5 Wood-pastures in Europe

Tibor Hartel,[1]* Tobias Plieninger[2] and Anna Varga[3]
[1]Department of Environmental Studies, Sapientia Hungarian University of Transylvania, Chuj-Napoca, Romania; [2]Department of Geosciences and Natural Resources, University of Copenhagen, Frederiksberg, Denmark; [3]Institute of Ecology and Botany, Hungarian Academy of Sciences, Vácrátot, Hungary

5.1 Introduction

Humans interact with their landscapes both physically, in how we extract resources, and culturally, through the different values that we place on landscapes and their components. These interactions have strong consequences for the structural and ecological properties of the landscape and its capacity to provide goods and services, as well as for the culture of the local human societies (Plieninger and Bieling, 2012). The values attached to cultural landscapes depend in part on their physical properties (their landscape structure and biodiversity content), but also reflect a particular set of human skills, knowledge and aesthetic judgements. Cultural landscapes are recognized for their potential for sustainable development and nature conservation (Barthel *et al*., 2013a,b). However, to understand the limits to and possibilities for conserving the sociocultural heritage and the ecological properties of cultural landscapes, we need to consider their social and ecological dimensions, and their historical as well as their current interactions (Plieninger and Bieling, 2012; de Snoo *et al*., 2013; Mikulcak *et al*., 2013).

Woodland grazing with livestock has been part of the landscape since at least the Neolithic era (Luick, 2009) and wood-pastures represent an important part of the European cultural and ecological heritage (Bergmeier *et al*., 2010; Hartel and Plieninger, 2014). Wood-pastures may have a wide diversity of forms and expressions in Europe, ranging from scattered trees in a pasture – a 'savannah' – to closed-canopy forests with high tree density grazed by livestock (Fig. 5.1 and Plate 5). The species composition of tree communities in wood-pastures and the age structure of their tree populations have also been shaped by human activity, most typically by logging, coppicing and pollarding (Jørgensen and Quelch, 2014) and, indirectly, through the impact of the grazing on regeneration.

The diverse and dynamic character of these systems and their uses are reflected in the various terms applied to them in Europe (Bergmeier *et al*., 2010): 'ancient park', 'savannah', 'pasture woodland', 'semi-open pastureland', 'traditional orchard', 'woodland pasture', 'wooded pasture', 'wooded meadow' and 'pastoral woodland'. The term 'silvopastoral system' is a more technical and formal term often used to describe types of land use that integrate modern livestock grazing with trees and their associated goods and services (Mosquera-Losada *et al*., 2009).

*E-mail: hartel.tibor@gmail.com

Fig. 5.1. Examples of wood-pastures in various locations of Europe: (a) a wood-pasture made by oaks scattered through pasture and arable fields in the western part of Lesvos Island, Greece; (b) *dehesa* wood-pasture in Monroy, Spain, scattered mostly with holm oaks; (c) traditionally grazed ancient oak wood-pasture in southern Transylvania, Romania; (d) wood-pasture with ancient willow pollards grazed by sheep in the lowlands of Transylvania, Romania; (e) oak wood-pasture grazed by pigs in Croatia; (f) 'Hatfield Forest' wood-pasture in Essex, UK. (From: (a–b) Tobias Plieninger; (c–d) Tibor Hartel; (e) Anna Varga; (f) Keith Kirby.)

In this chapter, we use the term 'wood-pasture' for treed landscapes in which livestock grazing co-occurs with woody vegetation (trees and shrubs). We emphasize the grazing by livestock in order to reflect the cultural nature of most European wood-pastures – pasturing is fundamentally a human activity (Hartel and Plieninger, 2014), although grazing by 'natural' large grazers such as deer can be important at some sites.

We provide a brief general historical overview of wood-pastures in Europe, and then look at how societies viewed and managed wood-pastures in different periods, and at the changing social, economic and cultural values attributed to wood-pastures. We highlight the recent fate of European wood-pastures and key messages for their conservation. Particular attention is paid to Eastern Europe, which is rich in wood-pastures that have been less well described and discussed than those in the central and western countries of Europe. We draw on an expert-based survey made in 2012 for 12 European countries (Spain, Portugal, Germany, Belgium, France, Switzerland, Italy, Hungary, the Czech Republic, Romania, Sweden and Greece) in order to produce a more complete picture of the extent of wood-pastures in these countries, the ecosystem services they provide and the threats that they face.

5.2 Wood-pasture: A Multi-purpose System

Trees and shrubs were considered important in pasture management because of their beneficial effects in protecting the soil from erosion, sheltering livestock against extreme weather conditions and providing favourable microclimatic conditions that might benefit grassland (Dorner, 1910; Gegesi, 1911; Manning *et al*., 2006). Trees in wood-pastures could provide various goods (wood, fruits) for local communities as well as being a regular or at least occasional source of fodder for livestock (Wessely, 1864; Vera, 2000; Oroszi, 2004; Jørgensen, 2013).

Oaks (*Quercus* spp.) were particularly important across Europe because of the diverse goods provided, including acorns, good-quality timber and cork. The pear (*Pyrus* sp.) was planted on many pastures in the 18th and 19th centuries in central and Eastern Europe because of its economic value and for protection against soil erosion. In lowland areas with high soil moisture content, the various willow species (*Salix* spp.) were maintained in grazed landscapes, their branches being used for making baskets, fences, binding, sticks or support for hay. These trees are common in many 'traditional' wood-pastures and hay meadows from the lowland and foothill regions of Europe, where the environmental conditions are suitable for them (Luick, 2009; Bergmeier *et al*., 2010; Oppermann, 2014).

Past and current land management often produces differences in the species composition and size distribution of trees between wood-pastures and closed forests. In the lowland foothills region of southern Transylvania (Romania) wood-pastures are still well represented (Hartel *et al*., 2013) and are generally dominated by oak (mostly *Q. robur* with some *Q. petraea*) and fruit trees, especially pear, with occasional dominance of hornbeam (*Carpinus betulus*) and beech (*Fagus sylvatica*) (Fig. 5.2). These tree species were selectively maintained by the local communities for their various services, at least in the 18th and 19th centuries (Dorner, 1910; Oroszi, 2004). The forests in this region (where livestock grazing is prohibited) are dominated by hornbeam, beech and oak; they lack pear and apple (*Malus* sp.) trees. The closed forests are mostly managed for timber production, trees being cut in 80–120 year cycles. Because the primary goal of the management of many wood-pastures was grazing, scattered trees in wood-pastures could be left to grow for several centuries (Hartel *et al*., 2013). Consequently, large, old trees are better represented in wood-pastures than in closed forests. Similar management-induced differences are known in other parts of Europe (Rackham, 1989; Vera, 2000).

