SYLVOPAST: a multiple target role-playing game to assess negotiation processes in sylvopastoral management planning

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Abstract

After a brief description of the framework of the model developed to simulate vegetation dynamics, fire propagation and agents' behaviour, the role-playing game rules are presented and related to the different points they are supposed to deal with: climatic hazard, animal grazing, forest management, grazing duty, financial support. The results of several sets of game sessions are analysed according to markers based on the main stakeholders viewpoints, leading to an evaluation of the negotiation process and to the way land was structured as a result of a step-by-step compromise between the players. General conclusions are drawn on how such type of role-playing games can provide a methodological framework to build up negotiation support tools and can be used with different kinds of persons.

Keywords:
Agent-based Modelling; Multi-agent System; Negotiation; Role-playing Game; Sylvopastoral Management

Introduction

1.1 During the last decade, socio-economic and technical studies on the development of sylvopastoral systems in French Mediterranean forests have identified a set of key constraints as well as some specific management indicators. Enquiries on the social perception of forest grazing have demonstrated the emergence of a feeling of power loss by foresters and hunters (Rovira 1993) and pointed out the need to take into account the multiple use of Mediterranean forests (Etienne 1990) in order to avoid land-use conflicts (Etienne et al 1998). Studies on management systems have shown the difficulties to adapt flock management constraints (Etienne 1996) and grazing calendars (Bellon and Guérin 1996) to sylviculture agendas (Chaumontet et al 1996) and forest use planning (Gauthier 1993). Finally, economic assessment of fire prevention management plans have shown not only how livestock production can reduce operating cost but also the need of public incentives to support the sustainability of the plan (Coudour et al 2000).

1.2 Sylvopastoral management planning is supposed to organise with a long-term perspective, the deliberate retention of trees with animals in interacting combinations for multiple products or benefits (Nair 1993). Under Mediterranean conditions, forest operations are mostly developed for public benefit out of a variety of motivations, such as fire prevention, conservation and biodiversity, rural development or landscape management (Bland and Auclair 1996). When they are made by forest planners alone, forest management plans take little account of sylvopastoral management or fail because they are not based on a deep understanding of multiple use rules and constraints.

1.3 To avoid potential conflicts and to support the complex negotiation process during the establishment of a sylvopastoral management plan, a companion modelling approach was applied. It consisted in integrating the multidisciplinary knowledge acquired on French Mediterranean sylvopastoral systems into a model capable of representing the interactions between ecological dynamics and social behaviours (d'Aquino et al 2002). In order to help foresters and livestock farmers to better integrate these interactions into their planning work, a multi-agent system (MAS) was designed to simulate different management strategies and to compare their impact on forest quality. This model was simultaneously coupled with a role-playing game (RPG) initially developed as a didactic support to sylvopastoral training programmes. But, once tested with real partners (a farmer playing with the forester he has really to work with), the Sylvopast RPG rapidly became a key means of enriching and improving the representation of the negotiations and interactions between livestock farmers and foresters involved in the management of the same forest. It made it possible to place stakeholders in the prospective situation that confront them under new environmental and social conditions, following the approach developed by Mermet (1993) and Piveteau (1994). The originality here was to combine a modelling approach based on multi-agent systems with the RPG methodology tested by these authors (Barreteau et al 2001; Bousquet et al 2002). Another original aspect of the approach was to build a tool flexible enough to make it possible to play with actively involved stakeholders such as the current users of the resource (local farmers and foresters), with potential regulators of the system (managers or administrators), technical experts (extensionists, technicians) or learners concerned with the topic (students, scientists).

The design of the RPG

2.1 To design the conceptual model of the RPG, two fundamental questions had to be tackled: how can the evolution of a sylvopastoral system governed by contrasting pastoral and forestry management rules be simulated in a playful way, and how can such a complex system be represented in such a simplified way as to be easily shared by all stakeholders ?

2.2 To answer both questions, all the environmental part of the problem was simplified into a vegetation dynamics model capable of accounting for realistic climatic hazards, simulating shrub encroachment according to management practices and threatening all the land with a realistic fire hazard. For the social part of the problem, as the main goal of the RPG was to stimulate the exploration of desirable futures, game rules were widely opened so that players could select their primary goals, choose management options, and plan their activities as freely as possible. The only rule was for them to negotiate with one another at regular intervals.

2.3 In order to retain the most significant results of the games, it was also necessary to keep in mind two other questions: how can the most viable type of co-operation between partners in the medium and long term be evaluated, and does a unique optimal spatial structure reaching the objectives of each stakeholder really exist ?

2.4 The first question was tackled by considering that shepherds and foresters plan their activities in very different terms. Strategic time for the shepherd corresponds to the lifetime of a ewe (10 years) whereas it is as long as the lifecycle of dominant trees for the forester (100 years). Tactical time for the shepherd is one day (animals have to graze every day) whereas it lasts one year for the forester (operational plan). But to provide fun playing the game, it was necessary to speed the running time, to warrant easy use of the computer and to set up simple easy-to-apply rules. Another basic requirement was to use indicators easy to understand and memorise, and memorandums adapted to each type of player.

2.5 The second question was tackled by obliging the players to locate their actions on a spatial grid representing a virtual Mediterranean forest with a realistic ratio between vegetation types. The forest representation was virtual, in order to prevent local neighbourhood problems from interfering with the game and to decrease possible tension between the players due to their common experience in a real case. But it was soundly realistic to make certain that the players recognised the forest as a typical Mediterranean one.

The multi-agent system

3.1 According to the main needs of the two principal stakeholders mentioned in the literature, several key factors were selected with their corresponding criteria of decision. Shepherds are particularly concerned with forage seasonality, which depends on forest canopy cover, and with travelling distance from one grazing unit to the other. Foresters give priority to fuel stocking control, forest conservation and biodiversity enhancement. The action diagram summaries the main objects integrated into the model, their attributes and possible actions (Figure 1). The two UML sequence diagrams explain the ordered sequence of actions to be developed by each agent over time (Figure 2) and detail the flock management operation (Figure 3).

