Management of grazing animals for environmental quality

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SUMMARY – Since the last decade, increasing importance has been given in the European Union to environmental concerns and sustainable development. This trend has led to consider grazing management not only as a way to transform primary production into meat or milk, but also as a tool to move grassland, rangeland or woodland trajectories towards higher biodiversity and lower environmental hazards. To warrant forest multifunctionality special attention is given to flexible grazing management techniques adapted to the potential multiple uses and the ecological dynamics of the forest. To reduce the threat of fire, grazing management is focused on stimulating dry forage intake and shrub browsing, and is adapted to the structure and spatial organisation of fire prevention management plans. To enhance biodiversity grazing management has shifted towards more diversified stocking rates, by organising grazing calendars adapted to the life cycle of endangered species or to high seasonal grazing pressure on specific ecological targets.

Keywords: Grazing, biodiversity, fire prevention, shrub encroachment.

RESUME – *"Gestion des animaux au pâturage pour la qualité de l'environnement". Au cours des dix dernières années, l'Union Européenne a accordé une importance croissante aux problèmes environnementaux et de développement durable. Cela a amené à considérer le pâturage non seulement comme un moyen de produire de la viande ou du lait, mais aussi comme un outil de gestion de la biodiversité ou de réduction des risques naturels. Pour assurer la multi-fonctionnalité de la forêt, le pâturage doit s'adapter aux différents usages, tout en rendant plus attractifs les espaces utilisés. Pour prévenir les incendies, la conduite des troupeaux doit garantir la consommation de l'herbe sèche et stimuler l'impact du pâturage sur les broussailles, tout en s'adaptant aux contraintes spatiales des aménagements de prévention des incendies. Pour accroître la biodiversité, la gestion pastorale doit être suffisamment flexible pour pouvoir ajuster les calendriers de pâturage aux cycles des espèces à protéger ou affecter des chargements élevés sur des zones à intérêt écologique particulier.*

Mots-clés : *Pâturage, biodiversité, prévention des incendies, embroussaillement.*

Introduction

In the past decade, increasing importance has been attached in the European Union to environmental concerns and sustainable development. This trend considers grazing management not only as a way to transform primary production into meat, milk or wool, but also as a tool to move grassland, rangeland or woodland trajectories towards higher biodiversity and lower environmental hazards.

In Mediterranean countries, grazing activities were based on a set of management techniques that were adapted to the local socio-economic constraints and traditions, but they now have to focus on the restoration of sound sustainability of the most essential functions of the Mediterranean forests or rangelands. For biodiversity conservation, grazing is an interesting tool to maintain a sustainable mosaic of plant and animal communities. But the corresponding livestock systems have to be based on an original association between conventional and range or forest feeding resources. When grazing is used to reduce the threat of fire, it must prevent the build-up of dry forage and reduce shrub encroachment. In this case, grazing management is focused on stimulating the intake of rough forage coming from ligneous species, and has to be adapted to the structure and spatial organisation of fire prevention management plans.

In temperate countries, grazing activities were based on a set of management techniques that were focused on feeding intensification and simplification, but now they have to limit their negative impact on environment quality and to focus partly on biodiversity conservation. This goal can be achieved by adapting grazing management towards more diversified stocking rates, by organising grazing calendars adapted to endangered species life cycle or by developing specific grazed areas selected in order to compensate for the negative impact of livestock farming systems on specific ecological targets.

A review on grazing management adapted to environmental quality concerns is proposed based on three non-conventional aspects: forest multi-functionality, fire prevention and biodiversity enhancement. It is based on examples borrowed from several studies, and leads to recommendations on how grazing, nature conservation or natural hazard prevention can be integrated into the common management of livestock systems.

Forest multi-functionality

Forest grazing has long been a normal activity in Mediterranean forests but dramatic socio-economic changes in the northern and southern parts of the Mediterranean basin during the 20th century have led to three contrasting situations. In the southern countries, with rapid population growth, precarious resources and a low standard of living, people's dependence on forest resources has continued and even increased (M'Hirit, 1999). In the north, the transformation of agriculture, together with industrialisation and economic growth, has intensified the rural exodus and the abandonment of traditional farming in the hinterland. Consequently, forests spread widely (marginal areas of France, Italy and Spain) or intensive agricultural practices penetrated into the woodlands (cultivated "dehesas" or "montados" of Spain and Portugal).