Regular grazing and other management interventions are needed in wood-pastures to maintain their often semi-open structure and the provision of ecosystem goods and services. The complete or even partial cessation of these activities will lead to structural changes in the wood-pastures, reflecting their intermediate state between open pastures and closed forests (Gillet, 2008). In the absence of management, shrubs and fast-growing trees tend to develop to the detriment of the grassland vegetation (Manning *et al*., 2006, 2009), but are also a serious threat to the old trees (Bergmeier *et al*., 2010). In many closed canopy forests in the traditional rural landscapes of central Romania, one can still commonly find overtopped large trees (hollowing, dying or dead oak, hornbeam

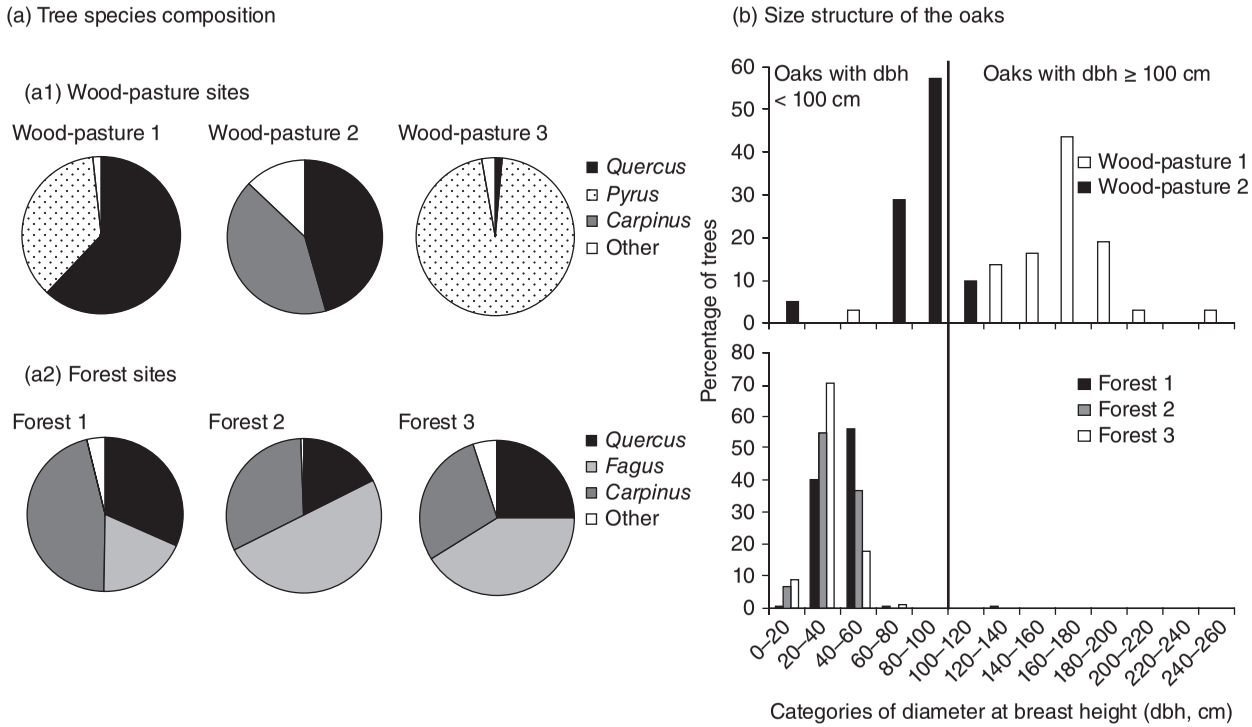

Fig. 5.2. (a) The tree species composition, and (b) the size distribution of oak trees (*Quercus robur* and *Q. petraea*) in three wood-pastures and three forest sites from the traditional rural landscapes of southern Transylvania (Romania) (from Hartel *et al*., 2013). In (a) the tree species include oaks (*Quercus* spp.), beech (*Fagus sylvatica*), hornbeam (*Carpinus betulus*), pear (*Pyrus*) and 'others', which are represented as shown in the keys; the four named species are always shown where they were identified. In 'wood-pasture 2' the high proportion of hornbeam is caused by the cessation of grazing in the past 10 years, as is probably the better representation of the smaller and presumably younger oaks in this wood-pasture compared with 'wood-pasture 1'. Oak size data for 'wood-pasture 3' are not shown because only one stem was identified in the sampling site.

and beech pollards), indicating that the area had a semi-open character in the past decades, most likely as wood-pasture. In contrast to regular management interventions in wood-pastures, intensive management of the grassland hampers the development of the woody vegetation. Both abandonment and intensification can thus lead to a shift from a multifunctional to a mono-functional land use, with a decrease in the richness and quality of the ecosystem goods and services provided (Bugalho *et al*., 2011).

Wood-pastures respond quickly to variations in the management regime and intensity which, in turn, are influenced by various historical and current shocks, demographic changes, industrialization and institutional development. The spatial and temporal dynamics of wood-pastures were and still are strongly linked to broad social and economic developments and to the different ways that societies have perceived and valued these landscapes and their components. To achieve sustainable use of the wood-pasture landscapes of Europe, we must understand how the nature of these links between societies and wood-pastures has changed over time (Hartel and Plieninger, 2014).

5.3 Historical Development of Wood-pastures in Europe

5.3.1 Forest grazing and pasturing in ancient times

Vera (2000) and Luick (2008), using a variety of written evidence, have reviewed the ways in which various societies from central and western Europe interpreted terms such as *forestis*, *silva*, *wald*, *silva glandiferae*, or *silva vulgaris ascuae*. These and similar terms used to name wood-pastures always included a 'non-tree' type of vegetation and land use as well, such as pastures, pasturing, cropped fields or even built areas. For example, in the English Domesday Book (1086 AD) *silva pastilis*, literally meaning wood-pasture, is distinct from *silva minuta*, which were coppices (see Buckley and Mills, Chapter 6).

Pollarding and coppicing were common management practices applied to trees in the Middle Ages and afterwards (Jørgensen and Quelch, 2014), with the former being most prevalent in wood-pastures. Pollarding was applied in cycles from less than 4 to 10 or more years (Rackham, 1989; Vera, 2000). Trees managed in this way may eventually become very old (Read, 2000; Lonsdale, 2013; Quelch, 2013), as pollarding slows the growth of the bole, and the relatively short height, with, for much of the time, relatively little canopy in relation to bole size, protects these trees from damage caused by storms.

Wood-pastures were at the heart of many local economies for centuries. For example 'pannage', the turning out of pigs into woods dominated by oak and beech so that they could eat the mast, was often combined with coppicing and pollarding, the pannage being critical to the fattening of the pigs. In many parts of lowland and mild-altitude regions of Europe, this practice continued up to the 20th century. The season usually started in September or November and lasted until December (Makkai, 2003; Jørgensen, 2013); during this time, the pigs were allowed to stay out in the woods the whole time (Hornyák, 1998). The value of the land might be measured not in terms of timber or firewood produced but in terms of the number of pigs that it could sustain in this way (Luick, 2009; Szabó, 2013).

