forest soil , intermediate in some pine forest soils , and lowest in most pasture and cropland soils . Soil CH_4 uptake is also seasonally dependent . Afforestation/reforestation of pastures increased soil CH_4 uptake , largely as a result of increases in soil aeration status and changes in the population and activities of methanotrophs (Tate et al . 2007) . We are testing whether soil methanotrophs could be used to capture CH_4 emissions in herd-homes on dairy farms and in barns .

Table 1 *Annual nitrous oxide emissions and methane uptake in New Zealand land use and land management systems .*

Land use	N_2O emissions($kg\ N_2O\text{-}N\ ha^{-1}$)		CH_4 uptake($kg\ CH_4\text{-}C\ ha^{-1}$)
	Measured	Modeled	Measured
Dairy-grazed	9 .6—11 .7	11 .9—14 .3	0 .5—1 .0
Beef-grazed	n/a	6 .5—9 .3	n .d .
Sheep-grazed	3 .7—4 .5	5 .5—8 .1	0 .6—1 .0
Deer-grazed	n .d .	4 .9—7 .4	n .d .
Ungrazed	0 .9—1 .8	1 .9—3 .0	<1 .0
Cropping	2 .3—3 .2 (season)	6 .0—7 .4	~1 .5
Shrub land	n .d .	n .d .	2 .3
Pine	0 .6	n .d .	4 .2—6 .4
Native forest	n .d .	n .d .	10 .5

Conclusions Strategies and best management practices for mitigation of N_2O emission include : improvement of overall N-use efficiency ; manipulation of N in the animal to reduce N excretion ; lower N contents of pastures - supplementary feed ; winter management - stand-off pads ; strategic application of farm effluents ; use of controlled-release N-transformation inhibitors and biochar . A new approach is being tested for CH_4 mitigation using the methanotrophs in soil to capture some of the enteric and animal effluent CH_4 in confined locations (e .g . , herd-homes and barns) .

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Investigation of affecting some climatic factors on distribution of plant societies in Eastern Alborz (IR-Iran)

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Key words: Temperature, precipitation, plant societies, Alborz Mountain

Introduction Climatic elements determine plant communities in each area, wherever important plant characteristics such as distribution, diversity and density are affected by climatic factors and different ecosystems are formed by these parameters. In fact, condition of vegetation in nature is affected from climatic factors and understanding of relationship between plant and climatic factors is important step in ecological management of rangeland ecosystems especially diverse mountain rangelands. Height effect moisture and temperature change which are the most important factors of distribution of plant associations (Song et al., 2006). The climatic factors with affection on soil moisture control changes of plant communities (Knapp et al., 2002). Plant communities due to affectability of climatic variations such as temperature and precipitation are created ecological plant groups of trees, bushy trees, shrubs and grasses (Taghipour, 2005). This research was done in order to recognizing and understanding of natural models between climatic factors and vegetation to determine ecological plant groups in mountain rangelands of eastern Alborz.

Materials and methods Mountain rangelands of eastern Alborz are located in Mazandaran Province in north of IR-Iran. Plant communities were identified by floristic-physiognomic method and were named based on dominant species. Sampling was done by randomized method. Data analysis was done with SAS statistical program and analysis of variance was done in completely randomized design with important degree factor of dominant species of plant communities.

Results and discussion The results of vegetation study showed five plant communities as follows: 1. *Festuca ovina-Stipa barbata* with associate species such as: *Brumes tomentellus*, *B. tectorum*, *Agropyron elongatum*, *Melica persic*; 2. *Stipa barbata-Festuca ovina* with associate species such as: *B. tomentellus*, *A. elengatum*. *A. cristatum*, *Hordeum glaucum*; 3. *Acantholimon pterostegium- Astragalus gossypinus*, with associate species such as: *Astragalus brachystachys*, *Verbascum thapsus*, *Thymus caucasicus*, *Acanthophylum pterostegium*, 4. *Onobrychis cornuta-Acanthophyllum pterostegium* with associate species such as: *Teucrium polium*, *Phlomis herba-venti*, *Astragalus aureus*, and 5. *Rosa iberica-Lonicera floribunda* with associate species such as: *Juniperus communis*, *Berberis integerrima*, *Cerasus pseudoprostrata*, *J. sabina*. Some study showed that distribution of grasses and shrubs is related to their humid needs in rangeland ecosystems (Jafari et al., 2001; Song et al., 2006). Also, the study of Walker et al (2005) showed that with increased of temperature, vegetation cover percentage and height of grass and shrub forms have.

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Differential effects of nitrogen and phosphorus additions on the ecology of soil and vegetation of dry tropical forests and derived savanna ecosystems in India

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Key words: landscape transformation, atmospheric nutrient deposition, natural forest, savanna, dry tropics

Introduction Landscape transformation and atmospheric nutrient depositions, important global change drivers, are rapidly occurring in Indian dry tropical regions supporting natural forest and derived savanna ecosystems. The Vindhyan Plateau, extending across the central part of India, potentially supports tropical deciduous forests have now been degraded into savannas due to anthropogenic influences through centuries. As a result the regional landscape shows vast expanses of savanna, bears intense cattle grazing especially during rainy season, interspersed with variously sized patches of forests (Singh 1989). Atmospheric nitrogen (N) and phosphorus (P) deposition values in these ecosystems range from 9.1-27.1 kg ha^{-1} yr^{-1} and 1.4-4.2 kg ha^{-1} yr^{-1}, respectively (Singh and Tripathi 2000). The objectives of this study are to understand the potential effects of N and P additions for eight years (from 1994-2001) on plant growth, tissue nutrient concentration, carbon (C) flux, soil nutrient availability and soil microbial biomass (C, N and P) in forest, ecotone and savanna ecosystems in dry tropical Vindhyan region.

Materials and methods The present study was carried out at three study sites, namely, natural forest, ecotone and savanna located in the Marihan Range of Mirzapur Forest Division ($24^0 55'$ to $25^0 10'$ N lat. and $82^0 30'$ to $82^0 45'$ E long; elevation 150-250 m amsl). At each study site, a sample area measuring 100m×100m was marked. Within each sample area, 9 randomly located permanent plots (each 12m×12m) were demarcated, of which 3 plots were added with N (Urea applied@ 150 kg N ha^{-1}), 3 plots received single super phosphate (@ 50 kg P ha^{-1}), and three plots without additions were treated as control. Beginning 1994, in each annual cycle (July-June), except in control plots, N and P additions were made in soil during July/August within 2-3 days after the occurrence of first significant rains.

Results Nutrient addition increased (about 1.5-2.5 times) density and aboveground plant biomass of herbs in these ecosystems. N addition considerably decreased the diversity of herbaceous vegetation, whereas the P addition has little effect. N addition increased the proportion of graminoids, whereas the P addition increased the abundance of few dicot forbs. Herb shoots nutrient content increased rapidly after initial nutrient addition. While N addition significantly increased the tissue N concentration in grasses, the P addition increased the concentrations of N and P in legumes in these ecosystems. Most of the tree species did not respond to first year nutrient addition. However, the responses were evident in few species in 2nd and 3rd year of nutrient addition. The fine root biomass responded positively to N addition with greater proportions in upper (0～10 cm) soil depth. The effect of P addition on fine root was less marked. Ammonification was dominant over nitrification in the forest and ecotone while the reverse was true in the savanna. Available nutrient status, N- mineralization rate and microbial biomass (C, N and P) were significantly affected by nutrient additions. Savanna ecosystem soil responded more rapidly to nutrient addition than the forest and ecotone. However, the responses were retained for a longer period in the forest and ecotone soils than in the savanna. Addition of N significantly increased the proportion of macroaggregates in forest and ecotone soils, whereas the same input decreased the proportion considerably in the savanna. Besides, N addition also altered the biological and chemical qualities of soil aggregates. The effect of P addition on soil aggregate stability was marginal. In the current scenario of N loading, continued soil N loading in forest may lead to increased macroaggregates with associated microbial biomass C and N and greater aggregate stability. In contrast, the extensively distributed savannas may show over all reverse trends leading to nutrient loss and reduction in its carrying capacity.

