PAPER

Factors influencing summer farms management in the Alps

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Abstract

We investigated the recent evolution and the present status of summer farms in the Veneto region, northeastern Italian Alps. This study area has experienced the abandonment and intensification in livestock farming that has been typical in the European mountains. An on-farm survey was conducted at 484 active units. Data were collected concerning farm structure and technology, herd composition and management, and the environmental and managerial practices. A clustering approach, based on structural and technical features, divided the summer farms into two clusters. One cluster included 189 units that were mostly owned by municipalities and other public institutions. These units contained renovated structures and modern equipment. The other cluster included 295 summer farms that were mostly privately owned and often contained obsolete structures and equipment. Herd composition and management practices were more intensive in the public cluster, while the environmental and management features of the pastures differed only marginally. Socio-economic viability, as estimated with a multicriteria approach, was higher for public summer farms. Our results indicate that the type of ownership is the main factor in the recent evolution and the present status of summer farm. The traditional, strict link between the management of summer farms and the optimal conservation of their pastures has been disrupted. These findings must be considered to devise effective agricultural and environmental policies in mountainous areas.

Introduction

Traditional and extensive agro-pastoral systems dominated the economy and shaped the landscape of the European mountains until the first half of the 20th century (Viazzo, 1989; Baldock *et al.*, 1996; MacDonald *et al.*, 2000). The modernisation and intensification of agricultural practices in the decades that followed led to the concentration of farms in the more productive areas; areas in which land morphology and climate impeded the adoption of intensive farming practices were marginalised and abandoned (Bernués *et al.*, 2011; Caraveli, 2000; García-Martinez *et al.*, 2009; Strijker, 2005). This process was particularly evident in the Alpine region (Caraveli, 2000; MacDonald *et al.*, 2000). The number of farms decreased of 40% between 1980 and 2000 (Streifeneder *et al.*, 2007); the remaining farms experienced profound structural and management changes.

In contrast with modern intensive farms, traditional farms are today recognised as sources of many positive functions (Gibon, 2005), including tourism (Thiene and Scarpa, 2008; Amanor-Boadu *et al.*, 2009), the control of forest re-growth (Giupponi *et al.*, 2006; Mottet *et al.*, 2006; Cocca *et al.*, 2012), the conservation of the land and cultural heritage (Hunziker, 1995; Baudry and Thenail, 2004; Kianicka *et al.*, 2010), and the protection of biodiversity (Marini *et al.*, 2009, 2011). Public subsidies are essential to ensure the economic viability of extensive farming systems (Uthes *et al.*, 2010). The remuneration of the positive externalities produced by these farms should be commensurate with the magnitude of external benefits produced (Gellrich *et al.*, 2007). The knowledge of local farming systems and the services they provide is necessary to devise effective policies for the agro-ecosystems of the Alps (Van Huylenbroeck and Durand, 2003).

Seasonal transhumance to summer farms is of particular interest. Throughout the mountainous regions of northern Europe, summer farms are temporary livestock farms that are utilised during summer to integrate the forage budget of permanent farms (Olsson *et al.*, 2000; Orland, 2004; Dodgshon and Olsson, 2007; Eriksson, 2011). In the Alps, summer farms are known as *Alpeggio* or *Malga* in the northern part of Italy, *Alp* or *Alm* in Germany, Swiss and Austria, and *Alpage* in France. The use of summer farms here is more than 2000 years old and is so typical of the region that the whole mountain chain was named after the practice (Orland, 2004). This practice evolved to exploit the seasonal and altitudinal variability of vegetation growth (Orland, 2004; Dodgshon and Olsson, 2007). During the summer months, while livestock grazed the high-elevation pastures of summer farms, lowland and mid-mountain meadows were cut to produce stores of hay for the winter. To ensure the sustainable use of pastures, common property and land use rights were designed throughout the Alpine area (Orland, 2004). The seasonal displacement of human and livestock dictated the schedule of farm activities and profoundly influenced the cultural traditions of rural societies in the Alps (Dodgshon and Olsson, 2007). The cultural landscape of the highlands were characterised by pastures, buildings and barns, paths, fences, and watering holes with a high aesthetic and natural value, especially in areas where woodlands would otherwise overtake the landscape (Thiene and Scarpa, 2009; Kianicka *et al.*, 2010; Scarpa *et al.*, 2010).

