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ORIGINAL ARTICLE

Stakeholder perceptions of grassland ecosystem services in relation to knowledge on soil fertility and biodiversity

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Abstract The concept of ecosystem services is increasingly being used by scientists and policy makers. However, most studies in this area have focussed on factors that regulate ecosystem functions (i.e. the potential to deliver ecosystem services) or the supply of ecosystem services. In contrast, demand for ecosystem services (i.e. the needs of beneficiaries) or understanding of the concept and the relative ranking of different ecosystem services by beneficiaries has received limited attention. The aim of this study was to identify in three European mountain regions the ecosystem services of grassland that different stakeholders identify (which ecosystem services for whom), the relative rankings of these ecosystem services, and how stakeholders perceive the provision of these ecosystem services to be related to agricultural activities. We found differences: (1) between farmers' perceptions of ecosystem services across regions and (2) within regions, between knowledge of ecosystem services gained by regional experts through education and farmers' local field-based knowledge. Nevertheless, we identified a common set of ecosystem services that were considered important by stakeholders across the three regions, including soil stability, water quantity and quality, forage quality, conservation of botanical diversity, aesthetics and recreation (for regional experts), and forage quantity and aesthetic (for local farmers). We observed two contrasting stakeholder representations of the effects of agricultural management on ecosystem services delivery, one negative and the other positive (considering low to medium management intensity). These representations were determined by stakeholders' perceptions of the relationships between soil fertility and biodiversity. Overall, differences in perceptions highlighted in this study show that practitioners, policy makers and researchers should be more explicit in their uses of the ecosystem services concept in order to be correctly understood and to foster improved communication among stakeholders.

Keywords Ecosystem services · Biodiversity · Soil fertility · Stakeholders' perceptions · Mountain grasslands

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Introduction

Since the 1990s, multifunctionality has been adopted as a key component of the European Union's Common Agricultural Policy (CAP) and has increasingly been used in scientific and political debates (Marsden and Sonnino 2008; Renting et al. 2009). It embraces all goods, products and services created by farming activities (Marsden and Sonnino 2008), thereby highlighting the non-marketed role of agriculture. More recently, the notion of ecosystem services [commonly defined as the benefits people obtain from ecosystems (MEA 2005)] appears to have promoted a conceptual shift from multifunctionality of agriculture towards multifunctionality of the agro-ecosystem (Simoncini 2009), conveying a more biodiversity-oriented perspective of multifunctionality. Moreover, several reports on the 2013 CAP reform have proposed that economic incentives should be introduced to encourage farmers to produce ecosystem services [e.g. European Parliament resolution of 8 July 2010 on the future of the Common Agricultural Policy after 2013 (2009/2236(INI))].

Given multiple available definitions of ecosystem services (see Lamarque et al. 2011 for a review) and the need for a precise description to present the concept to stakeholders, we defined ecosystem services as all direct *living* components or processes of natural or managed ecosystem used, consumed or enjoyed (passively or actively) *by humans* before any human *transformation* of ecosystem services. This definition highlights the contribution of the interactions between organisms and the physical environment (Mooney et al. 2009), and also the fact that ecosystem services are the end-products of nature (Boyd and Banzhaf 2007) and not the results of their human transformation (e.g. forage quality or quantity are the services which provide goods such as milk and cheese). The multiple ecosystem services can be classified following different criteria such as functional (MEA 2005) or spatial characteristics (Costanza 2008), decision context (Fisher et al. 2009) or specific context such as the agro-ecosystem (Zhang et al. 2007; Le Roux et al. 2008—see Fig. 1). In an agricultural context, this view of multifunctionality includes benefits from ecosystem components and processes for the agro-ecosystem, such as soil fertility, improved water cycling or pest control, as well as benefits from the agro-ecosystem to society (Zhang et al. 2007), rather than focusing solely on agricultural output.

The ecosystem properties that underlie ecosystem services depend largely on biodiversity and especially on functional diversity (the presence or abundance of particular functional groups or functional traits) rather than on species number (Hooper et al. 2005; Diaz et al. 2006; Le Roux et al. 2008). In particular, a growing knowledge on plant functional traits (e.g. leaf dry matter content, vegetative height and date of flowering onset) is making it possible to quantify ecosystem services based on responses of functional traits to environmental change and/or effects on ecosystem properties (Diaz et al. 2007; Lavorel et al. 2011). In addition, soil biodiversity and its links with above-ground communities play a significant role in ecosystem services delivery (Barrios 2007; Turbé et al. 2010). In agro-ecosystems, soil fertility is an important component of soil quality and corresponds to the ability of soils to support plant growth by ensuring the adequate recycling of organic matter, nutrients, soil physical properties and provision of water (Turbé et al. 2010), thereby contributing ecosystem services that support agricultural production. Nevertheless, increasing intensification of agriculture, which is usually associated with increased fertility through fertilizer use and liming, tends to decrease both soil (Bardgett 2005; Turbé et al. 2010) and above-ground (Walker et al. 2004; Schmitzberger et al. 2005; Klimek et al. 2007) biodiversity. Given such modifications of biodiversity, the supply of ecosystem services is likely to vary with land use and management intensity (Sandhu et al. 2010; Turbé et al. 2010), and it has been proposed that ecosystem services will peak at 'intermediate' levels of intensity (Haines-Young 2009), as usually found for biodiversity (Bardgett 2005; Tasser et al. 2005). Finally, sustainable landscape management needs to consider multiple inter-related ecosystem services (Bennett et al. 2009).