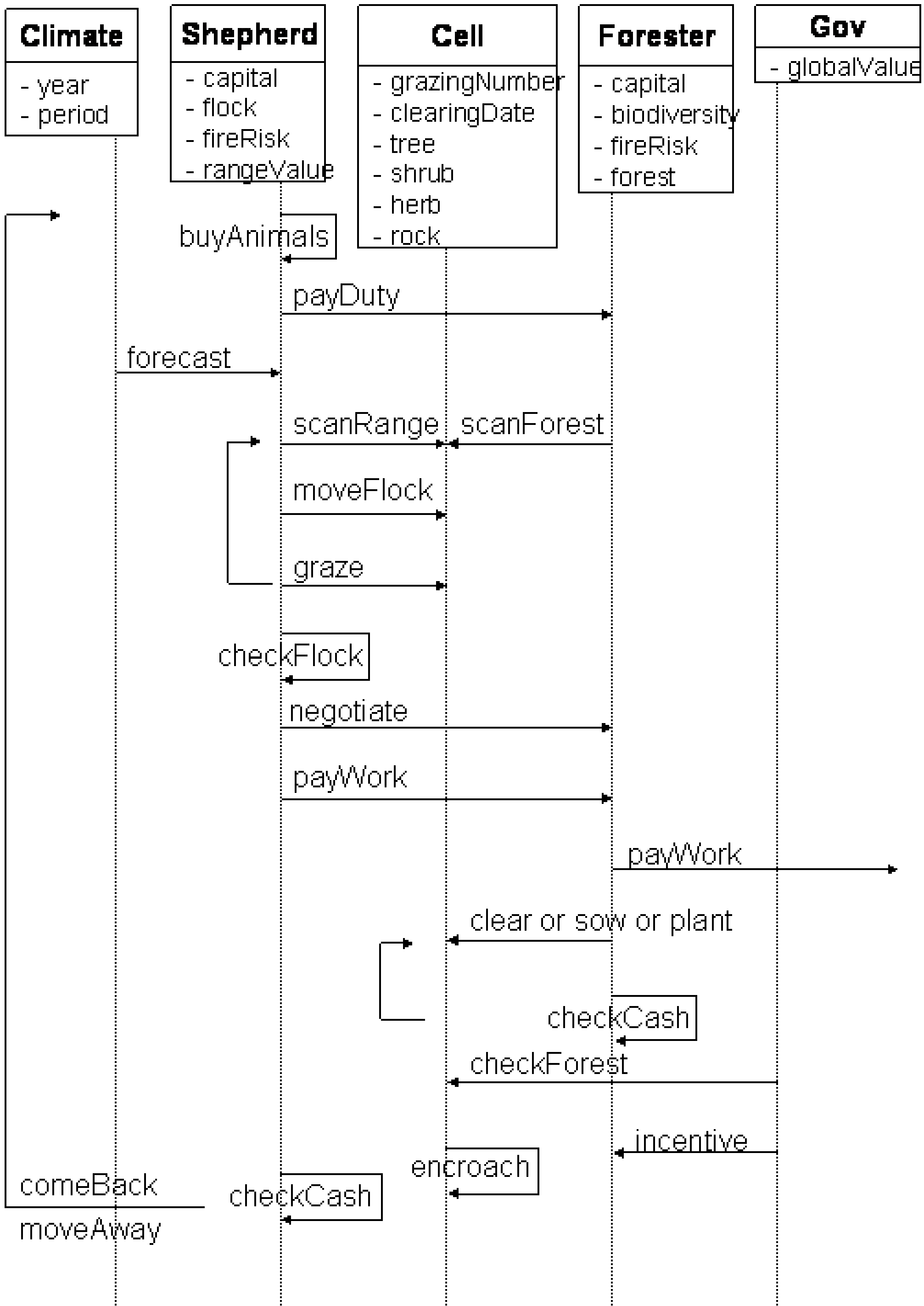


Figure 1. Action diagram of the Sylvopast model

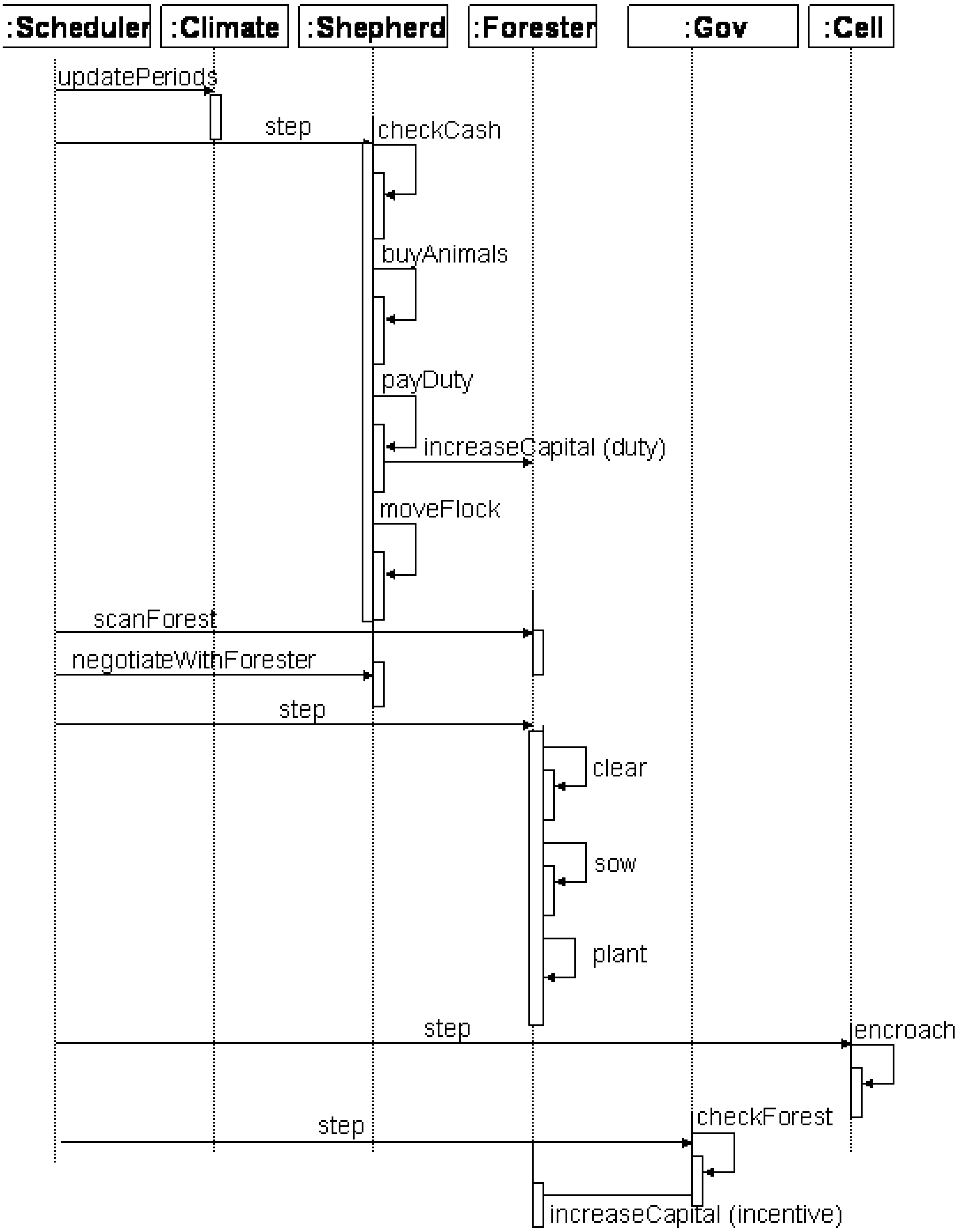


Figure 2. UML sequence diagram of the Sylvopast model

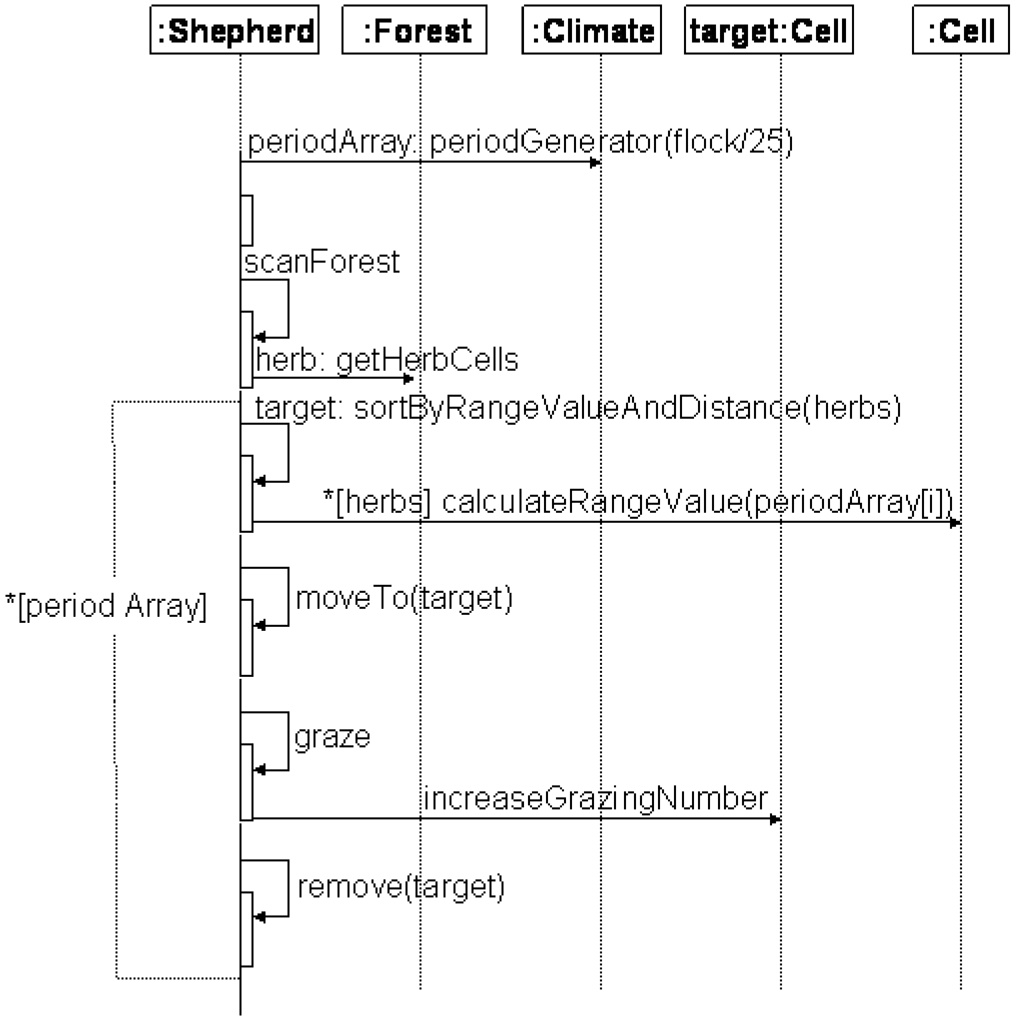


Figure 3. UML sequence diagram focusing on the grazing management

The ecological model

3.2 The basic principle behind the design of the ecological model is that the combination of basic plant types (tree/shrub/grass) can easily define the vegetation of any Mediterranean forest. These combinations lead to eight vegetation structures whose attractiveness differs depending on the user. Each vegetation type has its own natural dynamics running through the steps of natural succession. But this trend can be stopped by some catastrophic event such as a fire (Figure 4) or upset by activities such as grazing, shrub clearing or sowing, or else accelerated by tree planting (Figure 5). According to the recent literature available on French Mediterranean vegetation dynamics in relation with fire (Trabaud 1990; Arnaud 1995), shrub control (Etienne et al 2002) or grazing (Etienne at al 1996), a simplified model of vegetation dynamics was developed. It is mainly based on the transition states that are summarised in figure 4.

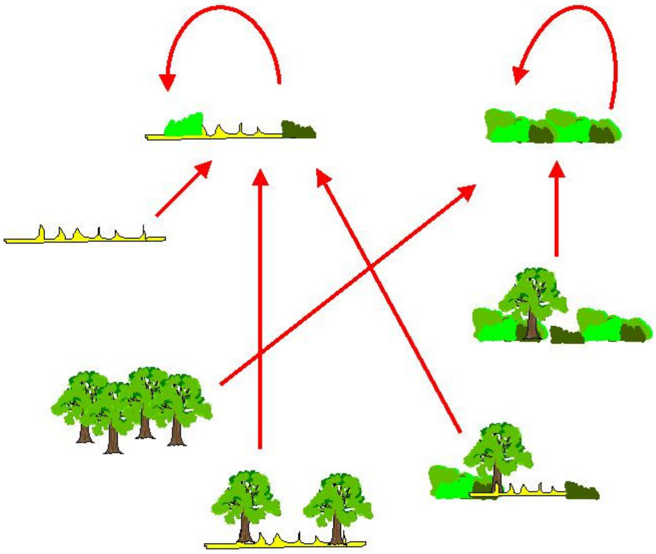


Figure 4. Transition states from grassland to woodland according to wildfires

