Where do we come from? Cultural heritage in forests and forest management

B 2

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Introduction

Forests are of great importance, not least as an integral part of complex land-use systems shaping the European cultural landscape. Compared to the rates of change of open land, forests are relatively persistent landscape elements. Still, over a longer term, forests have been very dynamic with respect to spatial extent, internal structure, and species composition. Forest expansion after the last Ice Age was followed by shrinking of the forest area owing to the expansion of agriculture and settlements, i.e. the classic frontier situation, which lasted in Europe over a long period. However, there have also been periods of temporary forest expansion, e.g. caused by the Black Death (Rudel 2009; Lagerås 2007). Forest transition (Mather 1992), i.e. the more recent change from forest decline to forest expansion, has taken place at different times throughout Europe, e.g. in Switzerland (Loran *et al.* 2016) and Germany (Johann *et al.* 2004) already in the first half of the nineteenth century.

The changes in forest area triggered successional patterns which were overprinted by human impacts, i.e. forest use and management (Kirby and Watkins 2015). Over time, societal demands changed and often diversified from various forest products to the full range of ecosystem services which today are in demand. The corresponding changes in forest structure and composition were reflected in changes in ecological characteristics, including biodiversity (Kirby and Watkins 1998). The diversity of these linkages between forest use and management and forest ecosystems has been addressed in a series of international conferences (e.g. Salbitano 1988; Agnoletti und Anderson 2000; Honnay *et al.* 2004). Lately, more weight has been given to aspects of cultural heritage (e.g. MCPFE 2006; Parrotta *et al.* 2006), and the concepts of 'biocultural diversity' (Agnoletti and Rotherham 2015) and 'biological cultural heritage' (BCH) (Eriksson 2018) have been promoted to foster an integrative perspective on cultural and natural heritage.

In this chapter we illustrate, in a series of six case studies from different parts of Europe

< Fig. B 2.1. Coppice with standards – a forest use system historically widespread across Europe. This silvicultural approach was tailored to produce firewood and construction wood for local people. At the same time, it turned out to support many light-demanding forest species and – where still present - has developed today into biodiversity hotspots (Photo: Hans Burger, Archive WSL 1925).

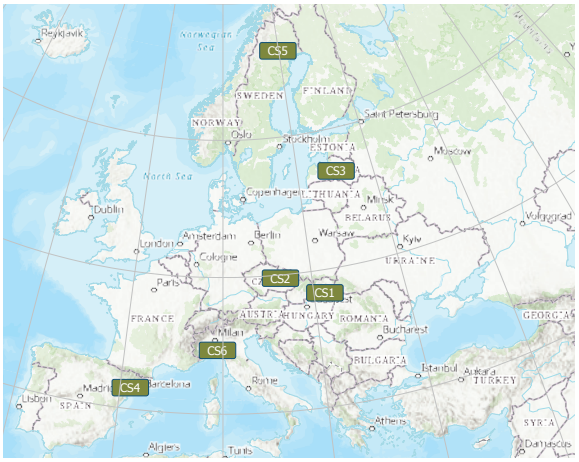

Fig. B 2.2. Location of the six case studies (CS1 to CS6) presented in this chapter.

(fig. B 2.2), how centuries of forest use and management have left imprints on forest ecosystems, and how acknowledging the legacy effects of the long-term inter-relationship between societies and their forests provides valuable background for sustainable forest management.

Case studies

CS1: Diversity of forest uses in floodplain forests of the border region of Hungary and Ukraine

Hardwood floodplain forests of Bereg Plain (Upper-Tisza region in Hungary and Ukraine) have been managed to provide a wide range of forest products for centuries (Takács and Udvari 1996; Demeter 2016). Pannage (i.e. the practice of feeding and fattening domestic pigs on acorns, worms, fish, and forest grasses) has been at the core of forest use, as old oak (mainly *Quercus robur*) forests on rich and moist sites are suitable for the production of high-quality oak timber and pigs (Sas 1928; Csiszár 1971). Oak trees were sold at auction and cut selectively by smallholders, providing construction timber, barrel staves for vineries, and other products to local communities. A continuous increase of the number of pigs was reported in the region from the mid seventeenth to the end of the nineteenth century (Lehoczky 1881). The importance of floodplain oak forest in pig breeding was also reflected in commons and village laws: *"One who cuts mast producing oak tree must be fined 12 forint"* (Belényesy 1957). In this period, 90 % of the oak forest in the region were high forest (Fekete 1888) and most of them were old semi-natural forests (Fekete 1890). As large old oak trees produced much larger acorn crops, it was in the interest of local communities to preserve them. Bereg Plain was split after World War I and divided between Hungary and the Ukrainian Soviet Socialist Republic. The resulting changes in legal and socio-economic circumstances contributed to the development of different trajectories for forest management and corresponding forest structure.

To document the diversity of forest uses in the second half of the twentieth century, 22 oral history interviews with local forest users were conducted (11 on the Hungarian side and 11 on the Ukrainian side) and the ecological impact of the uses recorded was assessed (Table B 2.1). Results show that in this recent period, local to international demand for oak railway sleepers, barrel staves, and construction wood triggered the development of the selection logging system. These timber uses together with pig grazing have also had the highest ecological impact.