As the identification of ecosystem services is motivated by human well-being, stakeholder involvement is particularly important in order to understand people's values and needs (Menzel and Teng 2009). Moreover, there is a specific need to explore perceptions of grassland ecosystem services in view of current policy change (e.g. CAP reform), which as mentioned above has been gradually shifting its focus from agricultural production to the provision of multiple ecosystem services. However, only few studies of ecosystem services have addressed the

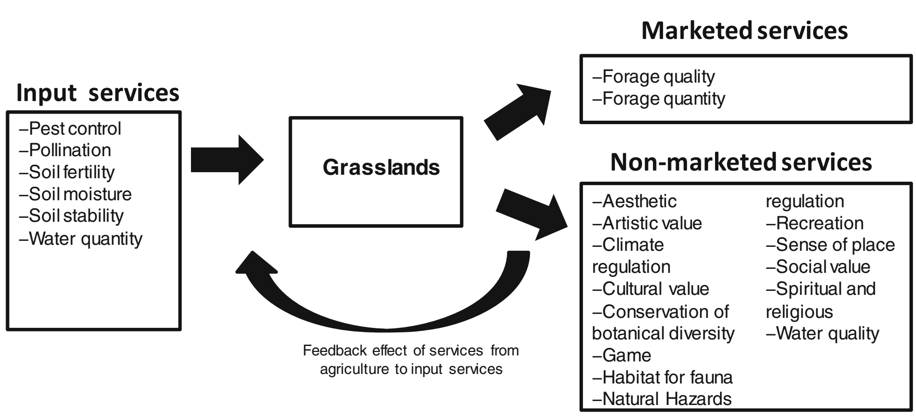

Fig. 1 Ecosystem services potentially delivered by semi-natural grasslands—adapted from (Zhang et al. 2007; Le Roux et al. 2008). Input services contribute to biological, physical and chemical processes supporting agriculture, marketed services contribute to agricultural productivity while non-marketed services do not directly contribute to agricultural income (except some specific cases like agro-tourism farms)

identification or perception of ecosystem services by stakeholders (Lewan and Soderqvist 2002; Pereira et al. 2005; O'Farrell et al. 2007; de Chazal et al. 2008; Quétier et al. 2010). Additional insights knowledge of ecosystem services among stakeholders may also be gained from studies of the perception of biodiversity (Fischer and Young 2007; Larrère et al. 2007; Buijs et al. 2008), plant uses (Pieroni and Giusti 2009) and/or the influence of plant diversity on aesthetic appreciation (Lindemann-Matthies et al. 2010). Likewise, ethnopedology examines soil and land knowledge by rural communities (e.g. Barrera-Bassols and Zinck 2003), and the studies of traditional or local ecological knowledge identify representations of environmental resources (e.g. Cheveau et al. 2008). However, such studies often focus on a single or few ecosystem services rather than on multiple interlinked services, which remain a significant gap in knowledge.

We propose to address these knowledge gaps by studying perceptions of multiple services by stakeholders and by placing these perceptions in the broader context of stakeholders' perceptions of the ecosystem through their knowledge of biodiversity and soil fertility. We place special emphasis on soil ecosystem services to address the lack of awareness by stakeholders of their role for the delivery of other ecosystem services (Turbé et al. 2010). Mountain semi-natural grasslands have traditionally delivered multiple ecosystem services in relation to their high levels of above-ground and likely below-ground biodiversity (Fig. 1). We used an approach based on interviews with regional experts and local farmers of mountain grasslands to explore: (1) the perception of ecosystem services and the relative importance of different services for different stakeholders of three European mountain semi-natural grassland regions and (2) in order to build a systemic view, how these perceptions are influenced by stakeholders' knowledge on biodiversity and soil fertility and by their direct involvement in management.

Materials and methods

Study sites

Permanent grasslands represent a very significant proportion of the European agricultural space (33% of the utilized agricultural area (UAA) in the EU in 2007—Eurostat 2010). Species-rich traditionally managed grasslands are strong asset for European society, but they are threatened by changes in land use, intensive management or abandonment (MacDonald et al. 2000; Gibon 2005; Spiegelberger et al. 2006). In this study, we focused on three European grassland-dominated mountain regions, chosen to represent a gradient in management intensity and associated soil fertility (Fig. 2): the French Alps (Villar d'Arène); the Austrian Alps (Stubai Valley) and the English uplands (Yorkshire Dales). These regions are all used primarily for livestock rearing (cattle or sheep) with heterogeneous management intensity and therefore soil fertility within each site, and represent a diversity of agricultural dynamics across European mountain grasslands over the last 50 years.

The upper slopes (above 2,500 m) of Villar d'Arène have been extensively grazed for centuries, but the lower slopes have undergone land use change over the last century. Following rural exodus at the beginning of the twentieth century, former arable land on terraced slopes (1,650–2,000 m) was abandoned and transformed into grasslands that are now cut for hay where they are accessible to machinery or grazed. In these grasslands, as well as in those grasslands managed for hay production since the 1700s (1,800–2,500 m), management practices have remained at low intensity, with low stocking rates, very low manure inputs (every 2 or 3 years) and a single annual hay cut. This management mosaic results in distinct patterns of fertility, floristic and functional composition, and associated ecosystem properties (Quétier et al. 2007; Robson et al. 2007). The Stubai Valley was mainly agrarian until the 1970s, but since then the labour force has shifted massively from agriculture to other sectors such as tourism. This has occurred alongside an important structural transition within agriculture from full-time to part-time farming (1970: 57% part-time farmers, 2000: 80% part-time farmers, ISIS, Statistics Austria). Therefore, a dichotomy appears between lightly used high altitude meadows (at and above treeline which lies around 1,900 m) where management intensity is determined by accessibility to machinery, and the bottom of the valley where meadows are used intensively, with high rates of fertilizer application and two or three cuts of vegetation per year. Some pastures and meadows are abandoned and colonized by shrubs and trees. The resulting vegetation is a mosaic of forest and diverse grassland types (Tasser et al. 2005, 2007). Traditionally, grasslands in the Yorkshire Dales were used for hay production and livestock grazing, using traditional methods of farming which