The south of the Mediterranean Basin

In the case of southern countries, stakeholder practices can be considered as a mining exploitation of fodder and firewood resources of the forest. In such a context, silvopastoral planning is necessary to avoid overexploitation of forest ecosystems, but only drastic regulations and strict supervision of the local farmers practices can reverse the degradation process. Presently, in some state forests of Morocco or in the natural reserves of Israel this strategy leads to the complete extinction of the traditional silvopastoral systems. Elsewhere, many northern-African countries, like Tunisia or Algeria, undertook a great deal of research studies on fodder trees and shrubs, mainly based on local species (Tiedeman and Johnson, 1992; Naggar, 1993). But the efforts made to convince local livestock farmers to establish fodder trees or shrubs in their rangelands, in order to decrease the browsing pressure on woodlands, failed because of the cost, the need of supplementary irrigation during establishment and the need for a temporary exclusion from grazing.

Only highly-resilient ecosystems such as the *Acacia caven* savannah in Chile (Ovalle *et al.*, 1990), the *Argania spinosa* woodlands in Morocco (de Ponteves *et al.*, 1990) or the *Quercus ilex* coppices in northern Africa (Auclair *et al.*, 1995; Bonin and Loisel, 1995) are able to tolerate such high harvesting pressure. Indeed, the limited literature available on Mediterranean forest understory productivity and use provided extremely high output figures compared with the average annual growth (Bourbouze, 1980; Madani *et al.*, 2001). To reverse this trend, only drastic socio-economic and political decisions will succeed in shifting the problem of forest vegetation degradation from a curative to a preventive approach in resource use, but this type of decision involves a clear increase of institutional commitment (di Castri, 1998).

The north of the Mediterranean Basin

In the case of cultivated woodlands, the structure of the silvopastoral system has been partly conserved but the reduction of grazing, the drastic thinning of the trees and the development of ploughing led to irreparable damage (Gómez-Gutiérrez and Pérez-Fernández, 1996). Recently, with the increase in environmental concerns, good sense prevailed again and a compromise was found between traditional grazing management and modern marketing. Controlled density and pruning treatments prolong the life of the oak trees. Stocking rate and tree density are adjusted to warrant the need for space for better production of pastures but also an effective soil protection. The two major tree species used to build up these sustainable agrosilvopastoral systems in Spain and Portugal are *Quercus ilex* and *Q. suber*. The management of the undergrowth consists in frequent grazing, sometimes favoured by the establishment of temporary pastures either through natural succession or through the sowing of annual legumes. Economic studies show strong differences between commercial net margins, according to the type of dominant tree in the silvopastoral system, and the ability of the farmer to combine livestock, crop and even hunting productions (Campos *et al.*, 2001).

In the case of abandoned landscapes, traditional practices have disappeared completely and are presently considered as an archaic management system. But new social and economic priorities re-emphasised silvopastoral management for its benefits to rural employment, landscape management and environment and product quality. This new trend appealed for clearer management rules that favour the goals and structures of the silvopastoral system as a driving force of a rural area maintenance project (Bland and Auclair, 1996). Some studies proposed a modelling approach of the functioning of silvopastoral systems at different scales (Bergez *et al.*, 1999; Etienne and Rapey, 1999). Other works check the possibilities for combining conventional and silvopastoral feeding resources to build up fodder systems capable of fitting with contrasting livestock systems (Bellon and Guérin, 1996; Talamucci *et al.*, 1996).