Because of its importance, forest grazing came under strong regulation. For example, in the Saxon area of southern Transylvania, forest grazing was regulated by a document commonly referred to as 'Andreanum', The Golden Charter of Transylvanian Saxons of 1224. A document originating in the 16th century records the Transylvanian Saxons asking István Báthory (the Prince of Transylvania, King of Poland and Grand Duke of Lithuania) to empower local authorities to control grazing with sheep and pigs in the oak forests in their territory (Teşculă and Goţa, 2007).

At about the same time, various local institutions such as the Church, the aristocrats or the community itself sought to restrict what could be done in their forests. There had long been cases where activities that interfered with the hunting interests of the nobility had been prohibited (Luick, 2009), but Oroszi (2004) notes moves to exclude livestock grazing and, especially, wood extraction. In one village of

the Saxon region of southern Transylvania, ploughing was prohibited in the vicinity of forests in the 16th century, because 'the plough is not good neighbour with the forest'. Oroszi (2004) suggests that this represents the first steps towards the more formally regulated and institutionalized forest management that developed in the 18th and 19th centuries (Savill, Chapter 7).

5.3.2 Driving the livestock out of the forest (18th–19th centuries)

The demand for timber and agricultural products sharply increased in the 18th/19th century with the rapid growth in human population (the population of Europe doubled in just 200 years) and the development of trade, industry, infrastructure and urbanization. Production needed to be intensified and new models of agriculture and forestry were introduced (Dorner, 1910; Oroszi, 2004; Luick, 2009). Livestock came to be seen as an enemy of modern forestry because trampling and grazing damaged seeds, saplings and trees. This created tensions between those keen to maintain forest grazing and pasturing and those seeking to protect forests and increase wood production.

The Hungarian journal *Forestry Files* (*Erdészeti Lapok*, in Hungarian) of the 19th and early 20th century contains a lively debate about the topic of forest grazing which probably reflects the situation in western and central Europe more generally. Those interested in wood production and forestry were concerned that the expansion of forest grazing and an increase of livestock density would damage woodland; while forestry was often blamed for the crisis, it was really more a result of inefficiency in the agricultural sector. There were calls for more woodland to be converted into agricultural land, and military maps from the 18th and 19th centuries show that in southern Transylvania previously wooded landscapes became pastures with scattered trees (Fig. 5.3). Similar changes were happening elsewhere, for example in Germany (Luick, 2009).

Foresters such as Emil Belházy (1888) set out the management interventions needed to achieve sustainable forest grazing, relating, for instance to tree densities, species composition and regeneration patterns. He considered that the primary aim of trees in grazed forests was to improve soil condition and grassland productivity.

Meanwhile, there were suggestions for agricultural changes, such as those made by Antal Lonkay (1903). He argued that increasing agricultural production using traditional (ancient) methods would degrade both woodland and farmland, and urged the intensification of farming so that there would be no need for the conversion of more forests in agricultural areas: 'The extensive agriculture is at its end; let's quickly help people and teach them how to do intensive agriculture in smaller land areas'. Lonkay called for the abandonment of the traditional production systems, which included crop rotation with a fallow period, and its replacement by cultivation with legumes to assure satisfactory production while allowing the land to recover. Such changes in the agricultural sector would allow forest grazing to be stopped and this would increase the potential for timber production. Hence, Lonkay also proposed the improvement of the forestry system and a departure from traditional woodland management. The efficiently managed forests would generate significant income for local communities to buy and plant fruit trees scattered through the pastures. Fruit trees would provide food for livestock, but also generate income from the fruit; this money could, in turn, be used to improve the maintenance of the pastures. He admitted that the strategy would require major institutional changes, but said 'we should not shrink from the difficulties at the beginning'.

The 18th and 19th centuries were thus marked by the widespread separation of the grazing from forests across Europe. Ancient wood banks and lynchets are still common in the historic landscapes of Southern Transylvania, delineating woodlands from other land uses (Szabó, 2010), separating ancient forestry from pasturing. Typical tree species planted along them were hornbeam (*Carpinus betulus*), black locust (*Robinia pseudoacacia*) and ash (*Fraxinus excelsior*) (Hartel, personal observations).