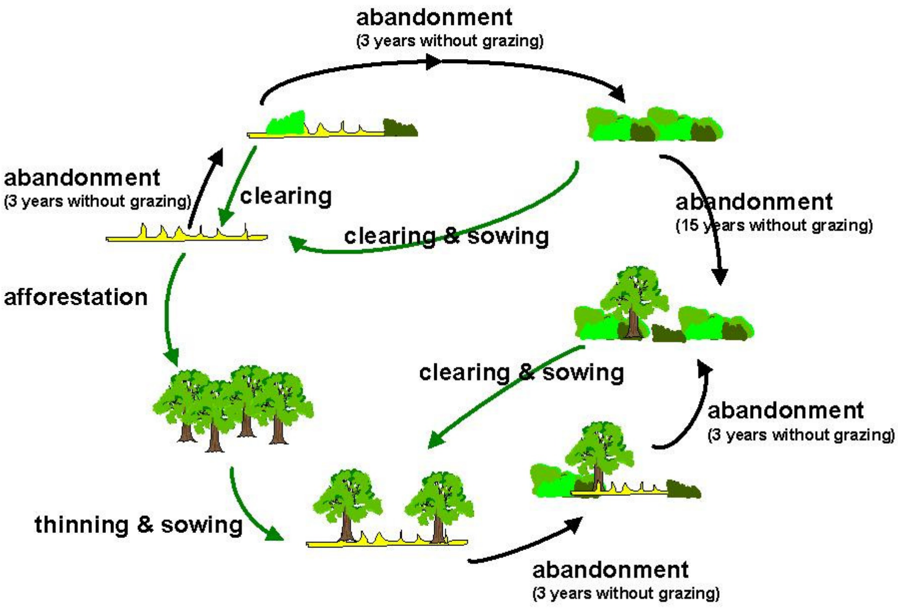
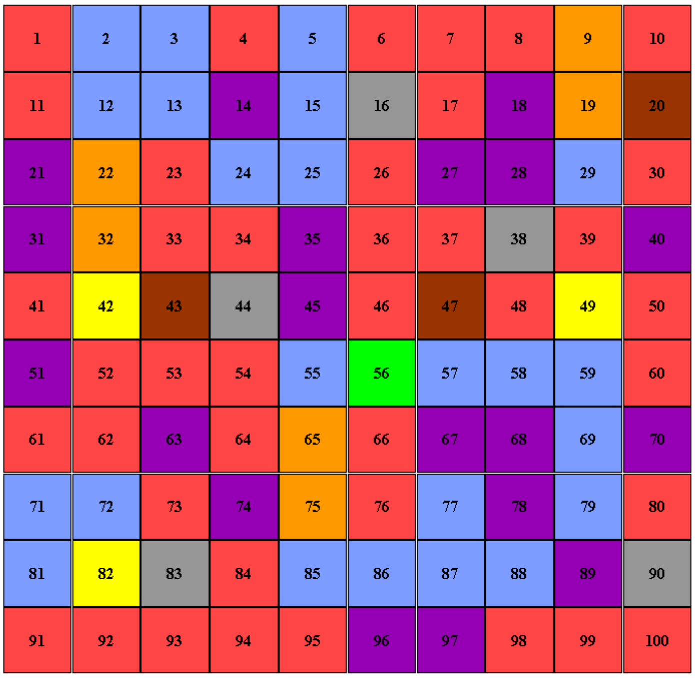


Figure 5. Transition states from grassland to woodland according to players operations

3.3 Fire dynamics was limited to simple fire propagation rules based on the wind direction and the amount of fuel weighted by the continuity between the different vegetation layers. The fuel criterion was synthesised into a fire risk index that also considered that in a grazed cell, the herbaceous layer does not produce any fuel. Then the propagation rule was very simple: when fire risk is null, fire stops; when fire risk is 1, fire is stopped in the neighbouring cell; when fire risk is 2, fire runs through the neighbouring cell; when fire risk is 3, fire runs through the four neighbouring cells.



3.4 The pastoral value of the vegetation depends on vegetation structure and climate (Armand and Etienne 1996). To simplify the game and on the basis of current observations on flocks grazing Mediterranean forests (Etienne et al 1996), vegetation types without grass were considered to have no pastoral value; and when grass is mixed with shrubs, productivity decreases. Compared to pure swards (table 1), the association of tree and grass enhances productivity when climatic conditions are dry because of better moisture conditions below the trees but depletes it a little when climate is rainy because of some lack of light (Etienne 2000).

