The role of traditional management practices in shaping a diverse habitat mosaic in a mountain region of Northern Spain

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ABSTRACT

Through traditional practices that typically impact the surrounding natural areas, rural communities worldwide have created and maintained landscapes forming a diverse mosaic of species-rich habitats. In Europe, where a high portion of species is dependent on the persistence of traditional rural landscapes, the progressive abandonment of agricultural activities has been often accompanied by a biodiversity decline, although the precise implications of landscape transformation for species and habitat conservation are not sufficiently well-known. This study applies ethnobiological and historical data collection methods (i.e., semi-structure interviews, participation in public meetings, literature review, and participant observation) to examine changes in traditional management practices and local perceptions of impacts on ecosystems diversity derived from the abandonment of traditional land uses in a mountain region in Spain that preserved a complex traditional farming system until the mid-20th century.. Data were analysed using qualitative content analysis and quantitative data analysis methods. Our results illustrate that traditional management practices, such as hay making, pastoralism of small ruminant livestock, lopping, prescribed burns, gathering of firewood, branch beating, or beekeeping, are locally perceived as favourable to habitat diversity. Our study also reveals that local perception of landscape changes in the area dovetails with scientific information, providing further

understanding of the particular ecological implications of each underlying driver of land use change identified. We conclude that the combination of local and scientific knowledge on ecological dynamics can help in the development of effective regional conservation strategies based on management practices simultaneously favourable to biodiversity and economically profitable. Our study provides evidence that rural communities can be a valuable source of information to document landscape historical dynamics and to monitor environmental changes, which might be particularly relevant for landscape-orientated conservation policies aiming to prevent the biodiversity loss resulting from the abandonment of traditional land uses.

Keywords: Biodiversity conservation, Oral history, Rural landscape, Traditional knowledge.

1. Introduction

Several studies report the geographical overlap between the world's biological hotspots and indigenous and local communities' homelands (Porter-Bolland et al., 2012; Guèze et al., 2015; Garnett et al., 2018). Through traditional practices closely connected to the surrounding natural areas, Indigenous peoples and local communities worldwide have created landscapes of high cultural and ecological value (Parrotta and Agnoletti, 2007). For example, historically low-intensity human disturbances have benefited stress-tolerant and habitat-specialist species over ecological competitors, often times resulting in high biodiversity in traditional rural landscapes (Calvo-Iglesias et al., 2006; Rotherham, 2013). Indeed, almost all contemporary European landscapes are shaped by human intervention, resulting in a rich mosaic of habitats and species diversity closely dependant on the persistence of traditional practices (Biró et al., 2014; Babai et al., 2015; Molnár et al., 2016; Kis et al., 2017).

In Europe, the Industrial Revolution generally led to the breakdown of natural resources exploitation by rural societies and to the progressive abandonment of traditional landscapes (Vidal-González, 2014), a process that became a major threat for the conservation of species linked to these ecosystems. Since the mid-twentieth century, further changes have taken place in Europe's rural landscape, resulting in additional land use changes, including the abandonment of agricultural lands. Agricultural lands abandonment has been particularly evident in European mountain areas, in which remoteness and deficient communications limited farming mechanization, favouring the decline of

traditional farming practices (MacDonald et al., 2000; Mottet et al., 2006; López-i-Gelats et al., 2011). The literature associates agricultural lands' abandonment to a combination of drivers including demographic, economic, technical, and institutional (van Vliet et al., 2015). Overall, these changes have resulted in a simplification and homogenization of agricultural and woody landscapes (Agnoletti, 2013; Plieninger et al., 2016; Lasanta et al., 2017). This is so, largely because the natural vegetation succession that takes place in abandoned areas favours both a high density of forest habitats and the reduction of the ecosystem mosaic shaped by traditional management practices (Rotherham, 2013; Viedma et al., 2015; Lavorel et al., 2017). However, the precise effects of each particular driver on European landscape transformation are not sufficiently well-known (Corbelle-Rico et al., 2015).

This study examines landscape dynamics, as reported by local inhabitants, in a mountain region of north Spain that preserved a complex farming system based on traditional land use activities until the mid-twentieth century. The paper is divided into two sections. First, we explore the local perception of traditional management practices to determine which particular historical land uses may have contributed to the shaping of a set of high diverse ecosystems in the region. We further document the techniques and ecological knowledge associated to the historical land uses identified during the analysis. Second, to understand the environmental implications derived from the abandonment of traditional land uses that took place from the 1950s to the present day, we present the drivers of landscape change in the region. For this purpose, we combine local inhabitants' discourses on historical landscape transformation with information provided by the literature, an approach that allows exploring the potential of local discourses to document landscape's land use change. We conclude with a discussion of the potential of traditional management practices to preserve rural landscape heterogeneity and the importance of using local discourses to document both landscape changes and the local ecological knowledge embedded in traditional management practices.

2. Case study

This research was conducted in the Liébana Valley, a region of 56,600 ha located in the Cantabrian Mountains, north Spain (Figure 1). The area is in a tectonic basin consisting of steep reliefs, with altitudes ranging from 300m.a.s.l. at the bottom of the valley to 2600m in the surrounding mountain system, with very limited communication routes to neighbouring regions. Liébana's orographic-driven

isolation favoured the societal and economic differentiation of its inhabitants, which remained self-sufficient until the mid-20th century (ETSIM, 1978; Arbeo, 2012).