Ancient land management systems were abandoned and new forms of production

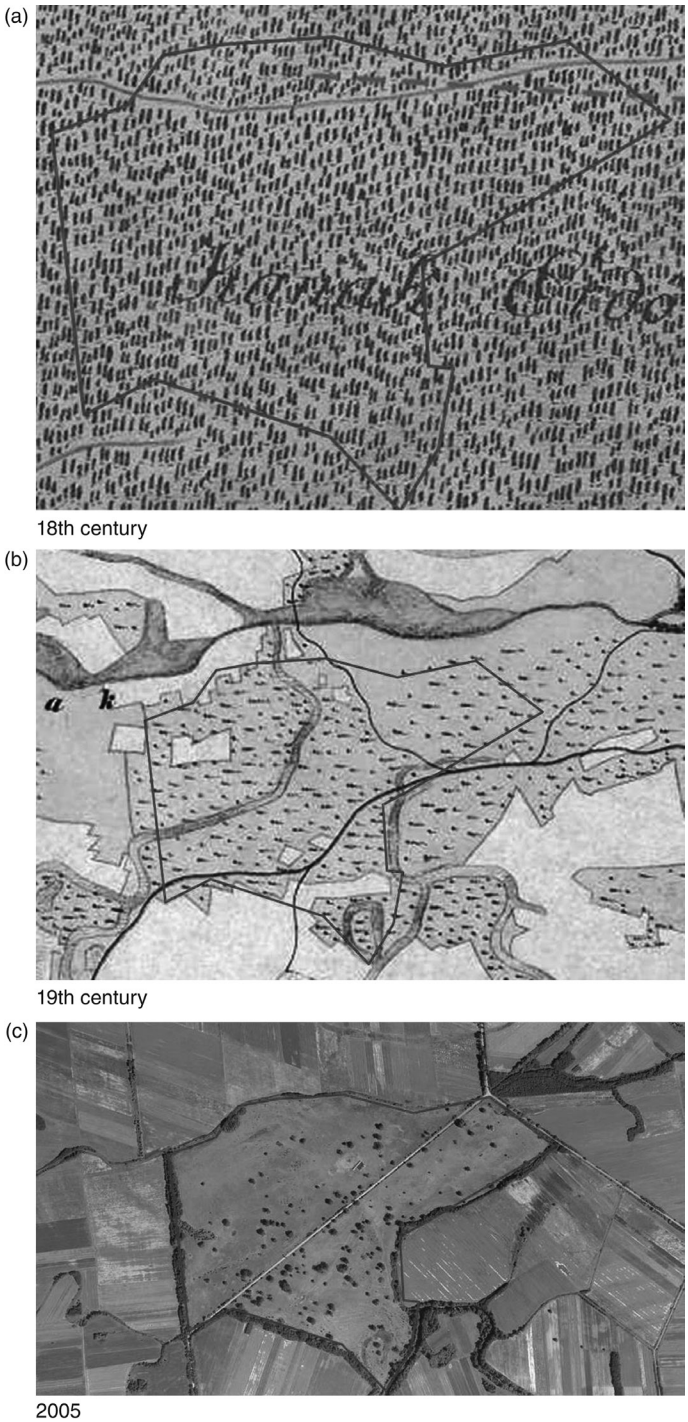

Fig. 5.3. Rókás wood-pasture near Túristvándi in Hortobágyi National Park, Hungary: (a) First military survey, 1784; (b) Second military survey 1858, Kingdom of Hungary and Temes, 2005; (c) Aerial photo 2005. (From: (a–b) Arcanum Database Ltd, Budapest, ISBN: 963 7374 21 3; (c) Hortobágyi National Park.)

adopted, which led to a reorganization of the landscape. The separation of agricultural and forestry land uses was reinforced in the 20th century by the development in many countries of separate institutions dealing with forestry and farming. Forest grazing by cattle, horses, sheep, goats or pigs was frequently prohibited by law. The economic value of timber was higher than ever before, resulting in the formation of closed canopy forests managed for timber production. This was accompanied by the rise of formal forestry education and a forest management attitude that was strongly focused on economic production. Similar changes in other land-use sectors, such as agriculture and water management, resulted in a splitting of landscapes into monofunctional land-use units that were institutionally and ecologically isolated from the rest of the landscape.

During the second half of the 20th century, the above processes led to the destruction of many wood-pastures in Europe. These pastures were either improved to allow more intensive livestock production or converted to arable and other land-use types with the removal of trees in the process. Where livestock farming was unprofitable, the wood-pastures were abandoned and the gaps between trees became infilled by natural regeneration.

5.3.3 New recognition for wood-pastures?

Despite the destruction of many wood-pastures in Europe as outlined above, trees, none the less, continued to be maintained or planted in pastures where they were seen to be beneficial for the soil or grassland, or where they provided shelter against extreme weather conditions. In western Europe, wood-pastures have survived more often at higher elevations or on less productive soils in the lowlands where low intensity grazing is still maintained. They have also survived in areas that are protected for various reasons, such as land used for hunting or amenity parks (see Fletcher, Chapter 9). In eastern Europe, ancient wood-pastures are still common even in lowland areas (Hartel *et al*., 2013).

In recent decades, the value of wood-pastures has increasingly been recognized and this should translate into more sympathetic policies and management. Their aesthetic, heritage and biodiversity values contribute to local economies through cultural tourism (Bieling and Konold, 2014). Wood-pastures often contain large, old trees which can be highly valued by the public. In the UK, several thousands of old trees in wood-pastures and hedgerows have been recorded by citizens, which has improved our understanding of the distribution and condition of the trees, and also created public support for their conservation (Butler, 2014).

A revival of academic interest in wood-pastures and veteran trees, which started in Britain during the 1990s (Kirby *et al*., 1995), is reflected in studies on the biodiversity potential of wood-pastures and veteran trees in other countries: the Czech Republic (Spitzer *et al*., 2008; Horák and Rébl, 2012; Vojta and Drhovská, 2012; Sebek *et al*., 2013); Portugal (Gonçalves *et al*., 2011); Romania (Hartel *et al*., 2013, 2014); and Sweden (Paltto *et al*., 2011; Koch Widerberg *et al*., 2012). Vegetation dynamics and landscape changes related to management regimes have been studied in Switzerland (Gavazov *et al*., 2009), the Italian Alps (Garbarino *et al*., 2010), Belgium (Van Uytvanck *et al*., 2008), the Netherlands (Vandenberghe *et al*., 2009; Smit *et al*., 2010), Spain (Plieninger and Schaar, 2008), Romania (Öllerer, 2012, 2013) and Sweden (Brunet *et al*., 2011). Other research on vegetation structure and the conservation status of wood-pastures has been taking place in Turkey (Ugurlu *et al*., 2012) and Greece (Chaideftou *et al*., 2011).

A common concern has been how scattered tree cover interacts with pasture productivity. Rivest *et al*. (2013) performed a global meta-analysis which showed that scattered trees (in densities ranging from *c*.15–50 trees ha^{-1}) do not compromise pasture yield. In the Swiss Jura mountains, extensively managed wood-pastures act as buffers against extreme climatic oscillations (Gavazov *et al*., 2009). The role of grazing regime and shrub composition and configuration in tree regeneration in wood-pastures has been another central topic (Pulido *et al*., 2001; Smit *et al*., 2006; Plieninger, 2007; Baraza *et al*., 2010; Cooper and McCann, 2010).

Some of these studies revive old knowledge, and Jorgensen (2013) highlights the need to consider the particular history of wood-pastures when planning management. The new and old evidence though seems to converge: having trees scattered across pastures can be good from both economic and ecological perspectives.

5.4 National Inventories of Wood-pastures

Most European countries lack a coherent nationwide assessment of wood-pastures. They are often not recognized as distinct landscape elements, partly because of the difficulty of identifying them consistently (Kirby and Perry, 2014). This applies at institutional and policy levels, but also with land-cover maps such as the CORINE database (a geographic land cover/land use database encompassing most of the countries of the Europe and parts of the Maghreb). When a field assessment of wood-pastures in central Romania was compared with a subsequent CORINE land-cover classification (Hartel and Moga, 2010), the wood-pastures appeared as several categories: 'agroforestry areas', 'transitional elements with trees and shrubs', 'semi-natural grasslands', 'pastures', 'forests' or 'heterogeneous agricultural areas'. Similarly, a Greek study found wood-pastures in the CORINE land-cover categories for scrub and/or herbaceous associations under 'sclerophyllous vegetation', 'moors and heathland' and 'natural grasslands' (Kizos, 2014).

The difficulties of categorizing wood-pastures arise because they are determined not only by their structural features, such as the presence of trees at various densities, but also by the presence of grazing management with livestock. A wood with a closed canopy and grazed by livestock is a wood-pasture in land-use terms, even though it will also be classed in land-cover terms as 'forest'. What is certain is that the areas of wood-pasture involved are much larger than was previously thought.

