Livestock grazing and biodiversity in semi-natural grasslands

Bertrand Dumont, A.G. Thorhallsdottir, Anne A. Farruggia, A. Norderhaug

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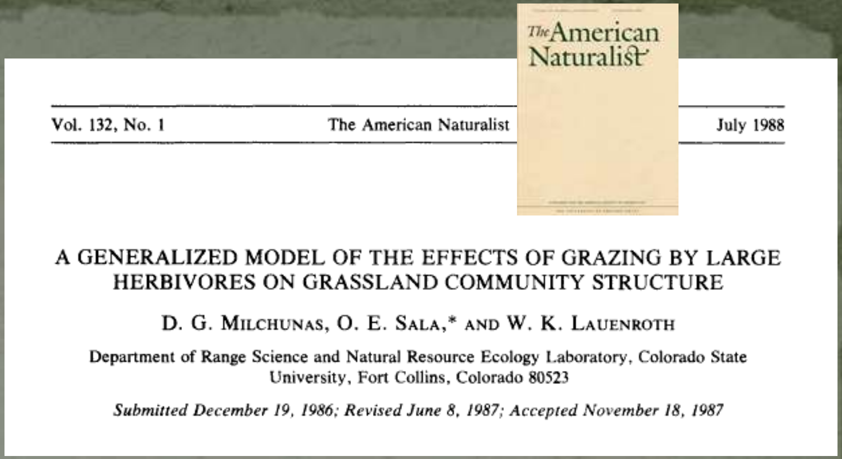
Grass-dominated ecosystems

Approximately one-third of the Earth's vegetative cover is savannah, grassland and other grass-dominated ecosystems

Grasslands

- Climatically-determined
  - Savannah and shrub steppe
  - Natural grassland
- Successional/agricultural
  - Maintained by grazing and other agronomic practices
  - Semi-natural grassland
- Not as clear division as previously thought
- Natural grasslands often proved to have a more anthropogenic background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A GENERALIZED MODEL OF THE EFFECTS OF GRAZING BY LARGE HERBIVORES ON GRASSLAND COMMUNITY STRUCTURE

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European grasslands

- Mainly successional/agricultural grasslands
  - Middle and south Europe
    - Agriculture has conquered most of the landscape for the last 9000 years
  - Northern Europe and Scandinavia
    - Pre-industrial agriculture (6000 yrs) based on animal husbandry and grazing of semi-natural grasslands
  - Iceland
    - Shorter grazing history: settlement during the 9^{th} century
    - A long-held view that sheep grazing is the culprit for land degradation and soil erosion
    - Grazing exclusion & re-seeding for ecosystem restoration

➔ Different views on grassland conservation

European grasslands

- Provide a large proportion of animal proteins
- Host a wide diversity of plants, animals and microorganisms of functional or patrimonial interest
- Face new social expectations
  - Support for other agricultural systems (pollination)
  - Landscape production

- How to conciliate production and other ecosystem services, while reducing the environmental footprint of livestock farming systems?

Threats on biodiversity

- Intensification in land use
  - Cultivation and fertilization
- Abandonment of marginal areas
  - Shrub encroachment
- Fragmentation of habitats

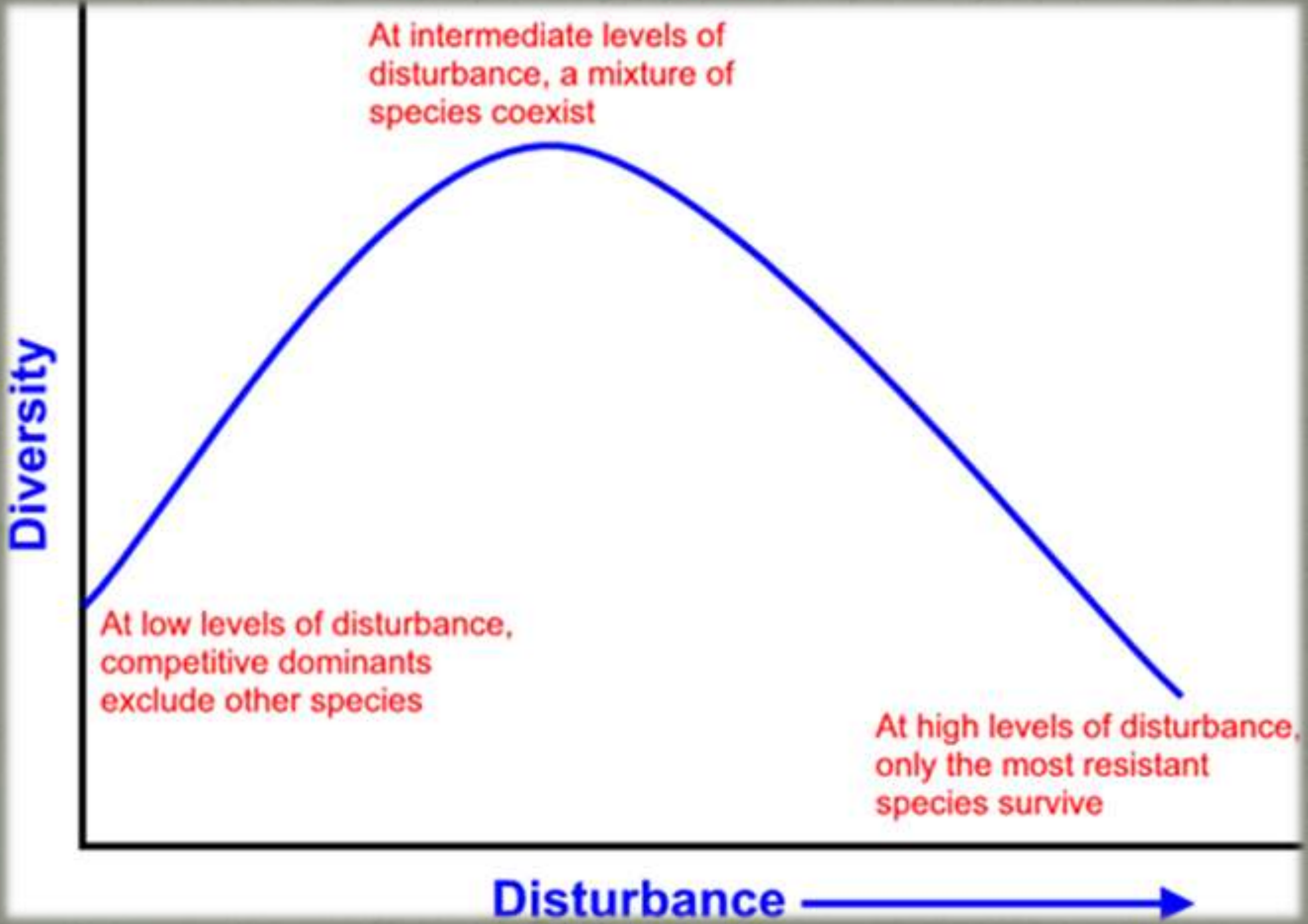
Grazing by livestock can be seen as a conservation tool with positive effects on biodiversity, but the quality of the management regime and grazing history are decisive