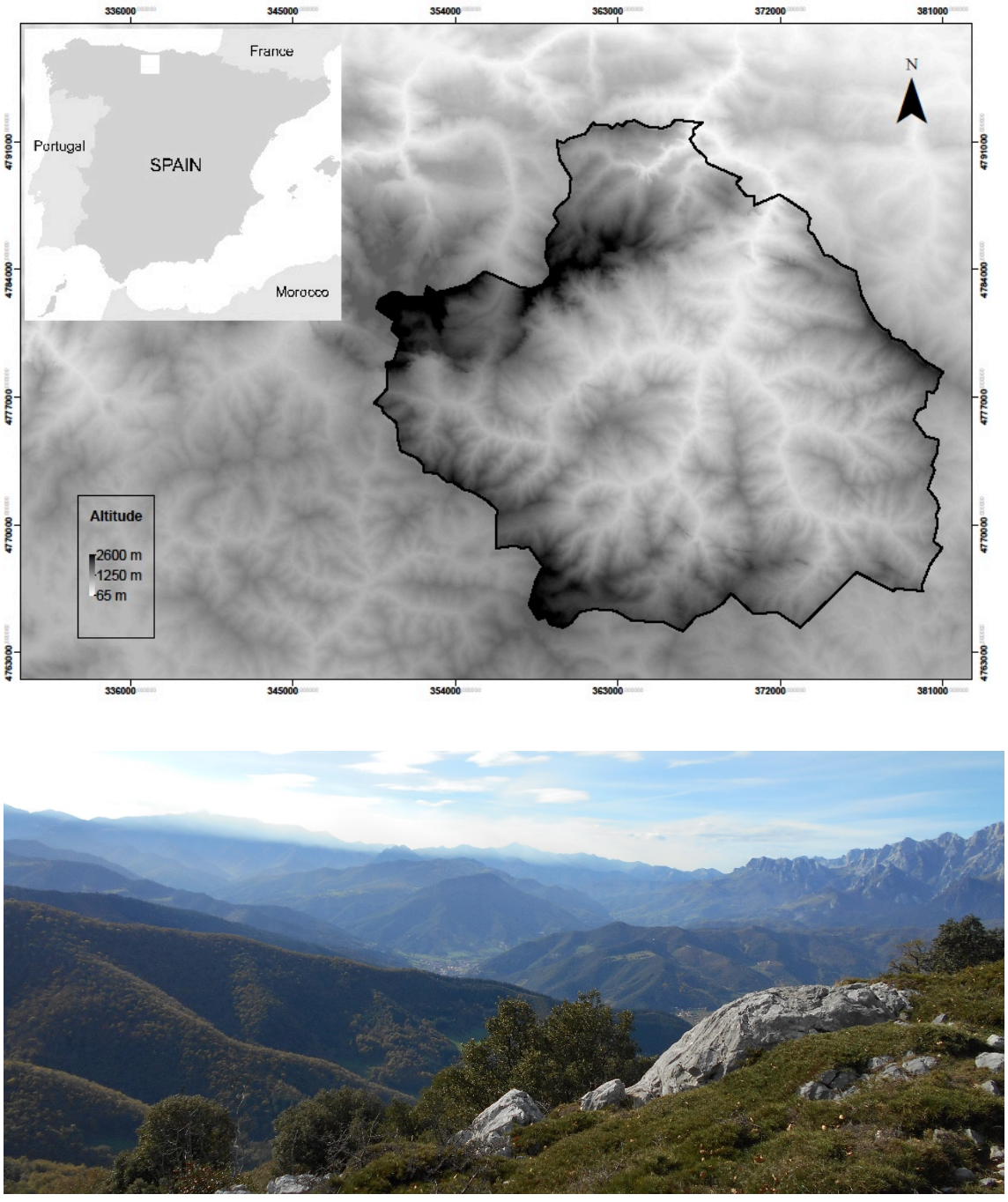

Figure 1. Geographical location and land surface elevation of the Liébana region (Cantabria, Spain). Panoramic picture illustrates the steep relief of the Liébana region. Photo credits: S. Guadilla-Sáez.

Subsistence farming in Liébana was structured around the region's large variation of climatic conditions, which is influenced by both Atlantic and Mediterranean climates (Bertrand, 1964). The traditional agricultural system combined cereal-legume crops at the bottom of the valley and in the

nearby hillslopes and livestock grazing in the steeper slopes and high altitudes. Topographic and climatic features also contributed to the presence of temperate deciduous forests from which Liébana's inhabitants obtained timber, firewood and fodder. Altogether, traditional land uses formed an altitudinal landscape mosaic structure consisting of dispersed human settlements surrounded by orchards or cereal crops in the valley, followed by a mixture of arable lands, meadows and forests in the lower slopes of the mountains, replaced by highland pastures and grasslands at higher altitudes (López, 1978; Castañón and Frochoso, 2007).

Between 1950 and 1980, the rural exodus associated to the region's integration into the market economy changed Liébana traditional landscape pattern. Migration, with the total population decreasing from 12,800 inhabitants in 1950 to 7,200 in 1981 –which continued to decline although at a slower rate in the following decades (ICANE, 2008)–, decreased the need of arable land supply. Additionally, the proximity to densely populated areas demanding meat and milk contributed to Liébana's specialization in livestock farming and its integration into supra-regional markets. As result, between 1955 and 1960, livestock farming became Liébana's main production focus (López, 1978; González, 2001). From a landscape perspective, the conversion from arable land into pasture resulted in the county's landscape gradual simplification and homogenization.

Liébana's livestock farming operations, however, did not reach the level of mechanization that characterizes other rural areas of Spain. Uncertainty related to the shaky national market price for milk in the 1970s led to low levels of investment in the mechanization of Liébana's animal farms, as compared to other rural areas of the Cantabrian mountain range. In addition, milk production quotas, established in 1986 with Spanish accession to the European Economic Community (EEC), contributed to invest in other economic activities, such as cheese production agri-businesses to channelize milk surplus (González, 2001).

The 1992 Common Agricultural Policy (CAP) reform, which addressed livestock farming innovation and encouraged intensive reproductive technologies, had important implications to extensive livestock farming in mountain areas such as Liébana. More intensive modes of livestock farming promoted by the CAP resulted in the progressive exclusion of local stock-breeders from farming (Corbera, 2006). From 1984 to 2003, Liébana experienced a decrease of a 40% in the number of livestock farmers, although the number of cattle heads remained steady (Rescia et al., 2008).

Noteworthy, since 1960s the Spanish Administration has implemented incentives for tourism development in Liébana. Such incentives include improvements in communication infrastructures as well as regional and private investments in ecotourism from the late 1980s onwards (González, 2001; Castañón and Frochoso, 2007). European initiatives in the 1980s further reinforced this trend. This is the case, for example, of the 'Operating Programme for Development and Economic Diversification of Rural Zones' (PRODER) subsidies, a program promoting rural economies' diversification through the development of non-agricultural activities. These initiatives have resulted in Liébana regional economy moving towards the tertiary sector, particularly rural tourism.

In addition, the designation of national and international Protected Areas labels in the 1990s has been adopted as a strategy for regional development (Corbera, 2006; Voth, 2007). The outstanding natural and aesthetic values of Liébana landscape contributed to its inclusion in Picos de Europa National Park (hereafter Picos de Europa) in 1995. Picos de Europa is part of the NATURA 2000 network of the European Union, and since 2003 designated as UNESCO Biosphere Reserve. With more than 2,000,000 visitors in 2017 (MAPAMA, 2018), Picos de Europa has become a successful touristic destination, increasing the number of visitors in Liébana since its establishment (González, 2001). Nonetheless, as in other protected areas, the large number of visitors has also contributed to the intensification of land use, with increasing demands for transport and accommodation infrastructures and leisure activities. This demand, however, competes for land with the presence of some extensive traditional practices key for the persistence of rural landscape, such as livestock grazing (González, 2001; Bernués et al., 2005; Corbera, 2006). Moreover, to ensure the compatibility of these uses with the national park conservation goals, park authorities' have regulated some traditional practices inside the protected area –such as extensive herding or firewood collection–. As in other European extensive land-use areas affected by a protection status (Riseth, 2007; Molnár et al., 2016), limitations to traditional uses have resulted in conflicts between park's managers and local population, particularly livestock herders (Rescia et al., 2008).

3. Methods

We used qualitative data collection methods to document traditional practices and perceptions of landscape change in the study area. Specifically, we used semi-structured interviews and participation

in public meetings. We also reviewed written sources to identify i) traditional activities potentially important for preserving the Liébana's natural habitats heterogeneity and ii) factors that historically promoted or limited the use of forest-related resources in the region. We used this background information to prepare interview guides. Particularly, for all the relevant traditional practices identified, we conducted in-depth interviews to comprehensibly document the traditional ecological knowledge associated to them. For some local practices, such as timber harvesting, livestock breeding, and beekeeping, documentation also included the use of participant observation.