Table 1: Grazing potential according to vegetation structure and climate

	Grass (G)	G + shrub (S)	G + S + tree (T)	G + T
Dry period	15	5	10	30
Mild period	30	15	15	50
Rainy period	45	20	15	40

The agent-behaviour model

3.5 The sylvopastoral management of Mediterranean forests implies the coordination of the two main agents: livestock farmers and foresters. But it also frequently involves other important categories of agents such as hunters, hikers or firemen (Etienne 1990). As a first step only the first two types were taken into account. The farmers were supposed to establish their farm near the forest and try to cover part of the requirements of their flock by having them graze the areas they were allowed to by the foresters. The observation of real cases for many years shows that farmers choose grazing units according to four main criteria: level of requirements of the flock, amount of forage available, climatic conditions and travelling distance (Etienne 1996; Etienne et al 2002). They plan their production system at two scales of time: a weekly or monthly scale for the grazing calendar, a ten-year scale for the ewe lifespan. Concurrently, Mediterranean foresters plan their operations on a yearly basis for the labour calendar or fire prevention, and a ten-year scale for tree regeneration and sylviculture. They schedule operations into some forest stands according to several goals. Regular clearings of the undergrowth are performed on zones strategically located to prevent fires from running across the forest or destroying the most productive stands. Selective thinning and clearing is applied to parts of the forest where biodiversity is looked after. Tree planting is developed in places where tree canopy is unsatisfactory or where a shift towards a more interesting dominant tree canopy is wished.

The role-playing game

4.1 In order to transform the MAS behaviour rules into game rules, each player was given the ability to do specific individual or shared actions. The farmer-player moves his flock from one cell to another, and can buy animals. The forester-player can modify the forest structure by using a set of three techniques: sowing (introducing grass) can be applied on any vegetation type without grass except rocks; clearing (getting rid of the shrubs) can be applied on any cell with shrubs and reforesting (planting trees) can be applied on any vegetation type without trees except rocks.

The game markers

4.2 To make their decisions or to argue during the negotiation, players need to share some markers and a common way of representation of the value of the markers. In Sylvopast RPG, markers were developed to define the vegetation structure, to evaluate management effectiveness and to measure cost-benefit efficiency.

4.3 First, the global spatial entity must be defined (Figure 6). The initial landscape is a virtual square forest of 100 cells subject to a westerly wind, and with some probability of fire and climatic hazards. The three primary colours represent the vegetation types dominated by only one plant type (blue for trees, red for shrubs and yellow for grass) and the other vegetation types are painted with the corresponding composed colour (e.g. orange for the overlapping of shrubs and grass). This marker is imposed by the model designer and must be rapidly learnt and adopted by the players at the beginning of the game. It allows monitoring of changes in the vegetation structure according to natural vegetation dynamics and technical operations. For instance, shrub encroachment occurs when a yellow cell changes to orange after three years without grazing; similarly, clearing applied on a brown cell changes its colour to green.

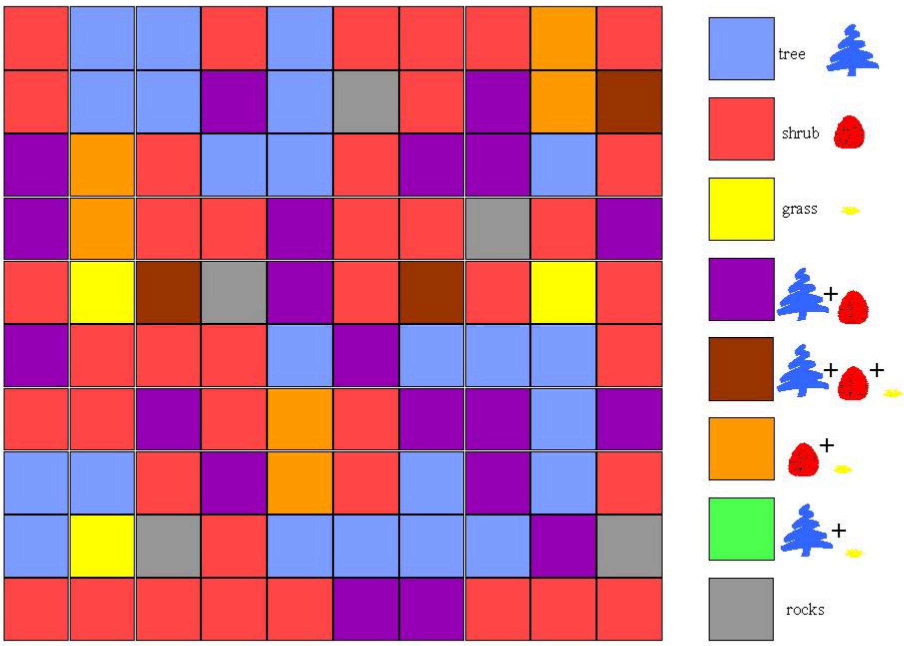


Figure 6. The interface of the Sylvopast model and RPG. The colours correspond to combinations of basic plant types

4.4 Management effectiveness is first linked with the way climatic variability and fire risk are taken into consideration during the game. For the climate, players know that a year can be dry, mild or rainy and how many dry, mild or rainy periods will occur during these types of year. But, as in the real world, they don't know in advance which type of climate is going to occur as the type of year and the climate of a period are sorted by the computer. For wildfires, the players can monitor the fire propagation index that is automatically calculated and summed up as the forest fire risk index or displayed on a map at the end of each turn. Obviously, as fire occurrence and setting place are difficult to foresee, they are randomly sorted by the model, fire being always set in a place encroached on by shrubs (red, orange, brown or purple cells).

4.5 Management effectiveness is also directly linked to the fulfilment of the objectives of each player. The farmer-player can monitor the grazing impact by checking the amount of forage collected in the forest and the amount of energy spent travelling. He can also evaluate if the forest was improved by the technical operations by means of the pastoral value index that is automatically calculated as the sum of the average forage productivity of each cell.

The forester-player can monitor two indexes that account for each of the goals he can aim for. The forest index gives an idea of the area covered by pure tree stands (number of blue cells); the landscape diversity index measures the global diversity of vegetation structures in the forest (note over 100).

4.6 Finally, all the technical operations have a cost which can be specific to a player (e.g. grazing duty must be paid by the farmer) or shared (e.g. shrub clearing) and they are planned every year at the end of the negotiation. The players have to avoid too many expenses and to secure enough incomes so their capital does not drop to unauthorised levels. The forester cannot run into debt and the farmer leaves definitely the forest if he is not able to cover, by grazing the forest, the maintenance requirements of 80% of his flock. The farmer's income comes exclusively from grazing whereas the forester's comes from the grazing duty and a government incentive. Wildfire occurrence and the average state of improvement of the forest determine this incentive. Fire risk decrease, landscape diversity increase and forest area increase are considered to be improvements. If the sum of the three markers is positive, the forester gets the incentive; if it is null or negative, he does not (table 2). After each wildfire, the forester gets a fixed amount of financial support to help him restore the forest.

Table 2: Mode of calculation of the average state of the forest

	Fire risk	Landscape diversity	Forest area	Average state
Turn 3	**200**	**22**	**21**	
Turn 4	**198**	**26**	**20**	
Turn 5	**198**	**28**	**19**	
Improvement 4/3	**+**	**+**	**-**	**+**
Improvement 5/4	**O**	**+**	**-**	**o**

The game rules

4.7

Shepherd player: A grazing duty corresponding to the size of the flock (1 per animal, starting at 250), has to be paid to the forester at the beginning of every round. During each round the shepherd moves his flock on k cells, k corresponding to the flock size divided by 25 (starting at 10) and sums up the feeding value of the cell to his capital minus the cost of travel. He selects the cells according to climate and vegetation as well as travelling distance.