Legal differences between the two countries led to different developments in forest uses systems. On the Ukrainian side, forestry law did not contain a clear regulation on forest grazing. Consequently, just as in the case of non-timber forest products, forest grazing can theoretically be practiced by the local population in the not-strictly-protected forest, provided they do not cause damage to the ecosystem (Forest Code of Ukraine 1994). In practice, it is up to the local forestry administration to control this activity. Nationalisation of goods in the Soviet period led to the abandonment of pig grazing by 1970, but selection logging is still a vital part of forest management (Demeter 2016). Until the end of the 1990s, a sanitary selection logging system and the above-mentioned pannage system fostered the preservation of several forests with near-natural structure (e.g. including large to very large trees) on the Ukrainian side (Demeter 2016; Demeter *et al.* 2017).

On the Hungarian side, timber shortage after 1920 led to a significant intensification of forest management and rotation forestry was preferred over low intensity selection system. Homogenisation of forest use with a rotation cycle of 80 to 100

Table. B 2.1. Forest uses mentioned for the second half of the twentieth century in at least 20 % of the oral history interviews conducted (11 interviews in each region). The values for spatial extent and biomass removal are adopted from Bürgi *et al.* (2013). Spatial extent: 3 = large proportion of forest area affected; 2 = about half of forest area affected; 1 = small proportion of forest area affected; 0 = part of other use. Biomass removal: 3 = massive removal; 2 = medium removal; 1 = little removal; 0 = part of other use. Listed according to the Ecological impact which is the product of spatial extent and biomass removal.

Forest uses and products	Hungary % mentions	Ukraine % mentions	Spatial extent	Biomass removal	Ecological impact
Logging/fuel wood	100	100	3	3	9
Logging/ construction wood	100	100	3	3	9
Hunting/sport	100	100	3	3	9
Collecting/litter/fuel wood	55	100	3	3	9
Logging/barrel staves	36	73	3	3	9
Logging/railway sleeper	18	45	3	3	9
Grazing/grass/acorn/pig	0	82	2	3	6
Collecting/acorn/sowing	100	100	2	2	4
Logging/grape stakes/poles	0	55	2	2	4
Collecting/mushrooms	55	100	3	1	3
Mowing/forest meadow/hay	45	82	1	3	3
Logging/wooden tools	9	91	3	1	3
Logging/oak grave marker	0	82	3	1	3
Collecting/fertile soil	9	55	1	3	3
Raking leaves/litter	9	45	1	3	3
Collecting/flowers	36	91	1	2	2
Collecting/acorn/fodder	9	73	1	2	2
Grazing/grass/leaves/sheep	45	9	1	2	2
Tourism/hiking	100	45	1	1	1
Grazing/grass/leaves/cattle	36	73	1	1	1
Collecting/wild fruits	0	55	1	1	1
Fishing	27	91	0	0	0

years has led to the significant loss of old stands and the homogenisation of forest structure (Demeter *et al.* 2017). Grazing of domestic animals in the forest was restricted from 1920, totally banned in 1961, and consequently abandoned in the studied landscape. At the same time, forestry changed from multiple-use towards single commodity forestry, resulting in an even-aged (middle-aged and mature) closed canopy, high forests with less old-growth characteristics (e.g. without large old trees and without large lying deadwood) (Demeter *et al.* 2020). Therefore, continuation and targeted restoration of selection systems and application of multiple-use management (e.g. grazing according to local demand) should be considered to diversify management and to restore the former structure of floodplain oak forests of the Pannonian region.

CS2: Historical forests in lowlands in the Czech Republic – game parks, designed landscapes, and biodiversity hotspots

The total forest cover of the Czech Republic is 33.5 % but the cover is distributed unequally (Bičík *et al.* 2015). In central Bohemia and southern Moravia, which have been continuously inhabited since the Neolithic Age, the forest cover is significantly below the national average. Some of these forests have important cultural and historical values and they are hotspots of biodiversity in an otherwise intensively used landscape (Šantrůčková *et al.* 2017).

Forest landscape development has been studied closely in a 113 km^2 region in central Bohemia, east of Prague, where the climate is moderate, and