From April to September 2016 we conducted a total of 39 in-depth interviews with 42 residents of the study area, resulting in 32 men and 10 women asked. Participants ranged from 32 to 94 years of age, with 57 percent of informants being older than 60 years (N=24). Respondents' educational level varied from primary school to postgraduate studies, with most informants specialized in agriculture, livestock, or forestry private activities (62 percent, N=26). Forest and National Park technicians (21 percent, N=9) and local key-actors involved in political, educational, or religious associations (17 percent, N=7) represented the other working categories of the total sample. To choose key participants with experience in the local traditional system to manage forest-related resources, we used 'snowball sampling' (Gamborg et al., 2012). The selected participants were listed as knowledgeable in one of the four activities identified as relevant during the first stages of fieldwork: livestock grazing (N=31, 74%), timber harvesting (N=29, 69%), non-timber forest products (hereafter NTFPs) collection (N=32, 76%), and hunting (N=14, 33%). Some respondents provided information on two or more of these activities. We collected information on each practice until we reached the saturation point, when no new information was coming from a new interview (Newing, 2011).

All interviews were conducted in the locality where the informants lived or at their worksites. Before each interview, participants were informed about the purpose of the study and the eventual publication of the information provided; assurance of informants' anonymity was given and a verbal informed consent for participating in the research project was obtained (Bernard, 2006; Newing, 2011). Interviews were conducted in Spanish, lasted about an hour and followed an outline of 10 to 12 open questions (see Appendix A for full questionnaire). All interviews were recorded, transcribed, and imported to Microsoft Excel software for coding.

Data were analysed using qualitative and quantitative data analysis methods. To document traditional practices and how they have evolved to present-day farming and forestry systems, we applied a detailed qualitative content analysis (Albuquerque et al., 2014). The analysis consisted in an open coding of the knowledge domains that emerged from in-depth semi-structured interviews. To ensure consistency of the ethnography information reported, we organized the information provided by holders of traditional knowledge into a codebook proposed by Pardo-de-Santayana et al. (2014). Code passages were arranged in columns of an Excel spreadsheet to facilitate the comparison across responses and to convey information of each practice (see Appendix B for coding examples).

To understand local population's perception of the historical land use change in Liébana, we applied both qualitative and quantitative analyses. Since regional landscape have changed substantially over the past 60 years, analyses consisted in coding the drivers of change cited by respondents born between the 1920s and the mid-1950s (minimum 60 years old). Using as starting point for the discussion with respondents: "What main changes, if any, have occurred?" followed by "What most contributed this change?" the interviews covered the topic of historical land use change. We applied qualitative content analyses to evaluate local perceptions on the impacts of the different drivers of change on landscape heterogeneity, classifying them depending on being unfavourable, indifferent, or favourable to landscape heterogeneity (Lopes-Fernandes et al., 2014). We conducted quantitative analyses to evaluate the perceived importance of a driver of change in regional land use change, measured as the frequency of respondents who mentioned the driver (Albuquerque et al., 2014). We distinguished between five main categories of drivers of change: demographic –e.g., rural exodus–, economic –e.g., integration into the market economy–, technical –e.g., farming mechanization–, institutional –e.g., European Union's PAC subsidies–, and ecological –e.g., ecological successional processes– (van Vliet et al, 2015; Plieninger et al., 2016; Colsaet et al., 2018).

4. Results

4.1 Perceptions of the potential of traditional management practices to biodiversity conservation

In this section, we describe the traditional practices that, according to the interviewees, have contributed to shape Liébana's landscape through generations (Table 1). Our description includes

informants' perceptions of how these practices support the maintenance of a more heterogeneous landscape mosaic.

Table 1. Traditional farming and forestry practices in Liébana.

Knowledge domain	Traditional practice	Cont.[a]	Transformation
Livestock farming	Transtermitance	No	Since late 1950s, transtermitance of collective herds to Liébana's summer upland pastures was mainly substituted by pasturing in private highland pastures of other regions, using trucks to move the animals.
Livestock farming	*Esmozar* (lopping)	No	Since 1980s, tree pruning for fodder was abandoned due to the availability of commercial fodder.
Livestock farming	*Quemas* (prescribed burns)	No	Prescribed burns have been abandoned, although regional forest administration is considering to reintroduce controlled burning as a method to reduce woody biomass.
Timber harvesting	*Subastas* (logging)	No	In the 1960-1970s, the use of animals for transportation of logs was largely abandoned in favour of tractors and machines. Timber harvesting tools, such as axes and saws, were also substituted by chainsaws. Currently, mainly exotic conifer species are professionally logged with sophisticated harvesting machinery such as tractor-mounted log loaders.

NTFPs	*Suertes* (firewood collection)	Yes	To collect firewood, neighbours need to request permit from the regional forest rangers. During autumn, foresters mark the wooded lots applying a similar criteria to the one used in the past. In stands dominated by holm oak or Pyrenean oak, firewood collection is done so to achieve a thinning to an area. Whereas in stands dominated by beech, forest rangers specify the trees appropriate for firewood cutting, such as crooked-growing trees.
NTFPs	*Sudar el corcho* (cork stripping)	Yes	Although cork stripping was abandoned since the 1970s, the practice has recently been reactivated in Liébana. Nowadays, a private company extract cork applying similar methods to the traditional barking, including the transportation of cork slabs by mules.
NTFPs	*Varear* (branch beating)	No	This activity is no longer practiced due to the injury risk of falling out of a tree.
NTFPs	Beekeeping	Yes	The traditional beekeeping system with bark hives changed forty years ago to the modern hive bee structure made of wood.
[a] Cont.: Continuity of the practice until present-day.			

4.1.1 Livestock farming

According to the informants, in the past, livestock farming was characterized by a collective organizational system in which families in a village contributed with a limited number of domestic livestock, mainly goats and sheep, to a common herding flock that was gathered each morning in the

village by a shepherd hired by the village council. Within this collaborative grazing system, known as *vecería*, villagers' domestic livestock –sheep, goats, cows, donkeys, horses– daily grazed together. Neighbours shifted turns to accompany the common shepherd, a system known as *cornuda*. Turns depended on the number of herding animals a family added to the common herd. For instance, "Each twelve lambs, you went one day. If you had six, half day, that is, you went one turn but next time you didn't" (male, 91-100 years old)[1]. This collaborative grazing system made livestock herding compatible with other farming activities, such as hay meadow, agriculture, or wood harvesting. As one informants described, the vecería system allowed "conciliation, so that people could work" (male, 71-80 years old).

In spring, villagers hired a shepherd or cowherd to take livestock to the higher pastures during the transtermitance (i.e., short transhumance from lowlands to highlands). Herds remained all summer in the highlands tended by a shepherd or cowherd, who lived in a hut with shepherds from other villages. During the transtermitance, villagers did not accompany the shepherd or cowherd but made turns to provide him with food. Informants pointed out that with the traditional herding practice, grazing animals were able to subsist with the resources available in the surrounding communal woodlands and pasturelands of Liébana. Informants also reported traditional practices that allowed obtaining fodder all year round. For instance, during the winter months after the hay making (Figure 2), community domestic livestock were able to freely graze in private fields, i.e., crops and hay meadows. Then, from March onwards, fields were closed to grazing, to allow the growth of grass that is cut in summer and stored for winter. Fields were opened again once the hay was cut, a system known as *derrotas*. During the months that private lands stay closed, livestock grazed in the forest commons.

[1] To guarantee confidentiality of informants, their ages are grouped into 10-year intervals.

Figure 2. Past (a) and present (b) hay making practice in Liébana. Photo credits a): Eusebio Bustamante Miguel, and photo credits b) S. Guadilla-Sáez.

