Maintaining Cultural and Natural Biodiversity in the Carpathian Mountain Ecoregion: Need for an Integrated Landscape Approach

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Abstract Landscapes located in the periphery of economic development, such as in parts of the Carpathian ecoregion, host remnants of both near-natural ecosystems and traditional agricultural land use systems. Such landscapes are important both for in situ conservation of natural and cultural biodiversity, and as references for biodiversity restoration elsewhere in Europe. This paper first reviews the

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contemporary understanding of benchmarks for biodiversity conservation in terms of ecosystems with natural disturbance regimes and pre-industrial cultural landscapes. Second, after providing a historical background, we review the challenges to natural and cultural biodiversity conservation and discuss current development trajectories. Third, we provide concrete examples from six Carpathian areas with different proportions of natural and cultural biodiversity. Fourth, we discuss the need for a diversity of management systems toward protection, management and restoration, spatial planning, and multi-sector governance for conservation of natural and cultural landscapes' biodiversity. Finally, we stress the need to encourage integration of management, planning and governance of social and ecological systems to maintain natural and cultural biodiversity. The natural vegetation of the Carpathian Mountains is mostly forests and woodlands. Natural disturbances as wind, snow, frost, fire and flooding as well as insects and fungi resulted in forests characterized by old and large trees, diverse horizontal and vertical structures, and large amounts of dead wood in various stages of decay. While some near-natural forests remain, in most of the Carpathian ecoregion pre-industrial cultural landscapes evolved. Human use created traditional village system with infield houses, gardens, fields, meadows and outfield meadows and pastures, and woodlands which not only provide ecosystem services but also represent cultural heritage. The maintenance of natural and cultural biodiversity may require active management of species, habitats and processes. However, designing management systems that emulate natural and cultural landscape's disturbance regimes is a major challenge requiring collaboration of private, public and civic sector stakeholders, and integration of social and ecological systems. Maintaining and restoring the traditional village system's social capital as well as functional networks of protected areas and implementing sustainable forest management in managed forests are thus crucial. The Carpathian ecoregion forms a quasi-experiment with new country borders that have created stark contrasts among regions regarding natural and cultural biodiversity. This ecoregion can therefore be seen as a landscape-scale laboratory for systematic studies of interactions between ecological and social systems to support the development of an integrated landscape approach to biodiversity conservation and cultural heritage.

1 Introduction

Since the emergence of the sustainable development discourse during the late 1980s, a range of international and national policies related to ecologically, economically, socially and culturally sustainable use of renewable natural resources have been formulated (e.g., Water Framework Directive 2000; Carpathian Convention 2003; Ioras 2003; Mayers and Bass 2004; Innes and Nitschke 2005). Stakeholders involved with management and governance of forests and cultural landscapes in rural regions are thus subject to the challenges of implementing ecological, economic and social

objectives of sustainability policies on the ground (Norton 2005; Vucetich and Nelson 2010), and encouraging sustainable development as a societal steering process (Baker 2006). Traditional sustained yield forestry and agriculture are therefore required to supply a broad range of goods, ecosystem functions and landscape values rather than only wood, fibres, energy and food (e.g., Angelstam et al. 2005; Merlo and Croitoru 2005). This transition is closely linked to the conservation of biodiversity, i.e., the composition, structure and function of ecosystems (Noss 1990). While Central and Eastern Europe has a reputation of being dominated by polluted environments due to heavy industrial development during the period of socialism (Baker and Jehlicka 1998; Szaro et al. 2002), the biodiversity status is frequently better than in Western Europe (e.g., Puumalainen et al. 2003; Edman et al. 2011).

The implementation of sustainability policies on the ground needs to conceive landscape as an integrated social-ecological system with components, structures and processes at various spatial and temporal scales and different levels of societal organisation (e.g., Sauer 1925; Berkes et al. 2003; Dyakonov et al. 2007). The European Landscape Convention captures this at the Pan-European policy level (Anon 2000). At the same time, there is a strong request to satisfy specific market demands in terms of raw materials and bioenergy. In addition, uncertainties related to climate change, political and economical crises and economic globalisation need careful consideration.

In Europe, the Carpathian Mountains are "a unique natural treasure of great beauty and ecological value, an important reservoir of biodiversity, the headwaters of major rivers, an essential habitat and refuge for many endangered species of plants and animals and Europe's largest area of virgin forests" (Anon 2007; Borsa et al. 2009). This can be explained by the comparatively short history of modern development based on use of natural resources compared to most of Western Europe (Gunst 1989). The dominating potential natural vegetation of ecosystems in the Carpathian ecoregion is forest and woodland (e.g., Mayer 1984; Bohn and Neuhäusl 2000/2003). However, due to a long history of traditional land use in Central and Eastern Europe and limited modernisation, remote landscapes can still be viewed as a total phenomenon where man and the biophysical landscape have been integrated based on the use of landscape goods, ecosystem functions and values for product development (Angelstam 1997; Antrop 1997, 2005; Vos and Meekes 1999; Jongman 2002).

The maintenance of biodiversity therefore encompasses two main visions. The first vision involves biodiversity in dynamic forest and woodland ecosystems with reference to the concept of naturalness (Peterken 1996; Egan and Howell 2001) including natural disturbance regimes at the scales of stands and landscapes (e.g., Angelstam and Kuuluvainen 2004). Naturalness implies that compositional, structural and functional forest biodiversity indicators should represent naturally dynamic forest conditions (Noss 1990). This vision is widespread regarding mountain forest biodiversity, and to some extent implicit in near-to-nature silviculture and plantation forestry (Grabherr et al. 1998; Peterken 1999; Mason 2003).

The second vision is that of the pre-industrial agricultural landscape, which is an important aspect of Europe's cultural heritage (Agnoletti 2000; Jongman 2002;

Sauberer et al. 2004; Antrop 2005; Bezák and Halada 2010). These cultural landscapes include arable lands, wetlands, more or less wooded grasslands, and patches of woodland and forest as the results of traditional agroforestry and agrosilvopasturalism systems, which integrate small-scale agriculture, animal husbandry, and tree management by pollarding, lopping, coppicing and tree felling. Although influenced by human land use for a very long time, the pre-industrial cultural landscape included structural elements such as dead wood and large old trees that are typically found in naturally dynamic forests and woodlands (e.g., Jonsson and Kruys 2001). Consequently, remnants of the pre-industrial cultural landscape provide refuge for species adapted to a pristine or near-natural forest environment (Angelstam 2006). At the same time, they host species dependent on and favoured by cultural landscapes' semi-natural grasslands (Zechmeister et al. 2003; Bezák and Halada 2010).