Any travel (diagonal forbidden) of 3 to 8 squares costs 5, and of more than 8 squares costs 10. At the beginning of any round, the shepherd can increase the size of his flock (each lot of 25 animals costs 25 and gives the right to graze a new square). But he must leave definitely the forest if his capital is lower than 80% of the flock size

The shepherd

4.8

Forester player: The forester can choose among three goals: to reduce fire hazard, to increase the area of dense forest stands (blue cells) or to increase vegetation diversity.

If the results of his actions have been more positive than negative, the global value of the forest is improved and he gets 250 from the Bank. In case of wildfire, a special grant of 500 is remitted to him in order to restore the burnt area.

The forester

4.9

Negotiation: At the end of each round, foresters and shepherds have 10 minutes to negotiate an improvement of the forest and to decide to support or not the corresponding operations. The way to negotiate is entirely free and to win the negotiation the partners can use any argument.

In case of disagreement at the end of the negotiation, it is the forester who has the last word.

Game calibration

4.10 Three options were taken when calibrating the RPG: to use realistic data for environmental parameters; to simplify the economic parameters while conserving realistic ratios or thresholds; and to force a few parameters to values that permit an effective use of the RPG.

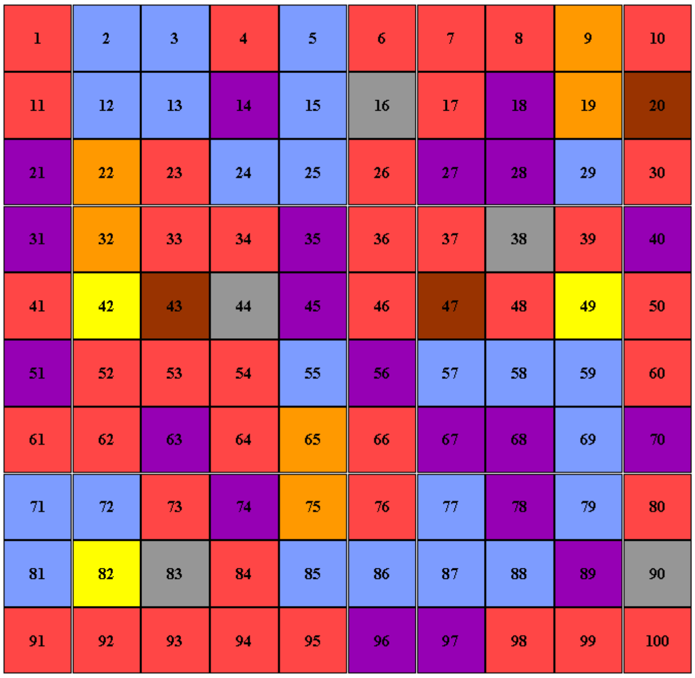
4.11 For example, the ratio between the different vegetation types of the forest corresponds to the average state of a littoral French Mediterranean forest but the location of the cells on the grid was calculated in such a way as to stimulate reactions by the players. Similarly, climate was simulated from real climatic data and forage productivity was simplified from experimental data, but the year of the wildfire and the cell where it is set were predefined in order to be able to compare different approaches during the game. Operation costs have no real values but are proportionally correct, and the amount of the grazing duty was formatted for grazing to be attractive to the forester. Finally some rules were adopted to warrant some fun playing the RPG such as to forbid the forester to run into debt, to push the shepherd out of the game when his flock is too thin or to hide to the players the way the government incentive is calculated.

Monitoring of the game

4.12 As Sylvopast was not designed to be just an RPG that permits to look at how different people play a game but to aid negotiation and stimulate a reflexive analysis on management planning behaviours, it was necessary to plan an efficient monitoring of the game.

4.13

Recording: Previously designed as a classic game, Sylvopast was run on a cardboard grid, with pins, adhesive coloured labels and false banknotes to be as funny as possible. But this way of playing required total dedication from the game master and made recording much of the action difficult. The shift to a computer device made it possible to visualise automatically the operations undergone during the game and to simulate their impact on vegetation dynamics.

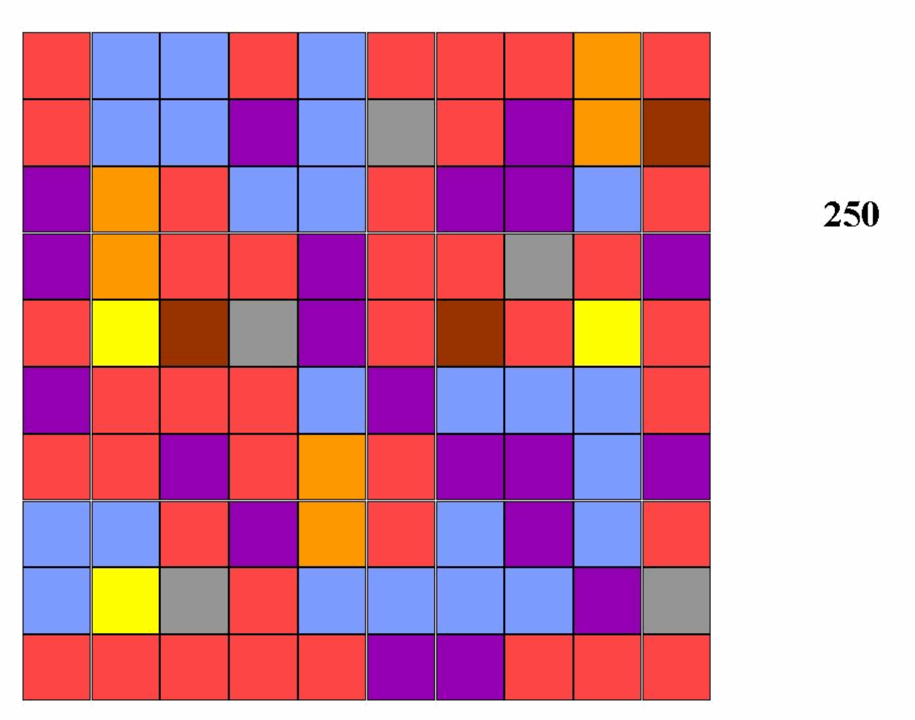


It also allowed carrying out automatic calculations and keeping a full record of all the strokes played and their sequence. Meanwhile, the game master and his assistants (when several games were played simultaneously) were free to observe the negotiation process and pick up the essential characteristics of the players' behaviour.

4.14

Debriefing: It was also considered to be very important to analyse collectively the results at the end of the game.

This debriefing was divided into four steps. First, a comparison of the evolution of the main markers allows checking if the initial goals of the players have been achieved. Then, the players summarise the main points of the game just ended, explain the way negotiations were held and justify their operational and financial strategy. Then, the game master makes a contradictory comment based on an accelerated replay of the game



Finally, a comparison with other games selected as typical examples of space organisation, behaviour or negotiation processes can be made if the players can benefit from it.

Results

5.1 So far, real farmers in front of real foresters have played 32 games of Sylvopast and of these, four corresponded to open conflict situations. Twenty games involved stakeholders already engaged in a sylvopastoral management plan and eight farmers or foresters not involved in the same project or not currently concerned by sylvopastoral management. Sylvopast has also been used in training sessions with simultaneous games for agronomy students (4), forestry students (10), and animal husbandry students (8). Since the year 2000, it has also been used as a tool to demonstrate the interest of RPGs during training sessions on "MAS and natural resources management" (13 games). Recently, its potential use to make people aware of the difficulties of negotiating a concerted management plan has been tested with forest managers (7) and with scientists not familiar with the topic such as conservationists and biologists (7), and economists (4). Finally, an experimental session was recently organised to test a repetitive use of Sylvopast by the same players: first time the preferred role, second time the opposite role, third time role randomly assigned (3 x 8).

