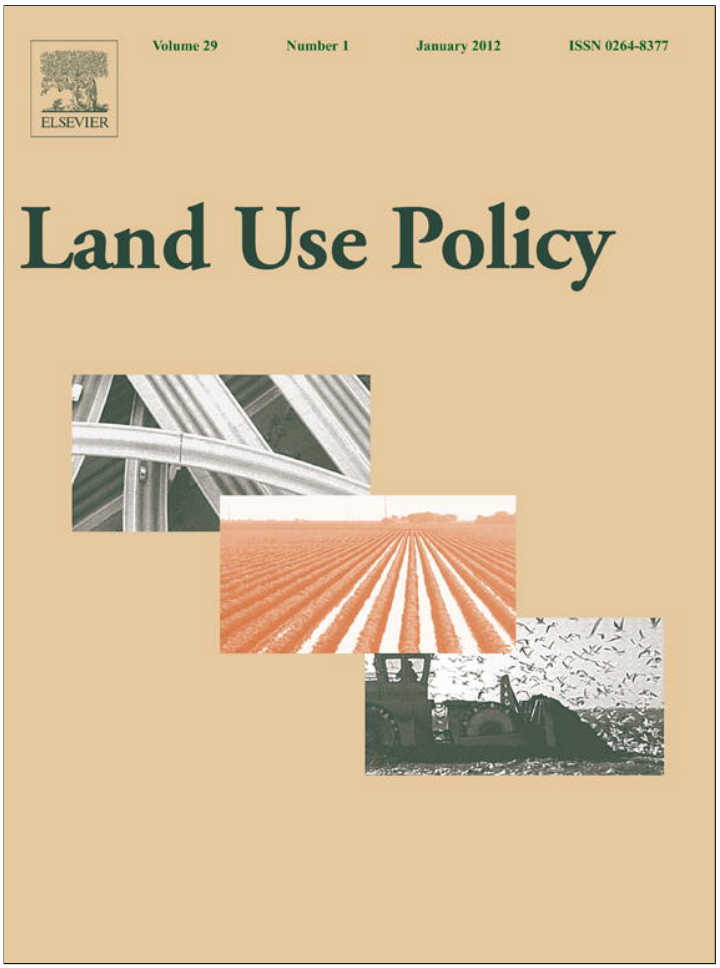

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Social–ecological heritage and the conservation of Mediterranean landscapes under global change. A case study in Olzinelles (Catalonia)

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ABSTRACT

Both biological and cultural diversities seem to be diminishing together along with the progressive interconnection of peoples and ecosystems of the earth under the rules and dynamics of global markets. This has led some conservationists and social scientists to highlight the need for enhanced knowledge on the complex interrelationships between cultural and biological diversities if successful conservation strategies are to be achieved. In this work we show how the long-term coevolution between peasants and their environment sustained habitats and species that are now declining along with rural exodus in a mountainous area of the Mediterranean, a region where the maintenance of diverse landscapes is very much related to the presence of traditional rural activities. We provide an account of agrosilvopastoral practices once performed by the local peasant community and show their embeddedness in a particular set of institutions and worldview within an adaptive social–ecological system. We argue that such practices constitute an essential social–ecological heritage entailing valuable insights for the conservation of Mediterranean landscapes under conditions of global change.

Introduction

Some conservationists and social scientists have pointed to the links between cultural and biological diversities and have highlighted the need to portray an integrated picture of the diversity of life in all its forms if successful conservation strategies are to be achieved (Maffi, 2005). For long, several disciplines have engaged in the study of the relationships between humans and the natural world, albeit with different conceptual frameworks and methods. Landscape ecology has stressed the role of specific practices of resource management in the configuration of heterogeneous landscapes at multiple spatial and temporal scales and across many different taxa and ecosystems of the earth (Turner, 2005; Benton et al., 2003). Ethnoecologists have showed that such management practices, mostly performed by indigenous and rural groups, are very much embedded in particular beliefs and knowledge systems of their local environment (Toledo, 1992), and have investigated how the creation, acquisition, transmission and loss of Traditional Ecological Knowledge (TEK) were connected to factors such as age, formal education and integration to market economies (Reyes-García, 2009). In this regard, TEK related management systems, mostly performed by resource-poor farmers (Altieri, 2002), are considered to contribute to the conservation of biodiversity through several practices that enhance the resilience of the social–ecological systems in which they operate (Berkes et al., 2000). Along these lines, the science of ecology and the various fields of applied ecology have experienced a conceptual shift toward the understanding of ecosystems as complex adaptive systems in which humans are an integral part (Berkes, 2004).

However, there is a need for enhanced knowledge on the complex interrelationships between cultural and biological diversities, especially when there are clear signs of mutual losses as we increasingly move toward a globally interconnected system. The Mediterranean region is a particularly illustrative example of these complex processes. First, it is considered a hotspot of global biodiversity (Myers et al., 2000) which highly diverse cultural landscapes result from the close historical interactions between natural (land heterogeneity) and human (stewardship) processes throughout millennia (Farina et al., 2003). The maintenance of such richness in life forms is very much associated to the presence of traditional practices of natural resource management. Second, Mediterranean biodiversity is highly threatened because of its particular sensitivity to land-use changes and invasion of exotic species (Sala et al., 2000). In the north rim of the basin, the cultural landscapes are being rapidly degraded due to land abandonment, agricultural intensification, urban sprawl and globalization (Farina, 2000; MacDonald et al., 2000; Stoate et al., 2001; Catalán et al., 2008). This notwithstanding, there is still a number of important semi-natural areas which play crucial social and ecological functions, including many mountainous areas where a large decrease of ecosystem services

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(e.g. water availability) is expected as a result of global change (Schröter et al., 2005). And third, the north rim of the Mediterranean hosts many highly industrialized and urbanized societies. All this offers a unique context to extend the current debates and methods analyzing biocultural diversity. That is, from mainly focusing on indigenous groups of remote areas to analyze processes which embrace more varied social groups affected by some degree of modernization (Cocks, 2006)—but who nevertheless have played a central role in the molding of the local biodiversity.

An integrated understanding of the relation between cultural impoverishment and changes in biodiversity demands paying special attention to specific processes occurring at different spatial scales and within specific social–ecological systems. In this research, we show how the long-term coevolution between agrosilvopastoral users and their environment has created and sustained particular habitats and species that are now declining after the disappearance of traditional management practices along with rural exodus in a concrete area of the Catalan Coastal Range (Olzinelles). To this aim, this paper proceeds as follows. (a) We first describe the study area and synthesize the social–ecological transformations experienced during its recent economic modernization and transition to a global economy, with a special emphasis on the recent changes in biodiversity. (b) We then present the chosen interdisciplinary methodological approach which combines archival data about historical land-uses and practices, interviews with local rural settlers, and a GIS analysis of land-uses. (c) We describe the particular practices once performed by the local peasant community that created and enhanced open habitats such as rain-fed croplands, vineyards, meadows and sparse forests, while showing their relevance in sustaining the biodiversity that is now declining. (d) We discuss our results in relation to global trends of TEK related management practices and their role in biodiversity conservation. (e) Finally we conclude by giving some insights regarding the management and conservation of Mediterranean landscapes under conditions of accelerated global change.

The case study

Study area

The old municipality of Olzinelles (22.87 km^2), aggregated to the municipality of Sant Celoni in 1927, is located in the north-eastern and outer part of the Barcelona Metropolitan Region (BMR), in the Montnegre Mountains. The Montnegre is part of the Catalan Coastal Range (Fig. 1), formed by low altitude mountains stretching for 150–160 km along the north-eastern coast of the Iberian Peninsula. Olzinelles' main features are somehow similar to those of the Coastal Range in terms of altitude range (125–700 m a.s.l.), mean annual temperature (14.6 °C) and rainfall (703 mm); it also shows similar presence of a large diversity of fauna species from western Mediterranean; evergreen oaks as the largest vegetation type; and the settlement pattern in dispersed farmhouses combining subsistence rain-fed agriculture with the exploitation of evergreen forests (see Table 1). About two thirds of the total area are included in the Montnegre-Corredor Natural Park, which has been recently incorporated in the Natura 2000 network. Our study area is also an example of extremely depopulated mountainous area. The process of rural exodus has been characteristic of many other mountainous areas of the north rim of the Mediterranean basin, in Catalonia (Boada, 2001; Vidal, 1979), in the Iberian Peninsula (Collantes, 2001, 2005), and in Europe (Martí-Henneberg, 2005). In Olzinelles, after land abandonment fields and meadows were afforested, housing areas were developed for second residences, and biomass accumulated in the forests.

Social–ecological transformations in the course of economic modernization (1750s–1960s)

Although the Montnegre Mountains have been inhabited since pre-Roman times (Abril et al., 1995), the origin of the settlement in dispersed farmhouses (*masos*) organized in small parishes may be dated back to the turn of the second millennium (Portals, 1998; Vilageliu, 1981). During the complex and conflictive transition from the medieval ages to market economy (Cussó et al., 2006), a few peasants holding the *masos* under emphyteutic contracts[1] with feudalists gradually accumulated land and gained control of the rights of access to it, thus consolidating as the new landlord class of the region by the mid 18th century (Otero, 2006, p. 84). As the demographic growth of the 18th century increased the demand for land, such landowners expanded their production by leasing plots to small and landless peasants (Serra, 2008) who settled in Montnegre Mountains (Rangil, 2009). Indeed, as Olzinelles increased its inhabitants from 89 to 147 between 1719 and 1787 (Abril et al., 1995), the landlords leased some plots of land to landless peasants through specific emphyteutic contracts (*rabassa morta*) allowing them to plant vines after forest clearance (Zaragoza, 2006, pp. 99–110). The local expansion of vineyards in the former forests reflected the trend of the Catalan economy toward an increase in cash crops after the subsistence-oriented agriculture of the previous century (Fontana, 1990). However, the mountainous relief of Olzinelles municipality, with little arable land, prevented the landowners from engaging in the wine specialization as was the case with the coastal area. Instead, most of the productive land was occupied by large expanses of forests, which had a central role in the economic activities of the largest estates. Forests of Montnegre Mountains provided firewood for the wine distilleries; firewood and charcoal for the city of Barcelona; and cork to manufacture the bottle caps for the French champagne industry (Nadal and Urteaga, 1997, 1998; Zamora, 1973). Oaks, pines and poplars from the region were sold to the shipyards of the coast as timber for the thriving naval construction (Otero, 2006, p. 82). The integration of the local forest production within the Catalan economy characterized the particular path of land specialization of Olzinelles.