In any case, it is crucial to design systems with silvopastoral plots that fit perfectly into the forage calendar of the livestock farms by filling gaps in the grazing system of the farm. According to the forage value of the tree leaves and fruits, or the type of interaction between the tree and the grass, the silvopastoral plots can play very diverse roles in the farming system. Silvopastoral plots with *Fraxinus angustifolia* can be reserved for hay in spring, then the sward regrowth can be grazed in summer. Meanwhile, the leaves of pruned trees can be grazed during fall (Fig. 1). Another example is that of *Quercus ilex* silvopastoral plots, which can be inserted in very different ways into a forage calendar either to feed animals during a critical period or to give more flexibility to the grazing system (Bellon and Guérin, 1996).

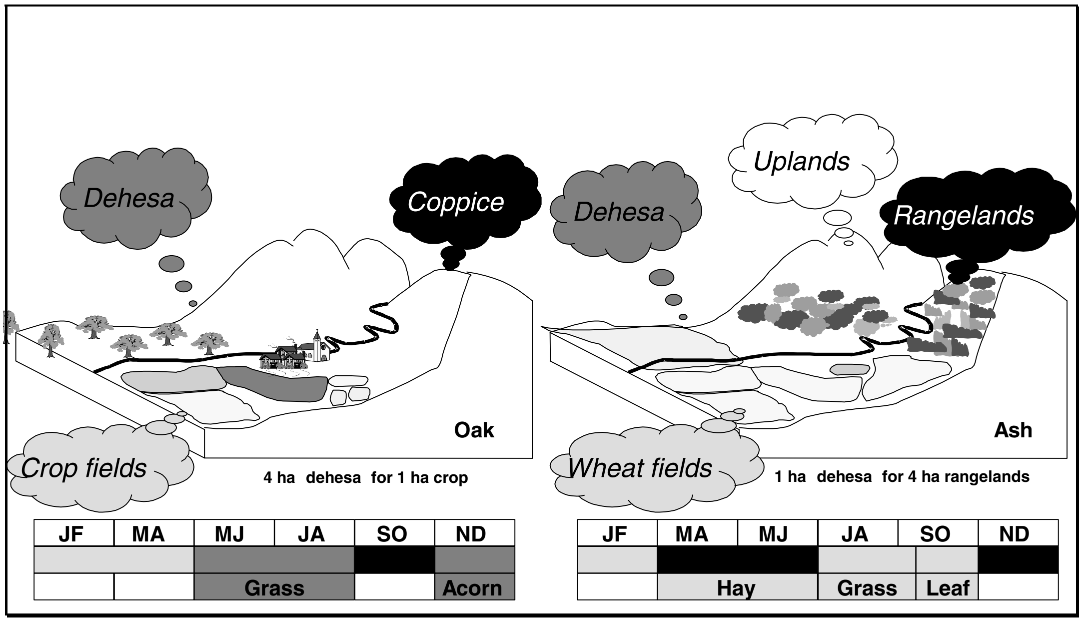

Fig. 1. Roles of forest grazing according to the forage value of tree leaves and fruits, and the type of interaction between the tree and the grass, in two Spanish livestock farming systems.

The economic analysis of silvopastoral systems provide strong variations in annual incomes both due to the impact of climatic variability and to differences in management. For example, in "dehesa" systems, traditional farms obtain a total income of around 130 €/ha, with 100 coming from animal production and 30 from trees. Meanwhile, farms that move to crop intensification obtain a total income of around 90 €/ha, with 80 coming from the animal production and 10 from the crops (Campos and Sesmero, 1987).

As multifunctionality enhancement is one of the goals of livestock management, grazing organisation has to build up and maintain the most appropriate vegetation structure according to the different users of the forest. If we simplify the description of vegetation structure by means of the combination of the three basic plant types (trees, shrubs and grasses), it is easy to visualise which structure is purchased by each type of stakeholder (Fig. 2). Foresters will look for tree stands for timber production or mixed stands for biodiversity enhancement. Livestock farmers will prefer to combine swards with wooded pastures, while beekeepers will look after dense and open shrublands dominated by melliferous plants. Hikers will follow different trails according to the season and their impact on blooming or mushroom springing up. Hunters will move from wooded pastures to close or multi-layered forests according to the type of game they are used to shoot.