Conclusions We conclude that when either N or P are added to tropical forest and savanna ecosystems the soil and plants are affected differently depending on the amount and the quality of organic matter present in the soil. Contrary to the general belief, N addition seems to have more powerful control on the structural and the functional qualities of soil and vegetation than the addition of P in these dry tropical ecosystems.

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T-FACE experiment in the Qinghai-Tibet Plateau

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Key words: warming, infrared heater, micro-climate, soil temperature and moisture, alpine meadow

Introduction Scientists have used both passive and active experimental designs to simulate climate warming. However, for many of the designs the conditions are so unnatural that quantitative extrapolation to field conditions is questionable (Kimball 2005). Here, our aims are to: (1) describe warming effect of the temperature free-air controlled enhancement (T-FACE) system on the microclimate and (2) assess the applicability and suitability for longer-term studies of climate warming on the ecology of an alpine meadow at Haibei, Qinghai-Tibet plateau, China.

Materials and methods The experimental site is located at the Haibei Alpine Meadow Ecosystem Research Station (HBAMERS), Chinese Academy of Sciences. In May, 2006 eight hexagonal arrays of Mor FTE (1000W, 240V) infrared heaters were built over grass along with eight dummy arrays over reference plots (Kimball *et al.*, 2007). The experimental design included two factors (warming and grazing) with each of the resultant 4 treatment combinations replicated 4 times to total 16 plots in a completely randomized block distribution in the field. Air temperature and relative humidity at the 30 cm height of the soil surface, soil temperatures (at 0, 5, 10, 20 and 40 cm soil depths) and moisture (at 10, 20, 30 and 40 cm soil depths) were measured and then 15-min averages were analyzed. The grazing treatment was imposed just once on August 16 in 2006, and there was no significant difference between grazing and no-grazing treatments by the end of growing season. Therefore, the grazing treatment plots were regarded as additional replicates, so that the results of the warming treatment were analyzed using 8 replications.

Results The degrees of vegetation warming during daytime averaged 1.18℃ and at nighttime averaged 1.69℃), which closely matched our set points of 1.2℃ and 1.7℃, respectively. The T-FACE system had little effect on daily air temperature at 30 cm above the ground surface in the growing season (15～20 cm above canopy in August). Average values of soil temperature at 0, 5, 10, 20 and 40 cm were significantly increased by 1.3～1.5℃ (0～20 cm) and 0.5℃ (40 cm), and warming only increased the diurnal soil temperature range at 5 cm. Although warming caused decreases of approximately 3～13% of relative value of soil water content from 10～40 cm on the volumetric basis, these differences were not significant ($P > 0.05$) between warmed and no warmed plots at the different time scales (hourly, daily, monthly and seasonal) for 10～40 cm soil depths. Therefore, the T-FACE system simulated the changes in vegetation and microclimate well that are expected with future global warming.

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Effects of orchard green cover on accumulation and emission of soil organic carbon

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Key words : orchard green cover , soil , organic carbon , soil respiration

Introduction Agriculture is an important emission source of greenhouse gases (GHG) . The emission amount of GHG from the land use changes reached 1.6×10^{15} g every year , which was the secondary important source of GHG (Houghton ,1995) . How to effectively control the agricultural emission amount of GHG has become an urgent problem . This paper preliminarily studied the effects of orchard green cover on characteristics of soil organic carbon to provide a reference for exploring the technology of GHG mitigation .

Materials and methods Two treatments were imposed in split-block experimental design with 3 replicates . Treatments were intercropping *Chamaecrasta rotundifolia* in orchards and weed-cleaning orchards . Plots were arranged randomly with the area in size of 4m×25m .

Results Compared with the control group , the total content of soil organic carbon (in 0~20 cm soil layer) , humic acid content and fulvic acid content in intercropped herbage orchards increased 37 .25% , 153 .78% and 6 .76% , respectively (Figure 1) . Daily change regularity of soil respiration rate in intercropped herbage orchards was similar to that in the control group . The respiration rate of soil reached the lowest at 8 : 00 am , then increased gradually , subsequently reached the maximum value at 20 :00 pm , then decreased gradually . However , the soil respiration rate in intercropped herbage orchards was 1 .15% ~44 . 23% higher than the control group (Figure 2) .

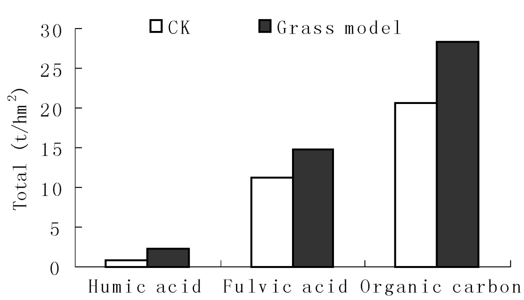

Figure 1 *The changes of organic carbon and compositions of soil .*

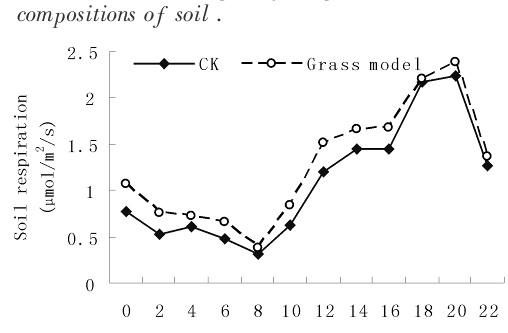

Figure 2 *The changes of soil respiration rate .*

Conclusions Planting herbages in orchards is an advanced and high efficiency soil management means , which has been widely applied in Europe , USA and Japan in recent years , and has a remarkable effect in preventing soil erosion especially . Orchard green cover could enhance the N-fixing ability of soil and improve the stability of soil organic carbon . The released rate of CO_2 in intercropped herbage orchards was higher than in weed-cleaning orchards , which could be explained by root respiration . The effects of orchard green cover on soil heterotrophic respiration will be continued further .

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Carbon dynamic in the decomposer subsystem of the *Leymus chinensis* grassland in northeastern China

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Key words: carbon, litter, microorganisms, dead root, soil, decomposer subsystem

Introduction More greenhouse gases especially carbon dioxide is discharged by human activities. Decomposer subsystem including dead roots, litter, soil and microorganisms is the main link of carbon cycle of a grassland ecosystem and play an important role (Frank et al, 2002). The objective of our study was to study the seasonal carbon dynamics in each component of the decomposer subsystem of L*eymus chinensis* grassland in northeastern China.

Materials and methods The study was conducted at The Ecological Research Station of Northeast Normal University in southeastern Songnen Plain of Jilin Province, China from May to October in 2002 and 2003. Litter was collected by a 2×2 m iron sieve collector. Soil and dead roots from 0 to 30 cm layer were collected in five plots (25×10 cm). Carbon contents in litter, dead roots and soil were analyzed by the method of potassium dichromate and carbon in soil microorganisms was measured by the method of Vance. Soil moisture, temperature and pH were also determined.