This trend intensified in the second half of the 19th century with the industrialization of Catalonia and the arrival of the railway in the nearby village of Sant Celoni (Abril, 1998). The selling of firewood, charcoal, timber and cork – meant to satisfy the mounting demands of energy and food of the growing Barcelona city – generated high profits for the largest landowners in Olzinelles, who were able to rebuild their farmhouses or build new mansions in the nearby villages (Abril et al., 1995). This accumulation of wealth was possible due to the particularly uneven landownership structure. By the middle of the century, only eight family estates – larger than 100 ha and with at least 90% of forested area – owned more than 60% of the Olzinelles territory (Otero, 2010, pp. 76–77). Their farmhouses were placed in the lower parts of the valleys with the largest streams, where the less steep areas were available for cultivation. In contrast with these wealthy landowners, three quarters of the people registered in the property documents had access only to less than 3 ha each, and about one third had plots of less than 1 ha. It was the growing small wine-producing tenant peasantry that – together with landless peasants – provided most of the workforce required by the forest exploitation in the large estates. Most of these poor peasantry were day laborers who endeavored in multiple practices and diverse tasks such as felling trees and shrubs,

[1] Emphyteutic contracts, widely used until 19th century, granted the tenant use-rights over the land, as well as the right to alienate, mortgage and pass it to his heirs, in exchange for an annual payment and some services (Garrabou et al., 2001).

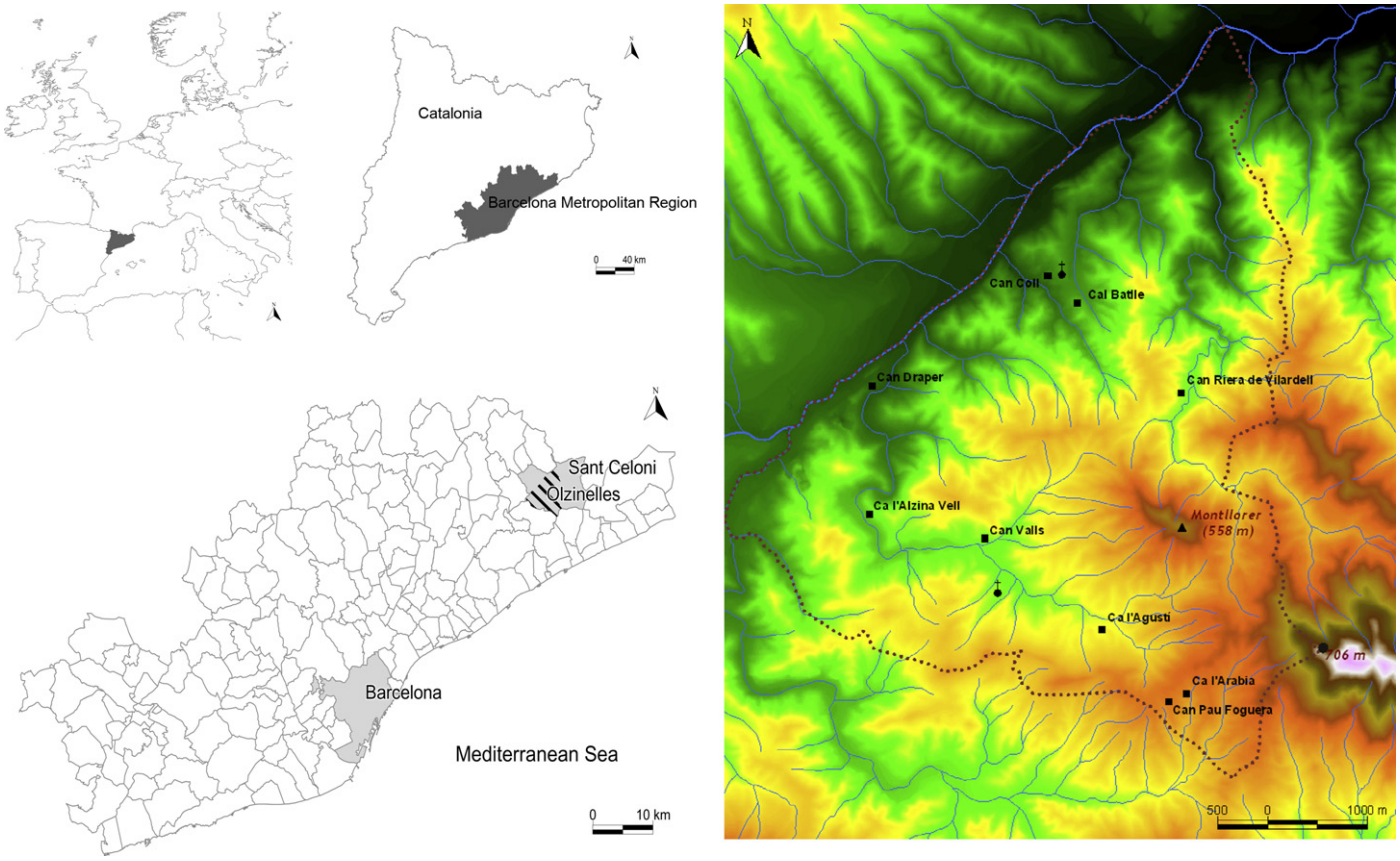

Fig. 1. Location of Olzinelles.

producing charcoal, debarking cork or in the first phases of in situ timber transformation.

But after the demographic growth of this period and as the phylloxera plague (arrived from France) hit the local vineyards during the last decades of the century, some of the small wine-producing peasants most likely abandoned the vineyards (see Fig. 2). They most likely moved as workforce to Sant Celoni village, where an incipient local industry based on textiles, corks, wood and milk was developing since the arrival of the railway (Abril and Portals, 2005). As opportunities for better-off paid non-farm jobs increased

Table 1
Land-use distribution and changes in Olzinelles (1853–2008).

Land use[a]	A. 1853–1862		B. 2008		C. Δ1853–1862 → 2008	
	ha	%	ha	%	ha	%
Irrigated cropland[b]	5.8	0.2	17.5	0.8	11.6	0.5
Rain-fed cropland[c]	121.9	5.2	28.2	1.2	−93.6	−4.1
Vineyard	206.3	8.8	1.3	0.1	−205.0	−9.0
Forest and plantation[d]	1866.3	79.5	2091.7	91.5	225.4	9.9
Unproductive[e]	147.7	6.3	33.2	1.5	−114.5	−5.0
Roads and motorway	0.0	0.0	50.5	2.2	50.5	2.2
Urban (sprawled)	0.0	0.0	61.9	2.7	61.9	2.7
Urban (compact)	0.0	0.0	1.5	0.1	1.5	0.1
Others	0.3	0.0	0.7	0.0	0.4	0.0
Total area	2348.3	100.0	2286.6	100.0	−61.7	−2.7

Sources: A: Property registers of Olzinelles municipality from 1853 (Archives of the Crown of Aragon, TER-963) and 1862 (City Archives of Sant Celoni, box 63). B: Data from municipal cadastre (Town Council of Sant Celoni, 2004) updated and revised by the authors (see "Materials and methods" section). C: B–A.

[a] In columns A and B, percentages relate to the total area of the municipality reported by the sources of that particular year. In column C percentages relate to the total area of 2008. Categories of land uses from different sources were homogenized in a common legend.

[b] Includes irrigated gardens, cereals and fruit trees.

[c] Includes rain-fed cereals and fruit trees.

[d] Includes coppiced sclerophyll forests and scrublands with dominance of *Quercus ilex* and/or *Q. suber*, with *Q. humilis*, *Pinus pinea* or *P. pinaster* as secondary species. It also includes chestnut groves (*Castanea sativa*); riparian forests with dominance of *Alnus glutinosa* and *Corylus avellana* as secondary species; plantations of poplars (*Populus* sp.) and plane trees (*Platanus* sp.); and plantations of pines (*P. pinaster*, *P. radiata*). Pastured woodlands registered in the sources of 1853–1862 are also included.

[e] In this land-use category, column A refers to the area declared to be unproductive (non taxable) and excluded from the property registers of 1853–1862. The value (6.3% of the total area) is similar to those reported by other authors using the same type of sources for the assessment of historical land-uses (e.g. Cussó et al., 2006, p. 53). Instead, column B includes the unproductive area occupied by quarries, bodies of water and farmhouses. Thus A and B are not fully comparable and the negative values in column C have to be read cautiously. We have classified urban unproductive lands separately (see the following three categories) to show important land-use changes that otherwise would have gone unnoticed.

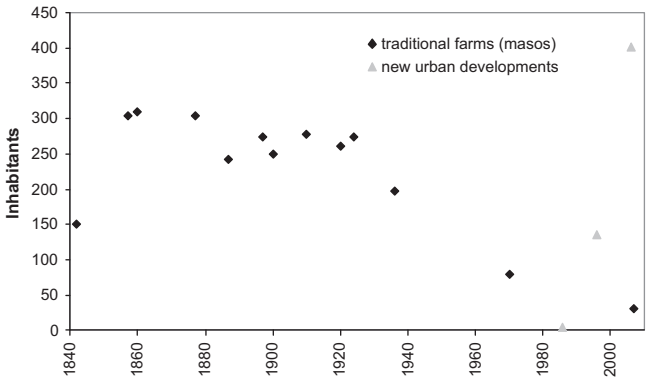

Fig. 2. Demographic evolution of Olzinelles (1842–2007).
Sources: Demographic censuses from 1924, 1936, 1970 (City Archives of Sant Celoni, box 121, 123, and P2-8), and 2006/07 (Town Council of Sant Celoni); Abril et al. (1995); Piqueras (2009).

in nearby coastal and industrial towns, many tenant peasants, small estate owners and forest day laborers left Olzinelles in the first decades of the 20th century (Fig. 2). Cereal fields and vines were gradually abandoned, making way for oak forests to recover spontaneously and for plane trees and pines to be planted by the landowners (Table 1). The uneven distribution of land property was reinforced with the overturn of the Republican agrarian reform by the Francoist regime after the end of the Civil War in 1939 (Tébar, 2006). In contrast to the small properties, worked mostly by family units, in the largest estates the owner family had sharecroppers, wage-earners and maids living and working in the estate, which could be managed by an administrator (Otero, 2006, pp. 109–112). They still profited from the sales of firewood and charcoal from coppiced woodlands (mainly Holm Oak and Cork Oak), slashed bushes of heather, and pine pruning; wood and timber from tree felling (plane trees, stone pines, poplars, and alders); and cork.

Olzinelles was thus progressively integrated in a larger open market economy. Products such as firewood or wine as well as industrial and other non-farming workforce – peasants that either commuted or emigrated – were provided to satisfy a growing external demand. As population increased during the 19th century, the estates' self-sufficiency declined and outside products such as wheat and derivatives, carobs, wine and oil had to be bought to feed local settlers and livestock (as early as in the last decades of the 19th century, Otero, 2010, p. 82). Nevertheless, and until very recently, many subsistence-oriented activities coexisted with the new modernization trends within a diverse and adaptive social–ecological system.