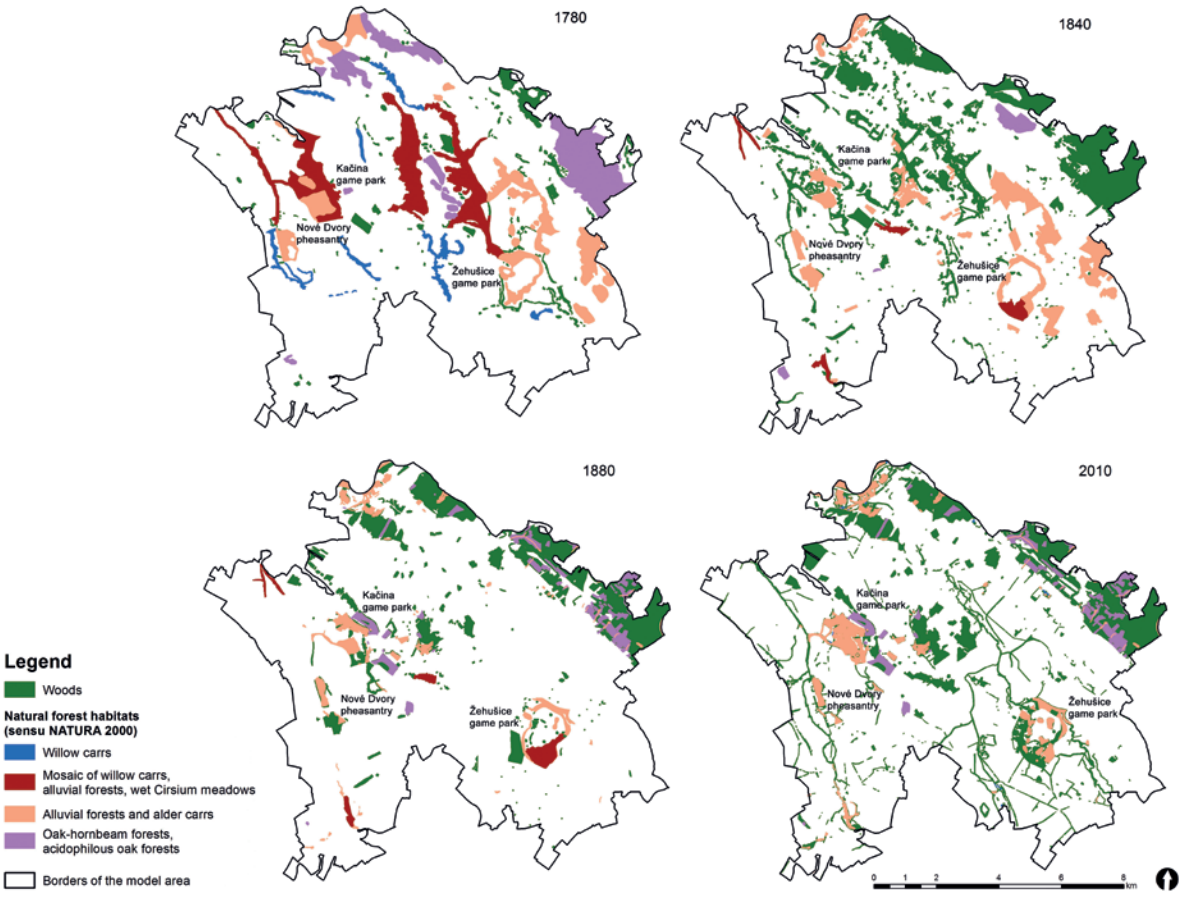

Fig. B 2.3. Development of all forests and forest types which today are classified as natural forest habitats (sensu Natura 2000 in Chytrý *et al.* 2010) in the study area in central Bohemia.

the altitude ranges from 200 to 250 m a.s.l. Forest cover has remained rather stable over time: 16.6 % in the 1780s; 17.98 % in the 1840s; 12.13 % in the 1870s; and 16.64 % in the 2000s (Skaloš *et al.* 2012). However, the location of the forest has changed a lot (fig. B 2.3). In the early eighteenth century, Baroque designed landscapes with game parks and pheasantries (i.e. areas where pheasants are bred and reared for the specific purpose of hunting) were established in this area. At the beginning of the nineteenth century, the gardens were redesigned. The newly created landscapes incorporated the Baroque game parks, and they were also enlarged. In the same period, the total area was also changed with respect to inner structure, function, and species diversity, as shown in the following example. In the eighteenth century, tall broadleaved woods dominated in game parks, whereas on slopes, coppice and scattered and shrubby woods prevailed. Over the course of the nineteenth and twentieth centuries, many small and scattered woodlots disappeared because of agricultural intensification (Jepsen *et al.* 2015; Szabó *et al.* 2018; Skaloš *et al.* 2011). Broadleaved woods on slopes were either converted into orchards or to intensively managed coniferous forests with a focus on wood production. Species-rich forests were retained almost only in (former) game parks and pheasantries near manors (Skaloš *et al.* 2012; Šantrůčková *et al.* 2015, 2017), making them important for cultural and natural heritage.

Despite their relatively small area and similar origin, these heritage forests are not a homogeneous group (fig. B 2.3). Žehušice game park has been continuously used for deer grazing since the 1820s; today this game park is privately owned. The area is

a mixture of alluvial forests, alder carrs, and mesic meadows. The Kačina game park and Nové Dvory pheasantry were nationalised in the 1940s, and they are still owned by the state. Hunting was abandoned several decades ago, the intensity of forest management decreased, and they are currently managed with a low intensity. The former mosaic of alluvial forests (dominated by *Salix alba* and *Populus nigra* or *Quercus robur, Ulmus minor, Fraxinus excelsior, Prunus padus*), alder carrs *(Alnus glutinosa)*, willow carrs (dominated by *Salix aurita, S. cinerea, S. pentandra*), oak-hornbeam forests/acidophilous oak forests (dominated by *Quercus petraea, Q. robur, Carpinus betulus*), and mesic *Arrhenatherum* and wet *Cirsium* meadows changed, as meadows were replaced by oak–hornbeam forests mainly in the nineteenth century and by alluvial forest and alder carrs in the twentieth century (Šantrůčková *et al.* 2015). Both game parks are protected as natural monuments and they are managed with nature conservation as a specific objective. Kačina game park is also listed as a special area of conservation under the European Union Habitats Directive (92/43/EEC).