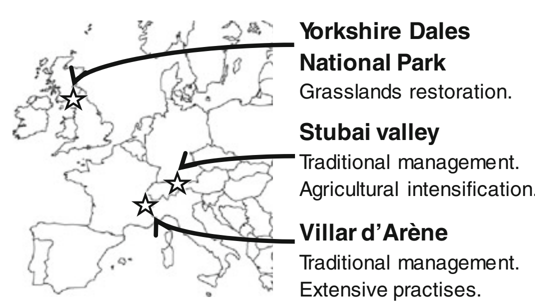

Fig. 2 Study areas location and their agricultural intensification characteristics

involved a single annual hay cut and inter-season grazing, with the application of some manure and lime (Smith et al. 2008). However, since the 1950s, there has been a shift to more intensive livestock and forage production with high rates of fertilizer application and multiple harvest of grass for silage. In recent years, there have been movements in the area to restore species-rich hay meadows by seeding (input from species-rich meadows), controlled cutting and reduced fertilizer use, but silage is still produced. Such variation in management intensity is directly related to plant species richness, functional composition, as well as to soil biological diversity and function (Donnison et al. 2000; Smith et al. 2008; de Deyn et al. 2011).

In addition to agriculture, tourism is a dominant economic activity in all three regions, which are recognized for their aesthetic, cultural and conservation value and offer opportunities for recreation. In Austria, agro-tourism is well developed, and Villar d'Arène and Yorkshire Dales are parts of national parks. All the differences across the three sites are important to consider in this study as they lead to potentially different supply and demand of ecosystem services across the three regions.

Stakeholders survey

We aimed to explore ecosystem services identified by different stakeholders related to grassland management and interrelationships between management and ecosystem services. We considered as stakeholders the individuals or sets of individuals who have an interest in ecosystem services because they benefit from them and/or could have an active or passive influence on their delivery (adapted from Billgren and Holmén (2008) and Reed et al. (2009)). We aimed to analyse in-depth stakeholders' discourses rather than obtain a representative overview of perceptions and compare them statistically between sub-groups. Therefore, our sample was designed to collect contrasting opinions and points of view (Fischer and Young 2007; Quétier et al. 2010). The same sampling strategy was used for each study site. Stakeholders were sampled as two groups: (1) regional experts working for governmental institutions, regional institutions or NGOs who represent consumers of their sectors of activity (agriculture, nature conservation, tourism or rural development) and act as decision makers and (2) local beneficiaries who are consumers (farmers and inhabitants) and/or producers (farmers). Then, within each group, we separated stakeholders into two groups, namely those with primary interests in agriculture and those from other socio-economic sectors (tourism, nature conservancy or rural development). All the interviewees were familiar with the regional study site, at least broadly for some regional experts who have expertise in similar agro-ecosystems.

Stakeholders' perceptions of ecosystem services related to management of mountain grasslands were elicited using different methods depending on their origin. Semi-directed individual interviews were used with regional experts because we wanted to elicit mainly factual knowledge, while a group interview was preferred with local beneficiaries because common perception on trends connected to a local context was the focus. Moreover, group interview was the chosen method for farmers to help them speak about unusual issues and build-up their ideas based on each others responses. Each participant was invited to give his/her opinion on the different themes of the interview guide. Semi-directed interviews are used to collect qualitative data in order to understand the interviewee's point of view. Open-ended questions give medium level of freedom to interviewees to scope their opinions on the subject, but also allow interviewers to reshape questions during the interviews to go into the predefined themes in depth (Grawitz 2001). Individual interviews and group interviews were considered comparable because in both cases 'the emphasis was on questions and responses between the researcher and participants' (Morgan 1997), a common template was followed (see below), and the group interview did not elicit group interactions (in comparison with a focus group approach). In total, 29 regional expert interviews and three group interviews involving a total of 24 persons were held (Table 1).

Participants selected by reputation or recommendations (snowball strategy) were recruited by phone and invited to an individual interview or a discussion group about the uses and values of grasslands. The term 'ecosystem services' was not used in order to prevent participants from trying to collect information before the interview. A common interview guide (Table 2) was used for semi-directive interviews and group interviews across the three regions. Interviews and group interviews lasted between 1 and 2 h and were carried out between summer 2009 and spring 2010. In order to start the discussion and test stakeholders' knowledge and perception of below-ground and above-ground components of grassland ecosystems, the first part of the interview focussed on their descriptions of biodiversity and soil fertility in the context of grasslands of their area. Further questions on relationships with agricultural practices and linkages between the two terms were asked if relevant. The second part of the interview focused on ecosystem services. We decided first to ask to participants to provide a spontaneous list given the previously discussed definition and second to request a ranking for the five most important ecosystem services from a proposed service list discussed with interviewee. This was in order to (1) check that people understand correctly the concept; (2) analyse stakeholders' perceptions and associations with the

Table 1 Stakeholders sampling (codes used in the results section refer to the respective individual interviews or group interviews)

		Villar d'Arène	Stubai valley	Yorkshire dales
Regional experts (individual interviews)	Agricultural sector	6 *(VAR1)*	6 (include 3 farmers) *(SVR1)*	3 *(YDR1)*
	Non-agricultural sector (nature conservation, tourism, …)	7 (1 tourism, 6 NC *(VAR2)*	3 (2 tourism and 1 NC) *(SVR2)*	4 (NC) *(YDR2)*
Local beneficiaries (group interview)	Farmers	3 *(VAL1)*	14 *(SVL1)*	4 *(YDL1)*

Table 2 Interview guide

Introduction	Can you describe particular characteristics of grasslands?
Soil fertility	(a) What is soil fertility?
	(b) How is soil fertility affected by agricultural activities?
	(c) Can agriculture lead to an increase/decrease in soil fertility?
	(d) How could you measure soil fertility?
Biodiversity	(a) What is biodiversity?
	(b) How is biodiversity affected by agricultural activities?
	(c) Can agriculture lead to an increase/decrease in biodiversity?
	(d) How could you measure biodiversity?
Relationship	Do you think there is a relationship between soil fertility and biodiversity?
	How do you think farmers/stakeholders have knowledge on soil fertility and biodiversity?
Ecosystem services	(a) Do you know the concept of ecosystem services, what does it mean? (only asked to regional experts)
	(b) According to the definition, could you give me some examples of ecosystem services delivered by mountain grasslands? Any other services? (except local farmers from the Stubai valley)
	(c) Scientists identified some other services, can you comment this list? Could you sort them by order of importance or identify the five most important?
	(d) Are there any links between soil fertility, biodiversity and these services?
	(e) How important is agricultural practice in the supply of ES?

term and (3) potentially complete our ecosystem services list.