Accelerated changes in the transition to a global economy (1960s–present)

By the 1960s profits from forest started to decrease as fossil fuels out-competed the use of firewood for cooking, heating and feeding manufacturing processes in the region (Sànchez, 2010). Coppicing, charcoal production and shrub clearing decreased markedly. In the southernmost half of the case study area, the mean firewood yield from tree species reported by official permissions decreased from 1350 Mg per year (1956–1963), with maximums exceeding 1500 Mg, to only 323 Mg per year (1964–1971), with minimums under 150 Mg (Otero et al., 2008, p. 118). The fact that official permissions report the firewood yield from shrub species only until 1962 is also indicative of this change in energy sources, as a consequence of which forests are now denser, have higher fuel load, and higher canopy cover (Otero et al., 2011). With the crisis of the forest economy, some landowners of Olzinelles sold their depreciated properties to real estate developers, who parceled the estates and sold them for second residencies to rural migrants from the Spanish countryside living in the densely populated cities of the metropolitan Barcelona (Piqueras, 2009). As the new urban inhabitants settled, the population rapidly exceeded the maximum number of people who had lived in the area following the traditional pattern of settlement back in 1860 (Fig. 2). The new developments and its environmental impacts came together with the construction of a motorway connecting the Catalan coastal area with France. Urban sprawling in the mountainous areas with high ecological value was soon perceived as a threat by an emerging environmentalist movement whose claims resulted in the declaration of Montnegre Mountains as a protected park free from urbanization in 1989. The Montnegre-Corredor Natural Park has now a total area of 14,753 ha and includes 69% of Olzinelles municipality. Not having the status of a National Park, its overall original goals were to make compatible the conservation of biodiversity of the area with the socioeconomic development of its inhabitants. All in all, the social–ecological system of Olzinelles radically changed specially after the 1960s. Skilled work from farmhouses in forestry, livestock and farming ceased; farming and livestock rising in the study area do not provide food and practically no monetary income either to local people anymore. The capacity to provide cash products to external markets is very low: wine and charcoal are no longer produced and cork and firewood production has greatly decreased.

As a consequence of these land-use and land-cover changes several species mainly dependent on the existence of human-made open habitats have been reported to be receding in the last decades. From the middle of 19th century, more than 200 ha of vineyards and more than 90 ha of rain-fed cropland have disappeared, while forests and tree plantations have increased by 225 ha (Table 1). This is a characteristic process not only in Olzinelles but also in the whole Montnegre Mountains, where similar settlement histories, management practices and land-use changes occurred (Piqueras, 2009; Guitart, 2010). According to Gutiérrez (2001), eight plant species with only one or few locations in Montnegre Mountains are threatened by loss of habitat due to decreasing rural activities and consequent forest densification and afforestation of meadows and open spaces.[2] In particular, one of them (*Geranium lanuginosum*), found in Montnegre Mountains in 1946 in clearings where firewood piles were recently burned to make charcoal (Montserrat, 1989, p. 141), has never been found again, the disappearance of charcoal making being the major threat for this very rare taxon throughout Catalonia (Gutiérrez, 2001). Another one (*Orobanche artemisiae-campestris picrides*) is considered extinct since it disappeared from the only location known due to afforestation and other changes in habitat (Gutiérrez, 2004; Guardiola et al., 2007). Butterfly assemblages in Olzinelles also seem to be affected by land-use related changes in habitat. Up to five species (including *Polyommatus icarus* and *Colias crocea*, see Otero, 2010, p. 104) showed clear declining trends as maritime pines (*Pinus pinaster*) planted in the grasslands around the farmhouse of Can Riera grew and the shadow area increased to 100% (Miralles and Stefanescu, 2004).[3] Although these species are not considered grassland specialists but generalist

[2] Gutiérrez (2001) reviewed the flora studies done by several botanists in Montnegre-Corredor area over the last decades (e.g. Montserrat, 1989), selected some taxa according to different conservation criteria (Gutiérrez, 2004), performed an in situ verification of the reported locations, and analyzed the major threats for each taxon. Data adapted to Montnegre Mountains by Otero (2010, p. 104).

[3] Transect walked in Can Riera de Vilardell (see Fig. 1) as part of the Catalan Butterfly Monitoring Scheme, which uses a standardized methodology for monitoring butterflies (Stefanescu, 2000). Between March and September weekly butterfly counts were made along a fixed route within 2.5 m on each side and 5 m in front of the recorder. The transect was 2298 m long, had a mean altitude of 260 m a.s.l. and went through different habitats as Holm Oak forest, Cork Oak forest, and

species (Stefanescu et al., 2007), in the Olzinelles transect their largest populations were found in grassland sections and rapidly decreased with reforestation (C. Stefanescu, pers. comm.). Several bird species highly dependent on agrarian fields have been reported to be declining in Olzinelles and Montnegre Mountains as a consequence of agricultural abandonment and afforestation (Ribas, 1996, 1997a,b).[4] Examples in our study area include the Crested Lark (*Galerida cristata*), the Skylark (*Alauda arvensis*), and the Partridge (*Alectoris rufa*, particularly related to vineyard abandonment), which at the Catalan level are similarly threatened by abandonment of cultivated land and extensive grazing, shrub encroachment and afforestation (Estrada et al., 2004). Other species affected by land abandonment in Olzinelles include reptiles particularly related to stone walls and vineyards (e.g. *Timon lepidus*, *Coronella girondica*), and amphibians that used to breed in ponds, sinks and fountains that now remain dry after being abandoned along with rural exodus (e.g. *Pelodytes punctatus*, *Triturus marmoratus*) (Otero, 2010). Last but not least, the diversity within cultivated species, especially fruit trees and vegetables, has greatly decreased since it was enhanced by long-term human selection of the preferred genotypes in terms of adaptation to local climate, taste or productivity (Otero, 2006, p. 180).

In addition to these processes of social–ecological transformation an increase of 0.75 °C in mean annual temperature and a decrease of water runoff and aquatic species from the main stream have occurred (Otero et al., 2011). All in all, this can be regarded as a paradigmatic example of the multiple transformations experienced by the cultural landscapes of Mediterranean mountain areas under conditions of accelerated global change.

Materials and methods

We designed an interdisciplinary methodology aimed at gaining a comprehensive understanding of the social–ecological system dynamics of Olzinelles, and implemented it during the course of a 6-year participant observation period (2005–2010). In order to know in detail how the local agrosilvopastoral practices created and enhanced those particular habitats, we relied on different types of information, which was then integrated by codifying key terms and by identifying in it cross-cutting themes. First, key documents providing records about specific management practices, land uses, social–ecological interactions and population were collected in local (estate, parish and city levels), regional and national historical archives. Documents included property registers, permissions for tree felling, demographic censuses, and landowners' diaries. Quantitative data were systematically collected, transformed into common units and aggregated in simple variables to allow calculations (e.g. area of a specific land-use; firewood yield per year; number of inhabitants). Qualitative information was collected through content analysis of documents, including transcription of old hand-written manuscripts.

Second, biographical in-depth interviews on management practices were carried out with a sample of 12 men and 8 women born between 1913 and 1960 who lived in farmhouses and/or worked in rural activities in Olzinelles. We chose this qualitative research method since it allows exploring such phenomena in-depth (Fischer and Young, 2007) and because very few original peasants were still left in the area. The interviewees were selected by snowball sampling (Bernard, 2006) and balanced in terms of access to land and labor conditions (small, medium and large estate owners, sharecroppers and day laborers), as well as of types of work (agriculture, livestock, forestry and housework). Interviews were recorded and transcribed for content analysis to synthesize the diverse practices performed by the peasant community to manage the fields, forests and livestock.

Third, a Geographic Information System (GIS) on land-uses was created from the cartography of the municipal cadastre in force, including data on land-use at plot level (Town Council of Sant Celoni, 2004). Data were updated through on-line search in the Directorate General for Cadastre Electronic Site of the Spanish Ministry of Economy and Finances (www.sedecatastro.gob.es/ovcinicio.aspx), and revised by means of field work and photointerpretation of orthophotos of the study area taken in 2005–2006 and provided by the Cartographic Institute of Catalonia at a scale of 1:5000 (www.icc.cat). About 267 physical elements of the Olzinelles landscape providing information about local management practices and their evolution through time (such as inhabited and abandoned farmhouses, stone terraces, vineyard huts, springs, and ponds) were georeferenced, photographed and described through extensive field work and introduced in the GIS.

Results

Practices

Management of forests, fields and livestock

Table 2 shows the forest management practices performed by the peasant community of Olzinelles. Holm Oak forests, one of the most important ones in terms of land-cover and productive activities, were coppiced every 7–10 years. Dead, dried up or bent oaks were selected, together with oaks reaching the diameter required by the market. Once they were cut down, the stump was carefully smoothed down with the axe so as to drain water off and avoid the tree to rot (Montserrat, 2007). Straight and healthy oaks were left standing and thus favored for the next harvest, which was done after 7–10 years with the same selection criteria.[5] The third selection was performed 7–10 years after the second one. After additional 7–10 years the cycle restarted, selecting the oaks that had been felled 21–30 years before, which had already recovered by sprouting (Interviewee #1). The coppice selection system was very similar for Cork Oak forests, though adapted to the production of cork.

Coppicing several stands of forest within the estate allowed the largest landowners to have a yearly yield, while keeping tree-covered land rather constant and maintaining heterogeneous forests in terms of canopy cover, light availability, and shrub cover. After the felling, a protection of dead leaves and twigs was made to protect the soil against runoff erosion. In the less accessible stands, charcoal was produced so as to reduce firewood weight by 5–6 times, to facilitate its transportation while maintaining its calorific content. Approximately every 20 years, or before tree felling, understorey was slashed to produce thin firewood or charcoal and uprooted to sell the stumps to the pipe manufacturers (e.g. *Erica arborea*). Coppicing, slashing of ground vegetation, and the grazing by pig herds and sheep flocks (Table 2) maintained the forests with both a low tree density and a low canopy cover. A

former meadows transformed to pine plantations. Data were available for the period 1994–2003 (Miralles and Stefanescu, 2004).

[4] Ribas studied bird species distribution by field sampling in UTM 1 km × 1 km squares. Each square was sampled once or twice a year during several years both for breeding (from March to July) and wintering (from November to February) species. In each sampling a transect of about 1–1.5 h of duration was walked whereby bird species were recorded by both visual and hearing contacts, and main habitat preferences were assigned to each of them (Pino et al., 2000). Different standard methods were used to quantitatively assess bird populations, namely total censuses, parcel censuses and punctual indexes of abundance (Ribas and Pons, 2001). Data adapted to Olzinelles by Otero (2010, p. 104).