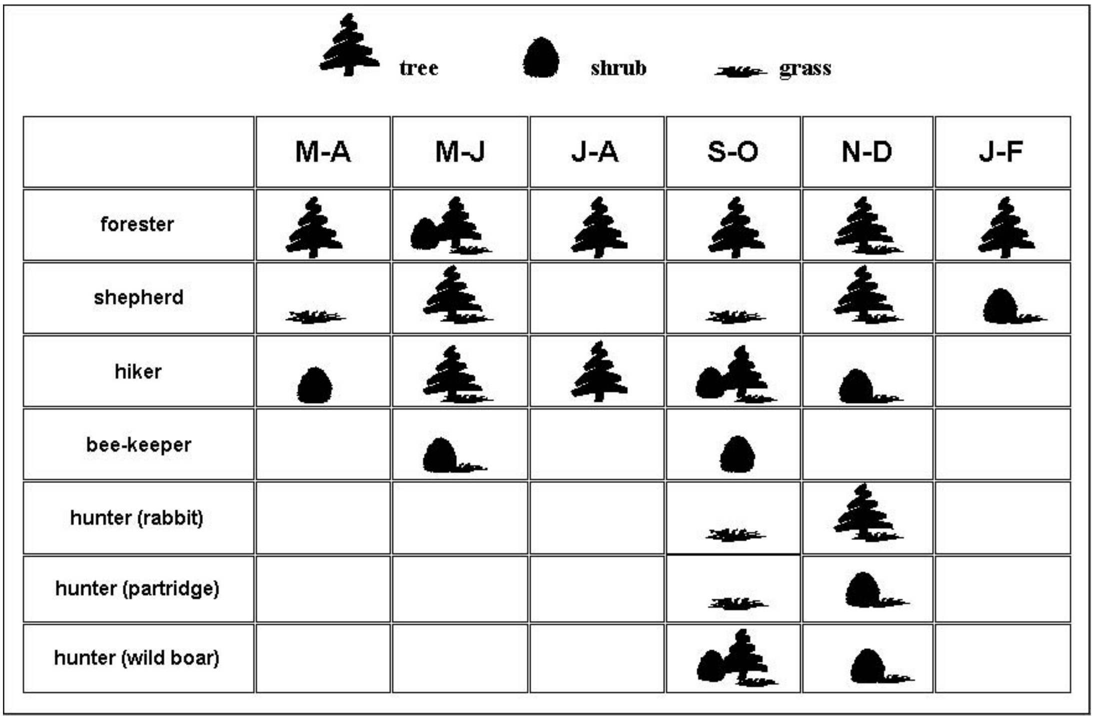

Fig. 2. Preferred vegetation structure of forest plots according to stakeholders activities and season.

Fire prevention

In southern France, innovating management systems have been developed by combining grazing and fuel-break maintenance. The main goal is to protect Mediterranean forests from fire, grazing being part of the management technique. Pastoral improvements, preferentially with legumes sown under tree canopy cover, increase competition with shrubs, protect well developed trees, favour wildlife and make forest management easier. Skilled management of these overseedings is required to find good equilibrium between tree canopy cover, shrub encroachment and climatic variability (Etienne *et al.*, 2002). Grazing reduces the threat of fire by preventing the build-up of dry forage and of palatable shrubs. Forestry operations such as thinning dense stands, converting coppice into high forest or replacing highly inflammable pioneer species by dense shade species increase the efficiency of the silvopastoral break (Etienne, 1996).

An important work has been developed on the most effective operational sequences to apply in order to establish and maintain fire prevention management plans in a sustainable way (Legrand *et al.*, 1994). It demonstrated how grazing is effective on many aspects. Simultaneously, more sophisticated techniques were developed to enhance browse impact on shrubs either through supplementation or through improved grazing management practices (Etienne *et al.*, 1996; Dumont *et al.*, 2001). Three factors affect browse intensity, particularly: palatability of the dominant shrub species, grazing management, and the type of animal (Table 1). Grazing management can increase browse impact on undesirable species through feeding management rules (protein-rich supplementation, range fertilisation, overseeding) and herding techniques (close herding, high stocking rate, adequate grazing season, appetite stimulation). It also partly controls litter fuel levels by disintegrating the dead material lying on the soil by trampling (Rigolot and Etienne, 1996). But, as tree regeneration is strongly concerned with browse damage (Fig. 3), specific attention must be paid for securing the replacement of tree canopy cover.