Despite their importance, we know little of how summer pasture systems evolved in the Alps in consequence of the decline and the intensification of the permanent farm systems (Herzog *et al.*, 2009). We investigated the present status of summer farms in the Veneto region of the northeastern Italian Alps and how they have evolved. This mountainous area is typical in that the traditional farming systems

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are being abandoned. The shift towards intensive systems has profoundly affected the livestock sector. The status of summer farms is mostly unknown because summer farms are temporary productive units, and no official censuses are available such as exist for permanent farms. The only available summer farm survey was conducted in the early eighties (Berni and Fabbris, 1983). The number of permanent livestock farms has decreased since the 1980s; we expected that the number of active summer farms had declined as well. We also examined how the utilisation of summer farms has evolved. We analysed the structural and technological features of active summer farms and whether these features were related to the intensity of the management of livestock and pastures. Finally, we used a multicriteria approach to index the multifunction services of summer farms and examined which among the structural, technological, management and environmental features contributed to the variability of the derived indexes.

Materials and methods

Study area

The study area comprises the mountain municipalities of the Veneto region of northeastern Italy (Figure 1), and covers approximately 4660 km^2. The elevation ranges from 50 to 3315 m asl (mean 1118 m; SD 610 m). The average daily temperature varies seasonally from -6 to +17°C (period 2001-2011; ARPAV, 2012), with precipitation peaks in late spring and autumn. The area comprises 173 mountain municipalities and 19 Mountain Communities (Figure 1). Mountain Communities are territorial institutions tasked with the promotion and management of the mountain resources of municipality groups; in the Veneto region, these functions include the management of summer farms. The population of this area is approximately 740,000 (15% of the Veneto region), and the population density varies from 24 inhabitants per square kilometer in less favoured areas to 350 inhabitants per km^2 in the most populated municipalities (ISTAT and IMONT, 2008).

In the lowland areas that characterise the rest of the Veneto region, cattle farming largely predominate over sheep and goat farming (Table 1; ISTAT, 1982, 2002). In the study area, however, the numbers and spatial densities of farms and cattle are much lower. In this area, 72% of cattle farms are dairy farms, compared with 46% of farms elsewhere in the region. Moreover, dairy cows account for 45% of cattle heads in the study area but only 19% in the rest of the region, where intensive beef production is an important industry. In the entire region, the abandonment of dairy farms has been dramatic: the number of farms has decreased by 75 to 81% from 1980 to 2000. This loss has mainly affected smaller and less intensive units, as the overall reduction of dairy cows was only 24-39%. As a result, the farms surviving in 2000 had an average herd size that was almost threefold larger that of the farms active 20 years earlier. This phenomenon has led to a general abandonment of grasslands and pastures.

Data collection

One aim of this study was to produce an updated database of active summer farms. For this purpose, we collected and combined the information available from regional and local administrations (*e.g.*, Mountain Communities and municipalities) and from veterinary institutions (*e.g.*, Local Sanitary Districts and the Regional Centre for Veterinary Epidemiology) that are officially involved in the management of summer farms. The resulting database contained the name of the holding, the type of ownership (public or private), the location (geographic coordinates were derived from the interpretation of orthophotographs when not otherwise available), and the farm status (active, abandoned).

During the summers 2007 and 2008, we conducted a field survey of 484 active holdings. Trained interviewers visited summer farms and collected data from farmers using a questionnaire concerning logistic, productive, economic and environmental features of the farms. The following variables (Table 2) were used to describe the general, structural and technical features of the holdings: type of ownership, accessibility, farmer housing, the availability of electricity power lines, renewable