[5] Memories of Joaquim Draper, owner of the estate Draper in Olzinelles, written 1989–1993, private archives from the Draper family (PAD).

Table 2
Forest management practices performed in Olzinelles (1900–1960).

Forest type	Practices
Cork Oak stands (*Quercus suber*)	Debarking (VI–VII): virgin cork from trees of >20 cm Ø; secondary cork 9–10 years after virgin cork; 12 years after secondary cork; every 14–17 years up to five times. Coppice selection. Felling competitor species: *Pinus pinea*, *Q. humilis*. Selective slashing of ground vegetation every 20 years (e.g. *Erica arborea*), conserving soil-improving leguminosae species (e.g. *Ulex parviflorus*). Charcoal making through the heating of piles of coppiced firewood covered with earth (absence of O_2). (Acorn) grazing by pig herds and sheep flocks. Cultivating fodders (e.g. *Lathyrus* sp.), cereals (e.g. *Sorghum vulgare*) and vegetables in low density woodlands.
Holm Oak stands (*Quercus ilex*)	Coppice selection every 7–10 years with complete cycles of 21–30 years. Sprout selection: 4 per stump (5–6 years after coppicing) and 2 per stump. Felling or slashing competitor species: *P. pinea*, *Q. humilis*, *Rubus ulmifolius*. Charcoal making through the heating of piles of coppiced firewood covered with earth (absence of O_2). Grazing by pig herds and sheep flocks.
Understorey	Slashing before tree felling. Felling and uprooting stumps of *E. arborea* and *Arbutus unedo*. Fine charcoal making through the heating of brushwood in kilns, pits or piles (absence of O_2).
Riverside	Layout of species according to their need of water, from the river to the outside: *Alnus glutinosa*, *Populus* sp., *Platanus* sp., *Pinus pinaster*, *P. radiata*. Felling with different rotations.
Pine plantations (*Pinus* sp.)	Pruning of lower branches to stimulate growth (*P. pinea*). Felling with different rotations (*P. pinea*, *P. pinaster*, *P. insignis*, *P. halepensis*). Gathering of pine cones (*P. pinea*).
Chestnut groves (*Castanea sativa*)	Sowing chestnuts or planting striplings after forest clearing. Felling to stimulate sprouting (after 14–15 years). Sprout selection: 2–4 per stump (4–5 years after felling); 1–2 additional selections. Felling (10–20 years after the first felling).
Plantations of plane trees (*Platanus* sp.)	Planting saplings and felling after 2 years to stimulate sprouting and growth. Sprout selection: 5–12 per stump (1 year after felling); 4–5 per stump (2 years); 2–3 per stump (4 years); and 1–2 per stump (12 years). Pruning (4 years after felling, together with sprout selection). Removing bent trees (6 years after felling). Felling (20 years after felling). Cultivating vegetables for self-supply and livestock feeding in young plantations.

Sources: Oral sources, archival information, fieldwork and GIS (see "Materials and methods" section). Additional information from Boada (1989), Pagès et al. (2005), and Piqueras (2009).

characteristic forest in Olzinelles would also contain several clearings with herbaceous vegetation, as it can be observed in the aerial photographs of 1956 (Otero et al., 2011). In the less extensive forest types of the study area such as the riversides, chestnut groves, plantations of pines and plantations of plane trees, spatial and temporal heterogeneity was enhanced by different pruning, sprout selection and rotations that varied according to forest types and production goals (Table 2).

Farmhouses in Olzinelles were usually located near small streams, most of which had irregular and meager water flows. Such streams were then terraced to create dry farming land and orchards, especially in the smallest farmhouses, as they were in steep terrains with little availability of arable land (Table 3). The management of field margins through the construction of stone walls, the planting of fruit trees, and the burning of spontaneous shrubs enhanced farmland biodiversity by providing refuges and feeding areas for several species (Benton et al., 2003). Vineyards spread out in steep slopes without terracing, where vines were laid out following zigzag draining ditches that avoided soil erosion by collecting water runoff in purpose-built pools. Soil fertility in agrarian land was conserved and enhanced by spreading animal and human manure; by burying green manure (e.g. leguminosae species), and also through crop rotation in the case of herbaceous farming.

Cereal fields and vineyards were ploughed at least once a year to prepare the land for sowing, and vineyards were hoed several times to weed. These practices prevented the encroachment of farmland by shrubs and trees and allowed the germination of spontaneous grasses such as *Brachypodium ramosum*, which was abundant in field margins and degraded scrublands; *B. distachyum*, frequent in field margins and southern slopes (Montserrat, 1989, p. 309); *B. phoenicoides*, abundant in field margins with a close water table (p. 310); *Dactylis glomerata* ssp. *hispanica*, found in short grasses from edges and paths up to 450 m a.s.l. in the coastal slopes (p. 299); or *Poa annua*, in cereal fields and gardens (p. 301). Several granivore bird species feed on cereals (wheat, oats, and barley) and spontaneous grasses from fields and vineyards, and could nest in the ground since heavy farm machinery was hardly used (e.g. Crested Lark, *G. cristata*; Red-legged Partridge, *A. rufa*) (Boada, 1984; Interviewee #3). Reptile species such as the Ocellated Lizard (*T. lepidus*) also benefited from the low plant cover in vineyards to sunbathe and used the stone walls from field edges to hide (Boada, 1984).

Sheep and goat flocks as well as pig herds grazed in the oak woodlands to feed on the roots, herbs, stems, shrubs, shoots, as well as on the lower branches of trees and on the acorns scattered in the ground (Table 4). Especially shady woods with low tree density and no shrub cover were used by the shepherds to gather the flocks during the hottest hours of the day and to supply them with salt. In the middle of the 19th century pastured woodlands were reported to represent up to 29% of the total area of the municipality.[6] They had a medium or low tree cover and included meadows with grasses such as *Festuca arundinacea*, very abundant in Olzinelles (Montserrat,

[6] Property registers of Olzinelles municipality, 1853 (Archives of the Crown of Aragon, TER-963) and 1862 (City Archives of Sant Celoni, box 63).

Table 3
Farming practices performed in Olzinelles (1900–1960).

Crop	Practices	
Gardens	Terracing streams and maintaining edges with stones, trees, shrubs, fruit trees, vines.	
	Constructing and maintaining irrigating ponds and ditches.	
	Conserving soil fertility: animal manure, crop rotation and green manure.	
	Cultivating vegetables for self-supply and livestock: fruits (pumpkin); bulbs (onion); leafs and stems (chard); flowers (artichoke); legumes (bean); roots (turnip), and tubers (potato).	
Dry land fields	Terracing streams and maintaining edges with stones, trees, shrubs, fruit trees, vines.	
	Conserving soil fertility: animal manure, crop rotation and green manure.	
	Cultivating wheat (*Triticum* sp.) for self-supply.	Ploughing, fertilizing and sowing (before XII).
		Hoeing.
		Harvesting and piling up wheat in the fields (VI–VII).
		Using different wheat varieties according to changes in demand.
		Threshing the harvest, grain collecting and haystack formation (VII).
		Grinding and producing flour, bran and bread.
	Cultivating for fodder, hay and grain for livestock: oats (*Avena sativa*), barley (*Hordeum vulgare*), lucerne (*Medicago sativa*), maize (*Zea mays*), sorghum (*Sorghum vulgare*).	
Vineyards	Cultivation in steep slopes without terracing: controlling soil erosion by zigzag draining ditches along which vines were laid out.	
	Cultivation in flat fields, vines laid out in lineal furrows.	
	Conserving soil fertility: animal manure and green manure (*Lathyrus* sp.).	
	Cultivating vine (*Vitis vinifera*) and producing wine for self-supply and trading.	Pruning, fertilizing, ploughing, planting new vines, grafting vines older than 3 years (I–IV).
		Hoeing and fumigating with sulfur (V).
		Hoeing and fumigating with copper sulfate (VI–VII).
		Harvesting (IX–X).
		Promoting intraspecific diversity in vines.
		Treading and pressing the grapes.
		Boiling and fermenting the juice, wine storage.
	Secondary crops: medicinal and aromatic plants (rosemary, oregano, sage, thyme); fruit trees (olive tree, fig tree, cherry tree), and fodders (lentils, vetches).	
Fruit trees	Cultivating olive tree (*Olea europaea*) and producing oil for self-supply (and trading).	Planting in olive groves or as secondary crops in vineyards.
		Pruning.
		Harvesting (XI–XII).
		Crushing the olives in the oil mill, pressing the paste in the press.
		Oil collection and storage.
	Cultivating fruit trees for self-supply (and trading).	Planting as secondary crops in vineyards and edges.
		Promoting species diversity: cherry tree (*Prunus avium*), fig tree (*Ficus carica*), peach tree (*Prunus persica*), pear tree (*Pyrus communis*), almond tree (*Prunus amygdalus* var. *dulcis*), plum tree (*Prunus domestica*), walnut tree (*Juglans regia*), loquat (*Eriobotrya japonica*), quince tree (*Cydonia oblonga*), apple tree (*Malus domestica*), jujube (*Ziziphus jujuba*), persimmon (*Diospyros kaki*).
		Promoting intraspecific diversity.

Source: Oral sources, archival information, fieldwork and GIS (see "Materials and methods" section). Additional information from Baylina et al. (2006).

1989, p. 304), and *F. rubra*, in pastures with *Bromus erectus* or in the riverside forests of alders (*Alnus glutinosa*) together with *D. glomerata* ssp. *glomerata* (p. 305).

Practices performed in the forests, fields and pastures were strongly integrated in a complex web of matter and energy coordinated by mechanisms operating at different spatial scales which ensured the feasibility of the productive system. Soil fertility was carefully managed through a proper manure allocation among the three subsystems and the farmhouses. The subsistence-oriented fields around the farmhouses not only fed humans, but also produced fodder, vegetables, stubbles and grain for livestock, which manure was then returned to the fields. Domestic latrines from farmhouses were periodically emptied and the excrements used to fertilize dry land fields together with animal manure (Interviewee #1). Some of the different types of manure (hen, pigeon, rabbit, sheep, goat, cow, pig, horse, and human) had different specific names and were used for particular purposes according to their properties. All the organic waste produced in the farmhouse was given to livestock, especially pigs, and converted into animal protein to feed the family unit. The leasing of grasses and acorns by the large landowners to foreigner temporal shepherds was partially paid by leaving in the farmyard of the estate the manure produced during the night by the sheep flocks (Rangil, 2009, p. 250; see Table 4), and about half of the total manure produced by these flocks would be left in the forests during their stay in Olzinelles (Tello et al., 2010). Forests were also an important source of key nutrients as potassium by the process of burning slashed brushwood and by spreading these ashes on the fields, a remnant of an old fertilizing technique (Olarieta et al., 2010). Integrated agrosilvopastoral systems operated also beyond the farm scale. Flocks of sheep and goats from the region grazed in Olzinelles for some months and then moved to nearby mountains of the Coastal and the Pre-Coastal Ranges according to grass availability (e.g. Montseny Mountains, see Table 4). Even transhumant flocks from the eastern Pyrenees arrived to Montnegre Mountains in November and then left back in springtime to feed on the high pasturelands after the melting of the snow (Interviewee #11: Miralles, 2005, p. 92).