The wood-pasture cover in Spain and Portugal is *c.*3.1 million ha (Costa *et al.*, 2014). Sweden has about 50,000 ha of oak-dominated wood-pastures (Ihse and Lindahl, 2000; Ihse, 2011). Germany records 5500 ha of wood-pastures, although other estimates suggest there might be between 50,000 to 100,000 ha (Luick, 2009). Hungary has *c.*5500 ha of wood-pastures, mostly in protected areas (Varga and Bölöni, 2009). The central part of Romania has over 5000 ha of oak-dominated wood-pastures (Hartel *et al.*, 2013). In Belgium, there may be 3500–4000 ha in the Flanders region, largely as protected areas. Around 15% of the mountain forests in the Swiss Alps are grazed by livestock (Mayer *et al.*, 2004), around 52,000 ha in the Swiss Jura (Herzog, 1998) and around 400,000 ha in the Austrian Alps (Herzog, 1998). In contrast, there are virtually no wood-pastures in the Czech Republic (J. Vojta and J. Horák, personal communication).

5.5 Wood-pastures as Multifunctional Landscape Elements: Past and Present

The overall tendency, particularly in the past century, has been for a reduction in the use of products from wood-pasture systems, although in the Mediterranean regions cork production is still significant. The harvesting of wood decreased or has stopped, while other products, such as medicinal plants and mushrooms, are now gathered much less often as traditional rural lifestyles have been abandoned. The grazing systems have also changed with shifts in the traditional livestock type and species.

However, new values connected to recreation and nature conservation have been recognized. Most of the wood-pastures from Hungary, for example, are maintained for their ecological values with traditional grazing. Table 5.1 presents data on the management and the use of variety of goods by local communities, both historically and currently, from wood-pastures in 12 European countries. The table is based on the responses of 16 academics working in those countries.

5.6 Threats to Wood-pastures

Even as the value of wood-pastures has become more widely recognized, so there has been a

Table 5.1. The management activities and the goods extracted from wood-pastures in the traditional past and in present. The extracted goods are presented for grassland (managed as pastures or hay meadows), woodland and where available for other resources.

Country	Traditional management	Current management	Trends in the diversity of goods extracted
Belgium	Hay meadow Pasturing (cattle) Wood-related goods: fodder (e.g. from pollarded *Fraxinus* sp. for cattle), scrub, firewood	Nature conservation Grazing management, sometimes haymaking	Reduction; extraction of wood-related goods stopped; new forms of valuation appeared
Czech Republic	Pasturing (sheep, cattle, pigs) Wood-related goods: coppicing Game	Wood-pastures are forested	Virtually no wood-pastures in this country
France	Pasturing (cattle, horses) Fodder Wood-related goods: wood extraction, foliage for grazing animals Fruits, medicinal plants, game, e.g. berries, mushrooms, game	Pasturing (cattle, horses) Fodder Recreational activities	Reduction; extraction of wood-related goods stopped; new forms of valuation
Germany	Pasturing (cattle) Wood-related goods: firewood, fruit trees (from Streuobstwiesen – orchards)	Pasturing (cattle, goats) Wood-related goods: fuelwood, firewood Timber (from composite forests) Recreational activities Nature conservation	Reduction; new forms of valuation
Greece	Pasturing (sheep) Wood-related goods: c[illegible]coppicing	Pasturing (cattle)	Reduction; change in livestock
Hungary	Pasturing (cattle, sheep, goats, pigs, horses) Wood-related goods: pollarding, pear trees (fruit)	Haymaking for management purposes Grazing (cattle, sheep, goats, horses) for management purposes	Reduction; wood-related goods tend to be abandoned
Italy	Pasturing Wood-related goods: coppicing	Pasturing (on the way to being abandoned)	Reduction; extraction of wood-related goods stopped
Romania (central part)	Pasturing (cattle, pigs, horses, buffalo, sheep, goats) Wood-related goods: coppicing, acorns, apple and pear trees (wild or domestic) Fruits, medicinal plants and other, e.g. dog rose, mushrooms Recreation Skopationsfest (Saxons in Transylvania)	Pasturing (sheep) Wood related goods Apple and pear trees (wild or domestic) Fruits, medicinal plants and other: e.g. dog rose, mushrooms Recreation activities Nature conservation	Reduction; change in livestock; new forms of valuation

Continued

Table 5.1. Continued.

Country	Traditional management	Current management	Trends in the diversity of goods extracted
Spain, Portugal	Pasturing (sheep, pigs) Wood-related goods: charcoal, firewood, cork, acorns	Pasturing (sheep, cattle) Wood-related goods Cork	Change in livestock; reduction of wood-related goods; new forms of valuation
	Other goods: honey, crop production	Recreational activities Tourism Nature conservation	
Sweden	Haymaking Fodder Pasturing (cattle, sheep, horses) Wood-related goods: pollarding, acorns (for pigs), scrub Fruits, medicinal plants, e.g. berries	Pasturing (cattle, sheep, horse)	Reduction; extraction of wood-related goods stopped
Switzerland	Pasturing (cattle) Fodder	Pasturing (cattle) Fodder	Reduction; extraction of wood-related goods stopped; new forms of valuation
	Wood-related goods	Recreational activities Nature conservation	

growing appreciation of the threats to their future persistence (Bergmeier *et al*., 2010; Beaufoy, 2014; Bergmeier and Roellig, 2014; Hartel and Plieninger, 2014).

5.6.1 Management changes

These can be summarized as land-use intensification, land abandonment and the conversion into other land cover forms. Land-use intensification typically involves the increase of grazing livestock density alongside the removal of woody vegetation and the use of chemical fertilizers. The result is a pasture with low biodiversity value and potentially low resilience, especially towards climatic variations. The decrease of grazing intensity, or its abandonment, results in shrub expansion and the reforestation of wood-pastures. Land conversion may be to built-up areas or infrastructure such as roads, or conversion to arable land. Any woody vegetation is usually removed in the process. While the immediate driving force for these changes is local economics, often they are encouraged by national and regional policies.

5.6.2 Policy mismatch

Through much of the late 20th century, agricultural and rural development policies supported the destruction of many wood-pastures in Europe. Public infrastructure programmes converted thousands of hectares of Spanish and Portuguese cork oak (*Q. suber*) and holm oak (*Q. ilex*) wood-pastures into irrigated land, eucalyptus plantations, artificial water bodies or industrial units (Joffre *et al*., 1999). From the 1950s onward, public agricultural policies in southern Germany provided landowners with grants for clearing scattered fruit trees (Herzog, 1998). Even now, forest services seek to abolish the grazing rights in the mountain forests of the Alps (Mayer *et al*., 2004).

Public incentives for wood-pasture conservation may be available, for example through agri-environmental schemes, but land managers are reluctant to participate in them. An analysis of schemes for wood-pastures and other farm woodlands in the German state of Saxony identified high production costs and opportunity costs for land use, contractual uncertainties, land-tenure implications and variable societal preferences for the ecosystem services

of wood-pastures as obstacles to scheme uptake (Schleyer and Plieninger, 2011).