Rapid changes in traditional land use patterns due to political and socio-economic changes (e.g., Angelstam et al. 2003b; Mikusiński et al. 2003; Bender et al. 2005) mean that the maintenance of cultural biodiversity are no longer automatically provided as a product of traditional land use (von Haaren 2002; Young et al. 2007). Imreh (1993) demonstrated for Transylvania, that villages had a very detailed and strict system of rules preventing too intensive land use from the Middle Ages until the eighteenth century. Long-term thinking, dominance of community interests upon individual interests and ecological process understanding were the most important characteristics of these rules.

During several hundred years of gradually intensified land use, the human footprint has resulted in gradients in landscape alteration from the centres of economic development into more remote regions (Mikusiński and Angelstam 1998, 2004; Konvicka et al. 2006). Already von Thünen (1875) noted that the type and intensity of land use was related to the distance from the market. The demand for timber, grain and other primary products was satisfied by imports from the periphery of the spreading industrial revolution (Gunst 1989), and reached Hungary, Romania and Ukraine for grain in the eighteenth to nineteenth century (Powelson 1994; Turner II et al. 1995), and then into forests (Fröhlich 1954). The exploitation of these resources depended on the facilities for transportation of bulky products such as railways and roads (Turnock 2001). As an example, the Hungarian export was initially restricted to live cattle herded to the destination countries until the mid-nineteenth century when the railways reached Hungary and grain replaced cattle for export (Gunst 1989).

From a biodiversity conservation perspective, these driving factors have led to gradual landscape changes that negatively affected specialised species (e.g., Tucker and Heath 1994; Törnblom et al. 2011a, b, c), habitat structure (Angelstam and Dönz-Breuss 2004), and processes in landscapes (Breitenmoser 1998; Szaro et al. 2002). This means that areas having the same stand scale forest structures could be affected differently depending on the landscape's location in relation to the centre and periphery of human economic development (Mikusiński and Angelstam 2004).

Whyte (1998) concluded that areas of retardation and tradition are still concentrated to northern Europe, the Atlantic periphery and mountain areas in Central Europe and the Mediterranean. Economic remoteness in Europe has thus both a West–East dimension, and lowland–mountain dimension. In the Carpathian Mountains the co-occurrence of the two dimensions explain why the region is still a hotspot for natural and cultural biodiversity (Miya 2000; Turnock 2002; Angelstam et al. 2003b; Opelz 2004; Oszlányi et al. 2004; Schmitt and Rákosy 2007; Reif et al. 2008). Understanding these legacies of the past is an important starting point for maintenance of biodiversity in the region.

We first describe the benchmarks of natural and cultural biodiversity visions. Second, we summarise the landscape history, review current trajectories of landscape development, and give concrete examples from six different landscapes in the Carpathian ecoregion. The discussion focuses on how management systems need to match natural and cultural disturbance regimes, spatial planning and that sectors governing landscape management need to be integrated. Finally, we advocate the need for establishing landscape governance and learning processes to maintain natural and cultural biodiversity in the Carpathian ecoregion. This involves the need for development of an integrated landscape approach for biodiversity conservation based on an improved understanding of both social and ecological mechanisms behind the different trajectories of landscape development.

2 Benchmarks for Biodiversity Conservation

2.1 Natural Disturbance Regimes

Conservation of biodiversity requires a range of disturbance regimes (Table 1) that result in ecosystems and environments to which species have adapted. As advocated within the natural disturbance regime paradigm for near-to-nature forest management (Hunter 1999), the management regimes chosen for different forest environments must tally with the ecological past of different forest types (Angelstam 2003).

Three main forest disturbance regimes are characteristic (e.g., Angelstam and Kuuluvainen 2004): (1) succession after stand-replacing disturbance from young forest to old-growth with shade-intolerant species in the beginning and shade tolerant species later on, (2) cohort dynamics on dry sites, and (3) gap dynamics in moist and wet forest. Regarding the evolutionary background of the temperate deciduous forest, and thus the woodland conditions in cultural landscapes, the ideas revolve around both abiotic disturbances such as wind and the interaction between large herbivores and vegetation (Vera 2000; Bengtsson et al. 2003). In the Carpathian Mountains forest dynamic is dominated by gap dynamics in shade-tolerant beech and other broad-leaved forest (Keeton et al. 2010), succession after wind fall (Fig. 1), ice storms (Kenderes et al. 2007), and riparian cohort dynamic in flood-plain forests (Gurnell et al. 2009).

Table 1 List of abiotic, biotic and anthropogenic disturbances affecting the maintenance of natural and cultural biodiversity

Disturbance	Natural biodiversity vision	Cultural biodiversity vision
Wind	Uprooting creates dead wood, bare soil and special microhabitats	Dead wood is often removed and used as fuel
Flooding	Natural stream dynamics creates important aquatic and riparian habitat	Irrigation and draining often occur, as well as active flooding to benefit productivity of meadows and pastures
Fire	Larger patches, lower frequency	Smaller patches, higher frequency
Large herbivores	Domination of browsers	Domination of grazers
Insects and fungi	Important natural disturbances	Not important
Anthropogenic	Not important, unless restoration measures are needed	Vital, includes mowing, pasturing, pollarding, coppicing, shredding etc.

Fig. 1 A near-natural forest landscape in the Hungarian Börzsöny Mountains after windfall. Photo: Per Angelstam

The Carpathian Mountains host Europe's most extensive tracts of mountain forest, the largest remaining natural mountain beech and beech–fir forests ecosystems, and areas of old-growth forest remnants (Schnitzler and Borlea 1998; Opelz 2004; Oszlányi et al. 2004). As a consequence, the region hosts populations of large carnivores and herbivores that have become locally extinct or very rare elsewhere in Europe (Perzanowski et al. 2004; Rozylowicz et al. 2011), specialised vertebrates (Mikusiński and Angelstam 2004; Edman et al. 2011). Additionally, there are many endemic species (Webster et al. 2001; Oszlányi et al. 2004).

Furthermore the Carpathians contain some of the most intact, wild river systems in Europe. Many of the last flooded forests are found in the valleys of the Carpathians. The mountains form watershed areas for the Danube, Vistula, Oder and Dniester rivers. Moreover, the Carpathian Mountains form a 'bridge' between Europe's northern forests and those in the south and west. As such, they are a vital corridor for the dispersal of plants and animals.