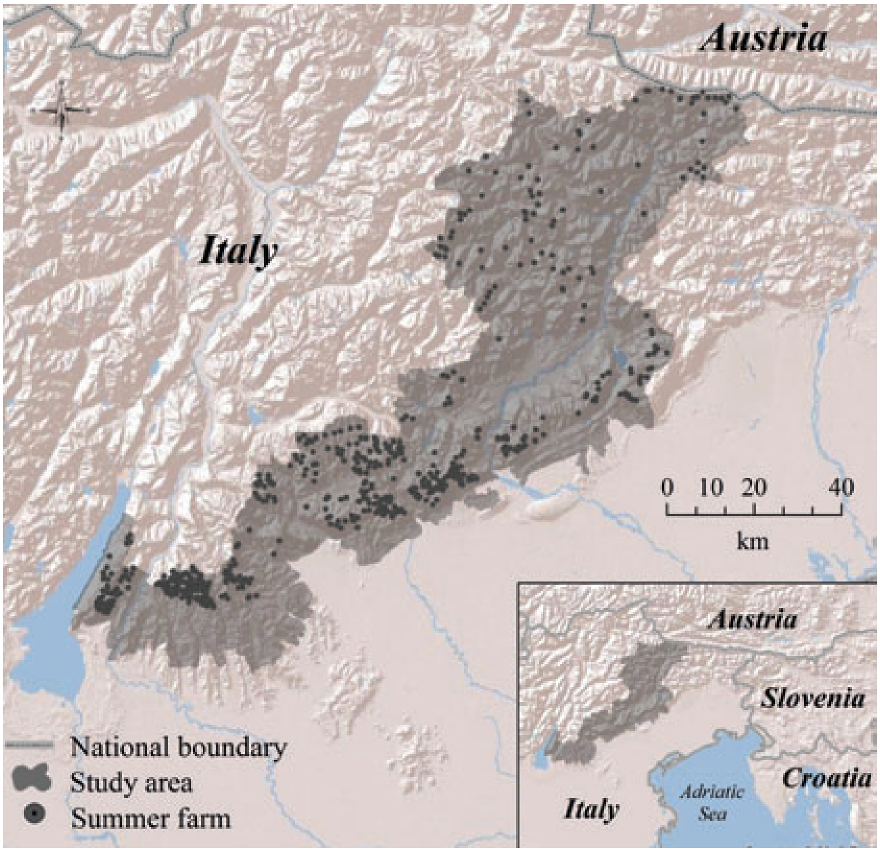

Figure 1. Study area and summer farms location in Veneto region, northeastern Italy.

energy and potable water, the availability of milking parlours and the equipment and room necessary for cheese making. A second set of variables describes how the holdings are managed and indexes economic parameters, including whether personnel resided *in situ* during summering. Additional recorded parameters included age of conductor, detailed numbers of the people employed in the livestock care, the duration of the summering period, the presence of cheese production and on-site product marketing, and whether the unit offered a bar, restaurant, or accommodation for tourists. Where relevant, the opening periods for such offerings and the number of people employed were recorded. These variables were chosen as proxies of economic data (*i.e.*, profit from product sales, revenues from agro-touristic activity and actual cost of salaries), which are unreliable when obtained by interviews. A third set of variables was used to describe the summered livestock. Livestock were categorised as dairy cows, dry/replacement dairy cattle, beef cattle, sheep or goats. The number of heads in each category was standardised as livestock units (LU) and calculated following EU livestock schemes (Table 2).

Table 1. Evolution of livestock sector in the study area and in the rest of Veneto region between 1980-2000.

	Mountainous area			Rest of the region		
	1980	2000	% Difference	1980	2000	% Difference
Administrative surface, km^2	7897	7897		10,467	10,467	
Grassland and pasture, km^2	1136	927	-18.4	767	689	-10.2
Arable crops, km^2	62	61	-1.6	5888	5742	-2.5
No. of cattle farms	8894	2698	-69.7	61,773	18,877	-69.4
No. of cattle	101,646	71,858	-29.3	1,289,054	859,479	-33.3
No. of dairy farms	8030	1980	-75.3	45,492	8625	-81.
No. of dairy cows	42,187	32,204	-23.7	265,339	163,213	-38.5
Dairy cows/farm	5.2	16.3	213.5	11	34.7	215.5
No. of sheep+goat farms	2276	907	-60.2	5008	2532	-49.4
No. of sheep+goat	11,192	12,257	9.5	8334	9573	14.5

Table 2. Data collected and variables calculated.

	Description
Ownership	Private (single or collective) or public (municipalities and other institutions)
Accessibility	Two classes: 1=by car; 2=on foot or four wheels drive vehicle
Potable water	Availability (yes/no) of potable water from pipeline
Electricity	Availability (yes/no) of electricity from power lines
Renewable energy	Use (yes/no) of renewable energy sources
Housing	Availability (yes/no) of housing for *in situ* residence
Milking parlour	Availability (yes/no) of milking parlour
Milk processing	Availability (yes/no) of equipment and rooms for milk processing and cheese seasoning
Resident farmer	Permanent *in situ* residence (yes/no) during summering
Age of summer farms conductor	Years
Employees for livestock	Total employees (n.) for livestock care (farmer, dairyman, shepherd, *etc.*)
Summering days	Duration (days) of the summering period
Agro-tourism	Offer (yes/no) of: bar service; restaurant; tourist overnight accommodation; cheese making; products retail
Employees for agro-tourism	Total employees (n.) for agro-tourism activities (cheese-maker, cook, waiter, *etc.*)
Opening days	Days (no.) of opening of agro-tourism
Livestock unit	Number of different livestock categories standardised as LU: cattle >2 years =1 LU; cattle 0.5-2 years = 0.6 LU; sheep and goats = 0.15 LU.
Dairy cows %	LU from cows in milk expressed as percentage of total LU
Dry cows and replacement %	LU from dry cows and replacement (calves, heifers) expressed as percentage of total LU
Beef cattle %	LU from beef cattle (calves, young bulls, heifers) expressed as percentage of total LU
Small ruminants %	LU from sheep and goat expressed as percentage of total LU
Grazing area	Mapped (1:10,000) during field survey and then implemented and measured (hectares) in GIS
Stocking rate	Calculated as LU/ha grazing area
Slope score of grazing area	Calculated from a DTM as Slope Score = 1(P<10)+2(P10-30)+4(P>30), where P<10= % of pixels of grazing area with slope <10°; P10-30= % of pixels with slope ranging between 10° and 30°; P>30= % of pixels with slope >30°
Elevation	Average elevation (m asl) of grazing area
Land use of grazing area	Obtained from interpretation of ortophotographs (1:10,000) with four categories: pasture=less than 10% of shrub/tree cover; wooded pasture=10-30% shrub/tree cover; re-forestation=30-70% shrub/tree cover; forest=>70% tree cover