The multifunctional nature of wood-pastures is difficult to manage under institutional structures that are organized as single land-use sectors. Under the Common Agriculture Policy of the European Union (EU), there are restrictions on agricultural support for wood-pastures, as some regulations consider them to be forests rather than pastures (Beaufoy, 2014) and forest policy is a matter for the member states, not the EU itself. However, the ecological values of wood-pastures make them an issue for environmental policy, and other societal values such as recreation, beauty, cultural history and sense of place relate to the spheres of public health and human well-being. Poor integration between these sectors poses major challenges to the design of effective mechanisms to safeguard wood-pasture.

5.6.3 Decline of old, hollowing or dying trees

The large number of old, hollow trees found in wood-pastures are important as keystone structures in ecosystems and the value of these has recently been recognized worldwide (Lindenmayer *et al*., 2013; Siitonen and Ranius, Chapter 11). Their cultural value is also increasingly emphasized (Butler, 2014). These trees are in sharp decline due to human-related factors such as cutting, reforestation and uncontrolled pasture burning and land abandonment. High losses of these trees often go unnoticed, especially in the traditional rural landscapes of Europe. For example, in central Romania many ancient oaks collapsed as a result of the severe, uncontrolled burning of wood-pastures in 2012 (Hartel *et al*., 2013).

5.6.4 Lack of regeneration

Intensive grazing, often linked with shrub removal, is detrimental to tree saplings. Lack of regeneration may also be an issue in traditionally managed wood-pastures (Plieninger, 2007), thus threatening the future continuity of the veteran tree populations.

5.7 Conclusion

European wood-pastures were created and managed by humans and, in the past, were intimately linked with farming systems. Their survival depends strongly on human intervention: wood-pastures have always undergone major structural changes as societies change. The most important factors threatening wood-pastures now are their structural simplification (typically by their transformation into either closed forest or open agricultural areas), the loss of scattered trees, in particular large and old trees, the lack of regeneration and inappropriate land-use policies. The change from multifunctional management into intensive mono-functional land use is the main driver of this change, reflecting the growing demands for timber and agricultural products.

We lack a coherent picture of the extent and status of wood-pastures in Europe. They are increasingly recognized for their historical, cultural, aesthetic and biodiversity values, but many gaps remain to be filled. A promising lead may be to encourage citizens to identify the scattered old trees in their neighbourhoods. Other local initiatives, with their successes and failures, should provide a valuable platform for knowledge sharing to improve our understanding and actions.

Recent research is focusing on understanding how agricultural production and trees can be better integrated alongside the other ecosystem services provided by wood-pastures. A new social and academic recognition of wood-pastures in Europe should, in turn, generate efficient policy measures to ensure their sustainable future.

Acknowledgements

We gratefully acknowledge support from the Alexander von Humboldt Foundation (TH) and from the European Community's Seventh Framework Programme under Grant Agreements No. 613520 (Project AGFORWARD; TH and TP) and No. 603447 (Project HERCULES; TP). We are grateful for the following researchers for sharing their knowledge of

wood-pastures in their own countries: Jan Van Uytvanck, Jakub Horák, Jaroslav Vojta, Francios Gillet, Claudia Bieling, Matteo Garbarino, Augusta Costa, Dan Turtureanu, Zsolt Molnár, Jörg Brunet, Thomas Ranius, Margareta Ihse, Alexandre Buttler.

References

Baraza, E., Zamora, R. and Hódar, J.A. (2010) Species-specific responses of tree saplings to herbivory in contrasting light environments: an experimental approach. *Ecoscience* 17, 156–165.

Barthel, S., Crumley, C.L. and Svedin, U. (2013a) Biocultural refugia: combating the erosion of diversity in landscapes of food production. *Ecology and Society* 18(4): 71. Available at: http://www.ecologyandsociety.org/vol18/iss4/art71/ (accessed 20 November 2014).

Barthel, S., Crumley, C. and Svedin, U. (2013b) Bio-cultural refugia – safeguarding biodiversity for practices for food security and biodiversity. *Global Environmental Change* 23, 1142–1152.

Beaufoy, G. (2014) Wood-pastures and the Common Agricultural Policy: rhetoric and reality. In: Hartel, T. and Plieninger, T. (eds) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 273–281.

Belházy, E. (1888) A legeltetésre szolgáló erdőkről [Regarding the forests used for grazing]. *Erdészeti Lapok* 27, 281–299. [In Hungarian.]

Bergmeier, E. and Roellig, M. (2014) Diversity, threats and conservation of European wood-pastures. In: Hartel, T. and Plieninger, T. (eds) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 19–35.

Bergmeier, E., Petermann, J. and Schröder, E. (2010) Geobotanical survey of wood-pasture habitats in Europe: diversity, threats and conservation. *Biodiversity and Conservation* 19, 2995–3014.

Bieling, C. and Konold, W. (2014) Common management of wood-pastures and sustainable regional development in the southern Black Forest (Germany). In: Hartel, T. and Plieninger, T. (eds) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 235–249.

Brunet, J., Valtinat, K., Mayr, M.L., Felton, A., Lindbladh, M. and Bruun, H.H. (2011) Understory succession in post-agricultural oak forests: habitat fragmentation affects forest specialists and generalists differently. *Forest Ecology and Management* 262, 1863–1871.

Bugalho, M.N., Caldeira, M.C., Pereira, J.S., Aronson, J. and Pausas, J.G. (2011) Mediterranean cork oak savannas require human use to sustain biodiversity and ecosystem services. *Frontiers in Ecology and the Environment* 9, 278–286.

Butler, J. (2014) Mapping ancient and other trees of special interest: UK citizens' contribution to world tree heritage. In: Hartel, T. and Plieninger, T. (eds): *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 203–215.

Chaideftou, E., Thanos, C.A., Bergmeier, E., Kallimanis, A.S. and Dimopoulos, P. (2011) The herb layer restoration potential of the soil seed bank in an overgrazed oak forest. *Journal of Biological Research* 15, 47–57.

Cooper, A. and McCann, T. (2010) Cattle exclosure and vegetation dynamics in an ancient, Irish wet oakwood. *Plant Ecology* 212, 79–90.

Costa, A., Madeira, M., Santos, J.L. and Plieninger, T. (2014) Recent dynamics of evergreen oak woodpastures in south-western Iberia. In: Hartel, T. and Plieninger, T. (eds) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 70-83.

de Snoo, G.R., Herzon, I., Staats, H., Burton, R.J.F., Schindler, S., van Dijk, J., Lokhorst, A.M., Bullock, J.M., Lobley, M., Wrbka, T. *et al.* (2013) Toward effective conservation in farmland: making farmers matter. *Conservation Letters* 6, 66–72.

Dorner, E.B. (1910) *Az Erdélyi Szászok Mezőgazdasága* [The Agriculture of the Transylvanian Saxons]. Pannonia Könyvnyomda Nyomasá, Győr, Hungary. [In Hungarian.]