Grazing as nature conservation tool

- Grazing
  - One of the main drivers of global vegetation dynamics
- The effect of grazing
  - Grazing history
  - Livestock species and breed
  - Pasture productivity
  - Grazing intensity
  - Grazing period
  - .....

- The connection between grazing and biodiversity

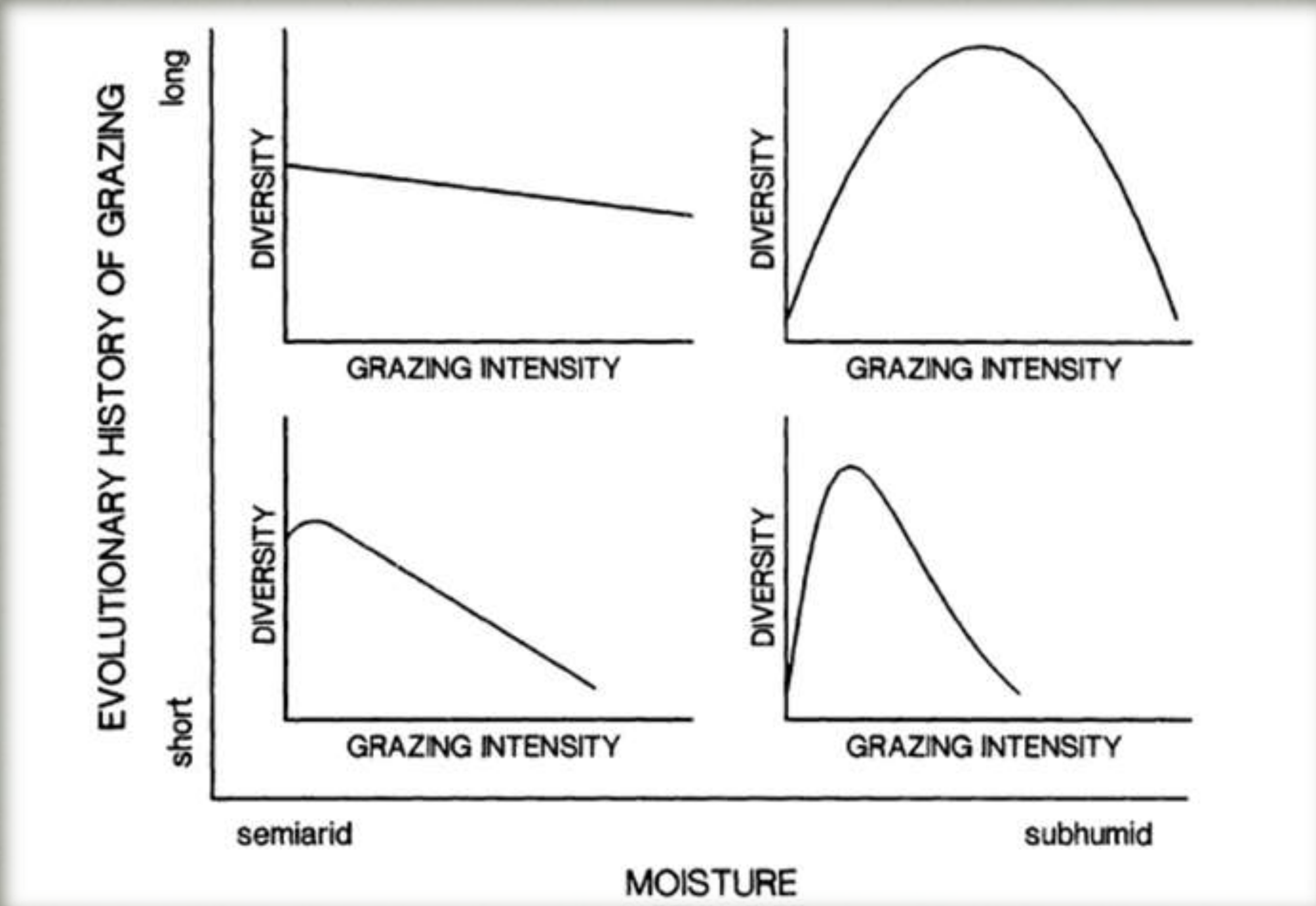
Intermediate disturbance hypothesis



i.e Connell 1978; Wilkinson 1999

Grazing is disturbance

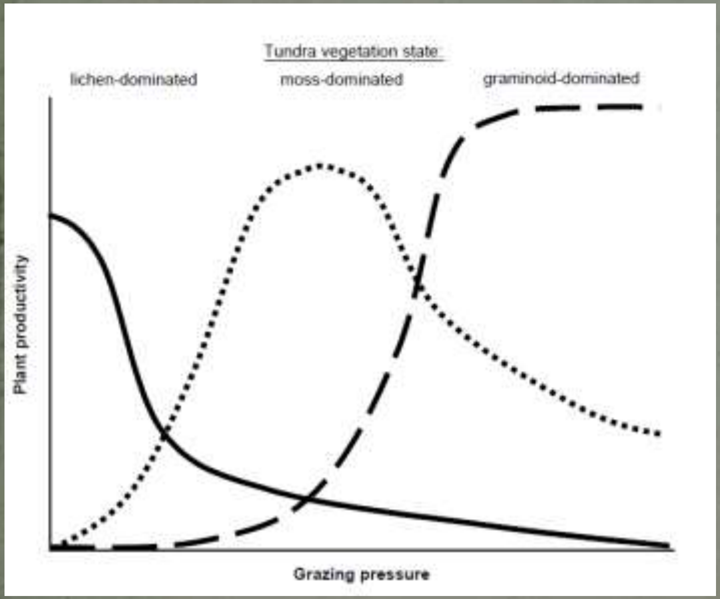
Relationship between grazing and biodiversity is a function of environment moisture and grazing history



Milchunas *et al*. 1988

Further development

- Moisture gradient generalized to a productivity gradient
- Incorporation of the state and transition model (Westoby *et al.* 1989) predicts that grazers can create alternative equilibria



- According to grazing pressure, we get different sward composition
- An example of different alternative stable stages in tundra ecosystems: the most productive and resilient grassland is created and maintained by large herbivores

Milchunas & Lauenroth 1993; van der Wal 2006; Blinnikov *et al.* 2011

Grazing creates mosaic of habitats