Diversification-oriented practices

As shown in Tables 2–4, a high diversity of species was used for maintaining livelihood security and also for commercial purposes, thus keeping options open and minimizing risks. Nourishment from fields and livestock was completed by hunting and fishing many local species of crustaceans (e.g. White-clawed Crayfish, *Austropotamobius pallipes*), amphibians (e.g. Perez's Frog, *Pelophylax perezi*), reptiles (e.g. Ocellated Lizard, *T. lepidus*), fishes (e.g. European Eel, *Anguilla anguilla*), birds (e.g. Red-Legged Partridge, *A. rufa*; Eurasian Blackbird, *Turdus merula*), and mammals (e.g. Southern Water Vole, *Arvicola sapidus*; Wild Boar, *Sus scrofa*) (Otero, 2010, p. 82). Also the gathering of mushrooms (e.g. genus *Lactarius*, *Amanita*,

Table 4
Livestock management practices performed in Olzinelles (1900–1960).

Livestock species	Practices	
Bovine	Producing cow milk for trading (and self-supply).	Mating in farmhouses with bulls or artificial insemination by a veterinarian. Renewing straw beds and taking manure out the shed every day. Milking and watering twice a day. Feeding: fodder and hay (lucerne, vetches, *Lathyrus* sp., herbs from field edges), bran mixed with beetroots, feed. 1–6 cows and 30–120 daily l yield per farmhouse.
	Raising calves for trading.	Mating in farmhouses with bulls or artificial insemination by a veterinarian. Renewing straw beds and taking manure out the shed every day. Feeding: cow milk, fodder (*Lathyrus* sp.), feed. 3–4 calves per farmhouse, slaughter at 1.5–2 years around 300 kg each.
Pigs	Fattening for self-supply.	Mating in farmhouses with boars. Feeding: mix of bran and boiled vegetables (beetroots, turnips, potatoes). Slaughter of 1–2 pigs per farmhouse yearly to produce cold meats.
	Fattening for trading.	Stabling the herds in the farmhouse. Feeding: mix of bran and boiled vegetables, feed. Grazing acorns (winter) and roots in the oak woodland. Herds of 100–200 pigs.
Poultry and rabbits	Breeding for self-supply (and trading).	Feeding: *Lathyrus* sp., by-products of grape pressing, herbs from field edges, lucerne, bran.
Ovine and goats	Raising for self-supply. Raising for trading.	1–2 animals per farmhouse: lamb, ram (castrated), ewe, goat or kid. Flock movement within nearby coastal mountains according to grass availability (e.g. Montseny Mountains). Transhumance from eastern Pyrenees to coastal mountains (grazing in Olzinelles and Montnegre Mountains from XI–III). Continuous mating. Set-aside baby females from slaughter to replace old breeding females. Periodical withdrawal of old ewes. Set-aside several baby males from slaughter to replace old males. Exchange of males with other flocks to "change the blood" of the flock. Grazing herbs, stems, shrubs, shoots, lower branches of trees and acorns in the oak woodland. Grazing cereal fields (oats) and stubble fields after harvest. Use of goats to suckle lambs (occasional). Salt supply every 1–2 weeks in special stones placed in shady woods. Putting the flocks out to pasture by sheepdogs or children. Flocks in farmyards during the night. Wool shearing (V). 200–400 heads, mostly ewes and lambs, with several goats, kids, rams (castrated and not) and billy goats.

Source: Oral sources, archival information, fieldwork and GIS (see "Materials and methods" section).

Russula, *Cantharellus*), asparagus (*Asparagus acutifolius*) and snails (e.g. *Helix aspersa*) and the production of honey in cork beehives were added to the list of local inputs used by the community as food.

Cooking and heating relied on different kinds of fuels obtained from several tree and scrub species: firewood from Holm Oak (*Quercus ilex*), Cork Oak (*Q. suber*), and Strawberry Tree (*Arbutus unedo*); fine firewood from heather (*E. arborea*) and vine shoots (*Vitis vinifera*); charcoal; pine cones (see Table 2). Hayforks and other tools were made from hackberry (*Celtis australis*); wicker baskets manufactured with crack willow (*Salix* sp.), and sticks for the gardens done with reed (*Arundo donax*). Ointments of snake skins, pig fat, and lizard or scorpion oils, together with a high diversity of medicinal plants, were used as remedies to treat many kinds of illnesses (Boada, 1984; Rangil, 2008). Intraspecific diversity was enhanced, especially in vines and fruit trees (Otero, 2006, pp. 180–182) but also in forest trees like the Holm Oak, as up to four varieties with different growth patterns and stand densities used to be distinguished.[7]

A diversity of management practices was used by settlers to secure water availability. Water from various sources (underground, stream, spring and rain water) was extracted and collected by means of wells, weirs, pipes and pools and stored in ponds for domestic uses and for the irrigation of farm gardens. Water was transferred by descending tunnels, channels, ditches or small aqueducts often equipped with various devices to change the direction of the water flow. Specially built sinks for washing clothes or providing water to livestock were constructed near the springs and ponds. Many of these water infrastructures enhanced the chance of aquatic species to complete their life cycles. In Olzinelles, ponds (up to 34) and fountains (18) were breeding sites for several species of amphibians such as the Parsley Frog (*P. punctatus*), the Fire Salamander (*Salamandra salamandra*) and the Marbled Newt (*T. marmoratus*) (Boada, 1984; Interviewee #5). The small weirs that kept water throughout the year favored the maintenance of fish and crayfish populations in streams with a high hydrological variability due to the typical Mediterranean climate (Otero et al., 2011; Interviewee #10).

Institutions regulating work and knowledge transmission

These management practices were embedded in a set of complex institutions, i.e. systems of rules-in-use governing the relationships not only between humans with each other but also with their environment. Such institutions were the product of learning as well as of power dynamics that regulated local agents' behaviors and the social–ecological interactions. Among those,

[7] PAD.

property rights and rules of access to land were of paramount importance. As explained above, a highly uneven landownership structure consolidated throughout the time in which Olzinelles embraced an increasingly open market economy. Types of work varied according the access to resources, the distribution of factors of production and yield, and the sort of remuneration.

In particular, forest works were mainly done by groups of 3–11 male peasants from the area who were contracted by the forest owners for specific tasks, such as tree felling, charcoal making or cork debarking. Just before the season, the group leader and the owner negotiated the remuneration of the workers, which could be a fixed amount, a day's wage or a yield-depending salary (Boada, 1989). Instead of cash, understorey clearing was often paid in-kind with the firewood and the stumps of the shrubs that had been cut down, although forest owners could then retain between a quarter and a third of the total brushwood yield (Interviewee #11). Some of the largest estates had 2–3 permanent groups of forest workers to do all the necessary tasks in their properties. Despite the great social differences, agreements between owners and workers were reached on a trust basis. In the official permissions, government foresters allowed a certain amount of firewood to be harvested, but often forest rangers were convinced to allow a higher amount with the condition that the felling was not abusive or in exchange for a bribe (Interviewee #2). In highly skilled works such as cork debarking, the owner himself and its male sons could contribute with several days of work.[8]

Agricultural works were mostly done by the farmhouse's family, either men or women, although it was crucial whether the family owned the fields or not. In the later case, different leasing contracts used to regulate the distribution of costs and yields between landowners and tenants. Vineyard tenants were obliged to give 20–25% of the grape/wine yield to the owners, and olive growers about 25% of the olives (Interviewees #1, 4). Besides the fields, leasing contracts could include the farmhouse where the tenant's family lived, and the obligation to assign several days work to the forest within the estate (Interviewee #4). During the most labor-intensive works daily wage-earners were contracted for specific tasks such as hoeing or harvesting, and labor could be exchanged among neighbors such as in the grape harvest, treading and pressing (Interviewees #1, 3, 4, 15). In the case of livestock rising, whereas milk cows were owned by the peasants, some of the calves that were sold as veal belonged to cattle businessmen that retained between one third and one fourth of the sale price (Interviewee #7). Cows and sows were brought to mate to the neighboring farmhouses with own bulls and boars, in exchange for some cash or even a piglet.

Besides taking care of livestock and gardens, women of the local families had a central role in the peasant economy. They cooked for all the family and for the workers who used to come to the estate during the most labor-intensive tasks such as the cereal harvest or the slaughter of pigs, often not eating themselves to make sure that the men had enough food, except during pregnancy and lactation (Rangil, 2009, p. 124). They were in charge of the conservation of grain and vegetables; the production of pork sausages and cold meats; of the preparation of preserves; and of the care of the kids, the elderly and the sick (Otero, 2010) hence contributing to the wellbeing and health of their communities.

In addition, and although not regulating work directly, the Church was a key institution which served to achieve social cohesion and to make sense to the daily life despite the characteristically uneven social and economic structure. Rich landowning families had their own pew in the Church with their surname written on it (Otero, 2006); were the ones contributing the most to the parish economy through donations; had private chapels in their farmhouses, and were good friends with ecclesiastic authorities such as the bishop of Barcelona (Interviewee #12). As charitable acts, they allowed poor families from the neighboring farmhouses and villages to harvest firewood from their estates, spend the night in their hayloft or receive food during some days a year (Interviewees #3, 12, 13, 14). The social and spiritual power of the Church was often recognized by peasants who attributed many paranormal phenomena to the priest—since he had access to written culture and was seen as capable of successfully fighting pests, storms and hailstorms, and invoking the much desired rain (Rangil, 2008).

Traditional mechanisms of intergenerational transmission of knowledge operated in Olzinelles. Boys started working with parents and older brothers in the fields and with livestock in the farmhouse (Interviewee #1), and girls joined their mother and older sisters in the housework. Children of humbler families started working as pig herders in neighboring farmhouses (Interviewee #11). They were later rented out as servants in the large estates, where they spent several months working in the fields, taking care of the cows or helping forest workers,[9] or they joined one of the groups of forest workers as apprentices, first with auxiliary tasks and then with hands-on learning of the most skilled tasks (Interviewee #4). The group leaders used to be the most skilled workers and taught the apprentices how to debark cork without harming the bare bark or how to fell trees in the desired direction. The coexistence of 3 generations in the farmhouse allowed the transmission of family and community memory – i.e. through the recounting of stories by the elders – which could go back as far as 200 years (Interviewee #11).