2.2 Pre-Industrial Agricultural Landscape

Traditional pre-industrial management of grasslands, woodlands and forests by grazing, mowing and tree management with different intensities produced a structurally diverse landscape (Fig. 2).

Due to the occurrence of elements of naturally dynamic forests such as large old trees, dead wood, slow-growing trees in the cultural landscapes forest species may thus be present outside areas normally characterised as forest, e.g., in semi-natural wooded grassland with trees managed to provide leaf fodder, fruits and material for tools. Semi-natural habitats such as mountain pastures with diverse and rich flora, hay meadows, small arable fields with hedgerows and other structural elements are the result of centuries of traditional management of the land (Baudry et al. 2000). Species-rich and structurally diverse biotopes along fences and stone walls also provide habitats for forest species. Extensive grassland management favours light-demanding vascular plants and associated animal species; and traditional management of arable lands create favourable conditions for species depending on open space and field-forest edges (Baur et al. 2006; Bezák and Halada 2010).

To maintain cultural biodiversity the methods employed in the pre-industrial cultural landscape need to be considered. Without a deep understanding of local knowledge (e.g., lexical knowledge, perception of a landscape) on ecological patterns and processes, it will be difficult to combine local and scientific knowledge in landscape management for biodiversity conservation (Babai and Molnár 2009; Molnár and Babai 2009).

Fig. 2 A traditional pre-industrial cultural landscape in the Carpathian Mountains, Volosyanka in Ukraine. Usually centred on the village street with farm houses, traditional villages have a characteristic zonation from the centre to the periphery (Angelstam et al. 2003b; Mikusinski et al. 2003; Bender et al. 2005). These zones include: (1) built-up area with farm houses, a church or a building of a local administration, (2) vegetable and fruit gardens, (3) fields, (4) meadows for hay, (5) pastures and (6) forests, all of which satisfy different needs of land users (Elbakidze and Angelstam 2007). Photo: Per Angelstam

3 Challenges to Natural and Cultural Biodiversity Conservation

3.1 The Landscape History Background

Understanding landscape history is critical for natural and cultural biodiversity conservation (Marcucci 2000). During the times of the Hungarian Kingdom (1000–1918/1920) and the Habsburg Empire (1526–1918) most of the inner and northern slopes of the Carpathians were one geo-political unit (Kann 1974; Magosci 2002). Because of mining activities, large deforestation and intensive use of timber was typical in some regions already in the thirteenth–fourteenth centuries (e.g., central Slovakia). By the seventeenth century, the main river valleys were mostly deforested. Intensive forest exploitation began only in the eighteenth century. Focusing on sustained yield wood production, monocultures of Norway spruce were created in the different parts of the Carpathians. Additionally, wood was intensively used for potash production, iron and glass manufactory. The most intensive logging took place in the second half of nineteenth until the beginning of twentieth century. Thus, already in the nineteenth century, there was a clear economic development gradient from the centre to the periphery of the former Habsburg Empire, and remote regions were characterised as a traditional cultural landscape based on animal husbandry (Good 1994).

During the twentieth century, land use was regionally transformed several times for geopolitical reasons. After World War II, in the countries remaining under Soviet influence, forests became nationalised, more or less effectively managed according to long-term plans (Augustyn and Kozak 1997; Augustyn 2004, 2006). Forestry led to the further reduction of beech, fir and mixed forests (Hensiruk 1992).

Agriculture in the Carpathian Mountains saw a period of intensification with the breakdown of traditional farming and the replacement of small- and medium-sized private farms with larger-scale state or collective farms in most of the region apart from Romania (Rey et al. 2007) and Poland. As Carpathian countries were industrialized, large-scale rural–urban migrations occurred (Turnock 2007). The percentage of forest cover differed, however, considerably even in neighbouring countries (Kuemmerle et al. 2007, 2008).

The breakdown of communism in 1989 reversed some of these trends. Agricultural sectors collapsed as prices for agricultural products and inputs (e.g., fertilizer) were liberalized. Guaranteed markets within the former bloc of socialist countries were replaced by external competition (Palang et al. 2006). The result was widespread land use change, particularly the abandonment of vast areas of cropland and grasslands (Kuemmerle et al. 2008, 2009b).

The joining of the European Union by some Carpathian countries and the application of the Common Agricultural Policy (CAP) started to modify land use of these countries (Bezák and Halada 2010). During the transition from planned to market economy local people have frequently returned to their traditional land use

practices. Non-wood forest products are part of the social fabric and livelihood, especially in forest-dependent communities.

3.2 *Trajectories of Natural and Cultural Landscape Development*

The natural forest and cultural landscapes in the Carpathian Mountains are presently developing in different directions. Concerning the development of natural forest biodiversity there are a diversity of trajectories, including:

1. protection of the remaining near-natural forests in reserves and national parks (Feurdean and Willis 2008);
2. intensification of forest harvesting (Kuemmerle et al. 2007, 2009a);
3. emerging ideas of close to nature silviculture (Fanta 1997; Brang 2005) in response to management and pollution legacies from communist times (Main-Knorn et al. 2009);
4. recreational and touristic use of forests (Abrudan and Turnock 1999).

Angelstam et al. (2003a) and Kuemmerle et al. (2007, 2008, 2009b) found that cultural landscapes developed along three different trajectories:

1. remained traditional (Vos and Meekes 1999; Jongman 2002; Antrop 2005; Elbakidze and Angelstam 2007);
2. changed due to intensified agriculture (Fearne 1997; Bezák and Halada 2010);
3. were abandoned with encroaching forest as a consequence of depopulation of rural areas (Kuemmerle et al. 2008).

Additionally, traditional village system may become disintegrated due to in-migration of non-native people (Baranyi et al. 2003; G-Fekete 2007).

Habitat loss and fragmentation are a unifying theme of the history of the European forests (Darby 1956) and cultural landscapes (Whyte 1998), and explain the local and regional extinctions of species, loss of habitat and alteration of landscape processes. Compared with Western European countries, the conservation status of many species considered endangered or threatened is remarkably better in Eastern and Central Europe than in most West European countries (van Swaay and Warren 1999; Angelstam et al. 2004b; European Environmental Agency 2010). By and large Carpathian forests maintain a relatively natural character. Stands with changed tree species composition or stands of non-native species are less abundant than in other mountain regions in Europe, and large intact forest massifs do occur (e.g., Soloviy and Keeton 2009). There is, however, a gradient from more altered forests in the west (e.g., the Czech Republic) to more intact in the east (e.g., Romania). The area of forests have increased in the Carpathians during the last decades, but air pollution and other environmental pressures have made forests sensitive to disturbances and large forest damages

have started to appear in the western part (Szaro et al. 2002). For Romania, Schmitt and Rákosy (2007) found that increasing modern agriculture and abandonment of less productive sites affect butterfly diversity negatively. The same pattern applies to forest species depending on natural forest structures (Brang 2005), and area-demanding large mammals (Angelstam et al. 2004b).