LU, livestock unit.

The stocking rate was calculated as the LU/ha of grazed area (see below). A fourth set of variables described the location, morphology, and status of pastures. In a subsample of 314 summer farms, the grazed area was identified with the farmer on an orthophotograph (1:10,000) and subsequently digitised using GIS software (ArcGis 9.2). Using a digital terrain model (DTM) with 10x10 m spatial resolution, the elevation of the grazed area was expressed as the average of the pixels; the slope was indexed with a continuous score ranging from 1 to 4 (Table 2), where 1 indicates that all of the grazed area is flat (slope <10°) and 4 indicates that all of the grazed area is steep (slope >30°). This scoring method, compared to the average slope, better describes how the morphology of the grazed area can influence its use by livestock. From the visual interpretation of orthophotographs, we categorised the grazed area for increasing shrub and tree cover as follows: free pasture = less than 10% of shrub/tree cover; wooded pasture = 10-30% shrub/tree cover; re-afforestation = 30-70% shrub/tree cover; forest = more than 70% tree cover.

Functional indexes

We used multicriteria analysis (Belton and Stewart, 2002), namely a simplified version of Multi Attribute Decision Making approach, to calculate indexes clustering on values of summer farms functions. We identified two main functions of the summer farms that have public relevance: the contribution to the livestock farming sector and the contribution to employment. We defined indicators of these functions and assigned a specific weight to each indicator to calculate a synthetic index for each summer farm. This method is transparent, provides a proxy of values that are impossible to collect with accuracy on such a large number of units, and might be used to assess the effect of alternative weighting schemes (weights) on the final index. The weighting scheme is a choice of the policy-maker and hence determined *a priori*. For this purpose, we consulted experts of the Veneto region who provided suggestions that helped us to define the structure of the analysis according to the local context. The value of the indexes range between 0 and 1, where zero means the worst and one means the best context. The composition of the indexes is detailed in Table 3 and described as follows.

Livestock index

The livestock index is the sum of the value assigned to the category of summered livestock parameter and the value assigned to the resident *in situ* during summer parameter. The first parameter values the integration of traditional management of summer farms with the farming of dairy cows. The second parameter values the summer farms in which the herdsman permanently resides *in situ* during the summering period; we assume that this guarantees better care of pastures and structures. The experts of the Veneto region and ourselves considered that it is more important to encourage the summering of dairy cows than the farmer's residency, and therefore assigned a higher weight (0.7) to the first than to the second (0.3) parameter.

Social index

The Social Index measures the provided job opportunities. It distinguishes between the activities closely related to animal husbandry and those associated with agro-tourism services or dairy product retail. For each type of activity, the score is calculated as the number of workers employed multiplied by the number of days during which the activity is performed. The obtained values are then normalised to their 90th percentiles, given the same weight (0.5) because both variables were considered as having the same importance, and summed to obtain a final value for the social index. This index can also be viewed as an index of the economic viability of the summer farm because units that are able to offer agro-touristic services and/or hire more personnel are also those that produce higher incomes.