5.2 The results discussed in this paper came only from the 32 first mentioned games as an exploration of possible negotiation and management strategies between real stakeholders building up a sylvopastoral management plan. However, some further points drawn from other uses of Sylvopast are commented upon when they are thought to be relevant to the adaptation of the game to other categories of players.

5.3

Markers: Five markers were used to monitor the livestock farmer's ability to forward his own interest in the negotiation. Two of them deal with the transformation of the forest into high productive grazing lands (pastures in yellow or wooded pastures in green), another is a global evaluation of the grazing value of the forest, and the last two refer to the capitalisation process through flock size or cash flow.

5.4 Tables 3 and 4 show the results of four types of agreement made by both partners in the negotiation. Cases 1 & 2 arise from a balanced negotiation but in one case priority was given to cash flow and in the other to flock size. Case 3 corresponds to negotiations dominated by the shepherd and case 4 illustrates negotiations dominated by the forester. If we consider that the farmers and foresters who participated in these games are representative of the stakeholders concerned by the topic, case 4 corresponds to 30 percent of the games, while cases 1, 2 and 3 occurred in respectively 25, 25 and 20 percent of the games.

Table 3: Value after ten rounds of five markers on the livestock farmer strategy compared with their state at the beginning of the game

	Yellow cells	Green cells	Grazing value	Flock size	Capital
Initial value	3	0	15	250	500
Farmer 1	6	7	35	325	680
Farmer 2	6	6	35	400	490
Farmer 3	8	10	47	450	1350
Farmer 4	4	5	23	250	420

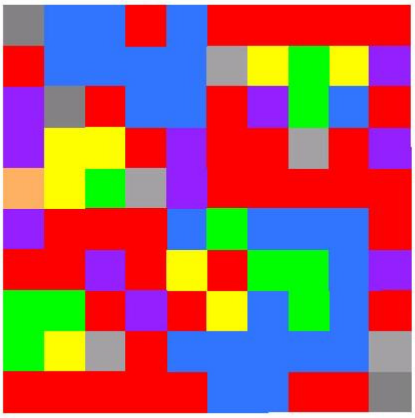
5.5 Five other markers were used to monitor the forester's ability to forward his own interest in the negotiation. Two of them deal with the forest sensitivity to fire (the burnt area and the global fire hazard), another concerns the transformation of the forest into high productive stands (blue cells), a fourth one is an ecological assessment of the forest development through an index of vegetation diversity, and the last one gives an idea of the level of investment in forest management according to cash flow.

Table 4: Value after ten rounds of five markers on the forester's strategy compared with their state at the beginning of the game

	Burnt cells	Blue cells	Fire hazard	Forest diversity	Capital
Initial value	0	23	216	12	500
Forester 1	23	10	179	12	325
Forester 2	12	20	172	30	450
Forester 3	1	25	160	28	250
Forester 4	14	29	167	16	275

5.6

Land-use patterns: Several games led to a final result which was adjudged satisfactory in terms of both productive markers and vegetation map. The pattern of spatial distribution of vegetation types was quite different among this set of satisfactory solutions. When the shepherd dominated the negotiation, an important increase in grasslands (yellow cells) and wooded grasslands (green cells) was observed (case 3 on Table 3). But this domination led to different land-use patterns (Figure 7). Some farmers developed grazing units composed of 4 to 6 green and yellow cells. In such a configuration, they first grazed all the cells available in one block moving from green to yellow cells according to climatic conditions and then moved their flock from one block to one of the nearest ungrazed one and repeated the previous grazing tactic. Other farmers developed a chain of alternating green and yellow cells. In this case, they organised a grazing circuit moving along the chain, the colour of the cell to be grazed being chosen according to climatic conditions.



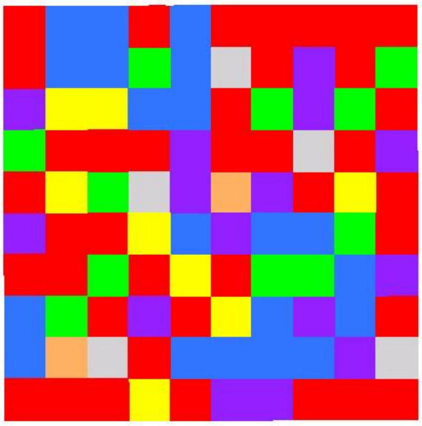
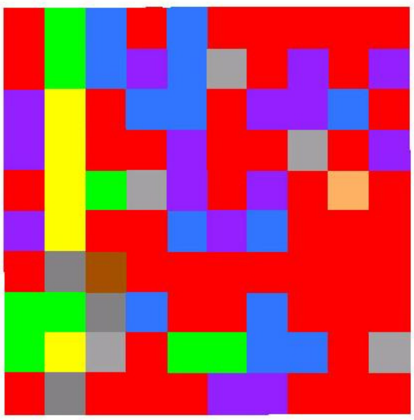


Figure 7. Land-use patterns arising from negotiations dominated by sheperds, grazing unit (left) versus grazing circuit (right) strategy (colour legend on figure 6)

5.7 When the forester dominated the negotiation, an important increase in woodland (blue cells) and other wooded areas (green, brown or purple cells) was observed (cases 3 and 4 on Table 4). But this domination led to different land-use patterns according to the main goal assigned by the player to the forest management plan (Figure 8). Some foresters gave priority to timber production and limited grazing to strategic cells in relation to fire propagation. In such a configuration, they developed pure forest stands of about ten cells and allocated to the shepherd the minimum of cells with grass (green, yellow and orange cells) necessary for him to survive. Other foresters focused their management on biodiversity enhancement. In this case, they operated on cells occupied by common vegetation types in order to develop original vegetation structures (green, orange and brow cells). But to maintain these new structures, they had to put pressure on the shepherds and oblige them to graze low pastoral value cells.



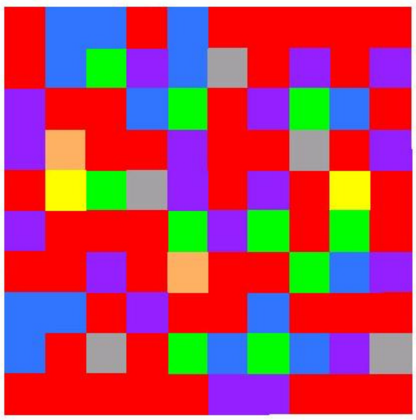


Figure 8. Land-use patterns arising from negotiations dominated by foresters, for timber production (left) versus

biodiversity enhancement (right) strategy (colour legend on figure 6)

5.8 Fire prevention strategy had a strong impact on land-use pattern (Figure 9) as well. When linear fuel breaks were preferred, vegetation types with grass and grazing were limited to a vertical "green and yellow" belt which separated the land in two main compartments. When alveolar gaps were selected, openings were located at the eastern edge of the woodlands to be protected and were managed in order to allow for permanent grazing. The first strategy was considered to be totally effective or non-effective according to the place where the fire was set, but was chosen by players who looked for a management plan quite simple to implement. The second strategy was always considered to be partly effective because it made it possible to avoid any big wildfire, but it required more skills as it depended on the success of the negotiation with the shepherd and thus a more elaborate argumentation.