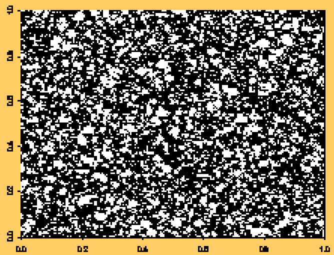
- Defoliation
- Trampling
- Dung deposition

Creating mosaics of short and tall patches, contrasting growth forms and competitive interactions

- Animals select for short rather than tall patches (patch grazing, Adler *et al.* 2001)
- Patch stability…

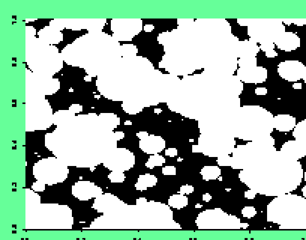
Inter-annual patch stability

Poor grasslands



Fine-scale stability patterns explained by Δ in plant palatability and local abundance

Large-scale stability patterns favour functional divergence



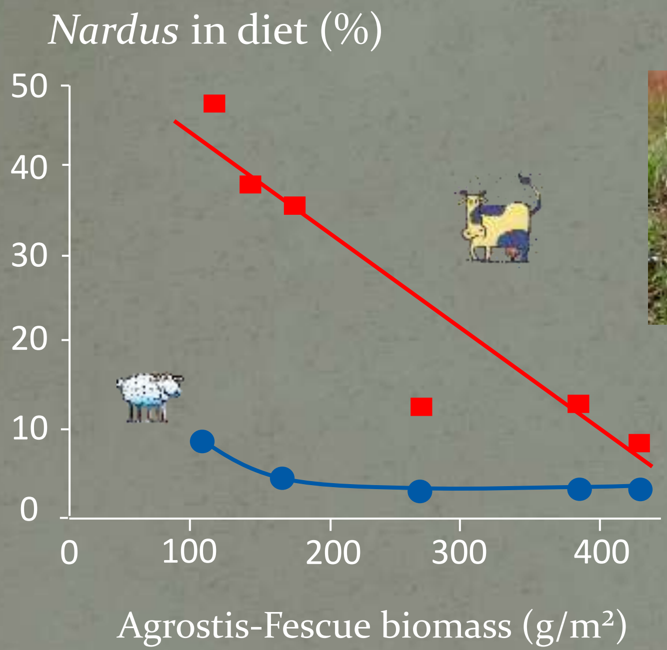
Mesophile grasslands

Large stable patches more frequent in lightly-grazed, productive swards

Rossignol *et al.* 2011; Dumont *et al.* 2012

Livestock species and breed

- Size matters !!!
  - Differences in requirements / gut capacity, in the ability to sort out preferred items and graze short swards, in digestive capacities



Grant *et al.* 1996

After 5 years, *Nardus* :

55-86% 

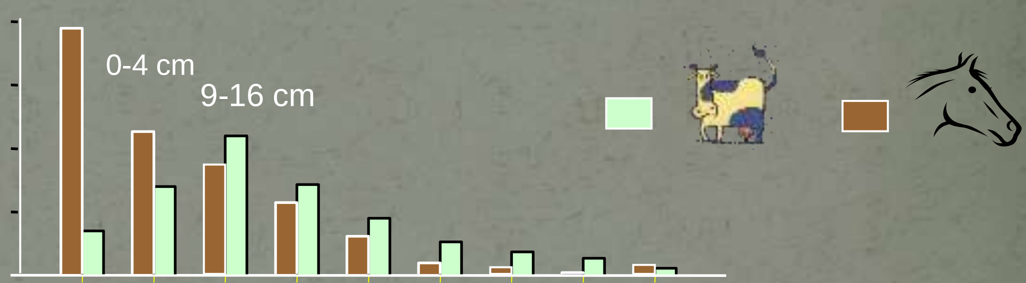
30-55% 

- In temperate grasslands, ≠ in size and experience in the young age explain most breed effects; stronger effects in constraining environments (Sæther *et al.*, 2006)