However, agrosilvopastoral management in Olzinelles was not only the result of traditional transmission of knowledge. The illiteracy of the peasant community gradually decreased during the 20th century as formal education was progressively implemented in the local school: in the southernmost half of the study area, for instance, the illiteracy of the population older than 10 years decreased from 26.3% in 1924 to 11% in 1970 (Otero, 2006, pp. 106–124). Management practices incorporated modern forestry and agronomy in many cases, and old measures which were used to count volume, weight and area were progressively substituted by the metric system. Although forest management (Table 2) was based on local ecological knowledge, it was also increasingly planned and regulated by landowners and State foresters educated at University. For example, the owner of one of the largest estates in Olzinelles studied agronomy in France and acknowledged in his memoirs the integration of local and scientific knowledge for the management of his forests: "*who taught me to know (. . .) the weight of standing trees and which and when should be removed so as to give space to the youngest? Not in France (. . .) If I know all this it is thanks to the sharecropper Joan Clapés, who during my childhood and my youth taught me, not everything but quite a lot*".[10] Similar dynamics have been seen in the case of farming, livestock management and hunting practices.

Worldview and spiritual practices

Some of the agrosilvopastoral practices described above cannot be said to be explicitly the result of a strategy consciously chosen by individuals. Rather, they were embedded in a set of traditions and beliefs within a particular worldview influenced by the local environment and the productive activities performed by the community. Farming had an essential role in shaping peasants'

[8] Book of incomes and expenses of the estate Arabia in Olzinelles, 1880–1887, private archives from the Arabia family (PAA).

[9] PAA.

[10] PAD.

worldviews and behaviors, since with the cultivation of land not only vegetables and cereals were grown. Also a whole number of social–ecological relationships which marked their perceptions of space emerged. Working the land implied that people spent large amounts of time and effort to try to understand and get to know about soil properties, useful plants, best paths, and then to give specific names, a whole rich knowledge that would improve the efficacy of their labor, e.g. by reducing the distance which was needed to go to and from their farmhouses. However, their knowledge of the close environment was so profound and entailed so much time and effort to learn it that their plots of arable land marked very close physical and cognitive borders of what constituted their own environments (see Table 3). Even very close woods nearby – only 5 km far from the farmhouse – were seen as very far-off, wild, woody and unknown places (Otero, 2008).

Management practices, traditions and beliefs were all closely interlinked. In general, tree felling finished in Saint Joseph Day (19th March) when the trees recovered the sap flow and, according to popular belief, felling would be harmful to sprouting and the timber would deteriorate faster (Interviewee #1; Gutiérrez, 1996). The moon was thought to exert an influence on trees. Evergreen trees (Holm Oak, Cork Oak, and pines) were cut down during waxing moon days, while deciduous trees (poplar, plane trees, and deciduous oaks) were cut down on the wane (see Table 2). If this was not observed, wood and timber quality was thought to get damaged fast. On the edges of fields and forests, along the tracks and near the farmhouses, unusually big and long-lived trees were conserved, under whose symbolic protection peasants used to meet and make deals on livestock and agrarian products (Broncano et al., 2006). Vines and olive trees were also under the influence of the moon: the main pruning of vines was done in the waning moon of February or March, while olive trees were pruned with waxing moon (Interviewees #1, 11; see Table 3).

Ethnographic research carried out in Olzinelles and in Montnegre Mountains also shows the traces of an old pagan animism. Informants told stories about magic creatures that were seen by them or by their relatives: flying snakes with long hairs in their back and a diamond in their head could eat people and keep wonderful treasures; beautiful water women lived in hidden underwater palaces and came out from streams in the full moon to do the laundry with captivating melodies; witches were able to start storms and kill children; and big creatures sat down on sleeping people making it difficult for them to breathe and inducing nightmares (Rangil, 2008, pp. 52, 113, 200, 201).

From our interviewees it has been possible to appreciate a certain capacity for *listening* and *understanding* many of the dynamics and elements which characterized the functioning of the natural systems sustaining their ways of life. In the case of cork, for instance, after debarking the forest workers engraved the bare bark with the year so as to know the age of the next cork. If this was not done, in the following peeling it was more difficult to know the age of the cork, and "*then you had to look at the cork and understand it*" so as to know if it was aged enough to be peeled (Interviewee #1). "Voices of water" (*veus d'aigua*) were natural springs of subterranean water that could be *heard* and its water used by installing small collecting structures and pipes to facilitate the filling of drinking jugs and buckets. Particularly skilled people in water knowledge (*saurins*) could feel the underground water and were contracted to identify the exact point where a new well should be dug. Even some mushrooms as morels (*Morchella* sp.) were heard crying when they were picked (Rangil, 2009, p. 213).

This rich spiritual life of the local peasant community is also illustrated by the presence of many superstitions and rituals. The ladder snake (*Rhinechis scalaris*) was captured alive and its tongue pulled out and hung inside a small bag on the newborn child's neck to relieve their pain when teeth emerged. The hedgehog (*Erinaceus europaeus*) was also sacrificed ad hoc and its teeth pulled out and used in the same way and for the same purpose. To reduce fever, some people used to catch seven beetles in the dunghill, crush them in a mortar, make an infusion and give it to the sick person without his knowledge (Portals, 1998, p. 111). The wrath of patron Sant Esteve that banished common magpies (*Pica pica*) from Olzinelles after one of them defecated on his bald head during a solemn procession was thought to be the cause of the absence of this species in the area (Interviewee #3).

Discussion

Our results show, within a very concrete Mediterranean geographical setting and defined temporal scale, the intricateness, the complexity, but also the indisputable interconnection between the changes in biodiversity and the disappearance of many cultural practices which had to do with the use of forests, fields and livestock. The dynamics of this particular social–ecological system and their relation to changes occurring at the global system can be conceptualized in terms of the SEIC model (Tàbara and Pahl-Wostl, 2007). In Olzinelles, historical changes occurred in the structure of rules and institutions (S) along the process of rural exodus starting in the first decades of the 20th century. Changes in energy and resources (E) uses occurred as a result of the penetration of fossil fuels in the region, the abandonment of firewood and charcoal, and the alteration of the agrosilvopastoral practices performed by the already decreasing number of peasants. Manual working and farm animals – mares, horses, bullocks, cows, donkeys and mules – were progressively substituted for tractors, harvesters, power saws and trucks (Interviewees #1, 2, 4, 5, 6, 9, 11, 15); which in turn required the replacement of the old wagon tracks into tarmac roads. Information and knowledge (I) were transformed with the increasing loss of practices and knowledge forms developed to enhance the production and resilience of the local system. All these transformations triggered a set of social–ecological changes (C) and feedbacks, clearly visible by the loss of many life forms that had historically adapted to human intervention on the land.

This is in agreement with the observation that the transition from an economy strongly dependent on local ecosystems services to a global market economy with intensified production systems results in a significant erosion of TEK related management practices (Gómez-Baggethun et al., 2010). However, the fact that from the middle of the 18th century until the 1960s the subsistence-oriented activities coexisted with the production of marketable products within a highly diverse and adaptive social–ecological system supports the idea that modernization does not necessarily erode all forms of local knowledge (Godoy et al., 1998; Reyes-García et al., 2007). The institutional and cultural setting described above provided this particular social–ecological system and the agents in it with the abilities to reorganize their relationships and practices according to changing circumstances. Certain practices and spaces left aside would also act as buffer zones that would protect them from disruptions or possible shocks derived by new economic demands, contributing to the adaptive properties of the system.

Such adaptive properties could operate at different spatial scales. For instance, the system was adapted to meet the peak external demand for wine of the last decades of the 19th century by converting forests to vineyards under specific leasing contracts, vineyards being afforested or reforested after the arrival of the phylloxera plague. The coppice selection system in the oak woodlands created an uneven-aged forest structure, more resistant to disturbances such as droughts or pests than even-aged ones (Hunter and Schmiegelow, 2010). When scarcity of food and basic items threatened people's livelihoods, as during the rationing of food

supplies under Franco's "autarky" in the post-war period (Aguilar, 2010), networks of barters among peasant families were put in place (Interviewees #5, 12), and flour production was increased by using highly productive and less quality varieties of wheat and by adding maize, acorns or by-products of wine production such as grape seeds (Interviewees #1, 11; Rangil, 2009). At the farmhouse level, buildings and tools were adapted to the size and the productive activities of the estates, including those involved in the transformation of agrarian products (bread oven, wine press, oil mill), the raising of livestock (stable, farmyard), the production of building materials for reconstructing the houses (lime kiln, brick kiln), and the lodging of sharecroppers and forest wage laborers. Peasants had a demonstrated capacity to deal with the uncertainty derived from the high variability of annual and monthly rainfall and to the extreme meteorological events. Besides making use of a high diversity of species for livelihood security and developing many mechanisms to secure water availability, the storing capacity and the annual consumption of wine and oil were calculated to last for two years to avoid shortages due to hailstorms or droughts, and also because peasants observed that grape and olive yields showed biannual maximums (Interviewees #1, 15, 17). Some natural perturbations as occasional snowfalls or stream floods were, however, considered to have a beneficial effect of renewal in woodlands and riversides.[11]

Our results emphasize thus the ability of the peasant community to use local resources for survival. This would include the ability to produce a surplus which was sufficiently large for trading purposes. But in addition, such surplus would be generated in a conservation-oriented manner as to ensure that it could be reproduced in the future. This required a set of management practices and a unique social–ecological assemblage which can be summarized as follows. First, it was placed in a low mountainous area from the Catalan Coastal Range with high forest potential, low availability of arable land and high rainfall variability. Second, it was the result of a thousand-year-old process of human settlement in dispersed farmhouses, whose management practices were adapted and integrated to a growing market economy from the middle of the 18th century while keeping many subsistence-oriented activities. Third, highly precise management practices of forests, fields and livestock were performed to secure a sustaining yield while conserving the resources' base. In particular, coppiced evergreen oak forests played a paramount role, with several productive layers (canopy, trunk, shrub, acorns, herbs and roots) that yielded many products (firewood, cork, brushwood, charcoal, pastures, and stumps). Fourth, a proper management of integrated agrosilvopastoral systems at different spatial scales with the partial conversion of biomass into livestock so as to have manure and traction ensured the feasibility of the productive systems despite the limiting soil fertility. Fifth, diversity was used and enhanced for livelihood security and also for commercial purposes, thus keeping options opened and minimizing risks: diversity of vegetable and livestock species; intraspecific diversity of vines and fruit trees; many edible wild species of several taxa; different kinds of forest fuels; diversity of natural remedies; several water sources and management mechanisms; and diverse institutions regulating labor relations and knowledge transmission according to the access to resources, the distribution of factors of production and yield, and the sort of remuneration.