Data analysis

All the interviews were recorded and subsequently analysed. Discussions on biodiversity and soil fertility were analysed using thematic coding. First, broad coding categories were defined (e.g. definition, relation with agricultural management, link with soil fertility) according to our research objectives and questions, and second categories were refined and specified according to the results (e.g. words used to define each notion). All the results were tabulated allowing easy comparison across study regions. Concerning the second section focusing explicitly on ecosystem services, a list of twenty-one ecosystem services was pre-selected according to a literature review (Fig. 1) and grassland local setting. Then, ecosystem services spontaneously identified or described during the interviews were scored against this list. The five most important ecosystem services ranked by interviewees were analysed without considering their rank order and aggregated by group of stakeholders and country. This was done to avoid potential errors linked to difficulties met by interviewees in ranking services (Lewan and Soderqvist 2002).

Results

Following our analytical strategy and the interview guide, we analysed successively the understanding of biodiversity and soil fertility by interviewee and their interests and uses of ecosystems (ecosystem services). As no strong differences in biodiversity and soil fertility knowledge across regions or stakeholder groups were observed, we present results overall and specify differences only where relevant.

Stakeholders' knowledge and understanding of biodiversity

Although the United Nations proclaimed 2010 to be the International Year of Biodiversity, we observed two types of reactions to the question 'What does biodiversity mean for you?': definition and critical comment ('*This is a buzzword'* [VAR2]). Four common different criteria appeared in interviewees' definitions: scale, type of organism (plant and animal), species variety and number. All interviewees described biodiversity at the species level, but some also described biodiversity of habitats or landscape, and two regional experts considered multiple scales of biodiversity from genes to landscapes. While stakeholders from Villar d'Arène referred mostly to flora, stakeholders from the Yorkshire Dales and the Stubai Valley spoke more about wildlife in general. One farmer from the Stubai Valley included the diversity of farm animals, but only one regional expert in nature conservation from the Yorkshire Dales specified that biodiversity is both above-ground and below-ground. Interviewees spoke generally about species, but some of them added the adjectives: heritage, rare, common or wild. Terms like number, abundance or richness of species, or the wealth of all living things were also used. Finally, interactions between organisms were mentioned only by one respondent.

> All the different life cycle chains of plants, birds and animals living in the countryside, how they interact together and keeping it as rich as possible. [YDR2, group code see Table 1]

Negative impacts of agricultural management on biodiversity were generally recognized, but positive benefits were also identified. Positive management effects on biodiversity were, for example, late hays cuts (good for seed dispersal and allowing ground nesting birds to fledge), mowing rather than grazing, reduced and well organized grazing and replacing sheep with cattle which are less selective. '*Mown grasslands are 'richer' than grazed grasslands. We can describe it as a decreasing gradient from good to less biodiversity respectively associated to mowing, well organized grazing, badly organized grazing*' [FL2].

Some respondents also discussed increases in common biodiversity rather than rarer species. The role of agricultural management in maintaining open landscapes and landscape diversity was also raised. Negative impacts of agriculture on biodiversity were related to the following practices: intensification of agriculture including heavy grazing, frequent cutting, inorganic fertilizer and slurry application, and pesticide use. But respondents also highlighted that extensification of management and associated low-grazing pressures can reduce biodiversity. Generally, management that is either too intensive or too extensive was considered to be negative. A regional expert in nature conservation also said that the impact of management is not always immediate, so the effect of management practices depends on the time scale of observations [VAR1]. Finally, the difficulty in distinguishing the effects of agriculture from those of abiotic factors such as geomorphology or altitude was noted. Effects of biodiversity on agriculture and why people are interested by biodiversity were also discussed by respondents, but the results are described in the ecosystem services section below.

Stakeholders' knowledge and understanding of soil fertility

Although the question initially sparked hesitation, low confidence and a need to remember academic definitions, soil fertility was either understood as soil quality or as fertilization effect, and three types of definitions were provided: (1) soil fertility as the ability of soils to sustain plant growth, plant diversity and yield or biomass; (2) the concentration or availability in organic and mineral (N, P, K) elements (given particularly by expert of non-agricultural sectors) and (3) description of activities for maintenance or improvement of soil fertility such as fertilization and liming. An increase in fertilizers, especially livestock manure, was related to improved soil fertility, and some respondents also considered the influence of abiotic factors such as water or moisture, temperature, altitude or solar radiation. '*We can add fertilizers as much as we like, if the soil is dry this will not change anything'* [VAR1].

Only five regional experts mentioned soil microorganisms during the interview, but they did not include this in their definition. When asking farmers from Villar d'Arène about 'what is a soil made of' in order to stimulate some responses about soil biota, they said 'earth'. They explained that in grasslands they are interested in vegetation but they do not work in the soil. '*To see if the soil is good or not you need to turn over soil as I do in my vegetable garden. I observed there that the soil is better where it is dry in contrast to a heavy or sticky soil*'[VAL1].

While some respondents differentiate natural fertility from managed fertility, *'Soil fertility is important for highland agriculture where intensive management is impossible'* [SVR1] *'Fertility in the sense … soil for agriculture or soil at natural state?'* [VAL1].