The expansion of the EU brings both advantages and disadvantages to the natural and cultural landscapes in the Carpathian Mountains (Hodge 2001; Buza and Turnock 2004). EU's Common Market, policies and funding intensify threats to the natural and cultural biodiversity and long-term ecological sustainability of the Carpathian ecoregion as a whole. These include development of mass tourism facilities, transportation infrastructure, agricultural intensification as well as abandonment of traditionally farmed areas. At the same time, increasing EU integration is also driving the adoption and implementation of a number of progressive EU laws and policies (Blicharska et al. 2011). The countries have been aligning its national laws and policies to important pieces of the EU legislation. These harmonisation processes represent potentially powerful tools for biodiversity conservation and sustainable development.

However, the efforts of the EU to maintain natural and cultural landscapes are contradictory, as the EU distributes more and more of its budget to improve biodiversity and rural sustainability, and at the same time, provides increasing financial support for the modernisation in economically remote regions. The extensive plan to develop the transport infrastructure within the new EU member states is a good example. Unless effective mitigation measures are implemented (e.g., Deodatus and Protsenko 2010), this will subsequently result in a decrease in the functionality of existing habitat networks, and threaten the last remaining reference landscapes for both natural and cultural biodiversity. While it is certainly possible to satisfy some cultural heritage values and elements of biodiversity in the long term, the maintenance of sustainable rural landscapes and ecosystem integrity is a major challenge (Anon 2004). Remedy measures are needed to halt the ongoing decrease in landscape diversity. This applies both to ecological and social systems. The lack of landscape-scale incentives in EU agri-environmental schemes hampers planning and management for functional connectivity of habitat patches (Larsson 2004). Additionally, social systems' ability to develop collaboration among sectors at multiple levels of governance need to be strengthened.

3.3 Case Studies of Natural and Cultural Biodiversity Challenges

To illustrate the challenges that conservation of natural and cultural biodiversity in the Carpathian Mountain ecoregions are facing, we review the situation in a suite of particular landscapes representing a gradient from natural to cultural biodiversity challenges (Fig. 3, see also Table 1).

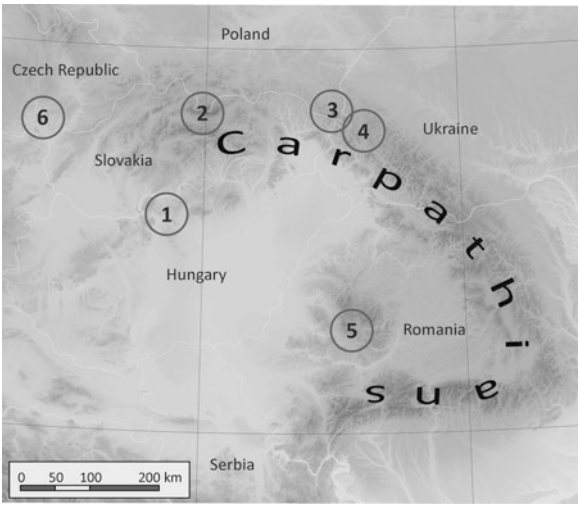

Fig. 3 Location of landscape case studies in the Carpathian Mountain ecoregions that represent a gradient from natural forest to cultural landscape visions for biodiversity conservation. *1*: Börzsöny Mountains in Hungary, *2*: Tatra National Park in Slovakia, *3*: Bieszczady Mountains in Poland, *4*: Skole and Turka in Ukraine, *5*: Apuseni Mountains in Romania, *6*: Lower Morava Biosphere reserve in the Czech Republic

3.3.1 The Börzsöny Mountains (Hungary)

The Börzsöny is a middle-range mountain region in Hungary (48°N, 19°E) forming the southern border of the western Carpathian Mountains. Located 60 km north of Budapest, the forested area has virtually no permanent settlements. The geomorphologic dichotomy between higher altitude (to 950 m a.s.l.) and valleys is manifested by the forest types. Forests are dominated by sessile oak (*Quercus petraea*), turkey oak (*Quercus cerris*) and hornbeam (*Carpinus betulus*). Natural disturbance includes ice break, windfall (Kenderes et al. 2007) and intensive deer browsing.

The Börzsöny Mountains have an unusual legal and governance status linked to its history of ownership and use. This predominantly state-owned forested landscape is part of the Danube–Ipoly National Park, but also managed by a state-owned forestry enterprise (Ipoly Erdő Zrt.) for timber production. This means that based on the duties defined by the conservation act the national park is in charge of the protection of biodiversity, whereas the forestry enterprise is responsible for timber production. This dual regulation is a constant source of conflicts between nature conservation and forestry. On the top of this, people from nearby Budapest are extremely sensitive to what happens to these forests in terms of cutting practices.

All these aspects (inherited age-class distribution of forests, conservation status, large-scale natural disturbances, and public awareness) led the forestry enterprise to change the predominant silvicultural practice characterised as uniform shelterwood system. This resulted in the current large coarse-grained mosaic with patches of a few hectares (from 0.5 to tens) with more or less even-aged stands, and a lack of biologically old stands, as standard rotation time has been 100–120 years.

The Királyrét Forest District initiated a large-scale experiment by leaving large areas severely affected by wind disturbance untouched, and managing more than half of the area aiming at transition from age-class forestry towards continuous cover forestry. The area (5,090 ha) has a management plan valid from 2007 to 2016. The strong belief is that with the successful implementation of this management approach based on the natural disturbance paradigm, a better reconciliation of the multiple use demands could be achieved. The Börzsöny Mountains is thus a good example of how societal choice drives forest management to emulate the consequences of natural disturbance regimes.

3.3.2 Tatra National Park (Slovakia)

The Slovak Tatra National Park (Tatranský Národný Park; TANAP) was founded in 1949, and the contiguous Polish Tatra National Park (Tatrzański Park Narodowy) in 1954. Both areas were included in 1993 into the UNESCO Biosphere Reserve (49°N, 20°E). Combined effects of air pollution, extreme weather and biotic agents have affected the forest condition in the Tatra National Park since early 1990s (Fleischer et al. 2005). On the one hand, natural disturbances such as strong winds are inherent part of the forest dynamics (Svoboda and Pouska 2008; Svoboda et al. 2010). They maintain or increase biodiversity and often change forest development towards more natural conditions by increasing the amount of dead wood and structural diversity (Jonasova and Prach 2004, 2008; Muller et al. 2008; Heurich 2009). On the other hand, they can cause serious social and political problems.