Garbarino, M., Lingua, E., Martinez Subirà, M. and Motta, R. (2010) The larch wood pasture: structure and dynamics of a cultural landscape. *European Journal of Forest Research* 130, 491–502.

Gavazov, K.S., Peringer, A., Buttler, A., Gillet, F. and Spiegelberger, T. (2009) Dynamics of forage production in pasture-woodlands of the Swiss Jura Mountains under projected climate change scenarios. *Ecology and Society* 18(1): 38. Available at: http://www.ecologyandsociety.org/vol18/iss1/art38/ (accessed 20 November 2014).

Gegesi, K.E. (1911) Legelő erdő és fáslegelő [Pasture woodland and wood-pasture]. *Erdészeti Lapok* 526–524. [In Hungarian.]
Gillet, F. (2008) Modelling vegetation dynamics in heterogeneous pasture-woodland landscapes. *Ecological Modelling* 217, 1–18.
Gonçalves, P., Alcobia, S., Simões, L. and Santos-Reis, M. (2011) Effects of management options on mammal richness in a Mediterranean agro-silvo-pastoral system. *Agroforestry Systems* 85, 383–395.
Hartel, T. and Moga, C. (2010) *Manual de Bună Practică Pentru Managementul Păşunilor cu Arbori* [*Good Practice Management of Wood-pasture Habitats*]. Mihai Eminescu Trust, Sighişoara, Romania. [In Romanian.]
Hartel, T. and Plieninger, T. (eds) (2014) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK.
Hartel, T., Dorresteijn, I., Klein, C., Máthé, O., Moga, C.I., Öllerer, K., Roellig, M., von Wehrden, H. and Fischer, J. (2013) Wood-pastures in a traditional rural region of Eastern Europe: characteristics, management and status. *Biological Conservation* 166, 267–275.
Hartel, T., Hanspach, J., Abson, D.J., Máthé, O., Moga, C.I. and Fischer, J. (2014) Bird communities in the traditional wood-pastures with changing management in Eastern Europe. *Basic and Applied Ecology* 15, 385–395.
Herzog, F. (1998) Streuobst: a traditional agroforestry system as a model for agroforestry development in temperate Europe. *Agroforestry Systems* 42, 61–80.
Horák, J. and Rébl, K. (2012) The species richness of click beetles in ancient pasture woodland benefits from a high level of sun exposure. *Journal of Insect Conservation* 17, 307–318.
Hornyák, G. (1998) *Galvács (Fejezetek a falu történetéből)* [*Galvács (Episodes from the History of the Village)*]. Bibor Kiadó, Budapest. [In Hungarian.]
Ihse, M. (2011) *Fler träd i hagen – bättre för djuren och jorden. Utredning om Förutsättningar för en ny Definition av Ersättningsberättigade Svenska Betesmarker – Principer och Kriterier* [*More Trees in the Pasture – Better for Animals and Earth. Clarification of Requirements for a New Definition of Eligible Swedish Pastures – Principles and Criteria*]. Landsbygdsdepartementet [Swedish Ministry for Rural Affairs], Stockholm. [In Swedish.]
Ihse, M. and Lindahl, C. (2000) A holistic model for landscape ecology in practice: the Swedish survey and management of ancient meadows and pastures. *Landscape and Urban Planning* 50, 59–84.
Joffre, R., Rambal, S. and Ratte, J.P. (1999) The dehesa system of southern Spain and Portugal as a natural ecosystem mimic. *Agroforestry Systems* 45, 57–79.
Jørgensen, D. (2013) Pigs and pollards: medieval insights for UK wood pasture restoration. *Sustainability* 5, 387–399.
Jørgensen, D. and Quelch, P. (2014) The origins and history of medieval wood-pastures. In: Hartel, T. and Plieninger, T. (eds) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 55–69.
Kirby, K.J. and Perry, S.C. (2014) Institutional arrangements of wood-pasture management: past and present (UK). In: Hartel, T. and Plieninger, T. (eds) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 254–270.
Kirby, K.J., Thomas, R.C., Key, R.S., Mclean, I.F.G. and Hodgetts, N. (1995) Pasture woodland and its conservation in Britain. *Biological Journal of the Linnean Society* 56, 135–153.
Kizos, T. (2014) Social–cultural values of oak wood-pastures and transhumance in Greece. In: Hartel, T. and Plieninger, T. (eds) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 171–184.
Koch Widerberg, M., Ranius, T., Drobyshev, I., Nilsson, U. and Lindbladh, M. (2012) Increased openness around retained oaks increases species richness of saproxylic beetles. *Biodiversity and Conservation* 21, 3035–3059.
Lindenmayer, D., Laurance, W.F., Franklin, J.F., Likens, G.E., Banks, S.C., Blanchard, W., Gibbons, P., Ikin, K., Blair, D., McBurney, L. *et al*. (2013) New policies for old trees: averting a global crisis in a keystone ecological structure. *Conservation Letters* 7, 61–69.
Lonkay, A. (1903) A legeltetés kérdése [The question of grazing]. *Erdészeti Lapok* 8, 687–697. [In Hungarian.]
Lonsdale, D. (ed.) (2013) *Ancient and Other Veteran Trees: Further Guidance on Management*. Tree Council, London.
Luick, R. (2008) *Transhumance in Germany. Report to European Forum on Nature Conservation and Pastoralism*. European Forum on Nature Conservation and Pastoralism (EFNCP) and University of Applied Sciences Rottenburg /Fachhochschule Rottenburg, Schadenweilerhof, Rottenburg, Germany. Available at: http://www.efncp.org/download/Swabian_Alb_F_F_Download.pdf (accessed 20 November 2014).

Luick, R. (2009) Wood pastures in Germany. In: Rigueiro-Rodríguez, A., McAdam, J. and Mosquera-Losada, M.R. (eds) *Agroforestry in Europe – Current Status and Future Prospects*. Springer, Dordrecht, Netherlands, pp. 359–376.

Makkai, G. (2003) *Az Erdélyi Mezőség Tájökológiája* [*The Landscape Ecology of the Transylvanian Plain*]. Mentor Kiadó, Marosvásárhely, Hungary. [In Hungarian.]

Manning, A.D., Fischer, J. and Lindenmayer, D.B. (2006) Scattered trees are keystone structures – implications for conservation. *Biological Conservation* 132, 311–321.

Manning, A.D., Gibbons, P. and Lindenmayer, D.B. (2009) Scattered trees: a complementary strategy for facilitating adaptive responses to climate change in modified landscapes? *Journal of Applied Ecology* 46, 915–919.

Mayer, A.C., Stöckli, V., Gotsch, N., Konold, W. and Kreuzer, M. (2004) Forest grazing in alpine regions: a re-evaluation of a multi-usage tradition. *Schweizerische Zeitschrift für Forstwesen* 155, 38–44.