In all cases, a relationship between soil fertility and agricultural activity was recognized. All respondents associated decreased soil fertility with reduced biomass or yield, but also decreased feed quality [SVL1]. Agricultural intensification and the uses of fertilizers, manure and lime (in the Stubai Valley and the Yorkshire Dales) were given as examples of how agriculture can increase soil fertility. Conversely, biomass removal by grazing or mowing without fertilization was considered to be a way that agriculture can decrease soil fertility. Only a few experts from Villar d'Arène explained that good agricultural management that is not too extensive and intensive leads to a good balance of soil components. Some experts from the Stubai Valley and a farmer from Villar d'Arène highlighted the fact that intensification of farming is driven by economic constraints. Intensification does not always lead to increased fertilization, but to a change in equipment that promotes soil erosion through compaction and subsequently decreases soil fertility. Finally, methods proposed by interviewees to assess soil fertility were soil analyses and observation of vegetation, i.e., greener vegetation and plants with large leaves such as clover (*Trifolium repens* and *Trifolium pratense*), rye grass (*Lolium perenne*), chickweed (*Stellaria media*), doc (*Rumex obtusifolius*) and ribwort plantain (*Plantago lanceolata*) were thought to be associated with high fertility. *'One year, a guy writes an « M » with chemical fertilizers in a grassland, and it was visible all summer. Even the difference between land where we put manure and the other can be observed by the difference in grass colour'* [VAL1].

Stakeholders' knowledge and understanding of ecosystem services

Regional experts

In general, the term 'ecosystem services' appeared new to respondents, except for two regional experts from Villar d'Arène from nature conservation organisations, two experts from the Stubai Valley working in agricultural sectors, and almost all experts from the Yorkshire Dales, including one who is involved in the UK National Ecosystem Assessment (NEA 2010). However, the general concept seemed to be understood broadly after a short introduction and definition, although people were more able to identify environmental services which are more linked to human made components of landscapes (e.g. beauty of terraces or small villages) or agricultural activities (see Lamarque et al. 2011 for a definition of the different services concepts) than ecosystem services *sensu stricto* from grasslands. In this section, only ecosystem services coming at least partially from ecosystem components and processes, according to our definition, are presented.

For all regions and stakeholders taken together, 18 of the 21 pre-listed ecosystem services were cited spontaneously (Table 3) after the presentation of our definition. In addition to our list, only air quality was mentioned once by an interviewee [VAR1]. Interestingly, to produce their list of ecosystem services some interviewees used a comparison of grasslands to other ecosystems such as forests or wetlands (*'Water availability is delivered less by grasslands than by wetlands or forests, but it's better than without vegetation soil.'*[VAR2]) and selected the service that grasslands deliver more than the other ecosystems. The state of grasslands (abandoned, well managed) or landscape diversity and fragmentation (presence of hedges, trees or a stream) were sometimes discussed as important elements which contribute to ecosystem services such as habitat for fauna or aesthetic value.

A common set of nine ecosystem services was identified across regions (Table 3) including two out of eight from

Table 3 Similarities and differences in ecosystem services identified and listed by regional experts of each region

Classification	Ecosystem services	Villar d'Arène	Yorkshire Dales	Stubai Valley
Input	Pollination			X
	Soil fertility			
	Soil stability	X		X
	Pest control			
	Soil moisture			
	Water quantity	X	X	X
Marketed	Forage quality	X	X	X
	Forage quantity		X	X
Non-marketed	Conservation of botanical diversity	X	X	X
	Habitat for fauna	X		
	Aesthetic	X	X	X
	Cultural value	X	X	
	Natural hazards regulation	X		X
	Recreation	X	X	X
	Water quality	X	X	X
	Climate regulation/ C-sequestration		X	
	Education			
	Game			
	Sense of place			
	Artistic value			
	Religious and spiritual			

Grey filled cell means mentioned, and 'X' means mentioned by more than one respondent the input category, one of two marketed services and six of the eleven non-marketed services. Only regional experts in the Stubai Valley and the Yorkshire Dales identified the three ecosystem services of pollination, forage quantity and climate regulation. Five ecosystem services, namely soil fertility, pest control, game, sense of place and spiritual or religious services, were identified by only one respondent across the three regions. When ranking ecosystem services, as in Lewan and Soderqvist (2002), a discussion arose from some interviewees about the difficulty of doing that due to: (1) the tight interrelationship among some ecosystem services; (2) the extent that some services are more important than other ones and (3) which standpoint they should take (themselves, society, their institution or organisation).

Floral diversity, soil stability, water quantity and quality, forage quality, aesthetic value and recreation were all recognized by regional experts of the all three study regions as important ecosystem services to be protected. Some dissimilarities were also observed across regions (Table 3), but the same trends were present between non-market and input services (8 against 2 for the Stubai Valley, 8 against 4 for the Yorkshire Dales and 8 against 5 for Villar d'Arène interviewees). Interestingly, ecosystem services considered as important by interviewees from the predefined list (Table 3) were not identical to those they mentioned spontaneously (Table 4). Again, when all regions were considered together, eighteen services were listed, but two were not common (pest control and sense of place). For example, more regional experts from the Yorkshire Dales considered input services as important, despite the fact that few were listed spontaneously by them. Conversely, non-market services were not considered important, but were frequently associated with the concept of ecosystem services.

Local farmers

Farmers had never heard about the term 'ecosystem services' and they did not discuss the definition. In contrast to regional experts, they had difficulties in ranking ecosystem services by importance. Forage quantity and aesthetic value were both ranked as being important by farmers at the three study regions (Table 5). Nine ecosystem services were considered to be important by farmers of only one study site. Only farmers from the Yorkshire Dales considered pollination, soil stability, water quantity, habitat for fauna, sense of place and artistic value as important. Stubai Valley farmers highlighted recreation as being important, and farmers from Villar d'Arène stressed the importance of pest control and soil moisture. Farmers from Villar d'Arène gave preference to input services (3 against 2) and marketed services, while farmers from the Stubai Valley and the Yorkshire Dales considered non-market services to be more important (4 against 6 for the Yorkshire Dales and 0 against 3 for the Stubai Valley). Six ecosystem services from our list, including natural hazards regulation, water quality and climate regulation, did not appear among the five most important ecosystem services of any of the regions.