Statistical analysis

Identifying and comparing homogeneous groups of summer farms

We first grouped summer farms into clusters that were homogeneous with respect to structural features and available facilities. For this purpose, we used the following variables:

i) Private or public ownership. Summer farms are owned in part by public institutions (mainly municipalities) and in part by private institutions (most often single individuals who may or may not be farmers). A different ownership structure may involve different interests and capacity for management and maintenance/improvement of the pastures as well as the annexed structures and equipment.
ii) The availability of potable water, power line electricity and alternative sources of energy. The availability of these facilities impacts the quality of life for personnel and the functions that can be performed by the summer farms (such as milk processing or agro-tourism services). In addition, renewable energy sources reflect an investment in the environmental sustainability of summer farms.
iii) The availability of housing for personnel. This variable was included because a small, but not negligible, proportion of the surveyed units (11%) had lost housing facilities over time. The impact of housing on

Table 3. Parameters, factors and weights used for the calculation of the livestock and social indexes.

Parameters	Factors	Values assigned to factors	Weights assigned to parameter
		Livestock index	
Predominant animal category	Beef cattle	0.1	0.7
	Small ruminants	0.2	0.7
	Dry/Replacement cows	0.3	0.7
	Cows in milk	1	0.7
Resident *in situ*	Yes	1	0.3
	No	0	0.3
		Social index	
Employees, farming	Summering period (d) x number of employees in farming°	Values standardized on 90th percentile	0.5
Employees, no farming	Agro-tourism opening days x number of employees#	Values standardized on 90th percentile	0.5

°Farmer, dairyman, shepherd; #waiter, cook, cheese-maker.

management options is obvious.
iv) The availability of a milking parlour. Hand milking has practically disappeared, and the availability of a milking parlour with respect to other types of mechanical milking is the main technological determinant. This parameter reflects the possibility and willingness of the owners to invest in improving their facilities.
v) The availability of a cheese-making plant. The recent evolution in cheese-making technology and in sanitary regulations requires specific equipment and rooms to perform this activity, which was typical of the traditional management of summer farms.

The data were analysed using the non-hierarchical clustering technique FASTCLUS (SAS, 2006), which is preferred in multivariate analyses of large datasets and controls redundancy and outliers (McGarigal *et al.*, 2000). The information were coded as binary (dichotomous) variables. The optimal number of clusters was determined using the cubic clustering criterion (CCC) statistic (McGarigal *et al.*, 2000). We expected that clusters of summer farms with modern structures and technology would be characterised by more intensive management systems. Intensive or extensive use of summer farms may be indexed by the investment in labour, the category of livestock, the size of the herd, and the productivity of the grazing land. We compared the identified clusters based on the proportion of farmer's *in situ* summer residency, the total number of employees (for all activities), the category of livestock (the % LU of the unit), the herd size, the surface of grazing area, the stocking rate, the elevation and the duration of the summering period. The differences between clusters were tested with a GLM analysis (PROC GLM, SAS 2006) for normally distributed variables (elevation) and log-transformed variables (stocking rate, herd size, and surface of grazing area). For the other variables the differences were tested with a one-way non parametric analysis (PROC NPAR1WAY, SAS 2006). For the farmer's residency *in situ* and the agro-touristic activity, that are binary variables, a chi square test was used (PROC FREQ, SAS 2006). Summer farms managed by the same operator as a single unit were treated as one entity.

Identifying determinants of function indexes

We determined how variability in the indexes was related to the structural, technical and management features of the summer farms, the environmental characteristics of the grazed areas, and the surrounding context of the lowland farms. For this purpose, we used the following explanatory variables:
i) Cluster and accessibility: the previously identified clusters were used as indicators of structural, technical and management differences. Accessibility clearly influences cost and management practices.
ii) Elevation and slope score: these variables represent the permanent environmental conditions of pastures that influence their productivity and the duration of summering.
iii) The size of the grazed area, number of LUs summered, stocking rate, and proportion of different land cover classes in the grazed areas: we used these variables as indicators of the intensity and care with which pastures are managed.
iv) The density of dairy cows: to obtain an index that represented the viability of livestock systems in the area surrounding each summer pasture unit, we calculated the number of dairy cows in each mountain community and divided it by the size (in hectares) of agricultural surface (ISTAT and IMONT, 2008).

We used a multiple regression approach to identify variables related to the livestock and social indexes. We first tested for multicollinearity among the explanatory variables using the variance inflation factor (VIF) as suggested by Zuur *et al.* (2010). We used a multimodel selection procedure based on the Akaike criteria (AIC) to identify the final model (PROC REG, SAS 2006), which was used to test the effect of the selected variables on the livestock and social indexes (PROC GLM, SAS 2006).

Results

Identification and comparison of clusters

The updated database contained 701 alpine summer farms, of which 536 were active and 165 were abandoned. The field survey was conducted at 484 of the 536 active units. The cluster analysis of this sample identified two main groups of summer farms; descriptive statistics are given in Table 4.