Another habitual practice to obtain winter fodder was lopping, or *esmozar*, described by informants as a type of pruning consisting in climbing to the tree crowns when branches bore acorns and leaves, and cutting them to use as stock for wintertime. Individuals of *Fraxinus excelsior* L., *Ilex aquifolium* L., *Populus* and *Quercus* spp. located in private fields or communal lands were pruned (Figure 3). Pruning

was done on crescent moon, reportedly to enhance the growth of the branches during the following year. After the cut, twigs were collected in groups up to ten named *coloños* or *tarmaos*. Once dryed, the *coloños* were stored in the farm to be given to sheep, goats and cows when snow did not allow them to graze outdoors. Woody parts that were not eaten by the animals were used as firewood.

Figure 3. Lopped tree, or *esmozado*, in a private field in Lamedo, Liébana. Photo credits: S. Guadilla-Sáez.

Respondents also reported the use of prescribed burns, or *quemas*, to promote pastures for livestock and to reduce shrubland. The practice consisted of applying periodical burns as a clearing method to suppress the expansion of shrubland of *Pteridium*, *Erica* and *Ulex* spp. Scrub burning did not affect the upper strata, i.e., tree canopy, and was followed by livestock grazing in springtime. Burning

required a permit from the forest ranger and participation was compulsory for all neighbours. Several precautionary measures were taking to avoid uncontrolled fires. For example, a firewall of four to five meters was done on the opposite side of the field where the burn started. If there was not a firewall, neighbours located themselves in the opposite side of the burn to avoid the spread of the fire.

Informants argue that the recent transition to cattle and rural depopulation have fundamentally changed herding practices. Nowadays, animal husbandry mostly consists in herds grazing in privately owned meadows protected with electric fences to prevent attacks from wild animals. In winter months, livestock is housed on farms and fed with fodder acquired in the market; whereas in summertime, herds are moved to upland pastures in motorized transport. As one informant reported: “Traditional extensive livestock systems is being replaced by a more intensive farming: meadows are fertilised by farmyard manure, grasslands are no longer harvested, and there is no livestock herding nor transhumance…” (female, 31-40 years old).

Depopulation is also considered an important driver of traditional pastoralism abandonment, as farming activities can no longer be distributed along family members. One informant explained changes in livestock farming in the area as follows:

> “Small ruminant livestock has been abandoned because they require too much work. You need a farming house, being all day long with them, herding dogs; and, still, they are vulnerable to foxes, wolves… People are no longer used to this type of work. In the past, families were also bigger, with the father, grandfather, children... Instead, now a single person has to mow the meadows, attend the cattle, and move it to upland pastures during summer… How can a person do everything? So, what does he leave aside? He leaves aside whatever gives him more work and less economic benefit. This is why sheep and goats have been abandoned and woodlands now look as they do” (male, 41-50 years old).

Thus, informants considered the abandonment of extensive livestock farming as a key determinant of landscape variability, contributing to the expansion of tree and shrub encroachment on grassy areas. As another interviewee noticed, “Nowadays livestock no longer goes into the forest, herders go to the farming house, or to private meadows instead” (male, 61-70 years old). In the same line, a retired shepherd observed, “There are no longer shepherds or cowherds. Cows are moved from farmhouses

to the meadows, with electric fences installed, and no one takes care of them. Is more abandonment possible?" (male, 81-90 years old). Moreover, informants argued that the resulting simplified landscape negatively affects the environment. In the words of one informant, "Traditional extensive livestock farming in Picos is essential… The disappearance of hay meadows and pastures, and the abandonment of the communal land results in fire risks and problems in diversity of plants, that is going to disappear" (male, 51-60 years old).

Aware of the effects of pasture abandonment, the regional forest administration –in collaboration with villages– is promoting some initiatives to restore pasturelands. One village council representative explained: "A mechanical clearing was made some years ago to recover part of our highland pasture... We increased the grassy area, positively affecting partridge birds, and now we are going to create a wetland for amphibians and for livestock to come and graze" (male, 41-50 years old). Informants argue that, after a mechanical clearing, livestock grazing improves the long-term effectiveness of such interventions. Moreover, according to herders, small ruminant livestock that browse on woody plants, such as goats, are "those who really clean the forest" (female, 41-50 years old) (Figure 4), for which the decrease of these animals has been determinant on Liébana landscape transformation. As one informant recommended, "There is a general idea that the Administration should give a payment to livestock farmers who accompany their flocks and have a minimum number of sheep or goats, so they would get an extra salary. It would be cheaper than forest fire prevention techniques" (male, 31-40 years old).

Figure 4. Goat browsing woody plants in Dobarganes, Liébana. Photo credits: S. Guadilla-Sáez.

4.1.2 Timber harvesting

Timber harvesting, or *subastas*, were habitual in villages with large areas of forested common lands. In Liébana, stands of *Fagus sylvatica* L., *Quercus robur* L. and *Quercus petraea* (Matt.) Liebl. were the most abundant tree species felled. These tree native broadleaf species shed their leaves before winter, for which timber harvest was scheduled while the trees were leafless, i.e., from late October to late March or April, before sap flows. Local loggers also harvested according to the moon phase, cutting during the waning moon to prevent decay and termite hazard. In the subastas, groups of four to seven neighbours used to go into the woods with the harvesting equipment (i.e., hand axes, saws, wool rope, and a carpenter's tape). They felled and limbed trees, bucking the tree to logs of prescribed lengths (e.g., into lengths of 1.40 or 2.80 meters for railroads ties), and transported them to a landing area, usually at the roadside, using draft animals such as cows, mules, oxen or horses. For remote areas, harvest operations included the construction of portable sawmills.

Income generated by the commercialization of trees was an important economic resource as it was used for the establishment and maintenance of villages' common services (i.e., electricity or piped water) or infrastructure (i.e., roads and bridges). When income was needed, the village councils requested an authorization to harvest trees to the regional forest administration. Regional foresters decided the volume and standing trees to be included in the woodlot, applying a criteria that most informants considered beneficial to forest conservation. As one interviewee pointed out, "Foresters examined the forestland and defined the areas authorized for harvest. Areas with presence of young trees were excluded, whereas areas with old trees that were about to fall or that were impeding stand regeneration were included in the cutblock" (female, 51-60 years old).

Cantabrian regional temporary banning of harvesting timber of native species in the late 1980s (Regional decree No. 64/1989, of 14 September) resulted in the end of traditional timber harvesting in Liébana[2]. Nowadays, professional timber harvesters operate in the region, using modern equipment for the logging operations, mostly harvesting plantations of *Pinus* spp. located in accessible private fields (Figure 5). Some informants argued that the 1980's regulation of tree harvesting ensured forest regeneration, but most of them considered that the traditional silvicultural management system implemented to remove the trees –i.e., shelterwood cutting, consisting in gradually replacing the mature trees of a stand through repeated cuts (Savill, 2015)– facilitated forest renewal. A respondent from a village with large area of beech forest stated: "In my opinion, the banning of timber harvesting is a step backwards… Seedlings of beech benefit from the removal of old trees, because standing mature trees do not allow understorey trees to develop... In dense stands, it seems necessary to cut by shelterwood cutting" (male, 91-100 years old). Neighbours used to collectively carry out some forestry operations associated to traditional timber harvesting, like maintenance of logging unpaved roads or path clearing of forest commons through manual removal or swidden–fallow management. As one informant described, "Each year, some brushing or thinning was done to a small forest area. This consisted in the removal of thorny scrublands and shelterwood cutting" (male, 81-90 years old).