Table 1. Factors modifying browse impact measured through utilisation rate (%) in southern France

Factor	Utilisation rate
Flock management	
Herding	12.4
Paddock	16.5
Camping	48.7
Grazing animal	
Cattle	14
Sheep	22
Goat	66
Grazing frequency	
2 periods	1
8 periods	15
14 periods	25
Fertilisation	
Unfertilised	6
Fertilised for 5 years	12
Fertilised for 10 years	18
Pastoral improvement	
Without oversseding	7
Sparse overseeding	11
Dense overseeding	17
Dominant shrub	
Cistus	6
Erica	10
Cytisus	37

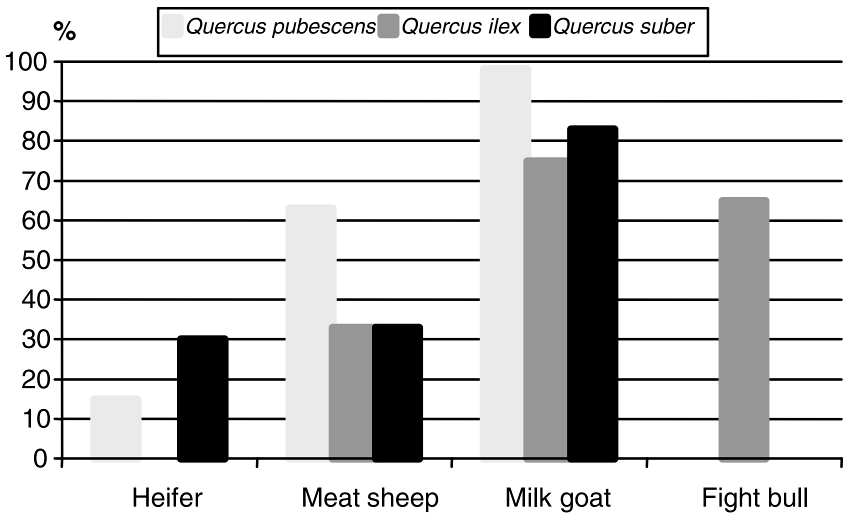

Fig. 3. Browse impact on oak regeneration according to the type of animal and the tree species.

To complete the assessment and evaluate the efficiency of such management plans, a detailed methodology was set up to measure costs and benefits during the many steps of the planning process (Coudour *et al.*, 2000). Land tenure negotiation, plan conception, farmers involvement, fuel-break build-up and functioning, fuel monitoring plus communication and administrative costs summed up from 41 to 67 000 € per year per plan. If the area covered by the fire prevention plan and the benefits coming from livestock production was taken into account, the net cost averaged 100 €/ha/year and was even negative if milk goats used to control fuel also were managed for cheese production (Table 2). Many adaptations of such integrated management plans have been set up during the last decade in the French Mediterranean region (Etienne, 1996). According to the type of forest (coppice or high forest, broad-leaved trees or conifers), land tenure, local livestock farming systems, and other common uses (hunting, cork, hiking, etc.) the land management plan (Fig. 4) will identify workable choices between permanent or temporary grazing, dense or loose fuel-break network, and global or specific fire-protected areas according to the primary goals of fire prevention (urban interface, heritage forest stands, productive woods, natural reserves).

Table 2. Comparative analysis of the cost (€) of fire prevention management plans in cork oak forests of southern France

	Investment	Functioning	Cost/ha/year	Net cost/ha/year†
Goat farming				
Building up	215 000	47 000	420	395
Current running	93 000	45 000	400	- 20
Sheep farming				
Building up	170 000	320 000	315	185
Current running	53 000	314 000	280	150
Cattle farming				
Building up	390 000	47 000	270	130
Current running	107 000	45 000	230	85

†Net cost includes all the incomes from the livestock production.