Table 4 Similarities and differences in ecosystem services considered to be the five more important by regional experts of each region

Classification	Ecosystem services	Villar d'Arène	Yorkshire Dales	Stubai Valley
Input	Pollination	X	X	
	Soil fertility			
	Soil stability	X	X	X
	Pest control			
	Soil moisture			
	Water quantity			X
Marketed	Forage quality	X		X
	Forage quantity	X		X
Non-marketed	Conservation of botanical diversity	X	X	X
	Habitat for fauna	X	X	
	Aesthetic		X	X
	Cultural value		X	
	Natural hazards regulation	X		X
	Recreation	X		X
	Water quality	X	X	X
	Climate regulation/ C-sequestration	X	X	
	Education			
	Game			
	Sense of place	X		
	Artistic value			
	Religious and spiritual			

The lists of ecosystem service were obtained from the combination of the five most important services identified by regional stakeholders in each study regions. *Grey filled* cell means mentioned, and 'X' means mentioned by more than one respondent

Table 5 Ecosystem services identified as among the five more important by farmers from each regions

Classification	Ecosystem services	Villar d'Arène	Yorkshire Dales	Stubai Valley
Input	Pollination		X	
	Soil fertility	X	X	
	Soil stability		X	
	Pest control	X		
	Soil moisture	X		
	Water quantity		X	
Marketed	Forage quality	X	X	
	Forage quantity	X	X	X
Non-marketed	Conservation of botanical diversity	X	X	-----
	Habitat for fauna		X	-----
	Aesthetic	X	X	X
	Cultural value		X	X
	Natural hazards regulation			
	Recreation			X
	Water quality			
	Climate regulation/ C-sequestration			
	Education			
	Game			-----
	Sense of place		X	-----
	Artistic value		X	
	Religious and spiritual			

List obtained from the combination of the five most important services identified by local farmers during group interview sessions in each country. In Austria, some services (noted '———') were not proposed during the group interview session. *Grey filled* cell means mentioned, and 'X' means mentioned by more than one respondent

Interrelationships between biodiversity, soil fertility and ecosystem services

Regional experts as well as local farmers were asked to identify and explain relationships between biodiversity and ecosystem services, as well as between ecosystem services from the list, with a special focus on soil fertility. Because linkages identified by regional experts were similar to those identified by local farmers, results are described overall and differences specified where relevant.

The results on biodiversity and fertility perceptions suggest that interviewees were only moderately aware of relationships between biodiversity and soil fertility. A negative effect of soil fertility on biodiversity was broadly recognized ('*A highly fertile soil will grow grass very well, a poorly fertile soil has the ability to be more diverse in the range of flora that can be found.*' [YDR1] '*Generalist species with large leaves and small stems grown on fertile soil*' [VAL1]), but non-linear relationships were also described ('*There is a link, but it's not simple*', '*generally an increase in fertility means less biodiversity, however it's not always the case'* [YDR1, YDR2 VAR1, VAR2]), such as an 'humpback curve' ('*the relationship is positive or negative depending on the level of soil fertility*' [YDR1, YDR2], '*do not manure beyond some limits, because after you change the flora*' [VAL1]). Besides, some regional experts based their explanation on the theoretical humpback curve between species richness and productivity (Grace 1999) that they know from their education. In addition, some respondents argued that factors such as temperature, climate or altitude influence vegetation, and fertility was not always perceived as having a direct effect on biodiversity ('*Each year the forage is different. Dry year plants have more stems and smaller leaves so it's not good for the forage.'[VAL1]).* In general, interviewees spoke more easily about plant attributes such as leaf size or colours than about species.

Soil fertility was perceived as having an overall negative relationship with multiple input and non-market services such as soil stability, climate regulation, water quality (due to nutrient leaching), pollination, aesthetic value, cultural services, education and recreation and sense of place. This is notably due to the perceived negative effect of fertilization on biodiversity. Positive links were only perceived with marketed services (forage yield and quality). Only regional experts from Villar d'Arène identified negative links between soil fertility and forage quality, and interviewees from Villar d'Arène and the Stubai Valley considered aesthetic value and forage quality as positively associated, but interviewees from the Yorkshire Dales perceived the relationship as either negative, or positive and negative.

Biodiversity was considered to impact positively on pollination, pest control, aesthetic value and sense of place. Relationships between biodiversity and forage yield were considered to be positive or negative ('*Farming methods which increase biodiversity bring soil fertility down, so methods for biodiversity are bad for productivity' [YDL1]).*

Relationships among ecosystem services were also identified regardless of biodiversity or soil fertility. For example, a decrease in water availability was considered to decrease forage quantity or soil stability, as well as aesthetic value. A regional expert from the Stubai Valley said that '*beautiful flowers are less usable for forage (in term of raw fiber, raw protein and contents)'* [SVR1], and regional experts from Villar d'Arène linked landscape aesthetics to its tidiness and also perceived a relationship with avalanche regulation. Some ecosystem services were also considered by some respondents to have no relationship with other services. For example, flood control was unrelated to any other service.

Discussion

We discuss below the results in relation to our two research questions. The first part of the discussion focuses on ecosystem services perceptions, while the second part deals with the perceived links between agricultural management and ecosystem services through fertility level. We finish by examining the implications of our findings for future studies on ecosystem services and provide some recommendations for policy implementation.

