Des broussailles dans les prairies alpines : organisation spatiale de l'activité et pratiques des éleveurs en vallée d'Abondance (Haute Savoie, France)

Olivier Camacho, Laurent Dobremez, Alain Capillon

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EDITOR'S NOTE

Translation: Gail Wagman

1 The degradation of rural landscapes due to a decrease in the maintenance previously provided by agricultural activity and to agricultural land abandonment are considered to be major problems in the Alps (Briquel, 2006; Gellrich *et al.*, 2007) and, in general, in European mountains (MacDonald *et al.*, 2000). Abondance Valley (part of the Chablais massif in Haute-Savoie, France) is distinguished by the encroachment of forest stands and shrubs. We particularly focused on the phenomenon of spontaneous afforestation and shrub invasion on permanent pastures (Camacho, 2004). In Abondance Valley, conditions are favourable to the rapid dynamics of woody species (Richard and Pautou, 1982). The space used by agriculture is still considerable[1] and the number of farmers (150 farms documented in 2000 in the six valley communes) appears to be sufficient so that the closing of the landscape is not considered irreversible.

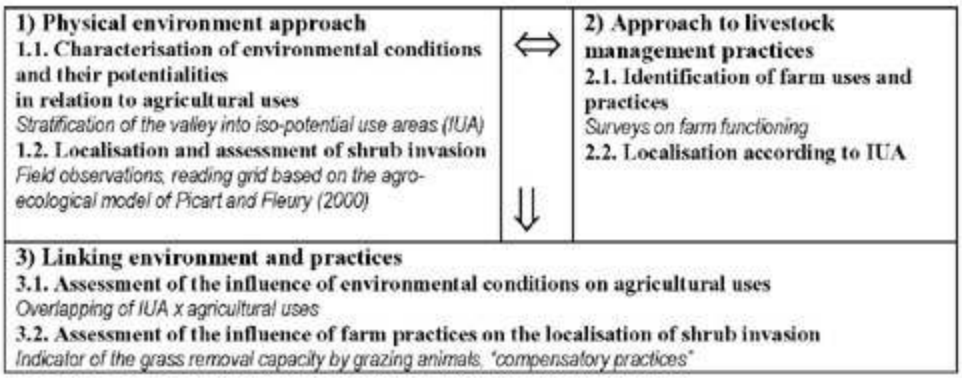
2 Abondance Valley is representative of a paradox commonly observed in the Northern French Alps: the mountainsides and alpine pastures are still used, whereas they are becoming increasingly afforested. Geographers provide keys for interpreting the distribution of the different forms of human activity in space by identifying physical and socio-economic determinants in particular. Ecologists have shown that farmers' practices and activities are an important factor in landscape transformation, but they do not study how these activities are organised and do not refer to internal farm mechanisms (Burel and Baudry, 1999). In this paper, we analyse the situation from an agronomist's point of

view in order to characterise and understand the spatial organisation of farm activities (Benoît *et al.*, 2006). By referring to two spatial scales – the field, the farmer's management unit where he implements his practices, and the valley where landscape closing is an issue – we will show that environmental conditions play a major role on the localisation of agricultural land uses in the valley, but that they do not adequately explain why pastures still in use are being invaded by shrub. To understand this situation, we must analyse farmer's practices linked to the functioning of the farm system.

Methods

3 The approach used is illustrated in Figure 1. At the valley scale, environment potentialities (1.1) and agricultural land uses (2.2) are compared so as to assess the influence of environmental conditions on these uses (3.1), and the shrub-encroached areas are localised (1.2). At the level of the field, farm practices (2.1) are evaluated (3.2) and compared to the shrub invasion assessment (1.2) in order to establish likely relationships between practices and shrub invasion. Surveys on farm functioning (2.1) allow us to identify the reasons for these practices.

Figure 1. Outline of the approach used.