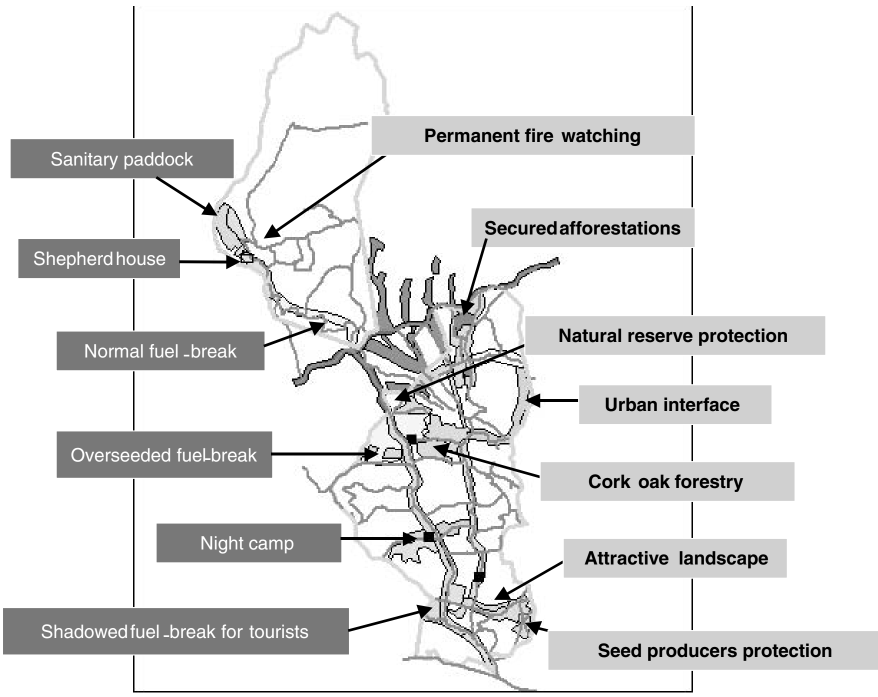

Fig. 4. Land management plan integrating grazing as a fire prevention tool.

Nature conservation

In many European countries, biodiversity is to a large extent the result of a traditional long use of the environment. So many authors argued that repeated disturbances must be guaranteed in order to affect periodically the structure and ecological sequences of non-forest habitats, particularly in Mediterranean areas (Seligman and Perevolotsky, 1994). In many temperate protected zones, human perturbations are required in order to maintain a sustainable mosaic of plant and animal communities that is the only insurance of an optimal biodiversity (Le Floc'h *et al.*, 1998). When dealing with human perturbations related to an economic activity, many authors confirmed a reduction in plant diversity and richness when grazing pressure decayed (Diez *et al.*, 1991; Seligman and Perevolotsky, 1994) or when tree canopy cover became excessively dense (Marañón and Bartolome, 1994; Médail *et al.*, 1998). That is the reason why grazing management has been more and more used to control shrub encroachment or to limit tree encroachment.

Shrub encroachment control

The relationships between grazing pressure and shrub dynamics have been assessed in two opposite ways. Historical approaches have been mainly based on the study of aerial photographs taken at different dates along the last 50 years. They showed a strong interaction between grazing management, rangeland allocation and shrub encroachment in both temperate and Mediterranean conditions. For instance in Ouessant (Brittany, France) a reallocation of sheep grazing from the outline of the island towards the interior, was registered during the middle of the XXth century as a consequence of the abandonment of cropping activities (Gourmelon *et al.*, 2001). This process led to the encroachment of the fringe with a strong negative impact on the populations of chough, the emblematic coastal bird of the island. Similarly, in the Pyrenees, important changes in transhumance practices during the second half of the XXth century provoked a sudden close up of the mountain pastures (Roura *et al.*, 2003), with a negative impact on the populations of the grey partridge (Novoa *et al.*, 1998).