Horse grazing

Two rows of teeth ➔ Grazing short lawns

Time spent grazing (%)



Sward height

Ménard *et al.* 2002

➔ Stable patches in horse-grazed pastures

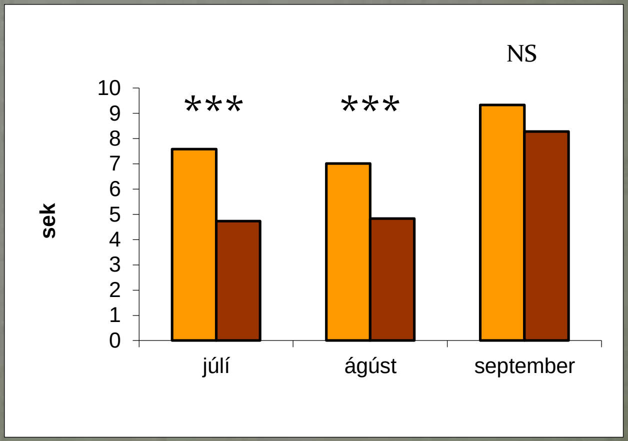
Different digestive regulation ➔ Roughage consumption

➔ Impact on sward composition

Biodiversity affects foraging behaviour

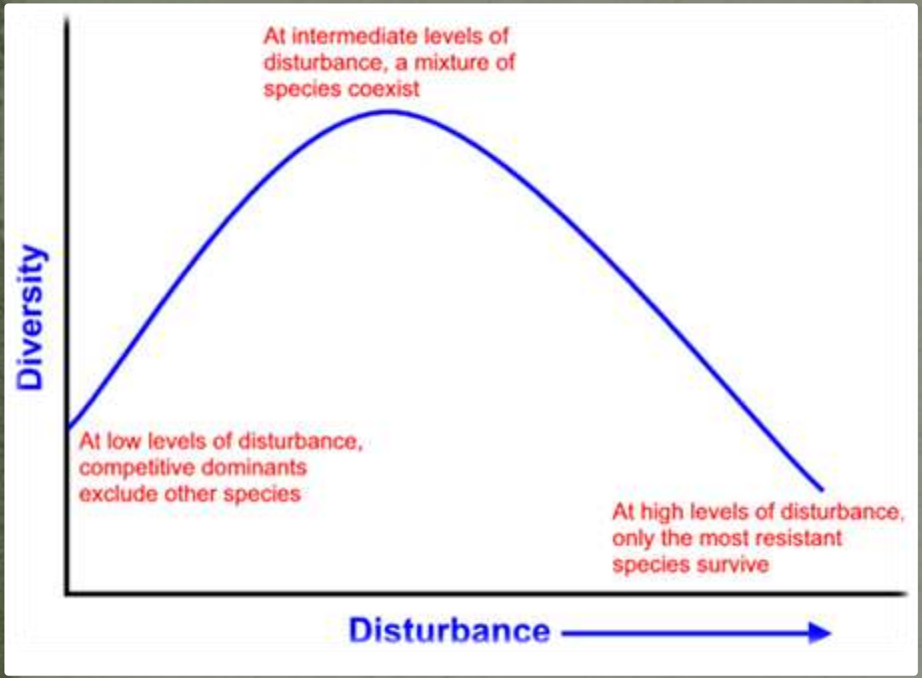
- Grazing horses in W-Iceland
- Two areas
  - High biodiversity - 30 species
  - Low biodiversity - 10 species
- Time at each feeding station (*Marginal Value Theorem* as a reference model)
  - Gain at each station
  - Traveling time between stations
- Stay shorter at each feeding station in high biodiversity
  - More to gain at the next station…

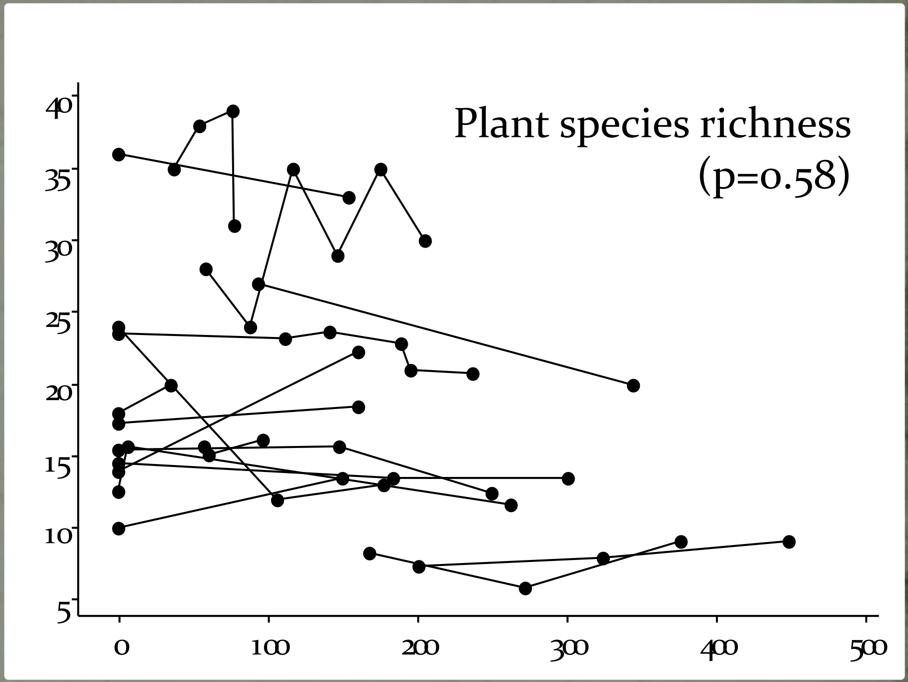
Feeding station



Time at each feeding station

Grazing intensity





Grazing intensity (LU.day/ha)