Ecosystem services perceptions: causes and implications

It is well established that ecosystem services are context dependent (Singh 2002; Diaz et al. 2006) and that differences in cultural background and agricultural intensification across regions exist. However, this study suggests that perceptions of ecosystem services by regional experts, in terms of identification and ranking, present several commonalities. Nevertheless, difficulties met by interviewees during the ranking exercise in relation to the different standpoints that they could adopt (i.e. adopting a personal view, that of their employers or the presumed point of view of broader society) suggest that people do not have a fixed set of preferences (Lewan and Soderqvist 2002). In contrast, at the local scale context seems to have a stronger effect on ecosystem service perception because local farmers place importance on different ecosystem services in the different regions. For example, farmers from the Yorkshire Dales, and more strongly those from Villar d'Arène, ranked input and marketed services as being most important, while Stubai farmers placed more importance on non-market services. This result is consistent with the high rate of part-time farmers (80%) in the Stubai Valley, of which a significant number are involved in tourism. Therefore, recreation, cultural and aesthetic values are of high importance to them. At Villar d'Arène, a recent vole (*Arvicola terrestris*) outbreak damaged grasslands and especially mown and fertilized grasslands (as found by Morilhat et al. 2007). Therefore, farmers identified vole control as an important ecosystem service delivered by some undamaged grasslands, whereas pest control was not considered important by farmers of the other regions who were not troubled by voles or other pests. Of note here is that voles, as a component of the ecosystem, are seen as a dis-service (i.e. a negative ecosystem service) because they damage large areas and reduce hay productivity. Differences between ecosystem services considered important by regional experts and local farmers within regions appear to reflect differences in technical (knowledge and background) and local knowledge (generated by practice and observations). This suggests differences in objectives or concerns across stakeholders (e.g. regional experts and local farmers) (Grimble and Wellard 1997) which could foster divergent priorities among stakeholders for ecosystem management. Such results highlight the need to increase people's awareness of the utility of particular services for sustainable management (Earl et al. 2010).

Some ecosystem services from our list were rarely (by local famer or regional expert from only one region) or never mentioned spontaneously or considered to be important by interviewees. For example, except for soil stability, ecosystem services delivered by soil biodiversity such as soil fertility or soil moisture were rarely identified. This is probably due to the fact that the roles that soils and their biodiversity play in regulating ecosystem processes and the services that they underpin are poorly understood from a scientific perspective (Bardgett 2005; Dominati et al. 2010; Turbé et al. 2010). These results highlight: (1) the limited ecological understanding and/or awareness by interviewees of some ecosystem services and (2) the difference between peoples' values and perceived needs (the individual demand) and the services potentially delivered by grasslands (the supply).

Regional experts did not associate some services with the ecosystem service concept, even if they did consider them to be important on the basis of the list they were provided. Services identified spontaneously were more 'visible' services, according to Lewan and Soderqvist (2002), such as recreation, aesthetic, natural hazards regulation, while during the ranking exercise 'invisible' services such as pollination and soil fertility emerged. This could lead to misunderstandings when these people are exposed to the term 'ecosystem services' in the media or policy. If relevant ecosystem services are not defined in detail, it is likely that the concept will be misunderstood by stakeholders, who may therefore not understand the importance of managing those ecosystem services targeted by policy. For example, in the European Parliament resolution of 8 July 2010 on the future of the Common Agricultural Policy after 2013 (2009/2236(INI)), ecosystem services are cited but not defined: '(…) *CAP must place a* *greater emphasis on sustainability by providing proper economic incentives for farmers to optimise the delivery of ecosysteme services and further improve the sound environmental resource management of EU farmland* (…)'. Therefore, according to readers, incentives may not be attributed for the same ecosystem services (marketed or non-market services could be promoted at the expense of input services). These findings further demonstrate the importance of asking stakeholders to define or explain individually what each service means for them, highlighting that each individual can have a different view of a specific ecosystem service in relation to their uses or interests. For example, water quantity can mean: water availability to irrigate my field, soil water availability for grasses, or freshwater for stock or domestic consumption. In addition, because each person can have different priorities or interests according to the standpoint taken (society, themselves, institution) (Lewan and Soderqvist 2002), it is important to specify whom interviewee represents during the interview (especially for ranking services) in order to correctly interpret data.

Although interviewees were able to formulate ecosystem services perceptions, it is important to note that the concept itself was not unanimously accepted. On one hand, it prompted debates with several respondents mainly due to an opposition to monetarization (*'Economic value of ecosystem could be dangerous because not all the services are valuable in term of money. Moreover does it mean that if we have money we can destruct nature?'* [VAR2]), and on the utilitarian rather than intrinsic value given to nature (*'Anthropogenic view of ecosystem'*[VAR2]. *Nature does not give service but human use nature. Ecosystem services should be renamed 'Interest for nature'* [VAR2] *or 'ecosystem exploitation'* [VAR1]). On the other hand, people have different interpretations for the concept. Some interviewees compared it to multifunctionality, positive amenities, externalities, High Nature Value farming, ecological intensification or natural resources. Indeed, it seems that people think more easily in terms of multifunctionality of agriculture than of ecosystem functioning, as suggested by a preferential focus on non-market services rather than on input services. This is probably due to the growing influence of multifunctionality in framing agricultural and rural development policy over the last 10 years. In this context, the ecosystem services concept is still emerging. Nevertheless, it is surprising that even interviewees from the Yorkshire Dales followed this pattern since multifunctionality was not well adopted in rural development programmes in the UK (Marsden and Sonnino 2008). This suggests that the widespread shift from multifunctionality to this new concept is not clear to some regional experts and needs to be better explained. For example, one of the strengths of the ecosystem services approach compared to the agricultural multifunctionality concept is that it can accommodate values outside farming and highlight the dependence of socio-economic activities such as agriculture on the functioning of ecosystems (Simoncini 2009).

Systemic perceptions: a way towards sustainable management?