CS3: Legacy effects of industry in forests contributes to the cultural-historical as well as their ecological value – forest biodiversity in Latvia

In a case study carried out in Zemgale (southern Latvia), we examined whether biodiversity hotspots, known in northern Europe as woodland key habitats (Timonen *et al.* 2010, 2011), occur in continuous forest land and to what degree scale matters in this process. The presence of 2797 key habitats was analysed at five spatial scales (with neighbourhood radii (r_n) of 80, 800, 1400, 2500, and 5500 m, upscaled by moving window averaging) and referring to forest cover in four reference years (1790, 1860, 1910, and 2010, according to historical maps; Fescenko *et al.* 2016). Zemgale (with total area 5178 km^2) was chosen as a study area, representing the most intense and diverse land-use history over the last three centuries in Latvia (Fescenko *et al.* 2014), and exhibiting a relatively high percentage of woodland key habitats.

The results showed that settlement activities of the recent past (occurring over less than a century), iron manufacture activities, and medium-intense logging during the eighteenth century had resulted in today's highly diverse forest pattern (Fescenko and Wohlgemuth 2017). This can be illustrated in the area surrounding the largest historic iron manufacturing centre Dzelzamurs of the Duchy of Courland/Semigallia, where ironworks ran from 1648 to at least 1705. Today, this area has one of the highest densities (5.1–30 %) of woodland key habitats (fig. B 2.4). Moreover, the woodland key habitats have had a surprisingly diverse and dynamic land-use history, indicating that such structurally and taxonomically diverse forest stands are linked to both the presence of old-growth and to heavily anthropogenically shaped forests. Regression models showed that short-term (50–70 years) and small (up to 250 m) gaps in past forest cover were significant positive predictors of woodland key habitat presence, and the resulting patterns resembled those caused by – in terms of frequency and intensity – intermediate natural disturbances. Overall, 73 % of woodland key habitats is located in forests – with non-centres continuous forest cover (details in Fescenko and Wohlgemuth 2017), a finding which is in line with several studies that have illustrated the importance of land-use legacy effects on today's diversity at various scales (Lunt and Spooner 2005; Fischer *et al.* 2006; Wohlgemuth *et al.* 2008; Boucher *et al.* 2014). Compared to other parts of central and southern Europe, intensification of land use in Latvia started relatively late and by the end of the seventeenth century, forests still covered about 65 % of the territory (Kaplan *et al.* 2009). Rapid development of agriculture and industry in the eighteenth and nineteenth centuries resulted in the lowest level of forest area (24 %) in the 1920s, lasting for just a few decades. From the 1940s onwards, forest cover started to increase again, reaching 55 % in 2012 (Fescenko *et al.* 2014). This relative short period of lowest forest cover, as well as the closeness of old forest patches throughout the landscape, could be essential for successful re-colonisation for old-growth dependent species, dwelling in the current woodland key habitats of Zemgale. Additionally, differences in soil, tree species composition, and legacies of old trees were important in the formation of today's species rich areas and about one third of woodland key habitats with diverse land-use history were found in wet alder woods or broadleaved forests, where old solitary trees were common (Fescenko and Wohlgemuth 2017).