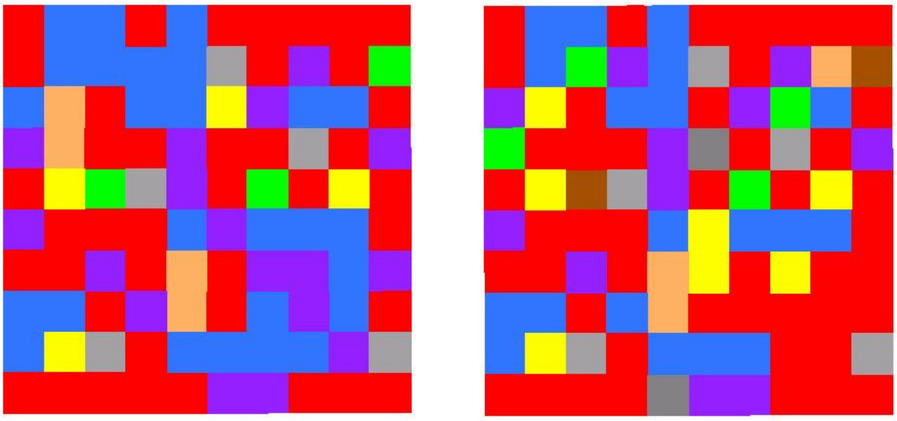
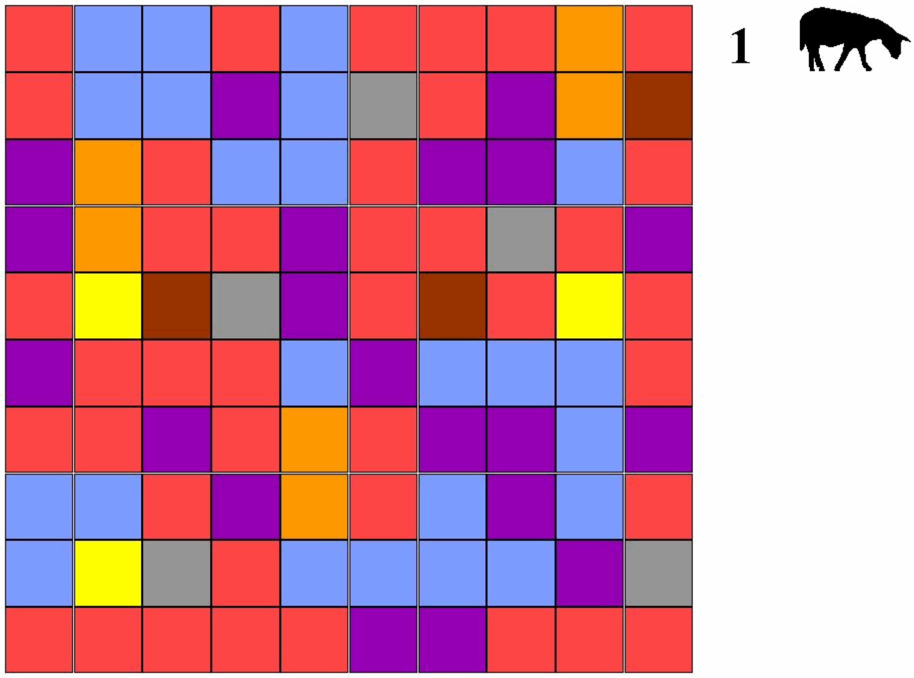


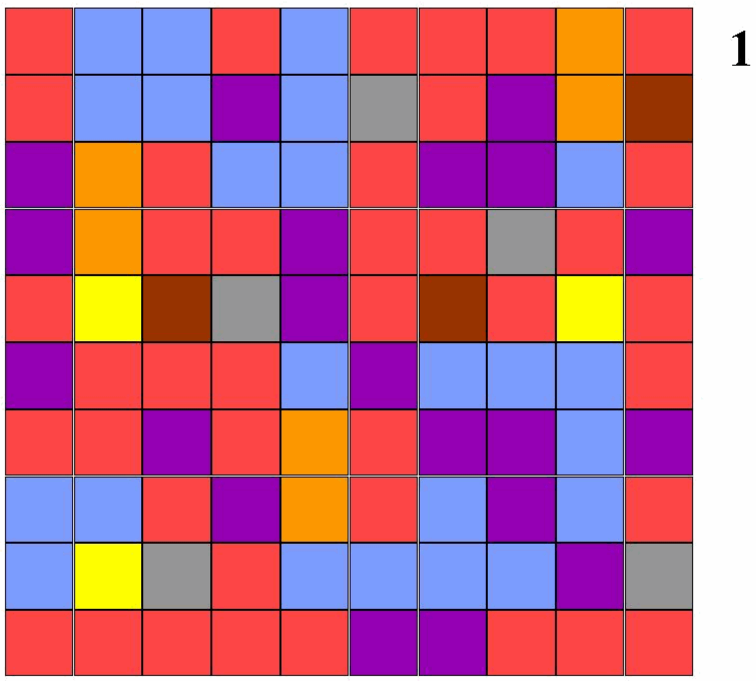
Figure 9. Land-use patterns according to 2 contrasting fire prevention strategies, linear fuel-break (left) versus alveolar gaps (right) (colour legend on figure 6)

5.9

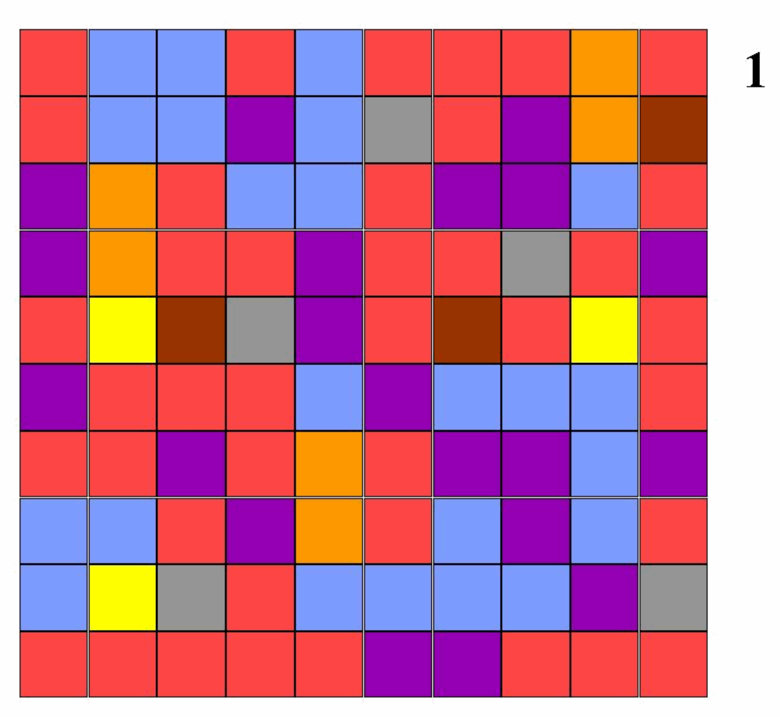
Negotiation process: Five main types of negotiation processes were observed during the 32 games with real stakeholders. "Fordom" (10) corresponds to sessions where the negotiation was dominated by the forester's arguments and gave priority to the fulfilment of the forester's goals.



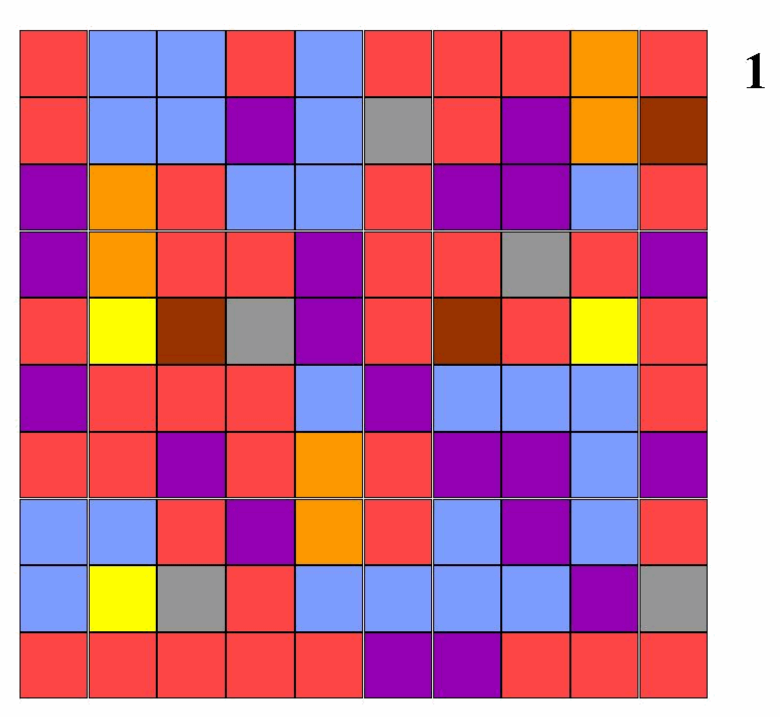
"Shepdom" (10) corresponds to sessions where the negotiation was progressively dominated by the shepherd's arguments and ended in the fulfilment of the shepherd's goals.