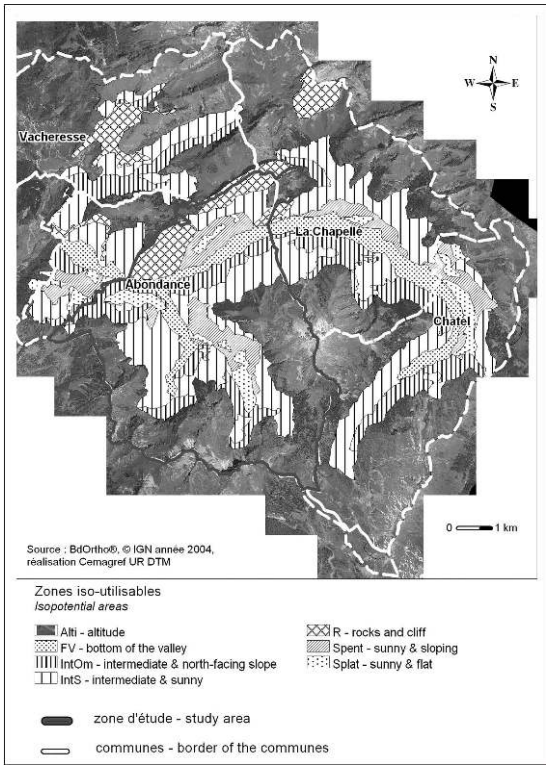
Iso-potential use areas in Abondance Valley

4 To study the influence of physical characteristics on the distribution of land occupations (forest, grasslands, etc.) and uses (cutting, pasture), we divided up this space into major entities based on the combination of environmental characteristics likely to influence forage production or harvest: *slope* (which determines the mechanical means used to cut hay), *altitude* and *global radiation received* (criteria that determine the vegetation growing season), using a digital field model and the *Solar Analyst* module of *Arcview®* software. To take the *soil* factor into account, we then compared the spatial entities resulting from this combination of criteria with the map of the *pedological landscapes* of Abondance Valley (Legros, 1986). We thus defined and determined boundaries for seven "*iso-potential use areas" (IUA)*, characterised by their suitability for agricultural techniques (Map 1):

- the *R* IUA includes those sectors where cliffs and boulders are dominant.
- the *Alti* IUA includes areas with altitudes of over 1,450 m., in reference to the generally accepted limit between mountain and subalpine storeys in the Northern French Alps.

- the *FV* IUA corresponding to the bottom of the valley: flat areas or ones with small slopes (slope of less than 31%) located at a minimum of 1,150 m altitude.
- between 1,150 and 1,450 m, pedological landscapes "S" were used to determine two other IUA. These are cleared forest areas, relatively urbanised, with southern exposure and humid and deep calcic brown soils. We can distinguish the *Splat* IUA (hedgerow landscape on terraces whose slopes are not greater than 31%) and the *Spent* IUA above this threshold.
- finally, two IUA of intermediate mountainsides were also distinguished: these areas do not correspond to the definitions of the preceding IUA. They refer to land on mountainsides where the slope is often steep. We can distinguish a north-facing IUA (*intOm*) (insolation of less than 800 kW x m^{-2}) and a sunnier IUA (*intS*).

Map 1. Distribution of iso-potential use areas in Abondance Valley and the boundaries of the study area.



5 We chose a study area of over 5,600 hectares within the limits of the commune of Abondance (Map 1) where the seven IUA are represented, where the diversity of the farming systems is representative of that of the valley and where, according to agricultural technicians, there are several zones with landscape issues where a variety of scrub invasion dynamics has been observed.

Surveys of farmers for the purpose of characterising their practices and understanding the logic of farm functioning

6 Twenty-seven farms using areas within the study area were surveyed for the purpose of understanding their functioning. A grazing calendar was established by identifying the plots used on aerial photos and by recording the technical sequence over the year for each plot (Hubert, 1994). Our presence in the field (for several months between 2000 and

2002) made it possible to establish a dialogue with the farmers so as to compare declarations and field observations in order to better understand how they used the land over a period of several years.