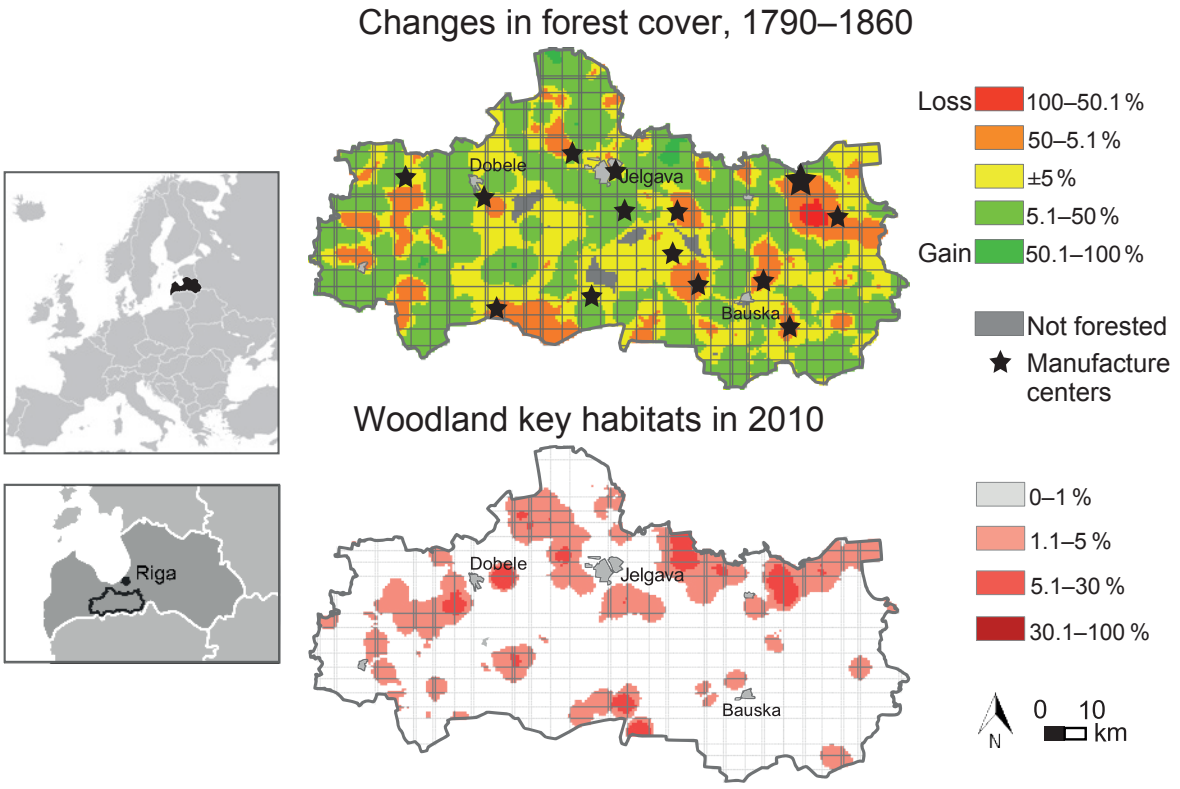

Fig. B 2.4. Location of the study area Zemgale (southern Latvia). Forest cover changes from 1790 to 1860 and distribution of woodland key habitats in 2010 in the study area. Landscape scale has a neighbourhood radius $r_n = 2500$ m. Percentages refer to grid cells of 500 x 500 m. Gain and loss of forest cover refer to the percent change in the corresponding grid cell. Stars denote locations of manufacturing centres before industrialisation in the nineteenth century. The biggest star (top right) denotes the location of the largest iron manufacturing centre Dzelzamurs of the Duchy of Courland/Semigallia. For details, see Fescenko and Wohlgemuth (2017).

Apart from the 'disturbance effect', the industrial activities in Zemgale's forests during the seventeenth to nineteenth centuries also had a 'conservation effect' by creating specific cultural structures and landforms, which safeguarded and even promoted forest biodiversity. For example, old slag-hills on the banks of forest streams around past iron manufactures prevented these streams from becoming dredged and straightened during the extensive melioration that occurred in the twentieth century, thus keeping the natural riverbed untouched up to the present time.

To some extent, industrial activities and intermediate logging 200 years ago, have replaced natural disturbances in Zemgale as the principal agent of dynamics in forests, creating spatially heterogeneous and bio-culturally diverse forest pattern. From a conservation perspective, today's forest management, therefore, should consider the historical continuity of habitat fragments, and maintain a set of structurally rich forests of mid- to late-successional stages at broader scales. Biodiversity would also be promoted by forest management based on emulating natural disturbances and focus on reducing differences between protected and managed landscapes.

CS4: From deforestation to 'spasmodic forestry' in a Mediterranean landscape of Catalonia, 1868–2005

Mediterranean forests have generally experienced overexploitation and deforestation for long periods up until the mid-twentieth century, often followed by expansion of forest owing to agricultural

abandonment after a turning point, which is referred to as 'forest transition' (Mather 1992; Meyfroidt and Lambin, 2011). The spatial scope and temporality of this historical process was different in different locations, and has affected the current ecological quality of forests; this can be understood by considering their site-specific socioecological transition (Otero *et al.* 2015). Up to the 1950s, the intensive use, together with cropland expansion, minimised forest extent and additionally reduced the quality of the remaining woodlands. The subsequent fast and widespread forest transition following rural exodus has entailed a woodland expansion; however, this has often occurred without recovery of the ecological processes and associated biodiversity (Marull *et al.* 2014). Therefore, Mediterranean forests in many places became less resilient and more vulnerable to climate change (Kröel-Dulay *et al.* 2015). The re-growing secondary forests are caught in a low ecological quality trap.