Sixth, management practices occurred within a structure of uneven power relationships producing uneven control of vital resources – land and forests – and landscapes with uneven distribution of the costs and benefits of social–ecological change among different social groups, especially large landowners and humble peasants (Martinez-Alier, 2002). Seventh, they were embedded in a particular knowledge system and worldview (Toledo, 1992) evolving out of the necessary interaction of local populations – subject to a limited mobility – with their local environment; an interaction that was being constantly adjusted by complex social–ecological adaptive processes and handled through generations by cultural transmission (Berkes et al., 2000). The coexistence of pre-modern thoughts and modern scientific planning of forest exploitation witnesses the dynamic and adaptive nature of such a knowledge system. And eighth, such practices enhanced the resilience of the social–ecological system, i.e. the ability to cope with changing environmental conditions, such as new economic demands, food scarcity, droughts or hailstorms, while maintaining essential structures, processes and feedbacks (Adger et al., 2005). It is worthwhile noting that although private landownership was fully established, these locally evolved institutional arrangements buffered the system from outside forces and contributed successfully to sustain resources as occurred in many systems of management of common-pool resources throughout the world (Ostrom et al., 1999; Dietz et al., 2003).

Conclusion

Accelerated global systems dynamics are impinging new pressures on the conservation of both biological and cultural diversities. To a large extent, these dynamics can only be fully understood if the processes occurring at the very local level are systematically documented and assessed. Much of the changes in land use and biodiversity within the municipality of Olzinelles have to do with changing patterns of organization that go beyond the contours of such local context and which have been increasingly conditioned by the rules and forces of global markets. The decrease of species from fields, meadows and sparse forests in Olzinelles and Montnegre Mountains come to add to the recently reported effects of land-use and climate changes in the biodiversity of the region, namely: (a) phenological alterations in some of the most abundant Mediterranean plants and birds (Peñuelas et al., 2002); (b) northward shifts in geographical ranges of butterflies (Parmesan et al., 1999); (c) negative impact of agricultural intensification and urban development in butterfly populations (Stefanescu et al., 2004); (d) upward shift of beech forests and replacement by Holm Oak forest at medium altitudes (Peñuelas and Boada, 2003); (e) decline of isolated heather heathlands (Bartolomé et al., 2005); and (d) naturalization of exotic tree species (e.g. Douglas Fir, Broncano et al., 2005). Our work goes beyond the mere reporting of such environmental changes by shedding light on their very close connexion with changing human management of resources.

The context-dependency of the management practices emerging from our analysis suggests the need to build conservation strategies based upon deep bottom-up knowledge of how local social–ecological dynamics work. In this sense, the historical and place-specific set of social–ecological interactions of human beings with one another and with their environment as well as the practices which yield diverse, autonomous and resilient social–ecological systems may be considered as our *social–ecological heritage*. The sound consideration and support of these many forms in which the social–ecological heritage is communicated and transmitted among local populations are crucial for any robust conservation strategy of Mediterranean landscapes and the ecosystem services they provide. As in many Mediterranean mountain areas experiencing similar land-use changes, in Montnegre Mountains the presence of granivore birds and some reptile and butterfly species will certainly depend on the availability of open spaces with annual grasses and other particular elements such as stone walls, therefore the conservation and enhancement of dry

[11] PAD.

land fields, vineyards and olive groves should be one of the priorities of land-use planning. The survival of several plant species will in turn depend on the existence of forests with a low canopy cover and clearings, so coppicing, slashing of ground vegetation and grazing should be planned in selected areas.

However, many of the practices analyzed in this work are neither longer viable – due to recent socioeconomic and land-use changes – nor to a large extent socially desirable because of the large inequalities that prevailed in those societies. Therefore, new conservation strategies should not try desperately to maintain or freeze such traditional practices, but rather to draw on such social–ecological heritage to lead the new system to a desirable dynamic stage. An adaptive co-management approach may be advisable where new institutional arrangements and ecological knowledge would be tested in an ongoing, largely self-organized process of learning-by-doing for problem solving (Olsson et al., 2004). In this endeavor, the maintenance of the processes that enhance both biological and cultural diversities in specific places is of paramount importance for global sustainability (Tàbara and Giner, 2004), since they are an indispensable source of alternative options upon which new ideas, strategies and pathways of sustainable management of natural resources may be devised.

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References

Abril, J.M., 1998. Teixidores i tapers. Industrialització a Sant Celoni 1860–1936. Publicacions de la Rectoria Vella, Sant Celoni.
Abril, J.M., Portals, J., 2005. Sant Celoni 1925–1935. De la Dictadura a la República. Centre d'Estudis i Documentació del Baix Montseny, Sant Celoni.
Abril, J.M., Miralles, M., Prat, E., 1995. Façanes al ras. Les masies dels termes d'Olzinelles i Sant Martí de Montnegre. Fundació la Rectoria Vella, Sant Celoni.
Adger, W.N., Hughes, T.P., Folke, C., et al., 2005. Social–ecological resilience to coastal disasters. Science 309, 1036–1039.
Aguilar, R., 2010. Del món rural al món urbà. El conflicte per la terra i l'aigua i la transformació urbanística de Matadepera, 1931–1983. Ph.D. Thesis. Universitat Autònoma de Barcelona.
Altieri, M.A., 2002. Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems and Environment 93, 1–24.
Bartolomé, J., Plaixats, J., Fanlo, R., et al., 2005. Conservation of isolated Atlantic heathlands in the Mediterranean region: effects of land-use changes in the Montseny Biosphere Reserve (Spain). Biological Conservation 122, 81–88.
Baylina, M., Boada, M., Rodoreda, G., 2006. El sot de Bocs. Terra de vinyes. Ajuntament de Sant Celoni, Sant Celoni.
Benton, T.G., Vickery, J.A., Wilson, J.D., 2003. Farmland biodiversity: is habitat heterogeneity the key? Trends in Ecology and Evolution 18, 182–188.
Berkes, F., 2004. Rethinking community-based conservation. Conservation Biology 18, 621–630.
Berkes, F., Colding, J., Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10, 1251–1262.
Bernard, H.R., 2006. Research Methods in Anthropology. Qualitative and Quantitative Approaches. Altamira Press, Oxford.
Boada, M., 2001. Manifestacions del canvi ambiental global al Montseny. Ph.D. Thesis. Universitat Autònoma de Barcelona.
Boada, M., 1989. Els arbres de la regió del Montseny. La vida entorn de l'arbre. Institut de Ciències de l'Educació, Barcelona.
Boada, M., 1984. Flora, fauna i plantes remeieres del Baix Montseny-Montnegre. Centre d'Estudis i Documentació del Baix Montseny, Sant Celoni.
Broncano, M.J., Boada, M., Ramírez, S., et al., 2006. Arbres i arbredes singulars del Montseny. Farell, Sant Vicenç de Castellet.
Broncano, M.J., Vilà, M., Boada, M., 2005. Evidence of *Pseudotsuga menziesii* naturalization in montane Mediterranean forests. Forest Ecology and Management 211, 257–263.
Catalán, B., Saurí, D., Serra, P., 2008. Urban sprawl in the Mediterranean? Patterns of growth and change in the Barcelona Metropolitan Region 1993–2000. Landscape and Urban Planning 85, 174–184.
Cocks, M., 2006. Biocultural diversity: moving beyond the realm of 'indigenous' and 'local' people. Human Ecology 34, 185–200.
Collantes, F., 2005. Declive demográfico y cambio económico en las áreas de montaña españolas, 1860–2000. Journal of Iberian and Latin American Economic History 23, 515–540.
Collantes, F., 2001. La montaña española en el desarrollo capitalista, 1860–1991: periferización segura, difusión condicionada. Ager: Journal of Depopulation and Rural Development Studies 1, 9–45.
Cussó, X., Garrabou, R., Tello, E., 2006. Social metabolism in an agrarian region of Catalonia (Spain) in 1860–1870: flows, energy balance and land use. Ecological Economics 58, 49–65.
Dietz, T., Ostrom, E., Stern, P.C., 2003. The struggle to govern the commons. Science 320, 1907–1912.
Estrada, J., Pedrocchi, V., Brotons, L., et al. (Eds.), 2004. Atles dels ocells nidificants de Catalunya 1999–2002. Institut Català d'Ornitologia and Lynx, Barcelona.
Farina, A., 2000. The cultural landscape as a model for the integration of ecology and economics. BioScience 50, 313–320.
Farina, A., Johnson, A.R., Turner, S.J., et al., 2003. 'Full' world versus 'empty' world paradigm at the time of globalisation. Ecological Economics 45, 11–18.
Fischer, A., Young, J.C., 2007. Understanding mental constructs of biodiversity: implications for biodiversity management and conservation. Biological Conservation 136, 271–282.
Fontana, J., 1990. La fi de l'antic règim i la industrialització: 1787–1868. In: Vilar, P. (Dir.), Història de Catalunya, vol. 5. Edicions 62, Barcelona.
Garrabou, R., Planas, J., Saguer, E., 2001. Sharecropping and the management of large rural estates in Catalonia, 1850–1950. Journal of Peasant Studies 28, 89–108.
Godoy, R., Brokaw, N., Wilkie, D., et al., 1998. Of trade and cognition: markets and the loss of folk knowledge among the Tawahka Indians of the Honduran rain forest. Journal of Anthropological Research 54, 219–233.
Gómez-Baggethun, E., Mingorría, S., Reyes-García, V., et al., 2010. Traditional ecological knowledge trends in the transition to a market economy: empirical study in the Doñana Natural Areas. Conservation Biology 24, 721–729.
Guardiola, M., Jover, M., Gutiérrez, C., 2007. Compendi d'addicions a la 'Flora de la cordillera litoral catalana (porción comprendida entre los ríos Besós y Tordera)' de Pere Montserrat. L'Atzavara 15, 147–164.
Guitart, M., 2010. Manifestacions del canvi global a la vall de Fuirosos (Montnegre). Anàlisi socioecològica dels canvis en els usos i les cobertes del sòl (1853–2009). Master Thesis. Universitat Autònoma de Barcelona.
Gutiérrez, C., 2004. Aplicació del Pla de conservació de la flora vascular al Parc del Montnegre i el Corredor. In: IV Trobada d'Estudiosos del Montnegre i el Corredor. Diputació de Barcelona, Barcelona, pp. 61–65.
Gutiérrez, C., 2001. Fitxes tècniques del catàleg de flora vascular d'interès conservacionista. Tàxons prioritaris i tàxons d'especial interès. Technical Report of the Flora Conservation Scheme. Montnegre-Corredor Park, Vallgorguina.
Gutiérrez, C., 1996. El carboneig. L'exemple del Montseny. Alta fulla, Barcelona.
Hunter Jr., M.L., Schmiegelow, F.K.A., 2010. Wildlife Forests and Forestry: Principles of Managing Forests for Biological Diversity. Prentice Hall.
MacDonald, D., Crabtree, J.R., Wiesinger, G., et al., 2000. Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. Journal of Environmental Management 59, 47–69.
Maffi, L., 2005. Linguistic, cultural, and biological diversity. Annual Review of Anthropology 29, 599–617.
Martí-Henneberg, J., 2005. Empirical evidence of regional population concentration in Europe, 1870–2000. Population, Space and Place 11, 269–281.
Martinez-Alier, J., 2002. The Environmentalism of the Poor. Edward Elgar.
Miralles, F., 2005. Mil anys pels camins de l'herba. Efadós, El Papiol.
Miralles, M., Stefanescu, C., 2004. Les papallones diürnes del Montnegre. Deu anys de seguiment amb la metodologia del BMS. In: IV Trobada d'Estudiosos del Montnegre i el Corredor. Diputació de Barcelona, Barcelona, pp. 105–112.
Montserrat, P., 2007. Una mirada de botànic i ecòleg a les muntanyes del Maresme. L'Atzavara 15, 115–132.
Montserrat, P., 1989. Flora de la cordillera litoral catalana (porción comprendida entre los ríos Besós y Tordera). Caixa d'estalvis Laietana, Mataró.
Myers, N., Mittermeier, R.A., Mittermeier, C.G., et al., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858.
Nadal, F. Urteaga, L., 1998. L'evolució del paisatge a les Serres del Montnegre i el Corredor (segles XVIII–XIX). Centre de Documentació del Parc del Montnegre i el Corredor, Sant Celoni, unpublished manuscript.
Nadal, F., Urteaga, L., 1997. L'evolució del paisatge a les Serres del Montnegre i el Corredor (segles XVIII–XIX). Centre de Documentació del Parc del Montnegre i el Corredor, Sant Celoni, unpublished manuscript.
Olarieta, J.R., Padrò, R., Massip, G., et al., 2010. Hipótesis y primeros resultados sobre los hormigueros como técnica de fertilización en los sistemas agrarios. In: Garrabou, R., González de Molina, M. (Eds.), La reposición de la fertilidad en los sistemas agrarios tradicionales. Icaria, Barcelona, pp. 109–125.
Olsson, P., Folke, C., Berkes, F., 2004. Adaptive comanagement for building resilience in social–ecological systems. Environmental Management 34, 75–90.