Field observations to localise and assess shrub invasion

7 Field observations were carried out on the totality of the enclosed pastures on 22 farms out of the 27, for a total of 107 grazed and uncut pastures located in the intermediate zone (mountainsides)[2]. They are based on a model of woody species dynamics in pastures, established by Picart and Fleury (2000). This model includes several ecological succession phases: (1) an initial phase (*net state*: no woody species in the centre and clearly defined borders); (2) a *beginning of propagation* of woody species that can occur either at the field edges that consist of a shrubby stratum, or at the centre (pockets of woody species); and (3) *confirmed propagation* phases (many pockets in the centre and/or edges consisting of bushy strata), terminating in a very shrubby state of the field as a whole.

8 The range of validity of this model corresponds to the mountain storey in the Northern French Alps up to the subalpine limits (towards 1,500-1,600 m), with the exception of the drier valleys (Haute Maurienne and Haute Tarentaise). This model is therefore not adapted to alpine pastures. In alpine pastures, we used studies on vegetation physiognomy based on satellite photos to assess the extent of woody vegetation (Bornard *et al.*, 2000).

Estimate of the grass removal capacity by grazing animals in the pastures

9 On the basis of technical references and, in particular, INRA feed tables (Jarrige, 1988) and grassland typologies (GIS Alpes du Nord, 2002), we estimated (in tonnes of dry matter) pasture production and the feed requirements of batches of animals that use them over a typical year. We therefore calculated an indicator of the removal capacity by grazing animals (ratio: animal requirements divided by the estimate of pasture production) for each pasture field (Camacho, 2004).

10 We hypothesized that there is an underconsumption of grass in uncut pastures. This situation, repeated several years in a row, leads to a disruption of the dynamic balance of the vegetation: appearance of grasslands consisting mainly of *Brachypodium pinnatum* (Balent *et al.*, 1999), encroachment of woody species (Duru *et al.*, 1998)[3].

Results

11 Cattle farming is the most common type of farming in the study area. The milk benefits from the Abondance cheese AOC (*appellation d'origine controlee*), whose specifications forbid the use of fermented forage (silage, wrapped bales) in animal feed. Farmers mainly use permanent pastures as the basic ration. From November to April, the animals are stable-fed with harvested or purchased hay. The rest of the year, the herds graze in the valley and then move to the alpine pastures in the summer.

Spatial rigidity of farm land uses

12 The farms surveyed mainly produce cow's milk (21 of the 27), sometimes processed into farm cheese, with a wide diversity of herd sizes (from two to 44 cows). In general, part of the grasslands is exclusively cut and the other is exclusively grazed. Cutting is not used as a tool to control strong spring growth, as in other regions. We are therefore dealing with very compartmentalised and specialised fields where the same batches of animals are present at the same season every year. This rigidity of grazing and the rigidity of allocation circuits between cut and grazed fields is indicative of a high degree of land use planning (Girard *et al.*, 2001), leaving little room for flexibility to adapt to the uncertainties of grass availability.

Environmental conditions structure the spatial distribution of agricultural land uses

13 Table 1 shows the strong links between the different IUA and agricultural land uses. For example, it is easy to understand why the flat areas or those with small slopes of the FV and Splat IUA are especially used for hay making because of the ease with which it can be mechanically harvested. In the Alti IUA (above 1,450 m), the phenology of graminaceous plants allows us to understand why farmers send their herds to graze between June and September[4]. The wide variety of uses on the sunny slopes of the Spent IUA is revealing of determinant factors that are not exclusively linked to ecological and geomorphological conditions. In steeply sloping fields (> 31%), cutting is just about impossible with a traditional tractor and even hazardous with mountain equipment. Regardless, we find cut meadows in several fields whose slope is close to 50%. This leads us to look for the farmers' reasons for these land uses.