[2] Despite being a repealed decree, the harvest of native species stands has not been reactivated in Liébana. Notably, informants reported it as an active legislation.

Figure 5. Past (a) and present (b) timber harvesting practice. Photo credits a) Eusebio Bustamante Miguel, and photo credits b) S. Guadilla-Sáez.

Locally, there is a general complain about the abandonment of forest management systems over the last few decades. Several informants argued that public administration should integrate into forest management planning actions to prevent the loss of traditional paths and to remove old or poorly formed trees from the stands.

4.1.3 Non-timber forest products

The harvest of forest products other than timber is an age-old practice in Liébana that forms part of its complex farming subsistence system. Participants indicated that firewood, cork, fruits, medicinal plants, mushrooms, and beekeeping were the major NTFPs collected from Liébana's forest commons.

In the past, firewood collection, or *suertes*, was an important rural livelihood strategy because it provided household fuel needs for cooking and heating, as well as for the production of charcoal for forges and braziers. Great volumes of firewood obtained from poor quality stands of *Quercus ilex* L., *Quercus pyrenaica* Willd. and *Fagus sylvatica* L. were collected during the autumn, once the hay cut had finished. To that end, two or three family members went into the forest with hand axes, accompanied with draft animals to drag firewood out of the woods. As one neighbour described, "We collected fuel wood from old trees or those damaged by wind or snow" (male, 71-80 years old). Firewood collection persists in Liébana, although the total amount of wood collected is lower due to depopulation and to the use of other energy sources. As one stakeholder indicated, "When butane gas arrived, the consumption of firewood reduced to less than 30 per cent of the volume previously extracted" (male, 71-80 years old). Informants argued that the decrease of firewood collection had a negative effect in the maintenance of local landscapes, as they consider that this practice was essential to clear up the forest floor and promote the growth and fructification of the remaining trees. Commenting on the abundance of biomass on Liébana's forest commons, several interviewees signalled its potential for producing energy. As one respondent said, "We can generate electricity with a biomass plant connected to power lines, or for public lighting… Also, in these close-packed towns, we can build a biomass central heating system for the whole village" (male, 31-40 years old). Informants, however, were also cautious about the limits of this practice: "If biomass starts being commercialized and everyone goes into the forest to collect firewood, it may cause ecological harm as a balance of forest biomass in the woodland seems necessary" (female, 41-50 years old).

Barking, or *sudar el corcho,* was common in the 1950s, when cork was used in the wine-producing industry. The traditional technique consisted of removing the bark around the stem of *Quercus suber* L., using an axe to make three cuts through the outer bark. First, a vertical cut was done from the stump up to the first branch, followed by two horizontal cuts around the tree in both sides, aiming to

produce rectangular slabs of cork as big as possible. Then, slabs were pulled off from the tree with special care for not damaging the slabs. Once removed, slabs were packed in piles and transported by draft animals. Barking was a seasonal activity limited to the summer months, “when the cork tree most *suda*” (male, 31-40 years old), i.e., during sap flow, which is considered to facilitate cork extraction. Because of its seasonality, barking used to involve up to fifteen neighbours of skilled labour on cork stripping. A tree could be barked every 14 years. However, since the introduction of plastic stoppers, the demand for cork decreased and the practice was abandoned in Liébana in the 1970s. Respondents argue that the abandonment of traditional barking has resulted in an excessive proximity between cork oak trunks with negative economic and ecological impacts. On the one side, woody encroachment reduces the production of cork, as illustrates the comment of a village council representative, “Scrubland up to the tree branches supresses the growing of the bark. Cork needs to be well-aired” (male, 31-40 years old). On the other side, tree spacing is alluded as fire prevention mechanism of these stands.

Local inhabitants also reported the occasional harvest of fruits, medicinal plants, and mushrooms for domestic use. They argued that fruit collection was more abundant in the past when acorns from *Quercus* spp. and *Fagus sylvatica* were mainly consumed by livestock, while nuts from *Castanea sativa* Mill. and *Juglans regia* L. were reserved for human consumption. The significant contribution of wild fruits to household consumption is considered a main driver of the development of harvesting techniques such as *varear*. Varear consisted of knocking down the fruits of a tree by beating the branches with a stick, named *caña* or *vara*, large enough to reach the tree crown. At least two people were needed to conduct the work: one person would climb on the tree and knock the crown and the other would assist during the climbing and collect the fallen fruits. According to the informants, this activity positively influenced fruit quality and production: “Knocking down tree acorns favours sap flow” (male, 81-90 years old). Furthermore, informants associate the abandonment of the activity of varear with the disappearance of some forest habitats: “Since chestnuts and walnuts are no longer knocked down, trees have decayed” (male, 90-99 years old). This practice was done in waxing moon and when trees were not wet. Acorn-bearing trees (*Quercus* spp.) were knocked in September and October, and their acorns loaded in bags for transportation to the town. Chestnuts (*Castanea sativa*) were harvested in November, and because their edible fruits are contained in a spiny husk, wooden tweezers to pick

the chestnuts were used. To prevent injuries from spines, baskets were used for chestnuts transportation.

Regarding medicinal plants collection, chamomile (*Chamaemelum nobile* L.) and *té del puerto* (*Sideritis hyssopifolia* L.) were picked by locals in mountain pastures during summertime. Frequently collected for self-consumption as an infusion, *té del puerto* has also commercial value in the local market, although the demand for the plant is low. In contrast, informants showed concerns about the need to regulate mushroom gathering, as beyond the occasional gathering done by locals, there is a growing demand of mushrooms from visitors to Liébana who freely collect them.

Beekeeping for honey production has also a large tradition in Liébana, where wild beehives, or *setas*, used to be abundant in the surrounding forest commons. Informants reported that wild beehives located in tree branches were directly cut. When nesting was inside old trees' hollow trunks, beehives were difficult to find. To find the hives, harvesters waited in a fresh water stream the arrival of a bee and then followed the bee back to the colony. Once in the tree, the harvester climbed with an axe to open the hollow trunk, removed the hive, and carried it home in a container. In the following three days, the hive was kept in the warmest place of the house, the kitchen, so that the heat melted the honey and separated it from the beeswax. Nevertheless, since the infestation of the parasitic mite *Varroa* in the 1980s, unmanaged wild honeybee colonies have disappeared from forests.

Informants reported that in the past most families in Liébana used to have two to four beehives made of bark in the orchard. Every year, bark hives were crushed, mixing honey, beeswax and cork altogether, and filtered through a fine cloth to obtain the honey. This activity was done in the warmest place of the house to facilitate filtration. Nowadays, beekeeping of the honeybee *Apis mellifera* L. is done in permanent beehives located in private or common lands outside the villages, placed at the low level of the valley in wintertime, and moved to the upland moors during the summer months. Over the last forty years, traditional bark hives have been substituted by wood hives, mainly built on *Pinus* spp. (Figure 6).


a)


b)

Figure 6. Traditional bark hives at *Casa de las Doñas* ethnographic museum in Enterrías, Liébana (a), and modern hives made of wood (b) in Valmeo, Liébana. Photo credits: S. Guadilla-Sáez.