Interviewees expressed rich and diverse perceptions of biodiversity, irrespective of their scientific knowledge (as found by Fischer and Young 2007). For example, farmers' descriptions of biodiversity are influenced by their animal husbandry activities (*'For us biodiversity is not the colour like you but it's the quality of forage and how cattle take advantage of it'*. [FL]) (as found by Larrère et al. 2007). A description based on uses of biodiversity can be interpreted as an ecosystem services approach. This contrasted with their very poor knowledge of soil biodiversity and of soil in general, which is probably because soils and their biodiversity are not visible. Indeed, soil fertility was often described in terms of fertilization practices and associated vegetation which are the visible elements of soil fertility.

Overall, two kinds of perceptions of linkages between soil fertility, biodiversity and ecosystem services appeared in interviewees' explanations (Fig. 3). These were influenced by their knowledge of soil fertility. Either soil fertility was seen as resulting predominantly from fertilization,

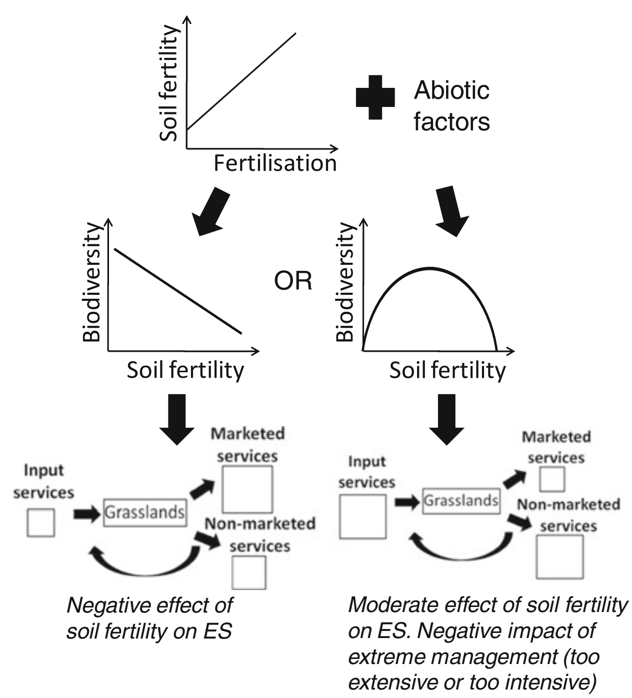

Fig. 3 Two kinds of perceptions of the link between soil fertility and ecosystem services (ES), through the relationship between soil fertility and biodiversity, extracted from the analysis of interviewees discourses

with effects perceived as being incompatible with biodiversity and with an associated decrease in several ecosystem services (i.e. input and non-market services such as pollination, pest control, aesthetics and sense of place), or soil fertility was seen as a soil property driven by abiotic factors (e.g. altitude and temperature) and agricultural practices which have, within a range of non-extreme values, a positive effect on biodiversity and thereby on multiple ecosystem services. Consistent with Sandhu et al. (2010) and Haines-Young (2009), these results suggest that intensification gives more importance to marketed services than to input services which are considered less important because chemical or mechanical inputs substitute ecological processes (bottom of Fig. 3). Nevertheless, the link between biodiversity and especially cultural non-market services (e.g. sense of place, conservation of botanical diversity) can be seen either positively or negatively, due to its dependence on personal perception and variation over time (Vira and Adams 2009). Therefore, it would be interesting to ask interviewees for further details on which aspects of biodiversity (e.g. rare species, species abundance, biodiversity of habitat) influence ecosystem service supply. For example, Lindemann-Matthies et al. (2010) found that while people's aesthetic appreciation increased with grassland species richness, this was modulated by the presence of particular species. Interviewees described more often relationships between ecosystem services and biodiversity by speaking about plant functional traits such as 'large leaves or dark green grasses' rather than species. This is consistent with scientific results which suggest that functional diversity has overall a greater relevance than species diversity to ecosystem services delivery (Hooper et al. 2005; Diaz et al. 2006; Le Roux et al. 2008).

Finally, while interviewees usually had no problem in perceiving causal relationships between fertility or more generally agricultural management (e.g. mowing), biodiversity and ecosystem services, they did not perceive interrelationships between ecosystem services. Awareness of agricultural effects was not sufficient to frame sustainable management in terms of ecosystem services, although interactions between ecosystem services can strengthen ecosystem resilience and enhance the provision of multiple services (Bennett et al. 2009). Moreover, ignoring interactions could lead to decisions favouring a single ecosystem service, which could decrease biodiversity if the particular service is not directly associated with biological diversity (Vira and Adams 2009).

Research needs and recommendations for policy implementation

While ecosystem services valuation studies are important to identify values involved in decision processes (Brander et al. 2009), they must be complemented by an assessment of stakeholders' perception of the concept (Termorshuizen and Opdam 2009). Both types of studies are important as they provide complementary information on willingness to trade-off conservation of one ecosystem service against another, and awareness and understanding of specific services, respectively. Moreover, our results support the need for additional research on demand for and supply of ecosystem services, rather than focusing on supply alone (Termorshuizen and Opdam 2009). This could help scientists to respond to stakeholders' priorities, but stakeholders' points of view are also needed to translate ecosystem functions into ecosystem services. Our results also show the importance of conducting case studies in order to capture local differences in terms of ecosystem service perceptions. In addition, future research should focus more on interrelationships between ecosystem services and systemic representations by stakeholders.

This study showed that it is essential for effective policy implementation and research to have a good understanding of stakeholders' perceptions of ecosystem services, which are themselves linked to their attitudes towards biodiversity management. Our results suggest that achieving sustainable management of grasslands ecosystem services and better acceptance of biodiversity conservation strategies requires: (1) more precise descriptions of which ecosystem services are considered and (2) improved knowledge of differences in interest and importance of services between stakeholders. We also found that (3) stakeholders' knowledge of biodiversity and soil fertility influences their perception of agricultural management effects on ecosystem services and (4) while stakeholders are aware of the effect of agriculture on ecosystem services supply, their knowledge on relationships between ecosystem services are not sufficient and need to be strengthened.

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