Table 1. Distribution of the uses of each iso-potential use area in 1999 in Abondance Valley, excluding cliffs and boulders.

IUA	Agricultural uses	*Including Hay making*	*Exclusively grazing*	*Grazing in summer*	Abandonment	Forest	Other types of occupation	Total
FV	56	*93*	*6*	*1*	11	4	28	100
Splat	63	*74*	*6*	*20*	7	11	19	100
Spent	57	*46*	*25*	*29*	17	19	7	100
IntS	37	*4*	*4*	*91*	21	41	1	100
IntOm	7	*26*	-	*74*	17	75	1	100
Alti	63	-	-	*100*	21	16	0	100
Overall	48	*16*	*4*	*80*	19	30	4	100

In % of each IUA; for hay and grazing in % of agricultural uses.

Localisation and estimate of scrub encroachment in alpine pastures

14 Field observations show that scrub encroachment is almost absent from agricultural plots at the bottom of the valley and benches, that it is generalized in alpine pastures and present, but at varying degrees, on the mountainsides.

15 Cutting, generalised in the FV and Splat IUA, makes it possible to control the dynamics of woody species. Likewise, in the enclosed pastures on the slopes that use a combination of springtime grazing followed by cutting, we find no confirmed scrub invasion[5].

16 In alpine pastures, 74% of the 93 pastoral units documented in the Haut Chablais are classified in the types of alpine pastures where the proportion of woody species (wooded pastures, alder groves, heaths) is the greatest[6] (Bornard *et al.*, 2000).

17 In the intermediate zone (mountainsides with steep slopes) and in the grazed and uncut fields, Table 2 shows that shrub encroachment is omnipresent (93% of the area of these pastures shows signs of shrub invasion)[7]. For the 107 enclosed pastures observed, the indicator of the grass removal capacity is weak (an average of 48% with a standard deviation of 16%). We can therefore assume that there is a generalised underconsumption by grazing of uncut pastures. Since this situation is repeated from one year to the next because of the rigidity of the grazing circuits, it is the most likely reason for the propagation of woody species.

Table 2. Distribution of scrub invasion phases of grazed and uncut pastures on the mountainsides (on the basis of 107 enclosed pastures for a total of 163 ha).

Scrub invasion phase (propagation of woody species)	Number of enclosed pastures %	Area %
Net state	7	7
Beginning of propagation	50	44
Confirmed propagation	42	49
All the enclosed pastures	100	100

Compensatory practices

18 Mechanical maintenance practices can be divided into two categories: (1) the cutting or chopping of ungrazed grass that is then burned on site; (2) the cutting or pruning of woody species. These can be seen as “compensatory practices” that aim at limiting the propagation of woody species but that do not always prevent the degradation of the grass resource[8].

19 Table 3 illustrates the relationship between shrub invasion in the enclosed pastures and the grass removal capacity by grazing, linked or not to mechanical maintenance[9]. Confirmed shrub invasion is especially correlated to a low removal capacity without complementary mechanical maintenance and is significantly less frequent in enclosed pastures where the relatively high removal capacity is associated with a mechanical maintenance.

20 The overall effectiveness of mechanical maintenance practices nevertheless appears to be limited (28% of the enclosed pastures where compensatory practices were taken are at the confirmed shrub invasion phase).

Table 3. Relationships between shrub invasion phases, grass removal capacity and compensatory practices on 107 grazed and uncut enclosed pastures on the mountainsides (given as the % of the number of enclosed pastures in each category).

Scrub invasion phase (propagation of woody species)	I ≤ 50%		I > 50%		Total
	Without CP	With CP	Without CP	With CP	
Net state	2	13	0	***20***	7
Beginning of propagation	39	55	60	60	50
Confirmed propagation	***59***	32	40	***20***	42
All of the enclosed pastures	100	100	100	100	100

I: indicator of the grass removal capacity; CP: compensatory practice. In italics and boldface, the categories where contributions are the most significant (according to the c^2 test), each enclosed pasture having the same weight (independently of its area).