Results and discussion The carbon content in litter (LC) increased gradually with the growth of the plants. Carbon content in dead roots (RC) began to increase from May and reached the peak in June. Dynamics of carbon content in microorganisms (CM) and soil (SC) showed a single-hump curve and a v" curve respectively (Figure 1). Carbon contents in the four groups of the subsystem were soil (81.3%~91.2%) > microorganisms (5.5%~16.9%) > dead roots (1.1%~2.4%) > litter (0.002%~1.6%) and carbon was mainly stored in the soil. LC, RC, CM and SC were affected by environmental factors (Table 1). Since the activity of microorganisms in soil restricted the release of carbon in litter, dead roots and soil by decomposition, they were the key in carbon transformation of the subsystem. Microorganisms were affected by soil temperature, moisture and pH in the study. Therefore, the three environmental factors affected on carbon dynamic of the whole decomposer subsystem.

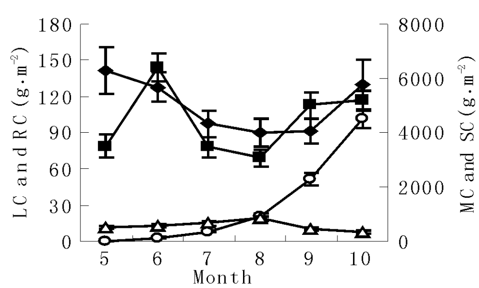

Figure 1 *Carbon content in decomposer subsystem (○ LC; △ :MC; ■ RC; ◆ SC).*

Table 1 *Correlations between each group C and main environmental factors.*

	T	SM	pH
LC	-0.7529^{*}	-0.5850^{*}	-0.0556
RC	-0.2710	-0.2580	0.4961
MC	0.8319^{**}	0.8325^{**}	-0.6616^{*}
SC	-0.5295^{*}	-0.4691	0.8889^{**}

Note: T: Soil temperature; SM: Soil moisture; pH: soil pH. Correlation significant** at $p<0.01$ and * at $P<0.05$

Conclusions LC and RC were the carbon source in the subsystem, dynamics of which determined the carbon input. The Dynamic of carbon in whole decomposer subsystem was decided by SC due to its high percentage of carbon content. Soil temperature, moisture and pH affected on carbon reservoir of decomposer subsystem.

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Methane seasonal emission from Mongolian sheep fed *Leymus chinensis*

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Key words: methane emission, season, Mongolian sheep, supplement, *Leymus chinensis*

Introduction Methane emission from ruminant enteric fermentation is a major anthropogenic contribution of increased atmospheric methane concentration. Sheep are dominating grazing animal in Inner Mongolia steppe (Chen and Wang, 2000). It is important to evaluate methane source or sink in the grazing steppe ecosystem to measure methane from sheep. The methane from Mongolian sheep fed *Leymus chinensis* was studied.

Materials and methods The sheep experiment was conducted at the Inner Mongolia Grassland Ecosystem Research Station of the Institute of Botany, the Chinese Academy of Sciences in Xilinhot. Four wethers, with a mean body weight (BW) of 45.3kg (SD 1.2 kg) were fed fresh *Leymus chinensis* in yard to measure daily methane emission in August and September 2005. Eight wethers weighted 47.2kg (SD 2.3kg) were housed and divided randomly into two groups in October and November. One group were fed *Leymus chinensis* hay, the other fed *Leymus chinensis* hay supplemented with 400g of concentrate. The intake and digestibility of dry matter (DM) and organic matter (OM) were measured. All animals were measured daily methane emission with method as Wang et al. (2007).

Results Methane daily emission from Mongolian sheep enteric fermentation was highly significantly affected by season (Table 1). Methane emission was increased with the decreased quality of *Leymus chinensis*. Season highly significantly affected methane emission per kg body weight of sheep. There was no significant effect of season on methane emission per kg DM and OM intake. Methane emission per kg DM and OM digested was significantly affected by season. Although supplement concentrate increased methane daily emission, but decreased methane emission per DM and OM digested.

Table 1 *Enteric methane emission from Mongolian sheep.*

Methane Emission	Aug.	Sept.	Oct.		Nov.		SEM	P
			Hay	Supplement	Hay	Supplement		
g/day	16.2	16.1	18.3	19.4	18.0	19.6	0.4	<0.001
g/kg body weight	0.36	0.32	0.39	0.43	0.36	0.41	0.01	<0.001
g/kg DM	12.88	13.81	13.75	13.49	14.33	13.54	0.25	0.08
g/kg OM	14.17	15.11	14.69	14.71	15.53	14.70	0.28	0.09
g/kg DM digested	23.65	27.71	26.34	24.13	30.09	24.00	0.62	0.01
g/kg OM digested	24.19	29.80	26.57	25.35	30.75	26.16	0.65	0.01

Conclusions Methane daily emission from Mongolian sheep was 16.1～19.6g from August to November. Sheep supplemented concentrate not only decreased methane emission per DM and OM, but also improved performance. Estimating methane source or sink in the grazing steppe ecosystem should consider sheep and season.

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Managing carbon sources and sinks in Australia's rangelands and tropical Savannas

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Key words: carbon markets, emissions, fire, grazing, sequestration

Background Australia's rangelands and savannas occupy about 80% of the continent and play an important role in the country's carbon balance. Grazing by livestock is the most extensive land use, and the savannas are subject to frequent, extensive fire, especially in the north, where annual rainfall exceeds 1000 mm. Savanna burning plus direct emissions from Australia's domestic livestock (mainly sheep and cattle) account for about 15% of Australia's accountable CO_2 equivalent (CO_2-e) emissions per year. In this paper, we discuss the potential to reduce emissions via land management instruments, ecosystem capacity to sequester carbon, and investment and management strategies that can lower the carbon footprint of land use in these ecosystems.

Greenhouse gas (GHG) emissions from Australian rangelands derive from three main sources: land-use change, livestock production and savanna burning (Table 1). Most land-use change in rangelands since 1990 has been deforestation of eucalyptus-dominated woodlands to increase pastoral production. In 1990, the CO_2-e emissions from deforestation were double those from livestock and ca. 20 times those from savanna burning. Since then, the rate of land clearing has decreased so that the emissions in 2005 were about two thirds those from livestock.

Table 1 *Accountable greenhouse gas emissions from Australian rangelands (source: NGGIC 2005).*

Sector	Net emissions (Mt CO_2-e y^{-1})		
	1990	Range 1991-1994	2005
Land use change (deforestation)	128.9	106.1 to 46.4	53.3
Land use change (afforestation)	0	-0.5 to -17.8	-19.6
Livestock (enteric fermentation and manure)	65.9	61.6 to 66.1	62.1
Savanna burning	6.6	6.1 to 15.8	8.6

GHG management There are few practical strategies to reduce methane emissions from livestock without reducing productivity. Genetic variation in the feed, and manipulation of feed quality provide potential methods to manage methane emissions from cattle. Improvement of rangeland condition may enhance sequestration, by increasing soil carbon stocks. With respect to fire, which is pervasive across the savannas, the potential to reduce GHG emissions and enhance carbon sequestration capacity is high. Current fire abatement activities over a 30,000 km^2 area in Western Arnhem Land, Northern Territory, are achieving accountable emissions reductions of ca. 100 000 t CO_2-e per annum. Recent research (Russell-Smith J et al. 2002; Williams *et al*. 2004; Beringer *et al*. 2007) in the mesic savannas has quantified critical components of carbon stocks and fluxes, e.g. area burnt, burning efficiencies, fuel dynamics, and net ecosystem and biome productivity (NEP; NBP). This indicates that the mesic savannas are net C-sink, of ca. 1-to-2 t C ha^{-1} y^{-1}. Sink strength is sensitive to fire regime, and reduction in the severity of the fire regime will lead to additional increases in carbon sequestration capacity.