Ostrom, E., Burger, J., Field, C.B., et al., 1999. Revisiting the commons: local lessons, global challenges. Science 284, 278–282.
Otero, I., 2010. The rural-urban socioecological transformation of Mediterranean mountain areas under global change. Local studies in Olzinelles and Matadepera (Barcelona Metropolitan Region). Ph.D. Thesis. Universitat Autònoma de Barcelona.
Otero, I. (Dir.), 2008. Harvest of harvests (Verema de veremes). Documentary available in original version with English subtitles at http://www.youtube.com/watch?v=DCxXfUgTNmE&feature=player_embedded.
Otero, I., 2006. Manifestacions del canvi global a la vall d'Olzinelles (Montnegre). Anàlisi socioecològica dels canvis en els usos i les cobertes del sòl (1751–2006). Master Thesis. Universitat Autònoma de Barcelona.
Otero, I., Boada, M., Badia, A., et al., 2011. Loss of water availability and stream biodiversity under land abandonment and climate change in a Mediterranean catchment (Olzinelles, NE Spain). Land Use Policy 28, 207–218.
Otero, I., Boada, M., Badia, A., et al., 2008. El canvi global a la conca de la Tordera. In: Boada, M., Mayo, S., Maneja, R. (Eds.), Els sistemes socioecològics de la conca de la Tordera. Institució Catalana d'Història Natural, Barcelona, pp. 95–129.
Pagès, J., Gutiérrez, C., Mora, J., 2005. Avis savis: En Pepito de can Pau Foguera. La Vall 282, 9–15.
Parmesan, C., Ryrholm, N., Stefanescu, C., et al., 1999. Poleward shifts in geographical ranges of butterfly species associated with regional warming. Nature 399, 579–583.
Peñuelas, J., Boada, M., 2003. A global change-induced biome shift in Montseny mountains (NE Spain). Global Change Biology 9, 131–140.
Peñuelas, J., Filella, I., Comas, P., 2002. Changed plant and animal life cycles from 1952 to 2000 in the Mediterranean region. Global Change Biology 8, 531–544.
Pino, J., Rodà, F., Ribas, J., et al., 2000. Landscape structure and bird species richness: implications for conservation in rural areas between natural parks. Landscape and Urban Planning 49, 35–48.
Piqueras, S., 2009. Manifestacions del canvi global. Anàlisi socioecològica dels canvis en els usos i les cobertes del sòl a la vall de Sant Martí de Montnegre-Vilardell (1853–2007). Master Thesis. Universitat Autònoma de Barcelona.
Portals, J., 1998. El Montnegre, una història de mil anys. Els llibres del Set-ciències, Arenys de Mar.
Rangil, D., 2009. Vògits, desfedors i modolons. Recull de cultura oral del Montnegre (II). Self-edited, Cardedeu.
Rangil, D., 2008. Històries i llegendes de l'any vuit. Recull de cultura oral del Montnegre (I). Self-edited, Cardedeu.
Reyes-García, V., 2009. Conocimiento ecológico tradicional para la conservación: dinámicas y conflictos. Papeles de Relaciones Ecosociales y Cambio Global 107, 39–55.
Reyes-García, V., Vadez, V., Huanca, T., et al., 2007. Economic development and local ecological knowledge: a deadlock? Data from a native Amazonian society. Human Ecology 35, 371–377.
Ribas, J., 1997a. Distribució geogràfica dels poblaments avifaunístics hivernals del Montnegre i Corredor. Technical Report of the Ecological Monitoring Scheme. Montnegre-Corredor Park, Vallgorguina.
Ribas, J., 1997b. Atlas parcial dels ocells nidificants del Montnegre i Corredor. Technical Report of the Ecological Monitoring Scheme. Montnegre-Corredor Park, Vallgorguina.
Ribas, J., 1996. Informe sobre la situació avifaunística del PN del Montnegre i Corredor: Catàleg. Caràcters generals i problemàtica de conservació. Technical Report of the Ecological Monitoring Scheme. Montnegre-Corredor Park, Vallgorguina.
Ribas, J., Pons, X., 2001. Estudi de la distribució i abundància dels poblaments avifaunístics del Montnegre i el Corredor. In: III Trobada d'Estudiosos del Montnegre i el Corredor. Diputació de Barcelona, Barcelona, pp. 35–43.
Sala, O.E., Chapin III, F.S., Armesto, J.J., et al., 2000. Global biodiversity scenarios for the year 2100. Science 287, 1770–1774.
Sànchez, S., 2010. Anàlisi socioecològica a la vall de Santa Fe (massís del Montseny). La transformació del paisatge a través de la història ambiental. Ph.D. Thesis. Universitat Autònoma de Barcelona.
Schröter, D., Cramer, W., Leemans, R., et al., 2005. Ecosystem service supply and vulnerability to global change in Europe. Science 310, 1333–1337.
Serra, E., 2008. La propietat. Mercat de la terra i evolució de la renda (segles XVI i XVII). In: Giralt, E. (Dir.), Història agrària dels Països Catalans, vol. 3. Universitats dels Països Catalans and Fundació Catalana per a la Recerca i la Innovació, Barcelona, pp. 511–557.
Stefanescu, C., 2000. El Butterfly Monitoring Scheme en Catalunya: los primeros cinco años. Treballs de la Societat Catalana de Lepidopterologia 15, 3–46.
Stefanescu, C., Herrando, S., Páramo, F., 2004. Butterfly species richness in the north-west Mediterranean Basin: the role of natural and human-induced factors. Journal of Biogeography 31, 905–915.
Stefanescu, C., Jubany, J., Torre, I., et al., 2007. Preferències d'hàbitat i tendències poblacionals de les papallones a Catalunya. Cynthia 7, 11–14.
Stoate, C., Boatman, N.D., Borralho, R.J., et al., 2001. Ecological impacts of arable intensification in Europe. Journal of Environmental Management 63, 337–365.
Tàbara, J.D., Giner, S., 2004. Diversity, civic virtues and ecological austerity. International Review of Sociology 14, 261–285.
Tàbara, J.D., Pahl-Wostl, C., 2007. Sustainability learning in natural resource use and management. Ecology and Society 12, 3, http://www.ecologyandsociety.org/viewissue.php?sf=28.
Tébar, J., 2006. Guerra, revolució i contrarevolució al camp. In: Giralt, E. (Dir.), Història agrària dels Països Catalans, vol. 4. Universitats dels Països Catalans and Fundació Catalana per a la Recerca i la Innovació, Barcelona, pp. 581–602.
Tello, E., Garrabou, R., Cussó, X., et al., 2010. Sobre la sostenibilidad de los sistemas agrarios. Balances de nutrientes y sistemas de fertilización en la agricultura catalana a mediados del siglo XIX. In: Garrabou, R., González de Molina, M. (Eds.), La reposición de la fertilidad en los sistemas agrarios tradicionales. Icaria, Barcelona, pp. 171–215.
Toledo, V.M., 1992. What is ethnoecology? Origins, scope, and implications of a rising discipline. Etnoecologica 1, 5–21.
Turner, M.G., 2005. Landscape ecology: what is the state of the science? Annual Review of Ecology, Evolution, and Systematics 36, 319–344.
Vidal, T., 1979. Èxode rural i problemàtica demospacial a Catalunya (1860–1970). Estudis d'Història Agrària 2, 193–207.
Vilageliu, J., 1981. Les parròquies rurals de Sant Celoni. Bilbeny, Sant Celoni.
Zamora, F. de, 1973 [1785–1790]. Diario de los viajes hechos en Cataluña. Curial, Barcelona.
Zaragoza, E., 2006. Sant Esteve d'Olzinelles i Sant Llorenç de Vilardell. Història de dues petites parròquies mil·lenàries del Montnegre. Analecta Sacra Tarraconensia. Revista de Ciències Historicoeclesiàstiques 78–79, 47–158.