The first group comprises 189 units (40% of the total sample). It is characterised as predominantly publicly owned (only 15% of the farms are privately owned) with good availability of structures and equipment. Almost all units have housing for personnel and potable water. Two thirds of the units have electrical lines, and 19% use renewable energy systems. Milking parlours are available at more than one third of the summer farms; close to 60% of the units are equipped for cheese production. This group will henceforth be referred to as public. The second cluster includes 295 summer farms that are mostly privately owned (70%). Less facilities and equipment are available here than in the public cluster. Almost half of these summer farms do not have potable water. Only one fourth of farms have electrical lines, and 17% do not provide housing for farmers. Milking parlours and cheese-making facilities are mostly absent. This group will henceforth be referred to as private. The statistical analysis of the indicators of management intensity (Table 5) showed that the public cluster differed significantly from the private cluster in the higher proportion of resident farmers, greater manpower employment, and larger percentage of dairy cows compared to dry cows,

Table 4. Profiles of identified clusters of alpine summer pastures.

	Cluster 1		Cluster 2	
	No. of summer farms	Percentage within cluster	No. of summer farms	Percentage within cluster
Private ownership	28	15	208	70
Potable water	187	99	165	56
Electricity power line	115	62	71	24
Renewable energy	36	19	18	6
Available housing	183	97	246	83
Milking parlour	67	37	9	3
Equipment for cheese making	106	56	20	7
Total	189		295	
Interpretation	Public ownership with multifunctional vocation		Private ownership	

heifers, beef cattle and small ruminants. Pasture surface, herd size and stocking rate were also greater in the public cluster than in the private cluster, but these differences, although statistically significant, were low. No differences in average elevation and summering days were found between clusters. Therefore, a more intensive management of livestock and products, but not of pastures, characterised the public cluster.

Determinants of the function indexes

The two indexes contained wide variability (the livestock index had an average of 0.64 with a SD of 0.32; the social index had an average of 0.31 with a SD of 0.22). The correlation between the livestock and social indexes was positive and statistically significant (r=0.61; P<0.001). However, the amount of variability that remained unexplained was still remarkable.

The analysis of multicollinearity retained all of the independent variables. The final models used to identify explanatory variables excluded the accessibility variable and the variables related to the management and status of pastures (*e.g*., the size of the grazed area, the number of LUs summered, the stocking rate, and the proportion of shrub/tree cover of the grazed areas) but retained the cluster, the slope score and the density of dairy cows (Table 6).

Private summer farms had lower values in the two indexes compared to public summer farms. The slope score negatively influenced the indexes. When the densities of dairy cows in the Mountain Communities increased, the function indexes of the summer farms located in these Mountain Communities also increased. The influence of the cluster variable was far greater than that of the other variables: its partial R^2 was 0.19 for the social index and 0.26 for the livestock index, with a total R^2 of the models that did not exceed 0.33. These values indicate that also other variables not included in the model had a remarkable influence on the indexes.

Discussion

We found that the recent evolution of summer farms has mostly been determined by the type of ownership; environmental constraints and pasture management have played a minor role. These findings will be discussed in the following paragraphs, while their policy implications will be addressed as a conclusion.

The type of ownership determined the evolution of summer farms

Our clustering approach demonstrated that the type of farm ownership is the main variable that determines the structural and technological features of the summer farms. Public units have far better facilities and equipment than private units. Public owners have been more willing and able than private owners to invest in the structure and equipment of their holdings. Public owners are typically municipalities (84%), which may have greater access to subsidies for infrastructure improvement and the maintenance/modernisation of buildings and equipment than private owners. In addition, public administrations regard summer farms as a fundamental component of their patrimony and cultural heritage and may determine that these farms deserve conservation irrespective of economic return. In contrast, private holders are driven by economic considerations, which discourage investments in summer farms due to the low rents, which do not ensure adequate returns. In our survey, most renting fees per season were approximately 150 euro/ha. Renters do not necessarily improve the summer farms they rent because the costs of investments will not be returned during the short-term duration of the contracts: we found that 30% of the contracts had a duration of 1-2 years and only 10% of contracts had a duration longer than 6 years.

As a consequence of this differing investment, the type of ownership is also the main determinant of the economic viability of the summer farms as well as their activity. The ownership variable accounted for most of the difference in the livestock and social indexes in the regression model. Because public farms are better equipped for dairy cows, cheese making, and agro-touristic services, they are rented by farmers who wish to exploit these opportunities. These functions require more personnel, who frequently reside *in situ*. Consequently, public summer farms had greater livestock indexes, kept more dairy cows and had resident personnel more frequently. Public farms had greater social indexes due to the greater numbers of employed personnel.