Limiting shrub invasion on the mountainsides depends on the farmer's logic

21 In steeply sloped fields on the mountainsides, some farmers make hay and thus contribute to controlling the encroachment of woody species. This practice is linked to the configuration of the field pattern, work constraints and the strategy of constituting hay stocks for winter. The survey revealed that very few farmers (5 out of 27) actually achieve hay autonomy by only cutting the grass in their fields on low slopes located in the FV and Splat IUA; others (7 out of 27) avoid cutting on the mountainsides, even if it means buying hay to complete their stocks.

22 In the uncut enclosed pastures, compensatory practices are another way of trying to control the dynamics of woody species. Farmers choose the places where they will implement such practices. Thus, the majority of dairy cattle farmers surveyed apply compensatory practices to all of the pastures grazed by dairy cows but not to all of the pastures grazed by heifers, some do not even apply these practices to pastures grazed by cows, whereas others do no mechanical maintenance whatsoever on any pasture. Ownership status also explains the attitude in relation to these mechanical maintenance: on two-thirds of the privately-owned pastures compensatory practices are taken or are not necessary (because they are cut at least once a year), but 80% of the communal pastures are not maintained. Farmers often mention the refusal to cut down trees by owners of pastures on verbal lease (common in this region) to explain why they are not maintained.

23 During the grazing season, farmers try to avoid a grass shortage risk by creating grazing units that are oversized in relation to the normal needs of the animals. On the medium term, this practice, which is repeated every year, appears to be in contradiction with the aim of sustaining the forage system because it leads to a degradation of the quality of the grass resource, even if compensatory practices help to prevent the dynamics of woody species. However, farmers no longer necessarily think in terms of productivity per animal and/or hectare. Some could even use areas left by others in the event that the degradation of the grass resource in some of their own pastures and/or their mechanical maintenance becomes too much of a constraint.

Discussion - Conclusion

24 We will begin by discussing the methodological limits and hypotheses underlying this work. We will then extend our reflection to management systems for these types of shrub-invaded environments and to the analysis of the spatial organisation of farm activities in mountain areas.

Methodological limits

25 The first limits concern the use and relevance of references in the absence of measurements of grass consumption rates. We did not take account of energy expenditures linked to moving animals from one place to another in the mountains that could, according to INRA data tables, increase the animals' needs from +10% to +20%, but this is more applicable to free grazing in alpine pastures as opposed to small mountainside pastures (1.5 ha on the average). Pasture productivity depends on climatic conditions; we took this partially into account by using only average values in the productivity ranges by type of pasture, as determined by the Northern Alps GIS. Our estimates of the grass removal capacity are such[10] that these discrepancies do not seem to be sufficient to cast doubts on the hypothesis of an underconsumption of grass, which is furthermore confirmed by the overlapping with ecological models (Balent *et al.*, 1999) and with field observations.

26 Moreover, Dumont *et al.* (2001) report that in the case of extensive cattle grazing, if the animals have a biomass much greater than their needs at their disposal, they may become overwhelmed and have a tendency to limit their grazing to certain areas, whereas the undergrazed areas are the same from one year to the next, favouring their colonisation by grasses that are difficult to eat and then by dense shrub stands (sloe, brambles, etc.) that limit the animals' mobility.

Range of validity of results

27 We chose this valley because it provided a good illustration of the situation of a landscape transformation despite the presence of a livestock activity. Studies focused on other regions of the Northern Alps show that free grazing on large fields appears to be fairly common (Havet *et al.*, 2006). This also seems to be the case in other mountain regions such as the Jura and the Massif Central, and could develop with the trend towards expansion: fields are larger, more broken up and more dispersed. Farmers generally manage larger areas than before with less available manpower. These different elements lead us to think that the situation in Abondance Valley is not really exceptional.