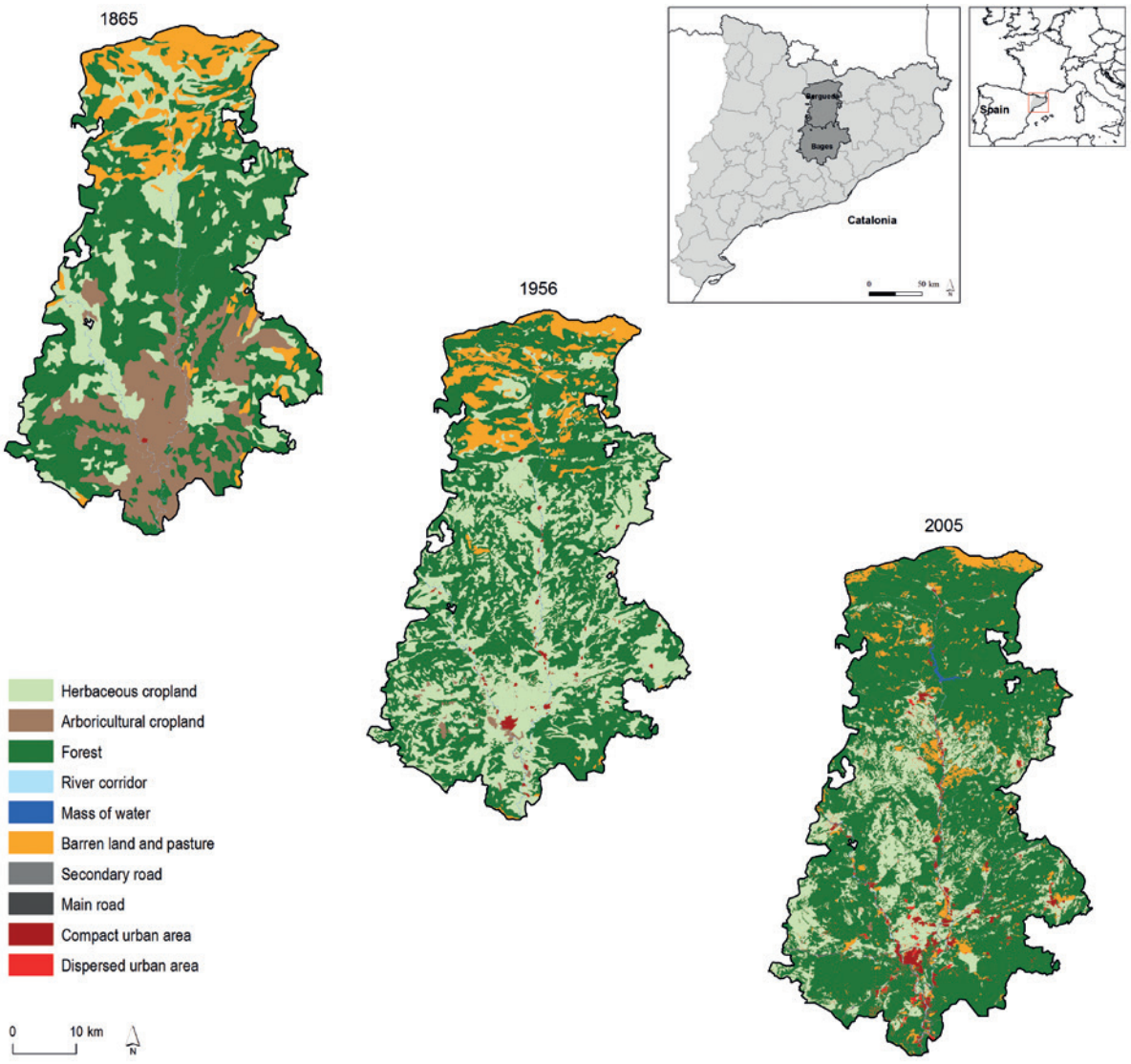

Fig. B 2.5. Land cover maps of the study area in Catalonia (1868, 1956, and 2005). Source: Metropolitan Laboratory of Ecology and Territory of Barcelona.

Their low resilience prevents them from maturing, and their low maturity keeps them in a low resilience state.

This process can be illustrated by the example of the study area in Catalonia (fig. B 2.5), which has experienced forest regrowth following rural abandonment during the last 60 years. The GIS reconstruction of three land-use maps of 1868, 1956, and 2005 shows how forests have encroached on former cropland and pastureland from the 1950s onwards, after a previous wave of deforestation. Forest inventories show the intensive use of woodlands up to the 1950s, and their poor ecological status in terms of age structure, diversity, and maturity. Today's forests are prone to wildfires, which in turn can force wood harvest, contributing to a vicious circle: the lack of appropriate forest management increases wildfires, and leads to the forced harvesting of fallen or burnt trees after these seemingly 'natural' disturbances – a sort of 'spasmodic forestry' (Cervera *et al.* 2019). The restoration of landscape mosaics could offer the chance of an alternative, more sustainable development pathway. An analysis of historical forestland trends can identify those areas where the mosaic structure of cultural landscapes can be restored by recovering pastures and croplands. This would entail restarting an intermediate disturbance that can improve biodiversity (Tscharntke *et al.* 2012). Those lands with forest cover after rural abandonment have to be differentiated from areas of continuous forest cover, with the potential to develop into mature forests, with older trees and richer soils, which should be preserved.

In general, Mediterranean forests combined with agroforestry mosaics (i.e. heterogeneous landscapes characterised by a set of land uses possessing contrasting disturbances) provide a synergetic contribution to biodiversity conservation based on the 'virtuous triangle' of forest cover, human appropriation of net primary production, and biodiversity (Marull *et al.* 2018). The lack of appropriate forest management can lead to increased wildfires, which in turn can lead to the 'spasmodic forestry' as described above. To break this vicious circle, we suggest combining sustainable forestry with farming and extensive livestock breeding as a means to perform an active ecological restoration. Historical knowledge can help in this task, by discovering the previous dynamics of current woodlands and providing a guidance to differentiate the scarce old forests from the forests that are younger as a result of the overuse up to the mid-twentieth century, and from many other forests that have regrown since the 1950s in abandoned steep lands.