"Agreement" (6) corresponds to sessions where, during the negotiation process, both stakeholders progressively agreed on a common objective and concentrated their efforts on reaching the target. "Aside" (2) corresponds to sessions where after a while both players decided to manage a specific part of the forest each without taking into account what was going on on the other part.



Finally "Exclusion" (4) corresponds to games in which the forester decided that sylvopastoral management was impossible and rapidly got rid of the shepherd.



5.10 All these examples demonstrated clearly that there is not one optimal solution to the management of this virtual Mediterranean forest, but a set of solutions corresponding to a progressive agreement between the players on a satisfactory final state according to desired future conditions. And the many Sylvopast sessions permitted to represent these desirable future conditions as the conjunction of a range of values for observable indicators (Nute et al 2000).

Discussion

6.1 Many points were improved during the development of the RPG. Some aspects are worth discussing, such as the way the model was simplified, the feedback from the RPG to the model, the adaptability of Sylvopast to multiple targets or the possibility to introduce a new role when negotiation is the central point.

6.2

Simplification of the model: The change in the rules regarding vegetation dynamics primarily concerned long-term processes such as the colonisation of abandoned areas by trees or the substitution of forest species, which were not included in the RPG. This made it possible to run the game faster but limited to 10 the number of rounds of one game. Contrary to the model, the negotiating methods were left entirely open, the only constraint being the need to develop a way of recording the sequence of actions of each agent. The method consisting in asking each player to justify each of his actions in writing was abandoned, since it excessively reduced spontaneity. The new method chosen involves a confrontation between two pairs of players (i.e. two players for the same role) in order to oblige them to explain their choices and discuss them with their partner, under the watchful eye of an observer. The observer also records every action taken during the game, carries out automatic calculations and keeps a full record of all the strokes played and their sequence.

6.3

Negotiation support: Special attention was paid to define clearly the negotiation context and to record the main steps of the negotiation process. Negotiation time was strictly limited to a short period (maximum of 10 minutes) to put the players under pressure. In most cases, the observer did not participate in the negotiation; he would only check that the game was played according to the rules or make a proposal to prevent a situation from getting stuck due to unexpected behaviours. Sometimes, when negotiation was the crucial point of the game either because the game was used to assuage a conflictive situation or because the participants were trained on how to negotiate, the role of mediator was added to the game.

6.4

Validation of the game: The strong interest and even enthusiasm shown by the different categories of users of the game in our many tests (more than 80 games already played) showed that at least some of the objectives had been reached. The forest representation was rapidly assimilated by the players who after one round argued for 'more yellow' or 'more blue' instead of saying 'more grass' or 'more trees'. The economic parameters were deemed realistic and the simplifications concerning flock management, sward growth or fire propagation were accepted as requirements of the game. Many players mentioned that the interest of being projected into the future greatly overcame the simplistic way forage growth and grazing calendar were represented in the game. The topics discussed during the debriefing sessions went into many more aspects than what happened during the game. Difficulties encountered in the real world were used as arguments to support a specific tactic or to object to the partner's.

6.5

A multiple target role-playing game: The Sylvopast RPG was used with a variety of players without specific adaptations. The only modifications made were to provide or not the technical information available on the memorandums, to restrict or not the possible goals and to introduce or not a mediator.

6.6 When managers played, the goals were open but the players benefited from the memorandums because the roles were reversed. The RPG was held to be a teaching aid enabling forestry practitioners to appreciate the constraints on herdsmen, and vice versa. The game thus enabled players to put themselves in the other players' shoes and better appreciate their needs and difficulties.

6.7 When stakeholders played, the goals were open but the players did not need any technical information as they were supposed to be experts. Sylvopast made it possible to "switch" the development operation based on a broad sample to an area that they manage on a daily basis. In that case, the game served to identify the main spatial organisation strategies developed and to establish a typology of the negotiating tactics used.

6.8 When students in agronomy, forestry or animal husbandry played, the game was used to evaluate the level of understanding of the interactions among sylvopastoral systems and to measure the players' ability to integrate several scales of space and time. With students from other disciplines such as management planning or environmental development, the game served to illustrate and analyse the negotiation process in a multiple-use scope and to point out how difficult mediation can be in such a context.

6.9 When amateurs with no knowledge of either animal production or forestry played, the game was used to test the clarity of its rules, their ease of application and ability to express clearly the problems of sylvopastoral development. But, in such cases, Sylvopast mainly served to make players aware of the complexity of forest development, and encouraged everyone to test, and even improve, their own natural resource management capability.

6.10
Limits of the method: Several questions remain, however. In terms of implementation, the use of a computer, made compulsory by the need to record automatically as much information as possible, may be perceived as an obstacle by some players compared to game devices such as playing-cards, coins, pawns or dice. Previous tests done with such implements which are seen as more funny showed that they stimulated the desire to win rather than the desire to act appropriately, and made it easier to cheat than did the computerised version.

6.11 As to the various categories of players, all those who took part in the first games had the same level of knowledge, to avoid distortions too great social or cultural disparities between them would introduce. But after some tests, the categories were mixed in order to increase the range of experiences and rationales.

6.12 One of the most interesting points in the results coming out from the available set of games was that there is no single optimal solution to the natural resource management problem. Several games leading to contrasting spatial configurations were found to be satisfactory by both players and fitted perfectly with their objectives. This led to testing a series of games in which the players searched for an optimum solution and played a new game when one of the players found the result unsatisfactory. In the first round, the RPG gives an idea of the current state of knowledge and power of the partners. In the following rounds, it points out their capacity of adaptation and flexibility to find a compromise towards a shared management objective. So far, this solution has only been tested with a single person playing both roles at once again and again until he finds the most satisfactory solution. Anyway, the optimal configuration of the RPG is 2 shepherd-players facing 2 forester-players in order to oblige the players to orally express their tactics and for the observer to write them down.

Conclusion

7.1 RPG can be considered to be an alternative to improve stakeholders' involvement in participatory natural resource management, mainly when the scale of action mismatch reduces the chance of achieving the participation goals (Hare at al 2002). Recent experiments on agent-based participatory modelling applied to water or land use management have demonstrated that there are different ways of coupling MAS and RPG (D'Aquino et al 2002). In some cases, the model simulates the dynamics of a resource and provides a dynamic basis for a negotiating game. In others the scientists' model has been converted into a role game with a view to validating or more clearly explaining stakeholder strategies. In the last cases, RPG is used for the collective construction of an MAS, which is implemented and supports the discussion on management scenarios.

7.2 Sylvopast RPG was developed under the second framework. The feedback with the MAS was crucial because the RPG was conceived as a blueprint of the model but aimed at making it easy to put the negotiation strategies into words and to understand the operations and decisions made by the agents. But since it has demonstrated its ability to be easily and effectively used by learners it also fits into the first framework as an entertaining negotiating game. It would be interesting to check if it could be used without any change as support to collective construction of a fire prevention management model designed to compare management scenarios under real conditions.

7.3 The RPG approach makes it possible to identify and often to resolve conflicts between goals, and during the debriefing stage, to test current or projected situations for goal satisfaction. The proposed process is firmly grounded in the body of multi-objective decision analysis and RPGs have proved to be useful tools to structure goal hierarchy, define desired future conditions, select interesting management alternatives, and build up scenarios integrating deep social interactions (Rauscher et al 2000).

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