In France, diachronic studies have been mainly associated with the application of the European agri-environmental policy. They showed the importance of grazing on the maintenance of open habitats and fragmented landscapes that favoured the conservation of a set of endangered plant and animal species (Véron *et al.*, 1999). In the Ariege hills, clear links were identified between grazing practices and passerines richness (Boyer, 1996). They led to range management recommendations in order to enhance endangered or rare bird communities. In the Northern Vosges wet fallow lands, highland cattle grazing was considered positive for plant diversity, non significant for spider communities and negative for nesting birds (Muller *et al.*, 1998). In order to preserve global biodiversity, grazing cattle was proposed as a good management tool but under precise stocking rate conditions.

Tree encroachment control

A comparative study on the impact of disturbance levels in three typical French Mediterranean forests (Etienne, 2002) demonstrated clearly how plant richness was positively affected by opening of the undergrowth (shrub clearing) and stimulation of sward development (P fertilisation and grazing) without removing entirely the tree layer. Whatever the dominant tree was, the higher levels of plant richness were gained by the major perturbation; while the controls registered the lowest scores (Fig. 5). Another comparative study between similar cork oak forests of southern Spain and northern Morocco showed that excessive human pressure on woody resources may lead to a loss of biodiversity mainly because rare or endemic species were replaced by generalist species (Ojeda *et al.*, 1996).

But Nature conservation and management deals with scaling problems and hierarchy of priorities according to the type of species to be protected, the level of perturbation required or the threshold of fragmentation not to be passed over, all of which may consistently vary. For instance, the impact of pine encroachment on the endangered species of the National Park of Cévennes was monitored and simulated at many different scales according to the home range of several protected species (Fig. 6). Consequently specific management units which are vital to the need for certain habitats, had to be considered into the current management of sheep farms involved in agri-environmental programmes (Etienne, 2001).

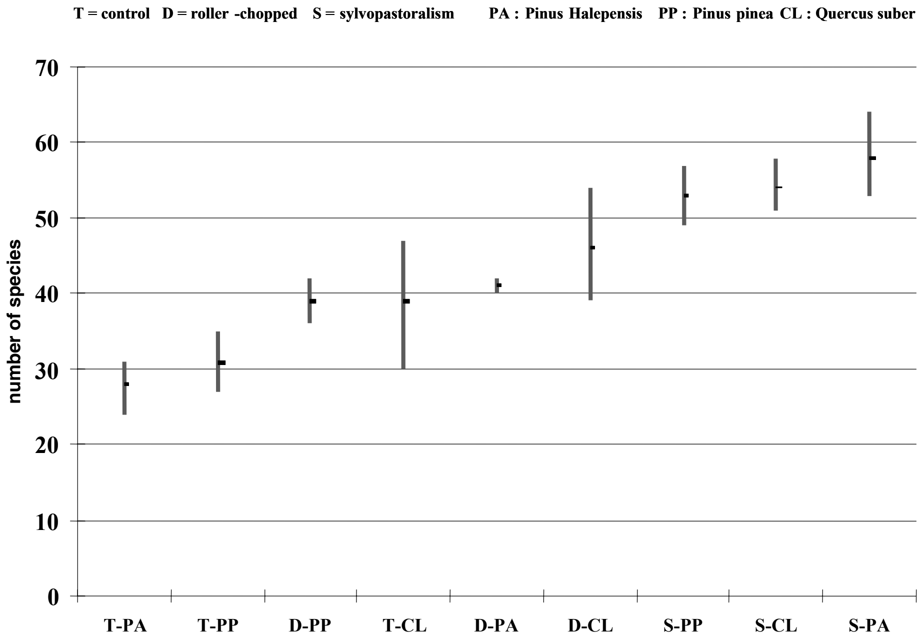

Fig. 5. Plant richness according to grazing management in 3 types of Mediterranean forests.