A windstorm in November 2004 felled 12,000 ha, and caused dramatic direct and indirect changes of land cover in the Tatra National Park. Subsequently, this facilitated the development of travel and tourism (new hotels, ski parks, etc.) (Kopecká and Nováček 2009). Despite the strict national and international conservation regulations, 93 % of the windbreak areas were commercially harvested, with only the most precious reserves saved for natural forest regeneration. Two years later salvage logging commenced also there. As the state environment authorities, influenced by the timber industry, were perceived to fail to protect even the most precious nature reserves from salvage logging, more than 1,000 people declared in 2007 the Ticha and Koprova valleys "Areas Protected by Citizens". Slovak Environment Inspectors declared that the logging had caused no harm to ecosystems.

This event can be linked to the history of forest management (e.g., Gąsienica-Byrcyn 1992). Commercial forestry with highly productive monocultures of fast-growing tree species is the base of classic sustained yield forestry as developed in Germany from the late eighteenth century, and was introduced to the western Carpathian Mountains in the nineteenth century. Forests dominated by beech and fir were thus replaced by Norway spruce plantations. Despite early pleas to grow mixed forests (e.g., Gayer 1886) Central European forestry developed further as a commercial activity oriented at high and sustainable timber yields and profits (Fanta 1997). During last three decades significant areas of mountain spruce forests in Central Europe suffered from forest dieback (Kubikova 1991) due to severe

bark beetle outbreaks and windstorms (Muller et al. 2008; Hais et al. 2009). This has triggered discussions to restore the natural mixed tree species composition and structure (Fanta 1997; Kenk and Guehne 2001). The Tatra National Park is an example where restoration of near-natural forests composition, structure and function need to be considered. In addition there is a legacy of cultural landscape vision (Byrcyn 1992).

3.3.3 Bieszczady Mountains (Poland)

Cessation of the traditional management of cultural landscapes, and the disappearance of its biodiversity, may result in the rehabilitation and restoration of natural forest biodiversity. A particularly interesting case is the Bieszczady Mountains area (49°N, 23°E) in south-eastern Poland (Angelstam et al. 2003a) where, due to the resettlement of local population imposed in 1947, the "Vistula operation", the average population density decreased from about 65 people/km^2 in 1939 to less than 10 inhabitants/km^2 50 years later.

After World War II, the meadows and agricultural land went through a period of secondary succession within abandoned villages, then collective farms were established with vast monocultures of rape seed and oats. By the beginning of the 1990s, those farms went bankrupt and until Polish accession to the EU, those fields were mostly abandoned and woody vegetation encroached. In the last 5 years, most of this area went under private ownership, and with the beginning of EU subsidies, a majority of former fields are cultivated again as permanent hay meadows or pastures. The absolute majority of forests remain as government property. Therefore, the forest proportion that was about 40 % in pre-World War II period grew up to about 85 % by the end of twentieth century (Augustyn 2006). Currently, the ecological conditions resemble near-natural forest conditions.

Linked to this, the natural biodiversity is probably the highest in several centuries. Historical cultural biodiversity, however, is preserved mainly in the spatial arrangement of land cover in valleys, where still signs of former villages, fields and pastures are visible. The recent establishment of EU's Natura 2000 network of protected areas, which lacked proper consultations at community level, is not very well received by local inhabitants. There are numerous disagreements with restrictions regarding extension of residential areas and tourist infrastructure. In addition attempts to extend the area of Bieszczadzki National Park are opposed by both the forest administration and local community. Nevertheless, there is also a growing awareness of benefits and opportunities of nature and culture values, and a number of people involved in agrotouristic business and guiding of tourists is gradually increasing. Since the extraction of timber is not economically profitable anymore, the conversion of this area into a protected wilderness zone becomes an option. Logging would be performed only to cover local needs for firewood, and the forest could be managed towards possibly the highest biodiversity. To conclude, this case illustrates that, given sufficient time, restoration of natural biodiversity is indeed ecologically feasible.

3.3.4 Skole and Turka Raions (Ukraine)

The Skole and Turka local administrative units (raions) (49°N, 24°E) are situated in the westernmost part of Ukraine's Carpathian Mountains in the upper part of the Dniester river basin. In the fifteenth century, people began to settle and introduced land cultivation traditions, which created today's cultural landscape.

During the last several centuries, Skole and Turka were first a part of Austria-Hungary, then Poland and the Soviet Union. The forests became a source for wood and wood products in the international market from the middle of the nineteenth century as Austrian forestry was introduced. The demand for spruce timber prompted the owners of the forests to replace the natural deciduous beech forests with spruce forests. During the Soviet regime (1939–1991), private land property was expropriated. Forests were state owned and private land was joined into collective farms.

Today this part of the Carpathian Mountains hosts intact remnants of both near-natural forests and traditional villages (Elbakidze and Angelstam 2007, 2013). The National nature park "Skolivsky Beskydy", created in 1999 in the Skole raion, covers almost 22 % of the total forested area. People have kept much of their material culture, architecture, costume and customs, and use this to attract visitors. Recreational and tourism activities are thus connected to both natural forests and cultural landscapes. The main industry in the area is forestry. The predominant state employers are educational foundations, forestry sector and health service.

Since 1991, when Ukraine became an independent state, the economic crisis has made local people's livelihoods directly dependent on the local use of natural resources. This has involved a return to their traditional agricultural land use practices. At the same time, forestry is being modernised and road building has commenced to make forests accessible for management (Elbakidze and Angelstam 2007, 2013).

Interviews with local politicians, managers and stakeholders involved with forest landscape issues and governance of natural resources in Turka illustrate the opportunities and obstacles for development based on natural and cultural biodiversity (Angelstam et al. 2009). Key development issues included:

1. harvest rates of forests, effects of logging on erosion and flooding events, access to fuel wood, effects of hauling wood on streams, and whether locals profit economically or not;
2. abandonment of the traditional village system associated to encroaching forest on abandoned fields, and thus reduced landscape attractiveness;
3. tourism as the main future new business sector, but limited by poor road access, lacking advertisement and investment opportunities;
4. degradation of villages as a socio-cultural units;
5. apprehension towards protected areas, as people do not want to be restricted in the use of the landscape.