Grazing intensity (LU.day/ha)

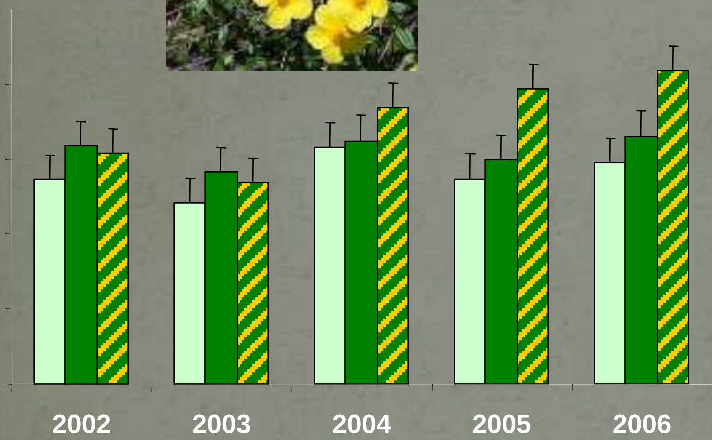
Scohier & Dumont 2012

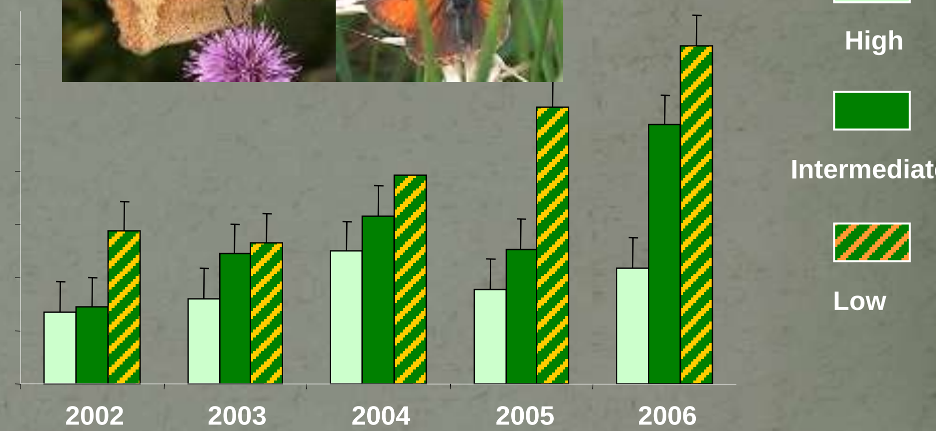
Observations did not fit predictions of the theoretical model !!!

Need to be tested with other species

Shifts in functional group abundance more rapid than changes in sp. richness

Grazing intensity





Dumont *et al.* 2009

Butterfly dynamics matches that of flowering plants ➔ Trophic hypothesis
(Loertscher *et al.* 1995; Collinge *et al.* 2003; Öckinger *et al.* 2006)

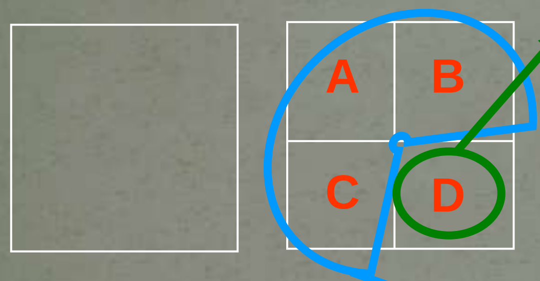
Sward heterogeneity provides more diverse habitats and microclimate ➔ Habitat heterogeneity hypothesis (Dennis *et al.* 1998; Wallis De Vries *et al.* 2007)

Less risk of negative direct effects (Lenoir & Lennarston 2010)