Market potential International demand for ecosystem abatement and bio-sequestration activities is likely to increase in coming years. Australian rangelands and savannas, which collectively cover several million km^2, offer significant potential to provide abatement and off-set products and services within international carbon markets, whether voluntary or regulated. We discuss this potential, and how the emerging demand for land-based carbon off-set products may affect land-management policy and practice in rangelands and savannas, within the pastoral sector, and with respect to Aboriginal people, who own extensive areas of the savannas.

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Grassland production under various meteorological conditions in Xilingol, Inner Mongolia, China

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Key words: grassland production, Inner Mongolia, meteorological patterns, prediction, steppe

Introduction In the area of the Xilingol steppe in Inner Mongolia, farmers were previously nomadic. Today, however, they graze mainly sheep and goats at permanent residences. The meteorological characteristics of this area are long, severe winters, warm summers, and little rainfall. Primary and secondary grassland productions are largely restricted by these meteorological conditions. In the present situation, long term meteorological forecasts by observatories are impossible, we propose an alternative method.

Materials and methods A system model was used to analyze the Xilingol steppe ecosystem (Figure 1). Meteorological data on daily mean air temperature and rainfall from 1953 to 2000 (48 yrs) were numerically classified into six typical year patterns using 10-day means/totals of these meteorological variables from April to October, which is the growing season for grassland vegetation, based on a numerical classification technique (*k*-means).

Results and discussion The six meteorological patterns in Xilingol are shown in Figure 2. We applied the system model to each meteorological pattern. The simulated results for aboveground biomass of grassland vegetation from 20 April to 10 September are shown in Figure 2. Meteorological Pattern 1, which has little rain in summer, is characterized as drought and there is little plant biomass. The plant biomass of pattern 4, which has relatively little rainfall in early summer, follows pattern 1. The other patterns have more rainfall in summer and plants show vigorous growth. Farmers can select an expected meteorological pattern based on the present weather conditions and their empirical knowledge, predict grassland production, and plan a grazing schedule. This procedure may not only assist in the creation of a grazing schedule but also help prevent degradation and desertification, and facilitate the recovery of production.

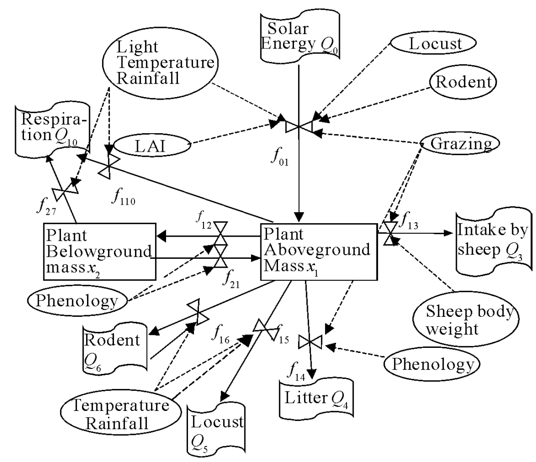

Figure 1 *System model of the Xilingol steppe ecosystem.*

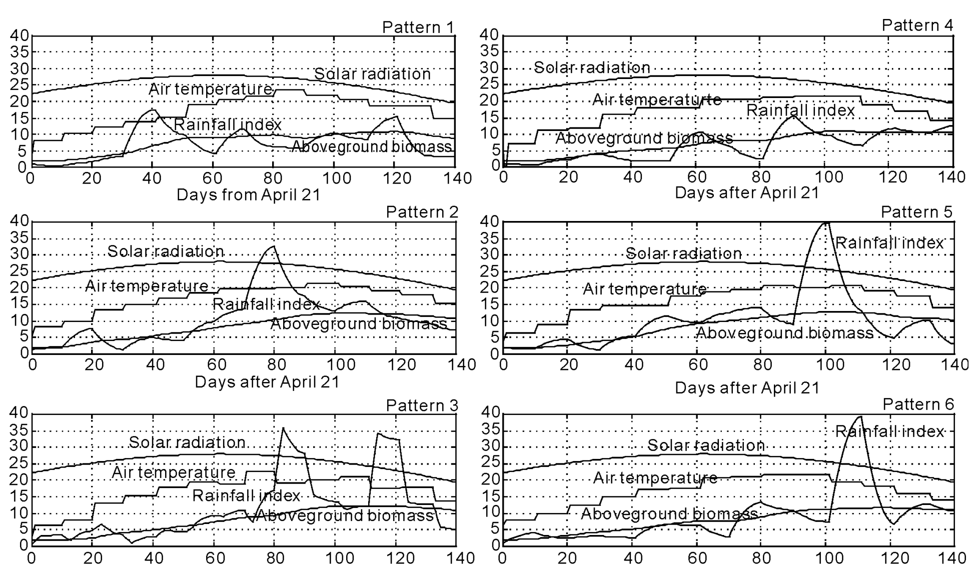

Figure 2 *Changes in solar radiation (Mj/ha/day), air temperature (℃), rainfall (mm/day) and biomass (10^2 kg/ha) for the six meteorological patterns.*

Carbon dynamics (2000—2006) over the northern Great Plains grasslands

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Key words: eddy covariance, flux tower, gross primary production, net ecosystem exchange

Introduction The grassland ecosystem in the U.S. Great Plains occupies was about 1.5 million km^2. However, the contribution of the grasslands to local and regional carbon budgets remains uncertain due to the lack of carbon flux data for the expansive grassland ecosystems under various land managements, land uses, and climate variability. An understanding of carbon fluxes across the ecosystem is essential for developing carbon budget models at regional, national, and global scales.

Materials and methods A remote sensing-based empirical model, piecewise regression model (Wylie et al., 2007; Zhang et al., 2007), was modified to estimate the grassland carbon fluxes in the U.S. northern Great Plains. The model explored the empirical relationship between environmental variables and tower-based measurements collected from six grassland flux towers and extrapolated the tower-measured data to the entire grassland ecosystem. We used this model to estimate the spatio-temporal carbon fluxes across the study area. Net ecosystem exchange (NEE) between land and atmosphere were measured using eddy covariance and Bowen-Ratio techniques. We partitioned 30-minute CO_2 fluxes into total ecosystem respiration and gross primary production (GPP) using the light response curve analysis (Gilmanov et al., 2005). The predictors include the MODIS normalized difference vegetation index (NDVI), precipitation, temperature, photosynthetic active radiation, and phenological metrics. We also incorporated the actual vegetation evapotranspiration data derived from a vegetation evapotranspiration (VegET) model (Senay and Henebry, 2007), which takes into account soil moisture and land surface phenology.

Results and discussion In the northern Great Plains grasslands, we estimated a 13 percent reduction of GPP in the dry year 2002 compared to the average GPP for years 2000-2006, which resulted in an anomalous net source of carbon dioxide (-19 gC/m^2/year) to the atmosphere. The carbon budgets depend, to a great extent, upon precipitation and its distribution in this region. Specifically, the 2006 NEE map (Figure 1) shows carbon sources in drier western regions and carbon sinks in wetter eastern and southern regions, which was in line with the east-west gradient of annual precipitation across this region. The annual NEE varied from -28 $g\ C/m^2$/year (source) in 2006 to 37 $g\ C/m^2$/year (sink) in 2001, with sources in 2002, 2004, and 2006, and sinks in other years (Figure 2).