To conclude, the Skole and Turka raions illustrate the need to maintain and strengthen natural and cultural biodiversity as infrastructures for local development, and to empower local stakeholders' ability to exercise governance.

3.3.5 Apuseni Mountains (Romania)

The Apuseni Mountains (47°N, 23°E) is an interesting part of the Carpathian mountains in terms of landscape, biodiversity and culture (Abrudan and Turnock 1999; Brinkman and Reif 2006). Studies of archaeology and vegetation history indicate that the human colonisation began more than 7000 year ago (Bodnariuc et al. 2002). However, the most extensive forest loss took place during the past 100 years.

The Apuseni Nature Park is located in the centre of the Apuseni Mountains, comprising a part of the Bihor and Vlădeasa massifs up to 1,880 m a.s.l., where three administrative units meet (Cluj, Bihor, and Alba counties). Feurdean and Willis (2008) showed that the landscape was continuously forested over the last 5700 years BP, but the forest composition and structure have been dynamic. While beech was the major tree species between 5200 and 200 years BP, Norway spruce forests appeared 400 years ago. During the last two centuries Norway spruce dominates as a result of selective forest clearance, intensive grazing and, more recently, plantations. This led to a large reduction in forest diversity and local extinction of many tree species. However, in most of the regions with lower altitudes up to about 1,300 m cultural elements are an essential component of the landscape. This involves multiple strategies grounded in local agriculture and based on a settlement network in which small hamlets predominate (Surd and Turnock 2000). Villagers have formed cultural landscapes rich in structures and vegetation types. Forests provide timber for construction and boards, firewood, wood pasture, berries and mushrooms. Unfertilized grassland occupies the steeper and less fertile soils, mainly providing pasture, while meadows are found on deeper soils fertilized with manure and harvested manually. Hence, consideration of both the natural and cultural legacies should be included in the management and conservation of landscapes (Feurdean 2010).

However, severe pollution problems associated with mining areas are a threat and forest and pasture zones are under pressure from villagers seeking to improve their incomes (Buza et al. 2001). At the same time, tourist pressure is growing.

The Apuseni Mountains illustrate the need for reclamation to cope with pollution from mining activity and mineral processing, management of building development, which is going on without consideration to natural and cultural landscape, and biodiversity conservation of both natural forest and cultural landscape legacies (Reif et al. 2008). This must the combined with sustainable solutions to problems of local community development (Buza et al. 2001). Dogaru et al. (2009) showed that high level of education increases peoples' awareness of environmental problems.

3.3.6 Lower Morava Biosphere Reserve (Czech Republic)

The Lower Morava Biosphere Reserve (LMBR) (49°N, 17°E) covers the unique combination of limestone cliffs of the Palava Hills—the westernmost outskirts of

Carpathians in the Czech Republic—the rare Central European lowland floodplains along the lower reaches of the Kyjovka, Dyje and Morava rivers. The LMBR is covered by managed alluvial forests, some 8,000 ha of continental floodplain meadows, and the largest European man designed landscape: Lednice-Valtice Cultural Landscape, a World Heritage landscape.

Land cover includes karst dry grassland, oak forests and Scots pine plantations, fishponds with fish farms and other standing water habitats, saline meadows and marshland, vineyards and other mostly intensively farmed agricultural land. Human activity formed the whole region for millennia. Most inhabitants in the LMBR engage in agriculture and small-scale industry with tourism as an alternative source of income.

The managing authority is the LMBR Public Benefit Corporation. It is the very first time in the Czech Republic that a BR is administered by a non-governmental organization. This concept of an independent and direct participation management is unique, as the rest of the Czech BRs are linked to official government protected areas and share responsibility for the management. In case of Lower Morava the founders of the Public Benefit Corporation came from a wide spectrum of society: representatives of local businesses, agriculture, industry, the Ministry of Environment and the largest nature conservation nongovernmental organization in the country. Local communities play a vital part in management via representatives in the BR's managing board.

Presence of various stakeholders with diverse interests within the reserve boundaries (the BR includes 20 sites designated by the Natura 2000 network, over 25 national categories of nature protection areas, the World Heritage Site and Czech historic zone, two Ramsar sites, and two Nature Parks) open a chance to cooperate on local, national and international levels in the fields of conservation and land management.

While co-ordinating projects the LMBR also serves as a platform, where different parties can seek compromise. This would never be possible without direct involvement of local people. To engage the locals in BR management and decision-making, the BR's managing board includes three regional community associations. To conclude, the LMBR has the advantage of receiving first hand feedback when proposing, for instance, new projects.

4 Discussion

4.1 Need for Diversity of Management Systems and Spatial Planning

The review of natural and cultural biodiversity visions, landscape history and trajectories of change, and the experiences from the case studies, clearly show that management for biodiversity conservation needs to consider both natural and

Table 2 Overview of six landscape case studies chosen with respect to visions for both natural forest and cultural landscapes

		Natural disturbance vision	Cultural landscape vision
Hungary	Börzsöny Mountains	++++	+
Slovakia	Tatra National Park	++++	+
Poland	Bieszczady Mountains	++++	++
Ukraine	Skole and Turka	++	+++
Romania	Apuseni Mountains	+	++++
Czechia	Lower Morava	+	++++

cultural dimensions of Carpathian landscapes (e.g., Oszlányi et al. 2004; Feurdean 2010) (Table 2).

The wide range of different even-aged, multi-aged and uneven-aged silvicultural systems (Matthews 1989; Puettmann et al. 2009) provides a high potential for emulating natural disturbance regimes by combining protection and management for both maintenance and restoration of forest biodiversity (Table 3). Similarly, if the traditional village system can be maintained, it will provide an important prerequisite and opportunity for ecological, economic and socio-cultural sustainable development (Parrotta et al. 2006) (Table 3).

Additionally, the spatial configuration of operational management needs to be considered. The European bison is a good example of population viability (Perzanowski et al. 2004) being dependent on active management for connectivity (Taylor et al. 1993) at the scale of landscapes and regions. For example in Poland, plans for the national network of ecological corridors were elaborated in 1998 (Liro 1998) and in 2005 (Jędrzejewski et al. 2005), but never implemented. In the Polish Carpathians only corridors linking summer and winter refuges of this species formally exist and are included into management plans of State Forests (Perzanowski et al. 2008). A large scale project leading to formal establishment of ecological corridors has been completed recently in Ukrainian Carpathians between Romanian and Polish borders (Deodatus and Protsenko 2010).