CS5: Sami land use meeting the timber frontier in nineteenth century Sweden – consequences for today's forest management

During the last 200 years, the boreal forest of northern Scandinavia has witnessed tremendous changes and the human use of the forest has gone from low intensity use by indigenous peoples, to high intense use by an industrialised society.

The indigenous Sami people have lived in and used the north European coniferous forest landscape for several millennia. Their homeland, today called Sapmi, crosses the Swedish, Finnish, Norwegian, and Russian borders. In the northern inland parts of Sweden, Sami people have been the dominant ethnic group until modern times, and even today traditional Sami reindeer herding is a very important livelihood. Nomadic families move on a yearly basis between different locations in the landscape. Each site is visited at a specific time of the year and provide a specific set of resources. Performed over centuries and even millennia, this has created gradients in the forest landscape with more intensively used hot spots in a 'sea' of less intensively used forests (Ericsson 2001; Berg 2010). Scots pine *(Pinus sylvestris)* forest was especially important. Open sparse old-growth pine heaths with recurring forest fires provide ground and pendulous lichens for the reindeer in the winter, and naturally occurring dead pines are used for firewood and the inner bark is collected for food (Rautio *et al.* 2014). The long duration of low intensity land use has left a unique historical legacy over thousands of square kilometres of northern forests. Trees with cultural marks (Östlund *et al.* 2009; Rautio *et al.* 2014 – Fig. B 2.6), changes in fire frequencies and vegetation pattern (Hörnberg *et al.* 2018), and traces of resource use, such as cutting of trees for lichen harvest (Berg *et al.* 2011), all tell the story of the long-term Sami land use.

At the end of the nineteenth century, a timber frontier swept over these same forests (Björklund 1984), driven by the industrial revolution and the need for wood products in Western Europe. Mil-

lions of very old Scots pine trees were cut and the overall forest structure changed dramatically (Linder and Östlund 1998). At the same time, the Swedish state claimed supreme ownership of most of the forestland of which the Sami people had previously been regarded as the supreme landowners. The timber frontier and a parallel colonisation frontier pushed the Sami people westwards and left them without proper tenure of their homelands. This remained an unresolved issue which has been repeatedly brought into courts over recent decades (Östlund *et al.* 2020).

Today most of the forest in northern Sweden is used intensively for the production of timber and wood for bioenergy. During most of the twentieth century, there was an ever-increasing focus on high forest yield and intensive management methods, such as the use of herbicides and nitrogen fertilisers, large-scale clearcutting and mechanised harvest (Östlund *et al.* 1997). Towards the end of the twentieth century, strong environmental criticism led to less intensive forestry methods (Simonsson *et al.* 2015). Even more recently, there has been an increased understanding of the challenges by the Sami reindeer herders. The possibilities for their livelihood are successively being more and more constrained in the managed forest of today. The main problem for the Sami reindeer herders is that the forest is becoming younger and denser, and thus provides less ground lichens for the reindeers to forage in winter (Sandström *et al.* 2016). To overcome this problem, new forms of interaction between reindeer herders and the forestry sector are being developed (Sandström *et al.* 2006) with incorporation of traditional ecological knowledge from the reindeer herders (Roturier 2009; Roturier

Fig. B 2.6. The old-growth Scots pine dominated forest landscape north of Lake Tjeggelvas in northern Sweden, traditionally used by several Sami families. The forest, which today is a forest reserve covers more than 50 000 ha and has high numbers of cultural remains (i.e. hearths, huts, culturally modified trees). Insert: a picture of an old Scots pine with a Sami bark peeling scar (Photos: Lars Östlund).

and Roue 2009). This is, however, a great challenge because there is an unbalanced relationship – on one side, the forest owners including the state have tenure of the forests, and on the other side, the reindeer herders only have the traditional right to use the grazing resources in the forest.

CS6: Hidden environmental heritage in the forests of the Apennines

Similar to the Catalonian case study (CS4), also the forests of the Apennines (the mountain range running down the length of peninsular Italy) have experienced a long history of intensive use. Until the enactment of the first state forestry laws instituted in 1822 in the Kingdom of Sardinia, and during the Napoleonic administration in other pre-unitarian states, the woodlands in the northwestern parts of the Apennine mountain range, were managed for production of a variety of products and services using different and multiple management systems; these systems involved grazing and mowing practices, and even temporary agricultural uses of forest soil (Moreno 2018; Cevasco 2004). The ecology of this 'land bearing trees', a termed used by Grove and Rackham (2003) for Mediterranean savannah, was largely influenced by the use of controlled fire, in particular in the beech *(Fagus sylvatica)* and Turkey oak *(Quercus cerris)* woodlands, as well as in rangeland bearing trees (Moreno *et al.* 2019), in combination with transhumance systems (i.e. seasonal movement of livestock from pastures at lower altitudes in winter to pastures at higher altitudes in summer) (Moreno and Raggio 1990; Cevasco *et al.* 2018). In the Upper Trebbia and Aveto valleys (in the Ligurian–Emilian Apennines) this particular type of woodland management, including different types of controlled fire to sow temporary crops (called *ronco*), has been used since the early Middle Ages for the management of white alder *(Alnus incana)* woodlands (Cevasco 2010; Agnoletti 2013; Molinari and Montanari 2016).