Managing shrub growth

28 We are aware of the practices used by farmers in this valley but we wonder if it is not possible to conceive of other practices to manage these environments overrun with shrubs. The grid used to assess the shrub phase of the pastures is not adequate to determine the respective roles of grazing and mechanical maintenance on the dynamics in progress. Many studies over the past 20 years have emphasized the interest of brush

and woody species in general, not just for biodiversity because they form an environmental mosaic, but also in the feed itself for herbivorous animals (Rousset and Lepart, 1999; Agreil *et al.*, 2004). Admittedly, this research was carried out in dry and Mediterranean pastoral zones and with small ruminants, but cows can also eat brush, even if the cow seems less fit than small ruminants for sorting vegetation in the pasture (Dumont *et al.*, 2001).

29 The use of mechanical means as a maintenance practice in addition to grazing is not the only solution available to cattle farmers. The efficiency of these mechanical means is itself subject to debate. Even if dairy farmers in the Northern Alps are aware of the importance of "teaching" heifers to graze on the slopes, they are still very much under the influence of the "grass culture" and have a tendency to discredit brush as a feed (Meuret *et al.*, 2006).

Spatial organisation of farm activities and work organisation on the farm

30 Like Girard *et al.* (2001), we consider that the physical environment does not completely determine the way land is used. It is certainly true that uses appear to be very structured by where the fields are located in Abondance Valley: flat areas (or ones with smaller slopes) are reserved for haymaking[11], and fields above 1,500 m in altitude are now reserved for summer grazing. However, along the mountainsides, it is necessary to understand the strategies of forage autonomy in winter and pasture maintenance logic in order to explain the presence of hay meadows and the localisation of shrub encroachment.

31 This work leads us to take a deeper look at the relationships between work organisation and land use. The case of Abondance Valley is an example – undoubtedly not that rare – where farmers manage the resource by planning the spatial distribution of fields between haymaking and grazing to constitute their hay stock for winter (integrating the possibility of purchasing hay into their logic) and by combining grazing and compensatory practices within a given framework of work organisation. Waiting until later to deal with the excess grass not consumed by the herd as the result of non-reactive grazing management (free grazing in enclosed pastures, avoiding the day-to-day job of strip grazing or herding) appears to be a fairly convenient means for lightening the workload.

32 With Soulard (2005) who proposes the implementation of a "geography of farm practices", we agree on the interest, at the level of a territory and particularly in view of agri-environmental challenges, of reconciling the spatial distribution of land uses with the understanding of farm functioning.

We are grateful to the Abondance Valley farmers for their warm welcome and their cooperation. We would also like to thank Karen Voron for her fieldwork on the enclosed pastures, as well as our colleagues, Dominique Borg, Jean-Jacques Collicard, Gilles Favier and Éric Perret for their support (statistical analyses and geographic information systems). Finally, we would like to extend our thanks to the two anonymous reviewers for their constructive criticism.

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NOTES

1. According to Corine Land Cover data, 43% of the valley's area is covered with grass and 44% with forests and shrubs.
2. 12 additional enclosed fields, with grazing followed by hay cutting, were studied.
3. The impact of grazing on the dynamics of woody species is not just limited to the consumption of grass (and young woody plantlets). Other possibilities exist such as trampling by animals and the direct consumption of scrub.
4. Despite these ecological reasons, the use of summer grazing alone in alpine pastures is nevertheless recent: in the past, many families made hay in small fields.
5. Observations on 12 enclosed pastures representing 16 ha (10 ha in the net state and 6 ha with a beginning of woody propagation).
6. In these types of alpine pastures, the average proportion of woody species ranges from half to three-quarters of the pasture area.
7. The most common woody species: spruce (*Picea abies*), hawthorn (*Cratægus sp.*), wild rose (*Rosa canina*), ash (*Fraxinus excelsior*), maple (*Acer sp.*), wild cherry (*Prunus avium*), hazel (*Corylus avellana*), etc.
8. We observed grasslands with Erect Brome (*Bromus erectus*) and Heath False-Brome (*Brachypodium pinnatum*) – species that the animals generally only consume as young plants – and whose expansion is considered as a sign of undergrazing, a precursor to shrub encroachment (Duru *et al*., 1998; GIS Alpes du Nord, 2002).
9. The shrub invasion variable and the one that combines removal capacity and compensatory practices can be considered as being statistically dependent with a probability greater than 97% (C^2 test carried out with STAT*lab*™ software by SLP®).
10. According to our estimates, grazing animals would have an average removal capacity of less than 50%, in other words, twice as much as their feed requirements, over 69% of the total area of the 107 enclosed pastures!
11. This nevertheless needs to be qualified: in the spring, depending on the configuration of his field pattern (no sloped fields within proximity of the stable), the farmer may graze his dairy cows on relatively flat grasslands.