4.2 Governance by Multiple Sectors at Multiple Levels

Several land use sectors affect the composition, structure and function of individual landscapes, and thus biodiversity (Table 4). The mixture of natural and cultural biodiversity necessitates the formulation of strategies for the integration of conservation tools for habitat protection, management and restoration across management sectors and spatial scales within a geographical area. The term "governance" captures this issue. Governance can be understood as a "collective" or a shared set of responsibilities of public, private and civil society actors. It includes multiple actors at multiple levels and is thus often referred to and described as multi-level governance (Bache and Flinders 2004). When it comes to

Table 3 Diversity of different forest management systems and traditional village systems to satisfy ecological, economic and socio-cultural criteria of sustainable landscapes

Criteria	Objective	Forest management system			Traditional village system
		Cohort	Even-aged	Uneven-aged	
Ecological	Dry site biodiversity	Light, large trees, dead wood			Open habitat, often grazed
	Mesic site biodiversity		Successional stages from young to old		More or less wooded grasslands
	Wet site biodiversity			Gap phase dynamic	Wet grasslands and woods
Economic	Wood yield, food		Effective economic production		Livelihood
Socio-cultural	Recreation and health	Open forest with large trees	Not compatible	Continuous dense forest cover	Attractive landscape for tourism
	Cultural landscape	Grazed forests, wooded grasslands	Not compatible		Maintenance of social capital
	Urban green space	Open forest, lawns	Not compatible		Wooded grassland

Table 4 Overview of managing sectors affecting natural and cultural biodiversity in the Carpathian Mountains, and estimation of their opportunities for spatial planning

	Hierarchical planning approach involving strategic, tactical and operational steps?	Control of entire landscapes and regions?
Protected areas	Yes	No
Water management	No	No
Forest management	Yes	No
Traditional village systems	No	No
Tourism and recreation	No	No
Transport infrastructure	Yes	No

implementation of biodiversity conservation policies, actors at local to global governance levels affect policies and outcomes on the ground. Within a given sector or policy area there are several levels (Primdahl and Brandt 1997).

First, at the international policy level, the Convention on Biological Diversity's "Ecosystem approach" can be used as one starting point. The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Application of the ecosystem approach will help to reach a balance of the ecological, economic and socio-cultural objectives of the Convention. The approach should be based on the application of appropriate scientific methodologies focused on levels of biological organisation, which encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems (e.g., Pirot et al. 2000). For forests, Sustainable Forest Management can be interpreted as an example of the ecosystem approach (Angelstam et al. 2004c). Thus, Natura 2000, being a system common for the entire EU and adjacent countries who have adapted it, becomes an important tool and part of an integrated approach towards sustainable management of natural resources since it is based upon assumed coexistence of nature and people (e.g., Stancioiu et al. 2010). The same integrated approach is required by the EU Water Framework Directive (2000). Both EU policies assume the coexistence of nature and people and focus upon maintaining both fundamental ecological processes and the appropriate state of natural resources on the one hand, and stakeholder participation on the other. However, in most of the cases (e.g., Romania) Natura 2000 network did not significantly improve the conservation status of species and habitats of European concern. A regional approach to conserving biodiversity and social acceptance is needed for the Natura 2000 network to comply with EU targets (Patroescu et al. 2006; Ioja et al. 2010).

Second, at the national level, policy instruments are then gradually developed, and may include legislation, information, subsidies, monitoring, education and vocational training. However, natural and cultural biodiversity is usually not maintained by formal institutions, rules and organisations, but rather informally by local people acting within different governance systems. Consequently, several policy areas with their respective planning traditions coincide: forestry, agriculture, tourism, transport infrastructure and the energy sector, as well as regional and urban planning. The newly introduced EU regulations may have the opposite effect, as they could destroy local land use traditions. For example, within 3 years, the quality rules for milk destroyed local animal husbandry in Ghimes, Romania (Molnár and Babai unpubl.).

Third, because different landscapes have different governance systems, it is important to understand how the actors' knowledge, attitudes and willingness to act correspond to the policy (Clark 2002; Angelstam et al. 2003c). The suite of policy instruments should ideally be adapted to the composition and structure of the actors in the actual landscape. The effects of policies on actual landscapes are thus indirect, and therefore subject to several potential barriers (Clark 2002; Rauschmayer et al. 2009).

Fourth, the effectiveness of the policy implementation process can be evaluated by the development of different indicators, which are monitored to measure change in local landscapes (Busch and Trexler 2003). However, results from monitoring

Table 5 Pros and cons of different approaches to formulate evidence-based performance targets about how much habitat is enough

	Comparisons	Natural experiments	Historical ecology
Landscape data	Good	Good	Variable
Species data	Good	Good	Limited
Sample size	Large	Very limited	Limited
Other aspects	Different species-habitat relationship in different regions may preclude valid comparisons	Same ecoregion	Hard to find relevant data about the occurrence of different species

should be compared with quantitative performance targets or other norms (Lammerts van Buren and Blom 1997; Angelstam et al. 2004d; Rauschmayer et al. 2009). This requires, for instance, systematic studies about how the amount and configuration of habitat affect the occurrence and viability of populations and species (Table 5, and e.g., Angelstam 2004; Angelstam et al. 2011; Bütler et al. 2004; Müller and Bütler 2010; Törnblom et al. 2011b).

Roberge and Angelstam (2009) presented a six-step procedure for identifying thresholds to be used in the determination of forest biodiversity conservation targets. These were:

1. stratify the forests into broad cover types as a function of their natural disturbance regimes;
2. describe the historical spread of different anthropogenic impacts in the forest that moved the system away from naturalness;
3. identify appropriate response variables (e.g., focal species, functional groups or ecosystem processes) that are affected by habitat loss and fragmentation (e.g., Roberge and Angelstam 2004);
4. for each forest type identified in step 1, combine steps 2 and 3 to look for the presence of non-linear responses and to identify zones of risk and uncertainty;
5. identify the "currencies" (i.e., species, habitats, and processes) which are both relevant and possible to communicate to stakeholders;
6. combine information from a suite of different indicators selected.

Using species as an example, this means that planners and managers need to understand that different species have different habitat affinities and quantitative requirements. To maintain ecological integrity and resilience usually requires landscape and regional perspective (Fig. 4). The maintenance of large intact forest areas is necessary for wide-range species such as large carnivores and herbivores (Breitenmoser 1998; Mikusiński and Angelstam 2004; Maanen et al. 2005). For bison, Perzanowski et al. (2004) concluded that this species have no chances for natural exchange of genes due to fragmentation and loss of large areas of natural habitats. The population viability thus depends on active conservation management (Kuemmerle et al. 2011).