Mikulcak, F., Newig, J., Milcu, A.I., Hartel, T. and Fischer, J. (2013) Integrating rural development and biodiversity conservation in central Romania. *Environmental Conservation* 40, 129–137.

Mosquera-Losada, M.R., Rodríguez-Barreira, S., López-Díaz, M.L., Fernández-Núñez, E. and Rigueiro-Rodríguez, A. (2009) Biodiversity and silvopastoral system use change in very acid soils. *Agriculture, Ecosystems and Environment* 131, 315–324.

Öllerer, K. (2012) The flora of the Breite wood-pasture (Sighişoara, Romania). *Brukenthal Acta Musei* 7, 589–604.

Öllerer, K. (2013). On the spatio-temporal approaches towards conservation of extensively managed rural landscapes in central-eastern Europe. *Journal of Landscape Ecology* 6, 32–46.

Oppermann, R. (2014) Wood-pastures as examples of European high nature value landscapes – functions and differentiations according to farming. In: Hartel, T. and Plieninger, T. (eds) *European Wood-Pastures in Transition: A Social–Ecological Approach*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 39–52.

Oroszi, S. (2004) Az erdélyi szászok erdőgazdálkodása [The forest management of Transylvanian Saxons]. *Erdészeti Egyesület, Erdészettörténeti közlemények* [Forestry Association. Forest History Publications] 63, 1–153. [In Hungarian.].

Paltto, H., Nordberg, A., Nordén, B. and Snäll, T. (2011) Development of secondary woodland in oak wood pastures reduces the richness of rare epiphytic lichens. *PLoS ONE* 6(9): e24675.

Plieninger, T. (2007) Compatibility of livestock grazing with stand regeneration in Mediterranean holm oak parklands. *Journal of Nature Conservation* 15, 1–9.

Plieninger, T. and Bieling, C. (eds) (2012) *Resilience and the Cultural Landscape – Understanding and Managing Change in Human Shaped Environments*. Cambridge University Press, Cambridge, UK.

Plieninger, T. and Schaar, M. (2008) Modification of land cover in a traditional agroforestry system in Spain : processes of tree expansion and regression. *Ecology and Society* 13(2): 25. Available at: http://www.ecologyandsociety.org/vol13/iss2/art25/ (accessed 20 November 2014).

Pulido, F.J., Díaz, M. and Hidalgo de Trucios, S.J. (2001) Size structure and regeneration of Spanish holm oak *Quercus ilex* forests and dehesas : effects of agroforestry use on their long-term sustainability. *Forest Ecology and Management* 146, 1–13.

Quelch, P. (2013). Upland wood pastures. In: Rotherham, I.D. (ed.) *Cultural Severance and the Environment*. Springer, Dordrecht, Netherlands, pp. 419–430.

Rackham, O. (1989) *The Last Forest – The History of Hatfield Forest*. Dent, London.

Read, H. (2000) *A Veteran Tree Management Handbook*. English Nature, Peterborough, UK.

Rivest, D., Paquette, A., Moreno, G. and Messier, C. (2013) A meta-analysis reveals mostly neutral influence of scattered trees on pasture yield along with some contrasted effects depending on functional groups and rainfall conditions. *Agriculture, Ecosystems and Environment* 165, 74–79.

Schleyer, C. and Plieninger, T. (2011) Obstacles and options for the design and implementation of payment schemes for ecosystem services provided through farm trees in Saxony, Germany. *Environmental Conservation* 38, 454–463.

Sebek, P., Altman, J., Platek, M. and Cizek, L. (2013) Is active management the key to the conservation of saproxylic biodiversity? Pollarding promotes the formation of tree hollows. *PLoS ONE* 8(3):, e60456.

Smit, C., Den Ouden, J. and Müller-Schärer, H. (2006) Unpalatable plants facilitate tree sapling survival in wooded pastures. *Journal of Applied Ecology* 43, 305–312.

Smit, C., Bakker, E.S., Apol, M.E.F. and Olff, H. (2010) Effects of cattle and rabbit grazing on clonal expansion of spiny shrubs in wood-pastures. *Basic and Applied Ecology* 11, 685–692.

Spitzer, L., Konvicka, M., Benes, J., Tropek, R., Tuf, I.H. and Tufova, J. (2008) Does closure of traditionally managed open woodlands threaten epigeic invertebrates? Effects of coppicing and high deer densities. *Biological Conservation* 141, 827–837.

Szabó, P. (2010) Ancient woodland boundaries in Europe. *Journal of Historical Geography* 36, 205–214.

Szabó, P. (2013) Rethinking pannage: historical interactions between oak and swine. In: Rotherham, I.D. (ed.) *Trees, Forested Landscapes and Grazing Animals: A European Perspective on Woodlands and Grazed Treescapes*. Earthscan from Routledge (imprint of Taylor & Francis), Abingdon, UK, pp. 51–62.

Teşculă, N. and Goţa, A. (2007) Istoria ariei protejate [The history of the protected area]. In: Mihai Eminescu Trust (ed.) *Planul de Management al Reservaţiei 'Stejari Seculari de la Breite'* [*The Management of the Breite Wood-Pasture Reserve*]. Mihai Eminescu Trust, Sighişoara, Romania, pp. 51–55. [In Romanian.]

Ugurlu, E., Rolecek, J. and Bergmeier, E. (2012) Oak woodland vegetation in Turkey – a first overview based on multivariate statistics. *Applied Vegetation Science* 15, 590–608.

Van Uytvanck, J., Maes, D., Vandenhaute, D. and Hoffmann, M. (2008) Restoration of woodpasture on former agricultural land: the importance of safe sites and time gaps before grazing for tree seedlings. *Biological Conservation* 141, 78–88.

Vandenberghe, C., Smit, C., Pohl, M., Buttler, A. and Freléchoux, F. (2009) Does the strength of facilitation by nurse shrubs depend on grazing resistance of tree saplings? *Basic and Applied Ecology* 10, 427–436.

Varga, A. and Bölöni, J. (2009) Erdei legeltetés, fás legelők, legelőerdők tájtörténete [The landscape history of forest grazing, treed pastures and wood-pastures]. *Természetvédelmi Közlemények* 15, 68–79. [In Hungarian.]

Vera, F.W.M. (2000*) Grazing Ecology and Forest History*. CAB International, Wallingford, UK.

Vojta, J. and Drhovská, L. (2012) Are abandoned wooded pastures suitable refugia for forest species? *Journal of Vegetation Science* 23, 880–891.

Wessely, J. (1864) Az erdő mint mentő a takarmány szűkében [The forest as refuge when the fodder is scarce]. *Erdészeti Lapok* 7, 209–221. [In Hungarian.]