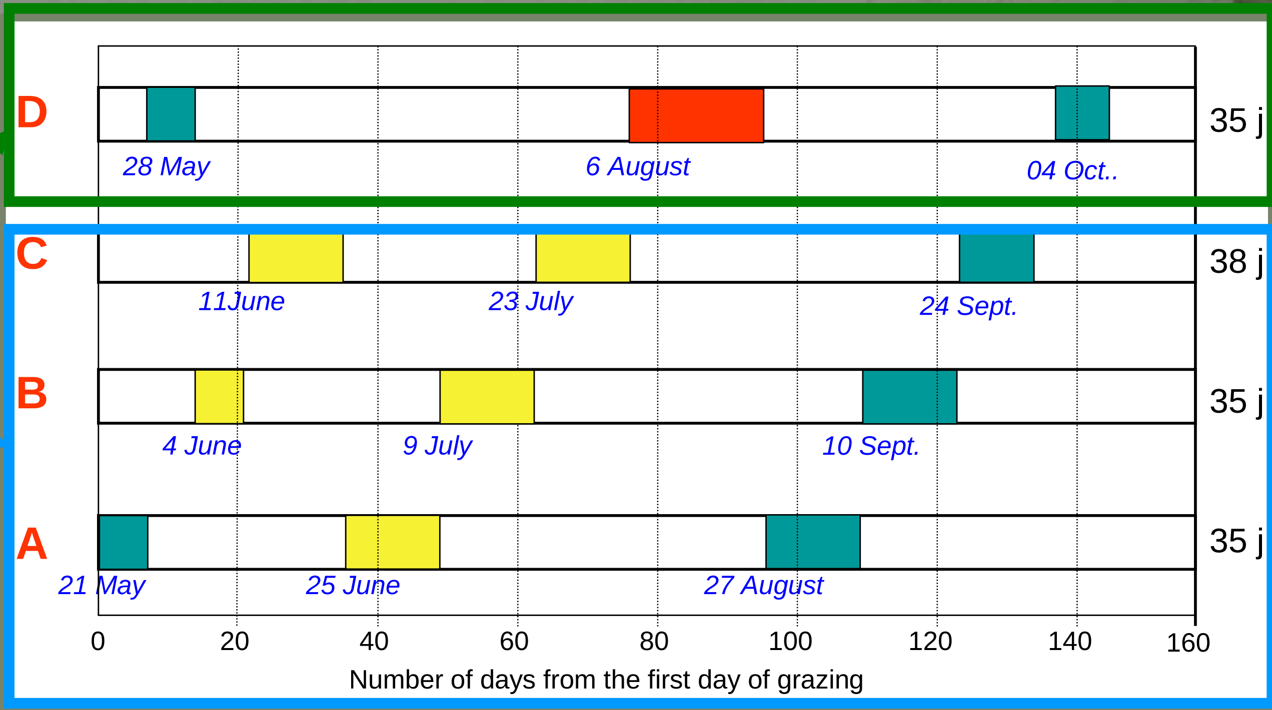
Grazing period

Continuous grazing

Ecological rotation



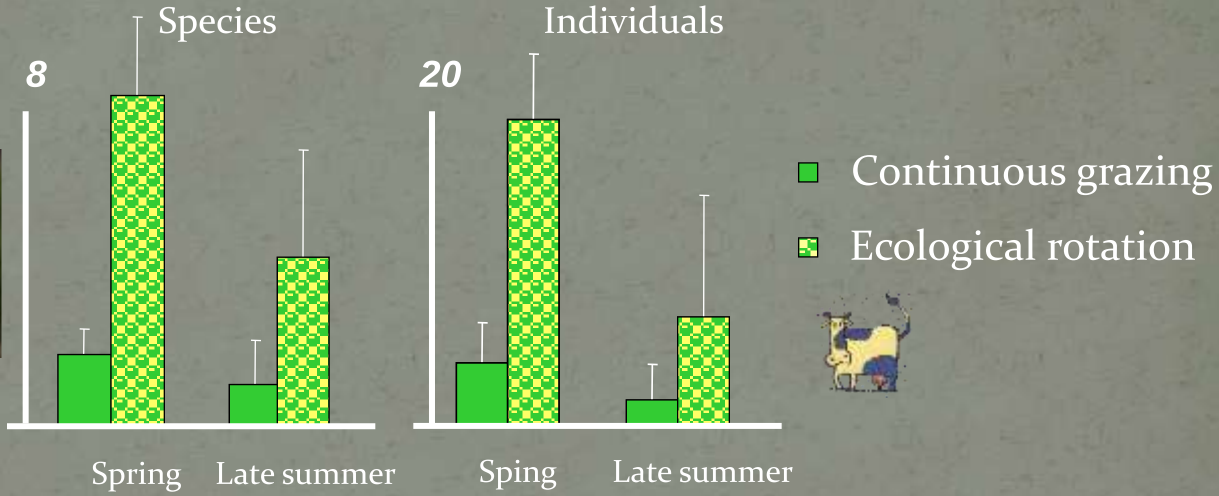
7  / plot (3,6 ha)



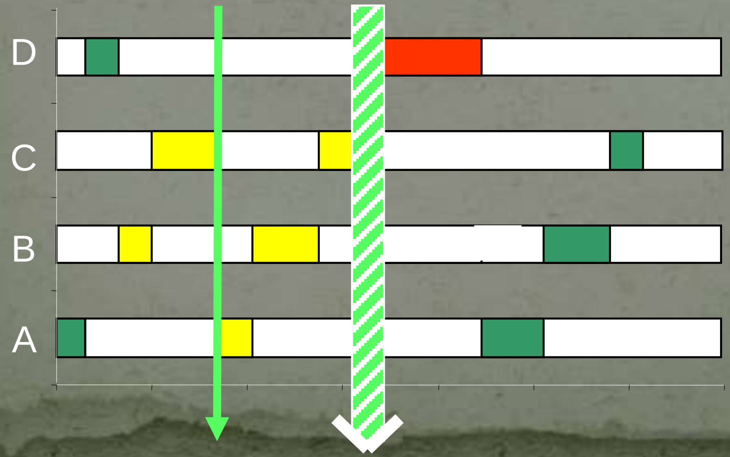
Preserving flowering intensity and sward heterogeneity is assumed to benefit nectar-feeding insects