Commenting on the decline of beekeepers in the region, informants were unanimous in the view that the maintenance of managed beehives is critical to avoid bee population decline, "Without wild beehives in the woodland, apiculture may save the bees from extinction" (male, 61-70 years old). Informants also pointed out the ecological threat of pollinator loss for wild plant reproduction if bee population declines: "It is said that without the bees, wild plants will not persist more than four years" (female, 61-70 years old).

4.1.4 Hunting

Hunting was an infrequent activity pursued by local inhabitants who went out alone or in groups to hunt for food and leisure. Hunters targeted both small game species such as red squirrel (*Sciurus vulgaris*), hare (*Lepus* spp.), and partridge (*Perdix perdix*), and big game species including wild pig (*Sus scrofa*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), and chamois (*Rupicapra rupicapra*). Predators such as red fox (*Vulpes vulpes*), grey wolf (*Canis lupus*), and brown bear (*Ursus arctos*) were also hunted. Informants reported that when predator species such as foxes or wolves were hunted, the hunter would show the dead animal door-to-door as a trophy and collect money as a reward.

Some informants reported the local disappearance of small game species like hares and partridges, which they associate to the abandonment of the cereal-legume cropping systems, "Wheat, chickpea, and lentil, which are hare's food, are no longer cultivated" (male, 80-89 years old). Habitat loss is also reported as a driver of small game species local extinction, "Many wildlife species have disappeared as result of pastureland conversion to scrubland; there used to be a lot of hares and partridges" (male, 31-40 years old). In contrast, landscape transformation to dense forests seem to have benefited other game species, particularly wild pigs, as they provide these species with food and cover. As one interviewee argued when asked about wild pig population significant increase, "Nobody collects wild fruits from the forest, so [wild pigs] have cherries, hazelnuts, grapes, wild apples, chestnuts, beech nuts, oak acorns…" (male, 31-40 years old).

Changes in game species are manifest in the current predominant hunting method in Liébana, the stand-hunting method or *batida* for wild pigs. Informants had different opinions regarding the ecological impacts of moving from a combined traditional hunting system to a predominant, almost unique, stand-hunting practice. Some participants felt that the use of the stand-hunting method helps to reduce wild pig population size, and even argue that the practice should be further promoted to regulate the species' stock. For example, one informant mentioned: "The criteria applied [by authorities] to stand-hunting method is not enough to respond to the ecological equilibrium needed between wild pigs and their natural habitat" (male, 81-90 years old). However, other participants considered that the stand-hunting practice has harmful conservation outcomes and highly interferes with the dynamics of the natural ecosystems. As one informant described,

> "For wild pigs, stand-hunting has higher environmental impact than other hunting methods consisting on spot and stalk hunting. In this method, the hunter is accompanied by a forest ranger who has previously selected the trophy animals, so the method has little impact on the rest of the fauna. Contrarily, stand-hunting involves fifty people shouting and running in the forest with up to thirty trained dogs chasing all types of animals. Moreover, this is done every weekend during six months of the year, and the vulnerable fauna living in the forest suffers from it... If we constantly change wildlife equilibrium, we influence plant community, as forest regeneration depends on the number of ungulates" (female, 31-40 years old).

Rental fees for big game hunting regulated by the regional forestry administration through the concession of licenses currently represents an important income for neighbouring councils. Informants reported that the economic revenue from recreational hunting is a great incentive for the local inhabitants to preserve wildlife, also commenting on further opportunities to obtain economic profit from game hunting, such as commercialising processed food products of game species to local restaurants.

4.2 Perceptions of landscape change

In this section we explore factors that, according to local informants over 60 years of age (N=24), have contributed to land use change in Liébana since the mid-twentieth century (Table 2).

Table 2. Drivers of regional landscape change reported by interviewees over 60 years of age (N=24).		
Drivers	n	%
Demographic drivers (e.g., population growth, migration, ageing, family status)	14	58
Economic drivers (e.g., market growth and commercialization, prices for agricultural/forestry products)	11	46
Technical drivers (e.g., agricultural mechanization, technological modernization)	3	12.5
Institutional drivers (e.g., agricultural policies, forestry policies, nature conservation policies)	23	96
Ecological drivers (i.e. successional dynamics)	18	75

Informants agreed that important land use changes have taken place in Liébana's landscape within the last decades. The most frequently cited driver of change corresponds to the institutional category, reported by 96% of the respondents (N=23). Demographic and economic drivers of change were mentioned in 58% (N=14) and 46% (N=11) of the interviews, with some of the informants associating demography with technological drivers. Three quarters of respondents (N=18) also cited ecological drivers (i.e., ecological successional processes) as a key factor of historical land use change in Liébana.

The most frequently stated landscape change due to institutional drivers referred to the prohibition of timber harvesting practices by the Cantabrian regional government in the late 1980s, cited by 54% of the informants (N=13). When asked about the consequences of this regulation, most interviewees considered that it resulted in the encroachment of woody vegetation and landscape homogenization, increasing wildfire risks due to the accumulation of vegetation and to the larger interface of forests and

human settlements. Similar concerns regarding vulnerability to wildfire risks were also reported by some of the interviewees when discussing fire suppression policies. According to informants, repeated prescribed burns helped to reduce shrub biomass without affecting the canopy layer, “Burning is forbidden nowadays, which is dangerous because any fire can easily become an uncontrolled wildfire” (male, 81-90 years old). Four interviewees reported shifts on goat husbandry legislation, a traditional activity that was first forbidden and now promoted by subsidies. National Park legislation was stated by 33% of informants (N=8) as the sole institutional driver for prohibitions to harvest timber, burn, hunt, fish, or collect NTFPs. Another informant noticed, “National Parks consist in excluding all economic activities benefiting local populations in favour to some theoretical interests, such as nature conservation” (male, 81-90 years old).

The second most cited driver of change, demography, was mentioned by 14 informants (58%), who argued that the rapid depopulation of the area and farmer’s ageing had resulted in the abandonment of agricultural activities such as livestock grazing and firewood collection. Most of the interviewees (N=11) also mentioned lifestyle changes, largely among the young generation who have abandoned subsistence farming and migrated. Few informants (N=3) associated depopulation and technological changes, arguing that present-day farming activities require high monetary investments on mechanization to start running a business. Informants also reported lifestyle changes that arguably decreased pressure from Liébana’s natural resources, such as the replacement of fuel wood by other types of fuel for cooking and heating, or the acquisition of fodder supply from market. According to respondents, forest was abundantly used in the past, “because [local people] lived from the resources provided by the forest” (female, 61-70 years old), and self-sufficiency of household economies implied daily livestock activities. Some participants (N=4) indicated that demographic changes had negative consequences for rural landscape conservation, as the abandoned meadows and cultivate fields have been gradually colonised by forest and shrub vegetation, decreasing habitat diversity.

Economic changes were identified as important drivers of landscape change by 46% of respondents (N=11). As one informant described, “Legumes, wheat, or potatoes crops were abundant in the past (…) When milk started to be commercialized, cattle number increased and arable lands progressively transformed to meadows for fodder” (male, 80-89 years old). Some interviewees also mentioned the national and the international markets as drivers of change, as they made traditional activities like

timber harvesting, livestock breeding, NTFPs collection, or field cropping no longer profitable in Liébana. The abandonment of these activities is considered to favour the expansion of scrublands, which cannot evolve to tree strata due to the lack of regular shrub clearings.