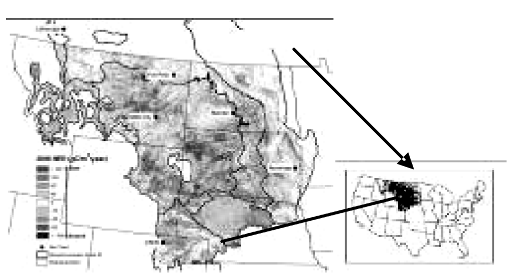

Figure 1 *Spatial distribution of annual NEE for 2006.*

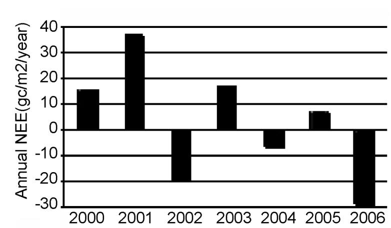

Figure 2 *Estimated annual NEE for 2000-2006.*

Conclusions The CO_2 exchanges over the northern Great Plains grasslands are highly variable in space and time.
The annual NEE transits from sinks to sources in the dry years of 2002, 2004, and 2006. If the climate becomes drier in the future, the ecosystems may change to larger carbon sources.

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Study on methane diurnal emission nearby Cuona Lake in Naqu of Tibet with different humidity

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Key words: methane diurnal emission, Cuona lake, wetland, humidity, Naqu, Tibet

Introduction It shows that the 70～80 percentage of atmospheric CH_4 is from biogenic sources. And it is believed that paddy fields and wetlands are the dominant sources of atmospheric CH_4 (Hu, 2005). We made a study on methane emission from the wetland nearby Cuona Lake in Naqu of Tibet with different humidity by field investigation, which can contribute to evaluating methane emission from wetlands in Tibet.

Materials and methods The field experiment site was located in nearby Cuona Lake in Naqu of Tibet. On August 2006, 3 treatments of CH_4 flux were imposed with 3 replicates according to the distance from the lake. Treatments were: (1) Lake level treatment (LT); (2) Wet treatment (WT), 100 meter far from the lake; (3) Dry treatment (DT), 500 meter far from the lake. LH, WH and DH were the humidity of 3 treatments, respectively. Using the enclosed chamber technique, CH_4 fluxes were measured. The chamber was a cylinder of 40 centimeter high and its base diameter was 30 centimeters. When measured, the base was inserted 5-centimeter underground, and sealed by distilled water. Samples collected by syringe were transferred into plastic gas bags for measurement by HP6890GC.

Results By the curve, it was proved that LH, WH and DH gradually decreased with the distance from lake. But it wasn t significant for all of treatments diurnal humidity variation. CH_4 flux of all treatments with time was as follows: WT>DT>LT. The trend of CH_4 diurnal flux of all treatments was accord with each other. A peak appeared in 3 curves respectively. WT peak and DT peak appeared at 15pm, and LT peak was at 17 pm.

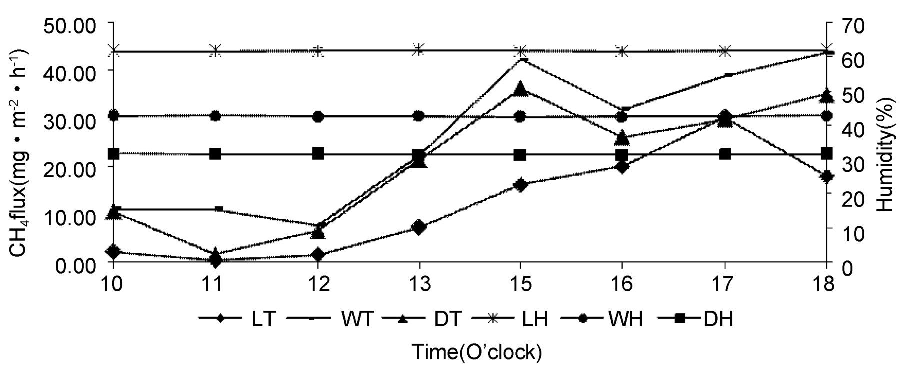

Figure 1 *Diurnal CH_4 flux and humidity dynamic nearby Cuona lake in Naqu of Tibet.*

Conclusions CH_4 emission flux of all treatments was positive, which shown that this wetland was the source of atmospheric CH_4. The CH_4 flux of LT was smaller, which may result in the inhabitation of CH_4 emission due to excessive humidity of the lake-level. Because of the far distance between DT and lake and smaller humidity, it didn't result in much higher CH_4 flux. With the moderate distance between WT and lake and with appropriate humidity, it could accelerate CH_4 emission.

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Effects of ice encasement during winter on different cultivars of *Phleum pratense* and *Lolium perenne* in Norway

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Key words: ice encasement, frost tolerance, grass, timothy, perennial ryegrass

Introduction Global warming may lead to milder winters at high latitudes (RegClim 2005). Fluctuating temperatures and more precipitation can increase the risk of ice encasement, although more research is needed to verify this assumption. Farmers may in future prefer to grow *Lolium perenne* (L.), which is forage grass more resistant to grazing and frequent cutting than the currently used *Phleum pratense* (L.). *P. pratense* is generally very tolerant to ice encasement and probably more so than *L. perenne*, although there may be variety differences. The aim of this study was to compare the tolerance of different cultivars of *P. pratense* and *Lolium perenne* to ice encasement.

Materials and methods Two varieties of *P. pratense* (Engmo, Grindstad) and two of *L. perenne* (Riikka, Gunne) were spring sown in a field at Holt, Tromsø, Norway (69.65°N, 18.91°E). At the end of autumn, turfs were dug out, put in growth containers and placed to form a dense sward. Single tillers from all varieties were sampled during winter for determination of ice encasement tolerance (LD_{50}) and frost tolerance (LT_{50}); (LD_{50}, = No of days required to kill 50% of tillers encapsulated in ice and stored in darkness at -2℃, and LT_{50} = Temperature needed for killing 50% of the tiller population) (Larsen, 1978; Gudleifsson and Bj rnsson, 1989).

Table 1 *Tolerance to ice encasement (LD_{50}, days) during winter* 06-07.

	P. pratense		*L. perenne*	
Month	Engmo	Grindstad	Riikka	Gunne
Nov	>44	>44	20	14
Jan	>63	46	>21	15
Mar	*	32	17	11

Not possible to estimate—data does not follow the expected curve

Table 2 *Frost tolerance (LT_{50}, ℃) during winter* 06-07.

	P. pratense		*L. perenne*	
Month	Engmo	Grindstad	Riikka	Gunne
Nov	<−21.1	−19.7	<−17	<−17
Jan	−25.9	−19.8	−18.5	−15.8
Mar	−19.2	−14.9	−16.8	−12

Results and discussion The tolerance to ice encasement was much higher in *P. pratense* than in *L. perenne* (Table 1). There was a high correlation between tolerance to frost and to ice encasement (Table 1 and 2). The more winter hardy *P. pratense* variety Engmo was more frost tolerant and had a much higher tolerance to ice encasement than Grindstad, whereas Riikka was somewhat more tolerant than Gunne (Table 1 and 2). Both LD_{50} and LT_{50} increased from November to January, but then decreased in March. At the same time the ambient mean monthly temperature increased from -5.7℃ in February to 1.5℃ in March (Figure 1).