The other variables that influenced the two indexes were the slope score (see the next section for a discussion of environmental variables) and the density of dairy cows. In the Mountain Communities, this variable was positively correlated with the livestock and social indexes of the summer farms. This result suggests that the local viability of dairy farming is still linked to that of the summer farms themselves. However, this link is feeble: the partial R^2 values were lower for the density of dairy cows than for the cluster and slope index (Table 6).

The management and functions of the summer farms are scarcely influenced by environmental constraints

Public summer farms held more productive livestock categories than private units. Public and private farms did not differ in the elevation of pastures, the length of the summering period, or the stocking rate (Table 5). Because elevation is strongly related to pasture productivity, we expected that summer farms with

Table 5. Management and environmental features of the identified clusters.

	Cluster 1, mean	Cluster 2, mean	P°
Management			
Resident *in situ*, %	76.2	40.7	<0.001
Age of conductor	47	49	ns
Total employees, mean	3.2	1.8	<0.001
Dairy cows, % of LU/unit	54	22	<0.001
Dry cows/replacement, % of LU/unit	32	54	<0.001
Beef cattle, % of LU/unit	3	7	ns
Small ruminants, % of LU/unit	9	14	ns
Agro-touristic activity, %	33.3	6.1	<0.001
Environmental			
Pasture area, ha	72.8	64.5	0.01
LU, total n.	57.5	45.7	<0.001
LU/ha pasture area	1.09	0.98	0.015
Elevation, m asl	1402	1422	ns
Summering, days	116	116	ns

°For frequencies a χ^2 test was used; ns, not significant.

Table 6. Multiple regression analysis of functional indexes.

Variable	Livestock index				Social index			
	b	t	P	Partial R^2, %	b	t	P	Partial R^2, %
Intercept	0.41	13.7	<0.001		0.26	13.3	<0.001	
Cluster, 1 *vs* 2	0.11	10.1	<0.001	25.1	0.06	8.5	<0.001	18.6
Slope index	-0.04	-2.9	0.005	2.9	-0.05	-6.3	<0.001	11.8
Dairy cows/ha in MC surface	0.08	2.4	0.019	1.3	0.07	3.4	<0.001	2.6
R^2, %		29.3				33.0		

MC, Mountain Community: local administrative institutions, grouping more municipalities, deputed to promotion and management of mountain resources.

more demanding livestock categories would be located at lower elevations and would have higher stocking rates and longer durations of summering with respect to units with less demanding livestock categories. However, we found no differences in these variables. This result suggests that the environmental features of the pastures do not constrain the management of summer farms, which is in accordance with Mrad *et al.* (2009). In the past, when the summer pasture was fundamental for the forage budget of permanent farms, management priorities were the optimal exploitation and maintenance of the sward in ideal conditions (Dodgshon and Olsson, 2007). This goal was achieved by carefully choosing suitable livestock, adapting the stocking rate to sward productivity, and adopting a series of care practices such as manure distribution and weed cutting. Today, concentrate feeding can overcompensate for pasture productivity, and access to summer farms by highly demanding livestock is mostly dependent on structural and technological features, as discussed above. Hence, the maintenance practices of the sward have relaxed, as is suggested by our multiple regression analysis, which revealed that the functional indexes were unrelated to the land cover composition of the grazed areas. Camacho *et al.* (2008) observed that pastures still in use in the northern French Alps were invaded by shrubs because farmers tended to use pasture areas that were oversized with respect to the grazing needs of the herd and to reduce costs by abandoning maintenance practices. This phenomenon seems to have occurred in our case as well: we found a significant negative correlation between the stocking rate and the size of pastures (n=330; r=-0.39; P<0.001) and that 20% of the units had dismissed the traditional practice of cutting weeds at the end of the season.

Amongst the environmental variables measured, only the slope score had a significant effect on the function indexes. This correlation was negative because investment in facilities and equipment occurs preferentially in units where these efforts are less costly and have a higher potential reward. The slope is still a constraint for high-producing dairy breeds that are unfit for steep terrains; these breeds move with difficulty on such terrains and have a higher risk of leg injuries.

Conclusions

In this study, we identified 536 active summer farms; Berni and Fabbris (1983) recorded 503 active units. Although we were able to detect more private structures than Berni and Fabbris (1983), the number of active summer farms did not change remarkably over the last few decades. Because extensive dairy farming systems that traditionally use summer farms (Sturaro *et al.*, 2009) have strongly declined (Cocca *et al.*, 2012), this finding was surprising. Therefore, understanding why and how summer farms are used is important.