5. Discussion

Our results suggest a general concern among local inhabitants regarding the loss of managed landscapes in the absence of certain traditional farming and forestry uses in Liébana. Overall, informants stated that local forest commons provided them with relevant goods and services and that local management practices favoured the occurrence of high diverse forest ecosystems in an open patchy structure. Our results also suggest that, according to local perceptions, institutional, demographic, and economic drivers have greatly influenced the spatial and temporal transformation of Liébana since the mid-twentieth century, favouring the ecological succession to shrub and tree encroachment of the landscape due to the progressive abandonment of traditional farming management activities.

5.1 Potential of traditional management practices to biodiversity conservation

Based on previous findings on the effects of human intervention in species distribution and long-term persistence of natural systems in Liébana, this research sought to assess local inhabitants perceptions of which traditional management practices historically performed in Liébana might have enriched its landscape. Specifically, results of previous empirical research showed that areas closer to human settlements or paths presented higher forest species diversity than less accessible areas. Moreover, presence of silvicultural practices, particularly regeneration felling operations, seem to benefit the presence of late-successional forest ecosystems in the Liébana valley (Guadilla-Sáez et al., 2019). Results presented here give valuable insights about the potential negative effects on landscape heterogeneity of the abandonment of certain traditional farming and forestry practices used in Liébana for the provision of fodder, domestic fuel and human consumption. Specifically, our study identifies seven traditional management practices with perceived positive effects for ecosystem diversity in Liébana.

First, the traditional mowing of meadows for hay making during the summer months and the autumn grazing might have helped to maintain biodiversity rich grassland patches thorough Liébana's mountain landscape. The gradual disappearance of grassland extension due to the abandonment of traditional hay making affects many European mountain areas and has been linked to the loss of plant species richness in these habitats (Doležal et al., 2011; Orlandi et al., 2016). Moreover, the decline in plant diversity affects the insect community richness and bird breeding, for which there are many conservation efforts being applied across Europe to restore semi-natural grassland habitats (Stoner and Joern, 2004; Jefferson, 2005; Graf et al., 2014; Valasiuk et al., 2018). For example, since 2016, a European Regional Development Fund is promoting the restoration and conservation of harvested meadows inside Picos de Europa National Park (UE-16-SOE1/P5/E0376). Still, most of these programmes consist on mechanical mowing to prevent grassland encroachment, but are not followed by autumn livestock grazing, although scientific literature evidences the importance of accompanying hay cut with extensive grazing to avoid nutrient losses in meadows' soils and subsequent plant species reduction (Jefferson, 2005; Doležal et al., 2011). Indeed, local informants reported that grazing after hay cut was key for the long-term maintenance of grasslands. In contrast, hay meadows located around human settlements are over-exploited due to agricultural intensification, a finding that goes in line with recent studies documenting the evolution of farmland management systems across mountain areas of Europe (Lasanta et al., 2017; Burton and Riley, 2018). High livestock stocking rates negatively affect grassland conservation and its associated biodiversity, for which it has been argued that to reduce the on-going severe loss of semi-natural grassland areas, conservation efforts should combine mowing with extensive grazing practices near farms and extensive grazing stocking rates in under-grazed marginal lands (Graf et al., 2014; Orlandi et al., 2016).

The second traditional management practice with a perceived impact in Liébana's ecosystem diversity is pastoralism. According to our respondents, traditional pastoral systems helped to maintain the grassland-woodland habitat mosaic on Liébana's mountain landscape, as regular livestock herding prevented shrub encroachment of pastures. Moreover, because of this positive role, informants argued that agri-environmental subsidies should support properly managed livestock farming to make profitable pasturing practices, as these go in line with nature conservation. This recommendation has also been put forward by scholars, such as Z. Molnár et al. (2016) who suggested the inclusion of nature conservation approaches to the traditional herding profession to shape an effective

management that will help to restore and sustain the former dynamic open patch structure of rural landscapes. Our informants further consider that economic incentives should be oriented to small ruminant livestock herding practices, whose number had recently declined. Informants argued that goat feeding behaviour prevents forest and shrub vegetation colonization over hay meadows and reduces the biomass load of woodland ecosystems. Interestingly, the potential of goat pastoral systems as a management tool to be included in wildfire prevention operations has also been reported in the literature (Landau, 2017; Marques et al., 2017).

Lopping is the third management practice with reportedly positive effects for natural ecosystems conservation in Liébana. The tree foliage harvest was an important fodder resource for livestock during the winter, but it also implied biomass removal. Although extensive biomass harvest might negatively impact biodiversity, the small-scale lopping of branches increases forest cover regeneration and enhances habitat diversity (Vetaas, 1997; Varguese et al., 2015). In our study, local people reported that the abandonment of lopping has resulted in a decline of tree species traditionally pruned for the provision of winter fodder. Informants partly attribute the abandonment of the practice to fodder availability in the market, for which isolated trees of *Populus* spp. and *Fraxinus excelsior* standing in private fields are no longer preserved for fodder production. Another explanation given by informants is the banning of the activity in relation to *Ilex aquifolium* L. by the regional forestry administration. The cessation of this traditional harvest practice is considered to be in detrimental of *I. aquifolium*, a finding consistent with studies linking anthropic activities in the past to the expansion of holly woods in central Spain (García, 2001; López et al., 2013).

Fire suppression policies on prescribed burns, the forth management practice considered to impact Liébana's ecosystems, also seem to have delivered undesirable long-term conservation outcomes, contributing to current large wildfires (Seijo et al., 2015). Local respondents are aware of the use of burning as management tool to prevent scrubland encroachment of pastureland and to remove understory biomass in forested areas. This approach matches with recent studies recognizing the potential of low-intensity prescribed burning as a cheap wildfire prevention technique (Seijo et al., 2015; Fernandes, 2018). Moreover, from an ecological point of view, the literature evidences that seasonal prescribed fires can help control the expansion of exotic over native plant species in areas with fire-adapted natural ecosystems (Kral et al., 2018; Barefoot et al., 2019). Thus, in a region with historical fire regime like Liébana, the reintroduction of periodical low-intense burns may benefit certain

stress-tolerant forest ecosystems such as forests dominated by *Quercus* species and chestnut woodlands (Hanberry et al., 2014, Seijo et al., 2015) and, in combination with livestock herding, help to restore grasslands (Múgica et al., 2018).

The fifth traditional practice locally perceived as having a positive impact on habitats conservation is the gathering of firewood, which also implied the removal of woody biomass from forests. Neighbours mostly selected standing dead trees, trees with evidence of disease, poor quality logs, dead branches, and twigs for firewood, for which firewood gathering acted as a clearing silvicultural treatment beneficial for the maintenance of healthy stands. Indeed, this local perception matches results from a recent study analysing the effect of selective logging for firewood in stands dominated by *Quercus* species in southern Mexican cloud forests (Ortiz-Colín et al., 2017). Moreover, the same study recommends a moderate extraction of biomass in *Quercus* spp. stands for optimal regeneration. As previously discussed, the removal of fuel biomass due to firewood collection also prevents the establishment of dense forest ecosystems, reducing wildfire risks. Several informants expressed the potential for producing biomass energy from firewood harvesting. This consideration is particularly relevant in the current context of climate change, as biomass burning may be a promising renewal source to substitute fossil fuels for electricity production or for combustion in residential heating (Sreevani, 2018). Still, informants advocating for the use of forest biomass for energy in Liébana recommended to provide general ecological information to local communities on a rational use of the resource, to prevent intensive firewood extraction. This recommendation is in line with recent studies warning of the ecological risks that large-scale deadwood stock extraction hold for the preservation of associated biodiversity (Stupak and Raulund-Rasmussen, 2016; Hof et al., 2018).