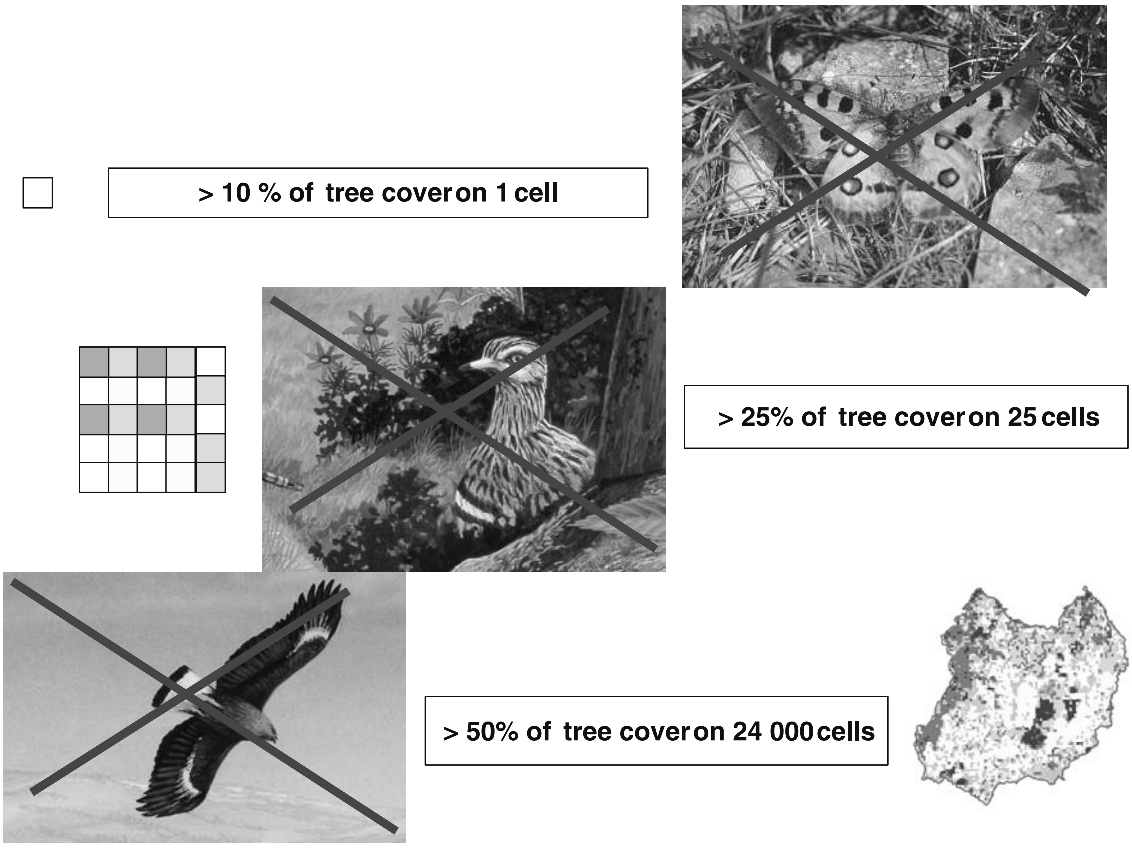

Fig. 6. Impact of pine encroachment on endangered animal species according to their home range.

In order to economically account for economical multiple use of the forest, a new methodology was developed to integrate stakeholders' welfare into the calculation of the net margin and the profitability rate of Spanish silvopastoral farms (Campos, 1999). Its application to contrasting silvopastoral systems showed the importance of revenues from maintenance of habitat for rare wildlife into the complete economic balance of livestock farms. The integration of environmental services into the evaluation of farming systems led, during the last decade, to a real revaluation of land prices and promoted political efforts to support a better balance between social and private total sustainable incomes (Campos *et al.*, 2001).

Conclusions

In a rapidly changing socio-economic context, new demands are constantly being made by society on Mediterranean forest managers. Currently, the demand gives priority to multiple uses, among which recreation and conservation are gaining more and more importance. This means that a scientifically sound conservation strategy should be developed, and locally-tailored sustainable grazing management should be implemented. As sustainability and multi-functionality have to be the two leading principles of a modern grazing policy, it is necessary to think about an efficient way to internalise the many positive externalities that characterise grazing impacts on many ecosystems. It will be the only way to develop the low-cost management practices that allow sustainable use, conservation and even regeneration of interesting habitats and landscapes. Particularly, special attention should be paid to flexible and reversible grazing management techniques adapted to the current agricultural conditions and integrating the dynamics of such complex systems.

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