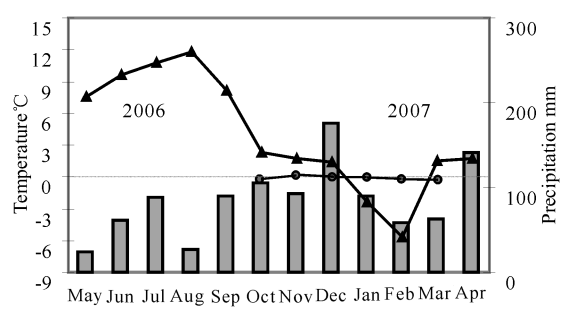

Figure 1 *Mean monthly air (▲) and at ground (●) temperatures, and precipitation from local weather station.*

Conclusion *L. perenne* is more susceptible to ice encasement than *P. pratense*. Varieties that are more frost tolerant also tend to sustain longer periods of ice encasement. More detailed climate scenarios are needed to predict the risk of ice encasement in the future.

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Spatial pattern and uncertainty of soil organic carbon and implications for sampling design

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Key words : sampling design , soil carbon storage , spatial heterogeneity and uncertainty , woody invasion

Introduction Woody encroachment has occurred in many arid and semi-arid ecosystems all over the world (Archer 1995) . Invasion of woody plants into grassland savanna has significant impacts on soil carbon storage and its spatial heterogeneity (Boutton et al . 1998) . We have limited understanding on the pattern of special heterogeneity and uncertainty of soil carbon and its relationship to the spatial pattern of woody vegetation in savanna landscapes . This understanding is essential for effective assessment and monitoring of soil carbon in savanna landscapes . The goal of this study was to develop an understanding of the spatial pattern and uncertainty of soil organic carbon (SOC) and how they influence the effectiveness of SOC estimation in subtropical savanna landscapes . The specific objectives were to : (1) quantify the spatial uncertainty of SOC ; (2) evaluate the performance of different point sampling designs in estimating SOC storage ; and (3) develop effective sampling strategies based on the spatial pattern and uncertainty of SOC .

Materials and methods This study was conducted at the Texas AgriLife Research La Copita Research Area (27°40′N , 98°12′W) in south Texas . The upland portions of the landscape are subtropical savanna parklands with discrete woody patches scattered in a continuous C4 grassland matrix . Woody patches with honey mesquite canopy and understory shrubs were classified as smaller clusters (1-100 m^2) and larger groves (>100 m^2) . A 160m×100m plot was established on the upland landscape with 10m×10m grid cells . Soil samples were collected at 2 random points in each grid cell . Additional subplots on 3 groves , 5 clusters and 3 grassland areas were also sampled with higher intensities . Soil samples were processed and SOC concentration was measured by combustion/gas chromatography using a Carlo Erba EA-1108 elemental analyzer . Aerial photo imagery was classified into either woody or non-woody classes and the woody patches were identified as clusters or groves based on their sizes . Kriging and conditional stochastic simulation approaches (Goovaerts 2001) were used to qualify the pattern of spatial uncertainty in SOC estimations . Based on the understanding of the pattern of spatial uncertainty , alternative sampling designs were developed and examined for their effectiveness measured as the estimation error as a function of sample density .

Results Average SOC content was significantly different between vegetation types and decreased from groves to clusters and grasslands (1832 , 1500 , and 1282 g C m^{-2}) . Spatial distribution of SOC based on kriging indicated that it was closely related to the spatial distribution of woody vegetation density . Results of the conditional stochastic simulation showed significantly greater levels of uncertainty of SOC estimations in groves than in clusters and grassland . Consistent differences in estimation error were found among the complete random sampling , stratified random sampling with even density , and stratified random sampling with uneven density (based on level of uncertainty) . Stratified random sampling with unequal densities had the lowest estimation error while complete random sampling had the highest at all sampling density . Estimation errors of all three designs started to level off when sampling density was higher than 100 samples per hectare . Results of the complete random sampling experiments with simulated landscapes showed that estimation errors increased with increasing woody vegetation cover for all sampling densities and both percentage of woody cover and relative abundance of clusters vs . groves influence the estimation errors . Results of experiments also showed that structured sampling would be most effective for clusters given the strong patterning from center to edge of the clusters .

Conclusions The invasion of woody vegetation into grassland , deserts and savannas has profound impacts on both the magnitude and spatial heterogeneity of SOC content . In order to evaluate effects of woody invasion on soil carbon at large spatial scales , understanding of spatial uncertainty of SOC is essential in designing suitable sampling regimes to estimate SOC storage . Our results showed that SOC had higher spatial uncertainty as well as higher concentrations in woody patches than in the grassland . High uncertainty of SOC in woody patches was likely caused by complex canopy structure , root distribution and animal disturbance . Assessment of alternative sampling designs demonstrated the effect of spatial uncertainty on estimation accuracy of SOC storage and helped generating effective sampling strategies to improve SOC estimation accuracy . This understanding of spatial uncertainty of SOC can also enable new approaches to estimate and monitor soil carbon storage over large landscapes based on remote sensing .

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Carbon sequestration potential of organic pasture in Thailand

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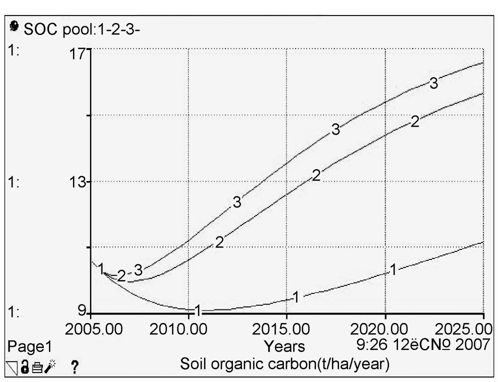
Key words: carbon sequestration, organic pasture, environmental model

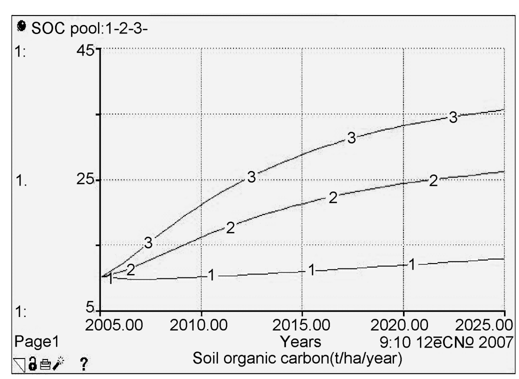
Introduction This paper provides the feature of a generic environmental model to demonstrate environmental impacts of the organic pasture used for beef production as compared with the intensive conventional pasture system. Both pastures had been utilized through the rotational grazing for 3 consecutive years. Carbon sequestration potential which is inversely associated with the Global Warming Potential was simulated.

The model The model was developed following the general stages of modeling strategies described in Forrester (1968). STELLA II version 9 software package (HPS, 1994) has been used in the model construction. The model described the interrelationships between the pasture production, cattle production, and soil organic carbon (SOC) accumulation in the farm boundary. The study focused on Northeastern Thailand. Two types of pasture systems selected for this investigation are the intensive conventional system and the organic system. The pastures were grass-legume mixed of Guinea grass (*Panicum maximum* TD 58) and Taphra stylo (*Stylosanthes guianensis* CIAT 184). The cattle were Thai Indigenous beef cattle. The system in this study involved the pasture production process, the cattle production process, the returning of waste from pasture and cattle into the soil organic carbon (SOC), and soil nutrient and uptake by plants.