The sixth management activity identified as positive for forest habitats conservation is branch beating (*varear*). According to informants, branch beating positively influences fruit quality and tree production. Literature corroborates the idea that manual harvest methods, such as beating the branches and collecting the fallen fruits, have lower incidence of damage and cracks on the fruit than mechanical harvest methods (Monarca et al., 2014), although the specific influence of harvesting in fruit production has not been documented. Informants also suggested that the cessation of this traditional harvesting method has had negative implications for the preservation of *Castanea sativa* and *Juglans regia* species. This outcome may be contrary to studies documenting the beating of trees with sticks as an epidemiological factor for disease incidence in some woody species (Panagopoulos, 1993). Still, the

abandonment of traditional agroforestry practices in *Castanea sativa* and *Juglans regia* stands seems to result in the long-term decline of these stands (Cantarello et al., 2014; Guadilla-Sáez et al., 2017), for which further studies describing the particular influence that branch beating may have in the persistence of these stands are recommended.

The last traditional management practice identified as environmentally friendly in the study area corresponds to beekeeping, an economic activity that provides pollination services to wild plants. Beyond the importance of bees for pollination of plant species, many studies across the globe have documented traditional beekeeping practices as an important part of the subsistence economy of rural communities (Oteng-Yeboah et al., 2012; Sight, 2014; Adal et al., 2015; Galbraith et al., 2017). Interviewees expressed concerns about the disappearance of unmanaged wild honeybee colonies from forests due to the parasitic mite Varroa, highlighting the need of the persistence of beekeeping in Liébana to avoid further bee populations decline. This concern dovetails with recent awareness about worldwide bee population loss, resulting in conservation initiatives promoting beekeeping as a management practice that does not compete for resources with other economic activities (Adal et al., 2015; Galbraith et al., 2017). However, high densities of managed honeybees may negatively impact on wild pollinators via competition for flower resources, for which conservation efforts should adapt beekeeping to the carrying capacity of the flower community at the landscape level (Torné-Noguera et al., 2016).

Overall, our results illustrate a consensus between the arguments used by local informants and the scholarly literature to identify certain management practices that could contribute toward nature conservation. However, our results also reveal a set of practices that according to local informants enhance ecosystem diversity, but that have not been documented in the literature.

5.2 Perception of historical land use change and its implication to traditional landscape conservation

The second objective of this study was to explore the potential of local discourses to document the driving factors associated to the historical land use change in Liébana and to further describe the perceived effects of different drivers on landscape transformation. Overall, local inhabitants perceive landscape change in Liébana since 1950-1960s as a progressive ecological succession to shrub and tree encroachment in areas that use to be pasture. These changes are associated to the abandonment

of traditional agricultural land use activities largely due to institutional, demographic, and economic drivers.

Scholars and local population describe rural exodus and market integration as significant drivers for the abandonment of traditional uses, resulting in the simplification of the landscape mosaic, initially through the transformation of cultivated fields into pastureland, and later through the gradual encroachment of scrubland strata in abandoned pastures (López, 1978; González, 2001; Rescia et al., 2008). Institutional factors are also reported as key drivers of change in Liébana, both in interviews with local stakeholders and in the literature (González, 2001; Castañón and Frochoso, 2007; Rescia et al., 2008). Nevertheless, local people's perception differ from scientific literature on who is the main agent influencing local land use regulations. Whilst the literature emphasizes the effects of the European Union Common Agricultural Policy in shaping Liébana's current economic, environmental and social situation (Corbera, 2006; Rescia et al., 2008), informants associate land use regulations to the Cantabrian regional administration and to the National Park management. This finding matches with previous research on the area reporting local communities' unfavourable attitudes towards conservation initiatives (López, 1978; González, 2001; Rescia et al., 2008). Moreover, despite the lack of a valid management plan to regulate traditional uses implemented inside the reserve (repealed in 2005 due to a legal action taken by local communities living within Picos de Europa buffer zone), local communities perceive that the National Park's authorities regulate land uses. Inhabitants' perception that forest uses are limited, despite the fact that Picos de Europe lacks management capacity to implement regulations, evidences that conservation initiatives are negatively perceived by communities even if the conservation outcomes have neutral impacts on local livelihoods (Bennet and Dearden, 2014; Babai et al., 2015; Lopes-Fernandez et al., 2018).

Ecological changes derived from the historical land cover change in Liébana described by local observations match those found in the literature. Both sources describe a successional trend to dense high forest coppices from abandoned lands. Concerns regarding an increase of fire-hazard associated to changes in forest fuels prevail in local discourses, a finding previously reported for *Quercus* spp. wood-pastures of south Spain (Garrido et al., 2017). This concern is also reflected in the recent literature associating fire-hazard in mountain rural areas of Spain with an increase in plant biomass and homogenized landscape resulting from the abandonment of traditional management practices (Viedma et al., 2015; Lasanta et al., 2017).

In sum, our results suggest that local understanding of the driving factors influencing land use change in Liébana dovetails with findings from the existing literature examining the spatial and temporal transformation of the study area.

6. Conclusions

The objectives of this research were to understand how the abandonment of traditional land use activities in rural areas might lead to a simplified habitat mosaic landscape, and to describe the ecological consequences of the driven forces associated to this process of abandonment.

In general, the local understanding is that the cessation of traditional practices adapted to the carrying capacity of Liébana's natural resources has had negative implications for preserving species and habitat diversity. In particular, our results illustrate a set of traditional management practices reportedly favourable to biodiversity, which could be explored for developing effective regional conservation strategies of high-valued ecosystems preserved by local inhabitants (Molnár and Berkes, 2018). Findings of this work dovetail with studies indicating that traditional practices may be a cost-effective, long-term sustainable tool for managing semi-natural habitats (Babai et al., 2015). Any regional conservation initiative in Liébana, and particularly in Picos de Europa National Park, may benefit from the inclusion of the traditional practices identified in this work into its management.

Our results also suggest that local discourses identify the same drivers of historical land use change than those documented in the literature, providing a detailed understanding of the particular ecological significance of each driver on rural landscape transformation. This finding supports the idea that rural communities provide valuable information to document landscape historical dynamics and to monitor environmental changes (Calvo-Iglesias et al., 2006; Parrotta and Trosper, 2012). These findings could be particularly relevant for landscape-orientated conservation policies aiming to prevent the biodiversity loss resulting from the abandonment of traditional land uses. For instance, this research provides information on traditional management practices that were banned in the past, and that are now being reconsidered for conservation objectives. These place-based management solutions include prescribed burns or the use of small ruminant livestock herding to prevent shrub encroachment. This finding supports arguments considering that, although not all traditional practices

might have positive ecological outcomes, some of them can be a useful source of information to site-specific conservation management strategies (Berkes et al., 2000; Joa et al., 2018; Molnár and Berkes, 2018). We recommend further research assessing the potential of local knowledge to monitor environmental landscape change.

Appendix A. Supplementary data

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