ABSTRACTS

Landscape closing due to the decline in agricultural activity is considered to be a major problem in the Alps. Abondance Valley provides a good example of this phenomenon and is also representative of a paradox commonly found in the Northern French Alps: the mountainsides and alpine pastures are still used, whereas they are becoming increasingly afforested. Environmental conditions play a major role in the localisation of agricultural land uses, but they are not sufficient to explain why pastures still in use are being invaded by shrub. Even if cutting makes it possible to effectively control the encroachment by woody species, this is not true for uncut pastures where grazing is not able to keep up with grass production. This situation is repeated every year and is the likely cause of the colonisation by woody species. To ensure their forage system and to simplify their work, farmers tend to establish grazing units that are oversized in relation to the needs of their animals. They implement compensatory practices that consist of mechanical maintenance as a complement to grazing to limit the dynamics of woody species. These labour-intensive practices are not used on all of the pastures. The analysis of farmers' practices by agronomists is therefore a useful complement to studies of physical and socio-economic environments, at the level of the grazed field as well as at that of the valley as a whole.

La dégradation des paysages par suite du recul de l'activité agricole est considérée comme un enjeu majeur dans les Alpes. La vallée d'Abondance illustre bien ce phénomène de fermeture de l'espace mais elle est en outre représentative d'un paradoxe assez répandu dans les Alpes du nord françaises : les versants et les alpages sont encore exploités et pourtant ils se boisent progressivement. Les conditions de milieux jouent un rôle majeur sur la localisation des usages agricoles de l'espace, mais elles ne peuvent pas suffire pour expliquer pourquoi l'embroussaillement gagne des prairies encore exploitées. Si la fauche permet de lutter efficacement contre l'avancée des ligneux, il n'en est pas de même dans les prairies pâturées non fauchées où la capacité de prélèvement par les troupeaux s'avère faible par rapport à la production d'herbe. Cette situation se répète d'année en année et c'est la cause la plus probable de la propagation des ligneux. Pour sécuriser leur système fourrager et pour simplifier le travail, les éleveurs constituent des unités de pâturage surdimensionnées par rapport aux besoins des animaux. Ils mettent en œuvre des pratiques de rattrapage, consistant en un entretien mécanique complémentaire au pâturage, pour contenir la dynamique des ligneux. De telles pratiques, exigeantes en travail, ne sont pas mises en œuvre sur toutes les pâtures. L'analyse des pratiques par des agronomes complète ainsi les études de milieux physiques et socio-économiques tant au niveau de la parcelle pâturée qu'à celui de la vallée.

INDEX

Mots-clés: agriculture de montagne, fermeture du paysage, prairie, pratique agricole, utilisation de l'espace
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AUTHORS

OLIVIER CAMACHO

Cemagref Grenoble, unité de recherche Développement des territoires montagnards/Chambre d'agriculture du Calvados, Lisieux.

LAURENT DOBREMEZ

Cemagref Grenoble, unité de recherche Développement des territoires montagnards.
laurent.dobremez@cemagref.fr

ALAIN CAPILLON

Montpellier SupAgro, Département Milieux, productions, ressources, systèmes.