Grazing period

Ecological rotation increased flowering intensity and sward heterogeneity



Farruggia *et al.* 2012



-19% grazing d. a year of poor spring growth

Grazing period

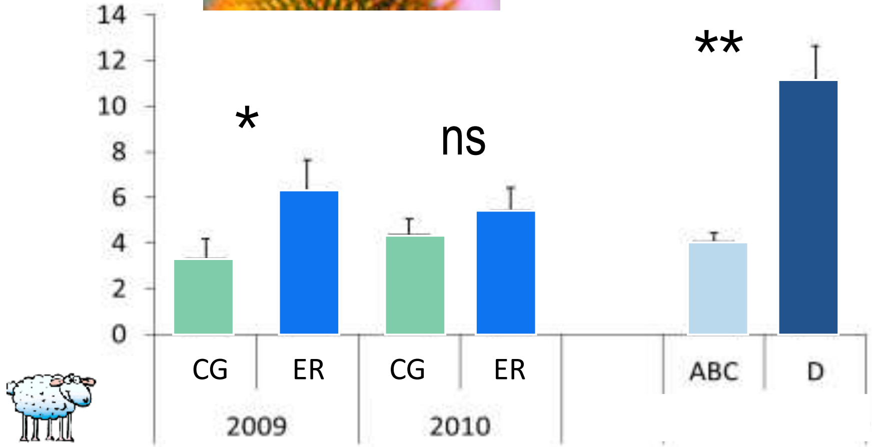
Benefit was lesser in sheep-grazed pastures

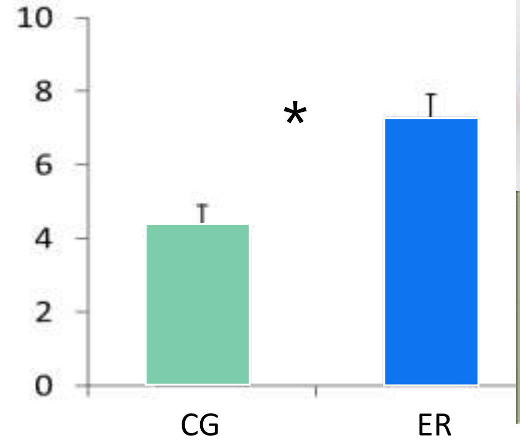
CG = ER

Same daily liveweight gain

Context affects the success of grazing practices!

Density



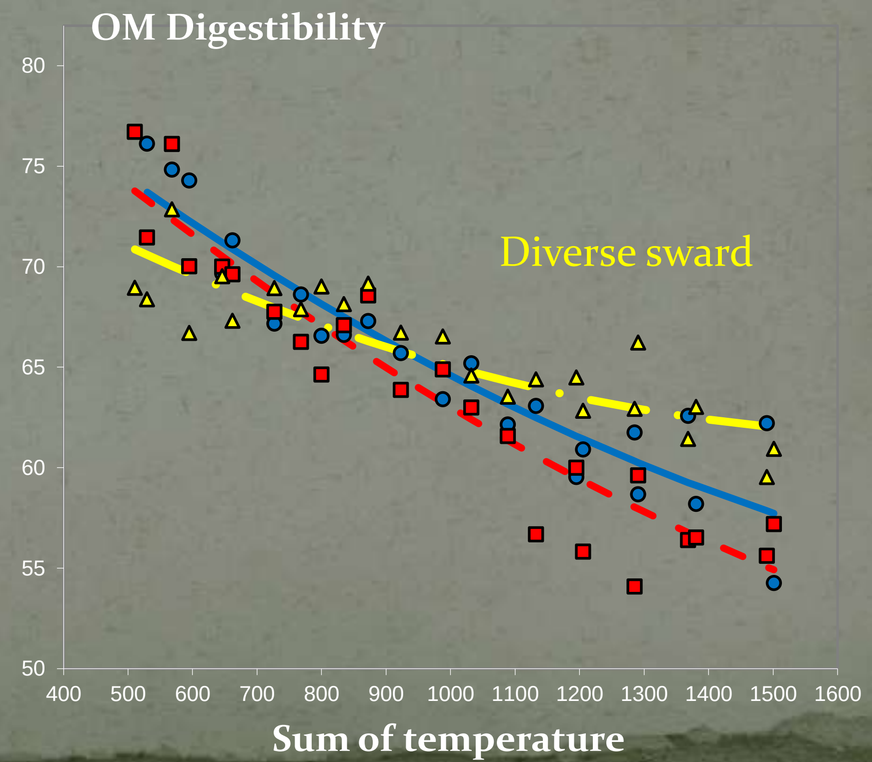


Scohier *et al.* 2013

Biomass, dynamics of sward production

- Greater stability of biomass production in diversified grasslands due to variability in plant species response to abiotic conditions, and asynchronicity of these responses (Yachi & Loreau 1999; Tilman *et al*. 2006)

- Greater stability in the digestibility of diverse swards (Michaud *et al*. 2011)



Milk from diverse pastures is richer in fatty acids (benefit to human health)

Maize silage → **Lowland pastures** → **Diverse upland pastures**

C18:3*n*-3 (omega 3)	+1,0	+0,8 (g/100 g AGT)
CLA-*c*9*t*11	+0,6	+1,3

(Ferlay *et al.* 2006, 2008)

(Lucas *et al.* 2006; Chilliard *et al.* 2007)

→ The abundance and diversity of dicotyledonous plants reduce ruminal biohydrogenation, which leads to a weaker transformation of omega 3 and CLA in the rumen

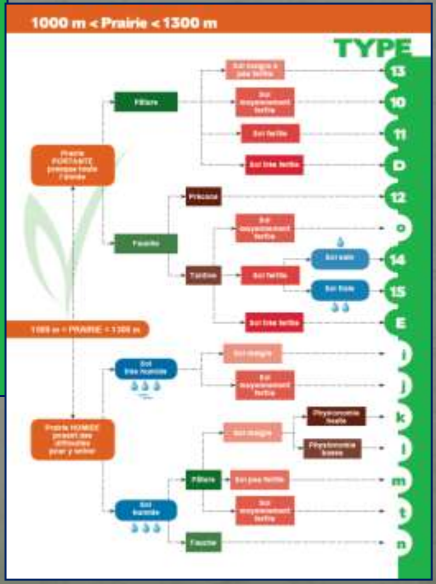
Grassland typology: a tool to evaluate multiple services provided by diverse grasslands