Results The organic pasture showed greater carbon sequestration potential (Figure 2) compared to the conventional pasture (Figure 1). Without external fertilization, the soil carbon under organic pasture would gradually increase from 10.0 to 12.75 t ha^{-1} for the 20 year period. With 50 and 100 kg N ha^{-1} yr^{-1} fertilization, the carbon content in the pasture soils would increase to 26.01 and 35.57 t ha^{-1}, respectively. The carbon sequestration potential of the organic pastures with 0, 50 and, 100 kg N ha^{-1} yr^{-1}, were estimated to be 0.14, 0.80 and 1.28 t ha^{-1} yr^{-1}, respectively.



1=0N; 2=50 kg N ha^{-1} yr^{-1}; 3=100 kg N ha^{-1} yr^{-1}
Figure 1 *SOC (t ha^{-1} yr^{-1}) of an intensive pasture.*



1=0N; 2=50 kg N ha^{-1} yr^{-1}; 3=100 kg N ha^{-1} yr^{-1}
Figure 2 *SOC (t ha^{-1} yr^{-1}) of organic pasture.*

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The effect of climate change on livestock carrying capacity of Inner Mongolia

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Key words: climate change, warm winter, carrying capacity, grassland degeneration

Introduction Since 1961 the annual temperature in Central and Eastern Inner Mongolia has increased by 0.9±0.2℃ with a 1.2℃ increase ℃ during winter (December to February) and spring (March to May) (Figure 1). Annual precipitation has varied markedly over this period with a decrease in the years since 1990. More than ten warm winter have happened since 1980 resulting in decreased mortality of old, weak and young animals resulting in an increased stocking rate in the following year with the potential for overgrazing. The combination of changing climate-temperature increase, precipitation decrease, and the chang in precipitation pattern - together with increased stock numbers have accelerated grassland degeneration.

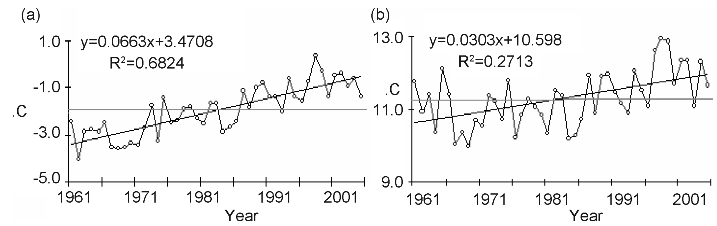

Figure 1 *Minimum(a) and maximum(b) temperature exchange in Inner Mongolia(54 stations 1961-2005).*

Methods A productivity model was used to calculate primary production allowing a comparison of theoretical and actual carrying capacity. Four banners (regions) were chosen for the analysis (Table 1).

Table 1 *Characteristic of represent stations*

station	longitudeand latitude	elevation(m)	Grassland Type	Mean annual temperature(℃)	Mean precipitation(mm)
A1:Dongwu	116°58′;45°31′	838.7	Typical grassland	13	258
A2:Xiwu	117°36′;44°35′	9959	Typical grassland	15	342
A3:Xisu	112°42′;42°43′	1101.7	Destification grassland	49	181
A4:Wuchuan	111°27′;41°06′	1595	Farming Area	29	351

Results The results show that a warm winter is one reason for the heavy stocking rate. Since the 1960s most of the area exceeded the theoretical carrying capacity by 20%-30%. Up to middle of 1980s, there were more than ten years warm winters in succession, temperatures were mild during winter each year with no heavy snow cover. These conditions decreased the mortality of old and weak animals thus increasing animal numbers in the subsequent year. resulting in an imbalance between stock number and the primary productivity of the grassland. The problem is exacerbated because herdsmen are reluctant to sell their animals and there is not a strong political will to restrict animal numbers. Unsensible lose weight was behind by the sensible animal number. The animal husbandry looks get harvest but low effectiveness. At the same time, the herds expand so fast. By 1990 30%-60% of the grasslands had degenerated; since 2000 degeneratrion has increased because of the prevalence of drought extending in some places from early spring to late summer. The climatic conditions during this period were sufficiently droughty to force even moderately stocked ranchers to destock by 30%-50%.

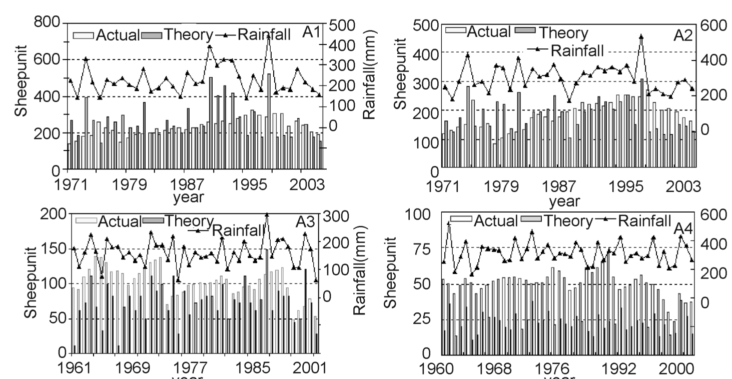

Figure 2 *The actual and theory carry capacity and growing rainfall in four banner of Inner Mongolia (A1 Dongwu banner A2 Xiwu banner A3 Xisu banner A4 Wuchuan county).*

Conclusions Overgrazing is a serious problem for the grassland of Inner Mongolia particularly during droughts. Although in some places grazing is forbidden, in others it is illegal to prevent grazing. Overgrazing is very harmful to the ecological system and ifgrassland degradation cannot be prevented then the ecological environment will be lost forever.

Study on temporal-spatial variability of climatic factors and its influence on net primary production of grassland in Inner Mongolia , China

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Key words : climatic factor , net primary production , GIS , water deficit , grassland

Introduction The climatic factors , especially rainfall in semiarid and arid areas , have overriding effects on grassland productivity . The purpose of this study was to identify the relationship among precipitation , temperature , evaporation and net primary production and then to estimate on effect of climate change on grassland productivity .

Materials and methods The meteorological data sets from 1957 to 2006 that we used were collected from 47 weather stations in Inner Mongolia . The spatial distribution of climatic factors was analyzed with the Inverse Distance Weighted (IDW) method embedded in ARC/INFO , which was based on GIS . The net primary production was calculated with the Synthetic model (Zhou *et al* ., 1996) .

Results The mean precipitation of all 47 stations in both May-September and the whole year showed slight decreasing linear trends , but neither was statistically significant (Figure 2) . In contrast to rainfall amount , there was profound and significant increase in the aspects of the temperature and evapotranspiration characteristics ; the biological temperature has been increasing by 0 .18℃ average per 10 years (data not shown) . As a result of the precipitation decreasing and the potential evapotranspiration increasing , the water deficit has become more and more severe (Figure 2) . Because of climate change , the net primary production of the grassland ecosystem has been decreasing year by year (Figure 2) . Otherwise , the spatial distribution of climatic factors showed an extreme imbalance , the distribution of precipitation descended gradually from east to west (Figure 1) , however , that of temperature and evapotranspiration was opposite .

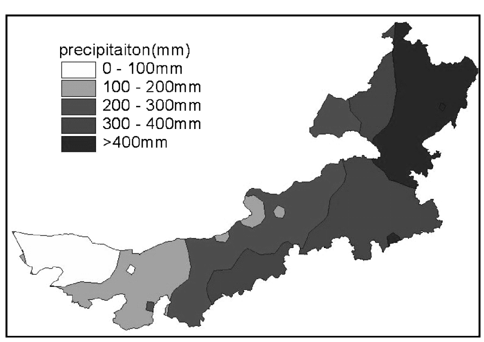

Figure 1 *Spatial distribution of average annual rainfall in the Inner Mongolia ,* 1957 -2006 .