Our study indicates that well-equipped summer farms are in high demand. In fact, all of the units equipped for maintaining high-producing dairy cows, processing milk and directly marketing cheese are rented by resourceful farmers who exploit these opportunities. In this way, summer farms may be important economic assets, and this activity may contribute to the viability of permanent dairy farms (Penati *et al.*, 2011). However, we found that only 40% of the summer farms surveyed had been renovated to suit these activities. This observation might explain why only 50% of the holdings kept cows in milk and only 26% processed milk into cheese; in the early eighties, milk was produced in 91% of the units and processed in 55% (Berni and Fabbris, 1983). To reverse this economic loss, policies supporting structural and technical investments in summer farms are needed. To be successful, such policies must take into account the type of ownership and the peculiarities of the present rent fees. Public owners, who generally want investments that result in improvements of patrimonial value, will likely be ready to take advantage of contributions for structural investments. Many public owners have already proven to be able to take such actions. Private owners and renters, who are constrained by the need for direct returns, are unwilling to contribute to structural investments that do not ensure adequate rewards. Therefore, policies must also remove obstacles preventing the remuneration of structural investments.

We suggest that policy measures should favour transparent rental fees commensurate with the potential economic value of the holding. The maintenance and renovation of summer farms would thus become economically attractive and self-sustainable rather than being dependent on subsidies as they are now. In addition, measures should support the negotiation of long-duration contracts to encourage resourceful renters to take initiative when owners are unable or unwilling. Market measures for private owners would also be useful for the remarkable proportion of public owners (35% of the summer units surveyed) who have thus far been unable to invest.

The development of agro-touristic activities, such as bar and restaurant service and tourist accommodation, may also improve the economic value of summer farms. Only 20% of the total units surveyed offered these services; however, these units had the highest social indexes and hence, the highest economic value. However, policies must promote the diversification of functions and incomes without a disproportionate involvement in off-farm activities, which risks the abandonment of farming practices (López-i-Gelats *et al.*, 2011). The labour and investment needed for these highly rewarding activities may compete with farming practices, and owners and renters could be tempted to progressively reduce resources for the care of herds and pastures. We found remarkable variability in the economic viability and functions performed by summer farms. This variability was mainly explained by the type of ownership and only partially by the local density of dairy permanent farms. Other influences, which we could not consider in our analysis, most probably include the socio-economic development of local communities and farms for the diversification of farming activities and tourism. Policy measures must take this variability into account to be effective (Van Huylenbroeck and Durand, 2003).

We found that summer farms with obsolete structures and equipment have not been abandoned but are instead used to keep low-demanding categories of livestock, such as replacement and dry cows. This practice may be due to new incentives that have arisen from agricultural policies. Access to grazing subsidies has become a significant source of income, especially for small farms (Gellrich *et al.*, 2007; Marini *et al.*, 2009). In the future, contribution to the ecosystem and landscape services might become more important additional sources of income as the European Community agricultural policy undergoes a greening evolution (Kaley and Baldock, 2011). Our finding that the traditional, strict link between the management of the summer farm and the conservation of its pastures has been disrupted has important implications. Because the optimisation of forage exploitation now plays a minor role in the economic, social and recreational functions performed by the holdings, pastures are often managed with sub-optimal stocking rates (Mrad *et al.*, 2009). As care practices are abandoned or slackened, changes occur in the botanical composition that are deleterious for forage value and allow for weed encroachment and forest expansion (Isselstein *et al.*, 2007; Camacho *et al.*, 2008). These phenomena are very difficult to reverse, and the loss of pasture surface or of forage value is often irreversible (Pavlu *et al.*, 2007). Greater heterogeneity in sward structure and the scattered presence of bushes and trees that characterise pastures managed with extensive grazing may increase the biodiversity of animal and plant communities (Boschi and Baur, 2007; Klimek *et al.*, 2007; Zeitler, 2003). However, the abandonment of care practices may have also negative effects, such as the progressive landfilling of watering pools, which are important habitats for many amphibian species (Solimini *et al.*, 2008).

We will not discuss here the variety of potential consequences for the landscape and biodiversity that result from the abandonment or slackening of pasture management. However, we wish to stress the importance of linking the use of pastures and access to public funds to correct management practices. In this way, summer farms can conserve their forage, landscape and biodiversity values. This is a fundamental issue for the future regional policies, given the expected evolution of EU policies.

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