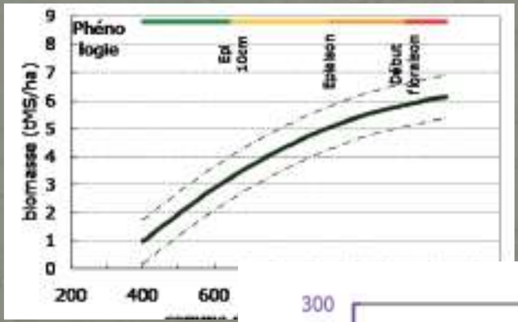
- 23 vegetation types defined based on altitude, practices, moisture and fertility gradients

Botanical composition

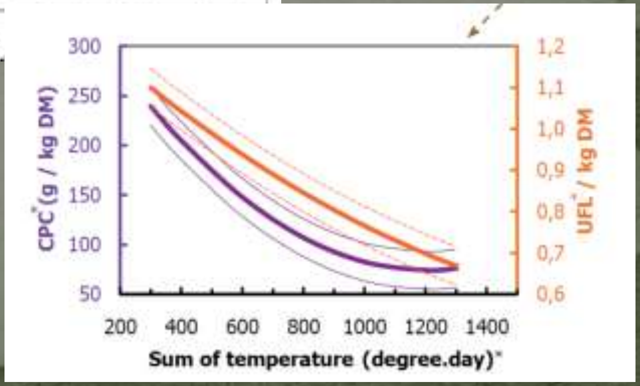
Dominant species

Indicator species





Agronomic potential
(biomass, quality)



A simple way to express services provided by each sward type

Provisioning services

- ❖ **Yield**

- ❖ **Production seasonnality**

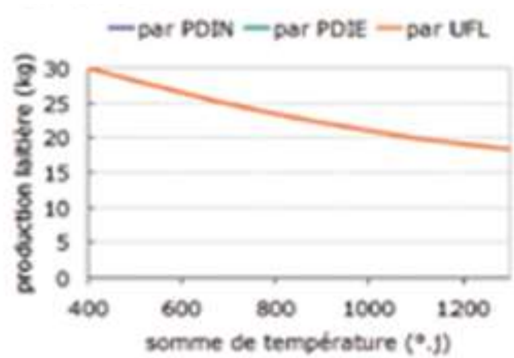
At 400 °C 60% of grass are vegetative

At 800 °C 80% of grass culms above 10 cm soil level

- ❖ **Forage nutritive value**

- ❖ **Management flexibilty**

- ❖ **Allowed milk production**



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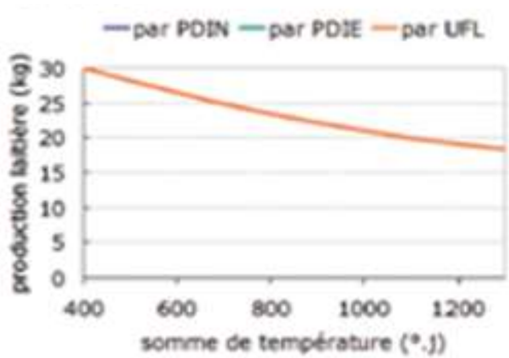

Cheese quality

❖ **Organoleptic potential**

Colour	Flavour
4/4	1/4

❖ **Nutritional potential**

Antioxydes	Insaturated fatty acids
3/4	3/4

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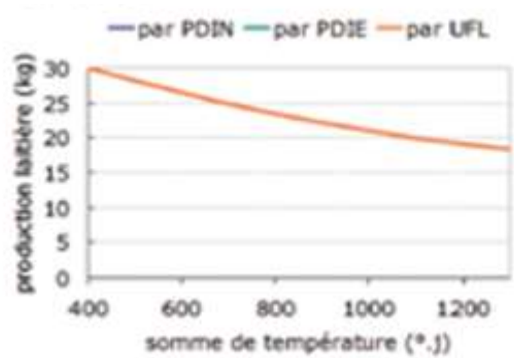

Regulating/cultural services

- Carbon sequestration
- Botanical patrimonial interest
- Colour diversity
- Pollinisation impact
- Fauna

Cheese quality

- Organoleptic potential

Colour	Flavour
4/4	1/4

- Nutritional potential

Antioxydes	Insaturated fatty acids
3/4	3/4

Basis for a multifunctional diagnosis tool to characterise services at farm scale

Designed for farmers and extension services

System description

Farm plots ⟷ **Herd**

Diversity of vegetation types, practices, grazing intensity

Animal requirements, milk yield, calving dates, concentrate

Analysis
(4 agregated criteria)

- Forage system 'consistency'
- Ecosystem services
- Quality of dairy product (cheese)
- Forage autonomy (PDO rules)

Take-home messages

- Grazing history led to different views of the role of livestock grazing with regard to grassland biodiversity
- Cows, sheep and horses have a role to play
- Taking account of fertility, grazing intensity, grazing period allows to define proper management
- Highlight the benefits of sward diversity and heterogeneity
- Diverse swards provide a wide range of ecosystem services
- New tools need to be developped to assess sward and forage system multifunctionality

Thanks for your attention

24-26 June 2014, Clermont-Ferrand, France

Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands

3 other resaons to come to Clermont

- Nice landscapes and the only other place in Europe where you can find andosols (Helgadóttir *et al*., 2013)
- Akureyri is the most beautiful town in the World and where you can eat the best lamb…

… but Clermont-Fd is the second most beautiful town in the World and where you can eat the best cheese!

- « Clermont-Ferrand has the best rugby team in Europe, second best is Munster » (J.D. Murphy, pers. comm.)