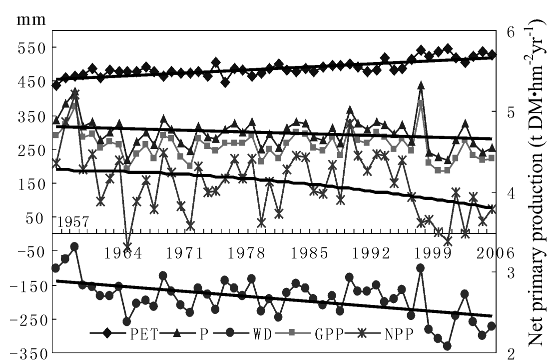

Figure 2 *Average annual amount of precipitation (P) , potential evapotranspiration (PEP) , water deficit (WD) , growth period Precipitation (GPP) and net primary production (NPP) .*

Conclusions The precipitation decreasing , climate warming , evapotranspiration increasing , and the spatial distribution imbalance of climatic factors resulted in the severe water deficit in the Inner Mongolia . This water deficit was the main limitating factor of the grassland productivity . The reasons above led to the drastic drop of net primary production of grassland ecosystem in Inner Mongolia in the past 50 years .

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Spatial patterns of main species of the grassland community in the recovering succession in Wangong sandy land

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Key words : wangong sandy land , recovering succession , grassland , community , spatial pattern

Introduction Stocks edge of the ecological and biological special character and the dynamic development in the community's appearance , structure and succession have an important impact on the direction . Population is the important character of population distribution pattern of ecological and biological aspects . Spatial pattern of the community structure is the basic form of one of the process Through the distribution pattern of population in the community , people can understand the status and role about the community , further know the situation in the mosaic of species and master of laws and the interaction between the community structure and dynamics

Materials and methods Wild grassland desertification selects mildly , moderate grassland desertification and severe grassland desertification plots are typical of the group . As setting up two pilot-line , one of which is still on the line . Using conventional investigation methods , each community type samples 30 and a total of 120 , and at the same time investigate the density of plant species , height and coverage . Population density is used as the number of characters in the pattern of population distribution .

Results and discussion Spatial patterns of main species in grassland community in the recovering succession were measured with 6 indexes , such as dispersion index , clump index , mean crowding intensity ,patchiness index , Green's index , the clump intensity index .Almost all of the spatial patterns of the main species of the grassland community in Wangong sandy land were clump . Clump distribution had a good advantage of promoting population invasion and inhabitation , community formation and vegetation restoration . In the process of community succession , the intensity of distribution pattern changed . This change could indicate population dynamics and pattern intensity which can be a measurement for spatial heterogeneity of community structure .

Species	Diffusivity	Full index	Negative two parameters	The average degree of overcrowding	Block index	Green index	Type of pattern
L . chinensis	8 .350	7 .350	0 .014	222 .750	1 .034	0 .490	Aggregation
Bupleurum	15 .223	14 .223	1 .653	37 .723	1 .605	2 .031	Aggregation
Stipa	93 .274	92 .274	3 .258	393 .607	1 .306	11 .534	Aggregation
Astragalus	1 .067	0 .067	160 .287	10 .847	1 .006	0 .007	Randomness
Species	Diffusivity	Full index	Negative two parameters	The average degree of overcrowding	Block index	Green index	Type of pattern
Salsola collina	3 .748	2 .748	9 .260	28 .418	1 .107	1 .374	Aggregation
bristlegrass	5 .552	4 .552	6 .120	32 .212	1 .165	2 .276	Aggregation
Corispermum	4 .223	3 .223	3 .724	15 .223	1 .268	1 .610	Aggregation
Serratula potanini	15 .008	14 .008	1 .080	29 .118	1 .927	1 .751	Aggregation

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Livestock diversity and climate change in rangelands

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Key words: livestock, animal genetic resources, climate change, rangelands

Introduction Domestic animal diversity is critical for food security and rural development. The 40+ domesticated animal species contribute directly and indirectly to 30-40% of the total value of food and agricultural production. In marginal environments, livestock is often the only means of survival. Today, there are 6536 local breeds reported by only one country, and 1080 transboundary breeds that occur in several countries, many of which are adapted to dry rangelands. Animal genetic diversity allows farmers to select stocks or develop new breeds in response to environmental change, threats of disease, changing market conditions and societal needs. However, animal genetic diversity worldwide is under threat. About 20% of reported livestock breeds are currently reported as being at risk, and the loss of within-breed diversity is not even known (FAO, 2007a).

Impact of climate change on livestock production and diversity Livestock producers will have to cope with both, slow climatic changes and more frequent extreme climatic events. It is expected that climate change will affect livestock production and productivity directly and indirectly. Its impact on livestock biodiversity is difficult to assess.

Direct impact Loss of animals through droughts and floods, or disease epidemics related to climate change may increase. If breeds occur only locally, there is a risk of them being lost in localized disasters.

Dry rangelands are some of today's most extreme environments. In the Near East, 90% of all breeds are kept in drylands. In Africa, these are 56%, 42% in Asia and only 19% in Latin America. On average, 46% of the breeds in the four regions are adapted to drylands. The distribution of some domesticated species, such as camelids, is restricted to drylands. More than 70% of the breeds of asses, 30% of horse, around half of sheep and goat and a third of cattle breeds are adapted to drylands. Further selection for breeds with effective thermoregulatory control will be needed to cope with climate change. It may be difficult to combine the desirable traits of adaptation to high temperature environments with high production potential. At higher temperatures, species substitution could be an option. The speed of adaptation will be crucial. If the available breeds cannot be selected fast enough to adapt to climate change, an increased need for movement of breeds which carry the desired traits will occur. This would require that livestock keepers, particularly pastoralists, continue to have access to a wide portfolio of genetics. They also need access to technologies for dealing with climate stress in animal husbandry.

Indirect impact Water, feed and fodder are the most important inputs for livestock production. Their overall and relative availability may be affected by climate change. This may be particularly crucial in rangelands.

Livestock contributes to and will be affected by climate change. Livestock now use 30% of the earth's entire land surface, mostly permanent pasture but also including 33% of the global arable land used to producing feed. The sector is crucial for adaptation and mitigation of climate change-because the livestock sector is a large producer of greenhouse gases (GHG) (18% of GHG emissions as measured in CO_2 equivalent are attributed to livestock, through enteric fermentation, land use and land-use change, and manure management) (FAO, 2006). Therefore, the various climate change mitigation policies and technologies are expected to influence the livestock sector. Ruminants supporting livelihoods in marginal rangelands or those used for landscape management may be excluded from GHG regulations, and improved pasture management for CO_2 sequestration should be encouraged.

Conclusion Long-term breed survival depends on the comparative advantage of the breed to provide the desired goods and services in a given environment. The past century has seen a dynamic sector development, and climate change will be one factor in addition to human population and technological advance, with socio-economic and biophysical components interacting at different scales. For the sector to be able to adapt to different scenarios of climate change, the international community must ensure the availability of a wide portfolio of animal genetic resources to livestock keepers and breeders. It must also undertake to facilitate exchange of animal genetic resources for food and agriculture and to promote technology transfer. The recent adoption of the *Global Plan of Action for Animal Genetic Resources* and the *Interlaken Declaration* by the international community provide for the first time an internationally agreed framework to promote creating these crucial conditions for the global livestock sector (FAO, 2007b).

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Authors Index—Volume Ⅰ