Long before the scientific observation of the nitrogen-fixing Frankia soil microorganisms in the late nineteenth century (1880s), the nitrogen-fixing and fertilising ability of the alder was well known to local naturalistic knowledge. The management cycle in eighteenth to nineteenth centuries was based on a 6- to 12-year rotation that included coppicing of alder (use of wood for cooking and heating and use of leaves as a green manure), turf stripping, turf burning, sowing of cereals (oats, *Avena sativa*; rye, *Secale cereale*) for one to two years, wood pasture, and alder regeneration from coppiced stools.

These production systems - involving the beech *(Fagus sylvatica)*, the Turkey oak *(Quercus cerris)* and the white alder *(Alnus incana)* woodlands – were particularly widespread in the common lands, and were abandoned in the decades between 1850 and 1950. The main causes for abandonment were the progressive abolition of local rights on common land and the development of 'improvement' policies sustained by the emerging agronomic disciplines in favour of intensive livestock production and modern forestry management. However, though forgotten, these systems have left a diverse environmental legacy, both in the current composition and structure of woodlands (relict pollarded and/or shredded trees (pollarding being the removal of branches at a certain height above ground and shredding being the repeated removal of all side branches leaving the main stem and top growth), repeatedly coppiced stumps, vegetal hedges used for the protection of temporary crops, etc.), in the soils (microcharcoals), and in the present biodiversity of the sites (e.g. presence of non-woody species and persistence of *Alnus incana* in these valleys). Similar alder-based farming systems are still widespread throughout the Himalayas (though the systems have been discouraged by governments since the 1960s owing to the 'environmental degradation' as a result of swidden agriculture, see Gros 2014) and now included in the proposed Globally Important Agricultural Heritage System (GIAHS; Koohafkan and Altieri 2017).

Archaeological and textual evidence has revealed that locally controlled fire practices, such as those in the *ronco* system, entail complex cycles with precise historical chronologies embedded within specific topographical systems of rights of use (Beltrametti *et al.* 2014). The experimental reconstruction and reintroduction of controlled fire practices could be a means to maintain the historically grown and anthropogenically determined biodiversity (Bürgi *et al.* 2013) and to preserve and reactivate the rich heritage and traditional knowledge which characterise the specific wood and wood pasture management in the Apennines (Cevasco and Moreno 2015).

Conclusions and outlook

Today's forests are shaped by the long-term inter-relationship between developing societal and political needs, the resulting impact on forest ecosystems, and the legacy effects of former natural and anthropogenic processes (Bürgi *et al.* 2017). The six case studies presented show the diversity of past forest uses in a broader European perspective; this perspective has developed in accordance with the potential of local forests to provide resources, ranging from acorns for pig pasture to bark for human nutrition, and to the specific fertilising ability of alder trees. Uses were not only determined by supply and demand, but the demand put upon the forests was modified by specific local legal restrictions and ownership, which for example led to forests being dedicated as game parks and hunting grounds in feudal societies or forest being shaped by long-term industrial activities. All these factors change over time, and what we call legacy effects in ecosystems contribute greatly to the cultural heritage of European forests – including values, such as high biodiversity or resilience of forest ecosystems. As illustrated by case studies 1 and 5, these values can be threatened by a change from a management primarily oriented towards local demand to an orientation towards an international market.

The analysis of the historical roots of today's forest ecosystems reveals two specific challenges for the future. The first challenge is to understand, value, and protect the biocultural heritage of forests. More historical research is needed to disentangle the complex relationship between people and forest over time, and particularly in such a way to encourage collaboration between researchers in different fields such as archaeology, ecology, and history (Agnoletti and Andersson 2000; Honnay *et al.* 2004). The second challenge is to use historical knowledge as an inspiration and guideline for future multiple-use oriented forest management systems (Swetnam *et al.* 1999). This is an even more complex task owing to the broad variation in the forest history of Europe and the always-existing mix of natural dynamics and anthropogenic influence over forest ecosystems.

To develop a site and history specific forest management, we suggest therefore a step-wise approach: (1) clarify the history of the area in question based on existing research or new, targeted analysis; (2) analyse the historical range of variability of the area including both natural and anthropogenic changes over time; (3) set up targets for restoration and management which take into consideration these historical aspects and especially the past multifunctionality of landscapes and the cultural legacy; and (4) make sure that management plans for the future integrate local demand and the history of land-use management as part of the site-specific bio-cultural heritage.

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Fig. B 2.7. Larch – "Wytweide", pasture system in Volleges, Le Biolley sur chemin in southwestern Switzerland (Valais). The "carpet-like" gras is typical for these historical pastures in mountain forests (Photo: Franz Fankhauser, 1919 Archive WSL)