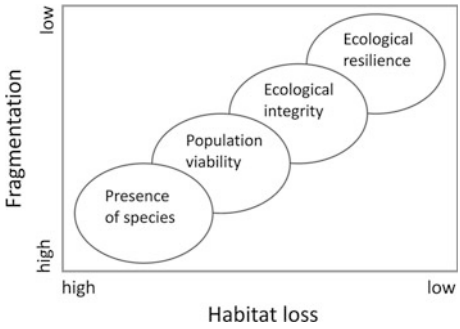

Fig. 4 Illustration of the increasing challenge in terms of mitigation the effects of habitat loss and fragmentation by conservation to achieve different levels of ambition for biodiversity conservation (see Angelstam et al. 2004a, c; Svancara et al. 2005; Tear et al. 2005)

The successful maintenance of all representative land cover types in a landscape to conserve natural and cultural biodiversity can be viewed as a series of partly overlapping and complementary "green infrastructures", each of which have different properties to which species are adapted. The required quality and extent of such habitat networks depends on the requirements of the species. For example, a species specialised on old-growth forest and with large area requirements will need more habitat area then a generalist with small area requirements. The umbrella species concept (e.g., Roberge and Angelstam 2004), whereby conservation management for specialised species confers protection to less specialised species in a particular habitat, is a useful concept as this means that knowledge about species' qualitative and quantitative habitat requirements can be used to formulate conservation targets. Additionally, large carnivores could act as flagship species and help to manage the landscapes and regions (Rozylowicz et al. 2011).

Thus, to steer towards agreed policy goals, there is a need for hierarchical planning with increasing resolution from broader ecoregional (i.e., international) to finer spatial and temporal scales (Angelstam and Andersson 2001; Angelstam et al. 2011). This often requires international co-operation across borders between adjacent regions in different countries (Opelz 2004; Elbakidze and Angelstam 2009). In addition there is a need for bottom-up approaches to engage the range of land owners, managers and actors in local landscapes (Angelstam et al. 2003c; Sayer and Campbell 2004).

4.3 Integrated Landscape Approach to Biodiversity Conservation

To conserve natural and cultural biodiversity a participatory and holistic approach is thus needed (Angelstam 1997; Reif et al. 2008; Pauleit et al. 2010), which requires interaction among different actors in a landscape. Apart from operational management of natural and cultural biodiversity and multi-level governance, we stress two additional important prerequisites to be satisfied. First, sustainability assessments should provide a strategic orientation to policy-makers, governors and

managers (Weaver and Jordan 2008) such as landscape scale performance targets for the amount and configuration of habitats needed to maintain biodiversity (e.g., Angelstam et al. 2004a; Villard and Jonsson 2009). Second, platforms for multi-level governance are needed where owners, managers and stakeholders could develop solutions, resolve conflicts and together improve the level of sustainability within a landscape (Lickers and Story 1997; Baker 2006; Gilbert 2007; Elbakidze et al. 2010).

The term integrated landscape approach (e.g., World Forestry Congress 2009) captures the need to consider a larger functional geographical area when addressing sustainability, and to include both social and ecological systems and their interactions (Borrini-Feyerabend et al. 2004; Dudley et al. 2006; Singer 2007). De-constructing the landscape approach Axelsson et al. (2011) identified five core features:

1. focus on a large area of tens of thousands up to millions of hectares depending on the sustainability issues in focus;
2. collaboration among multi-level partners representing all societal sectors and fields of interest;
3. a commitment to sustainable development and an analytic approach to address sustainability;
4. production of new knowledge and knowledge management to identify useful traditional knowledge for socially robust solutions (Gibbons 1999; Daniels and Walker 2001);
5. sharing of knowledge and experience.

However, there are a number of barriers when attempting to apply a landscape approach for the conservation of natural and cultural biodiversity by a wise combination of management and non-intervention (Holling 1995; Soran et al. 2000; Gutzwiller 2002; Sandström et al. 2006; Lawrence 2009). The remedy has to combine multi-level solutions, and satisfy the economic and societal needs of the people in the long term. Successful approaches should be based on, and strive for transdisciplinarity, which implies participatory action research involving the stakeholders (local population, experts, administration, and politicians), and joint practical implementation of research findings (Reif et al. 2008; Axelsson 2010).

There are some important prerequisites to make this work. First, the land-use managers and planners need to acquire an attitude of "learning organisations" i.e., organisations must be flexible and allow personnel to work and learn at the same time (Lee 1993; Sayer and Campbell 2004). Next, researchers have to show true interest in contributing to practical and socially robust solutions outside the academic world. Finally, socially robust solutions to management and spatial planning as a collaborative learning process with local people need to be developed. Maps are often a useful way to communicate sustainability and planning issues and to get feedback from different stakeholders.

There are several approaches to establish such a dialogue among actors. The international model forest network, which forms a partnership between individuals and organisations sharing the common goal of sustainable forest management is

one example (Besseau et al. 2002; Axelsson and Angelstam 2006; Axelsson et al. 2008). The UNESCO's biosphere reserve concept is another (UNESCO 2002). Both concepts imply that a management unit consisting of an actual landscape with its characteristic ecosystems, actors and economic activities is used as a site for syntheses, innovation, development and education. Ideally, what Boutin et al. (2002) termed adaptive management teams should be formed whereby researchers, land managers and policy-makers share decisions and responsibilities toward the success or failure of the strategy they jointly adopted.

5 Conclusions

Biodiversity conservation in Europe's landscapes is based on both natural and cultural visions. The introduction of sustained yield forest management and intensive agriculture generally lead to a reduction of the amount of dead wood, functional connectivity and intact areas of natural woodland and cultural landscapes. A major challenge is to identify and use as guidelines for management evidence-based performance targets for biodiversity conservation for agreed levels of ambition rather than negotiated targets such as forest certification, or the state of the environment in already managed and altered landscapes. It is also critically important that land management becomes spatially explicit at several spatial scales ranging from trees and stands to landscapes and regions. Additionally, participatory conservation management planning with societal arenas for combining top-down planning with bottom-up implementation is crucial. We argue in favour of a novel win–win oriented approach to research and development, which is based on exchanging knowledge and experience gathered over long time in different countries and regions. This will be of mutual benefit for both science and practice, and thus for continued sustainable use and conservation of natural resources providing a basis for human well-being and quality of life. Ultimately, acknowledging and adopting this perspective requires the gradual development of a new transdisciplinary profession able to facilitate ecosystem management at the landscape scale. This necessitates improved mutual feedback between the science, engineering and art of integrated natural resource management and governance.

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