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## Survey paper

# The Primeval Beech Forests of the Carpathians and Ancient Beech Forests of Germany: joint natural heritage of Europe

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**Abstract**

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The European beech *Fagus sylvatica* L. ssp. *sylvatica* L. is exclusively found in Europe. The beech survived the last ice age in small refuges in the south and south-east Europe and went on the colonisation of large parts of the continent. The post ice colonization of the landscape by the beech took place parallel to the settlement of land by humans and the formation of a more complex society. For centuries much of the Carpathian mountain forests remained untouched. Virgin forests constitute a natural heritage of global significance. In 2007 the primeval beech forests of the Carpathians (Slovakia, Ukraine) were added to UNESCO´s World Heritage List. On 25 June 2011, the UNESCO World Heritage Committee added five of Germany´s beech forest regions to the World Heritage List. This extended the transboundary world natural heritage site „Primeval Beech Forest of the Carpathians", located in the Slovak Republic and Ukraine, to include a number of German forest regions, and renamed it „Primeval Beech Forests of the Carpathians and Ancient Beech Forests of Germany". The paper is aimed at the presentation of the outstanding universal value of the ecological processes in the Joint World Heritage Sites, and present principles of their Integrated Management Plan. Ultimate goal is to achieve that management and socio-economic sustainable development practices are in harmony with primary objectives of WHS protection, biodiversity conservation, ecosystem and landscape stability, rational use of natural resources, ecotourism development and with potential of the landscape in largest possible extend.

**Keywords**

ancient beech forest, Carpathy, Germany, primeval beech forest, World Heritage

## Introduction

Europe´s beech forests are deciduous forests which are dominated by the European Beech (*Fagus sylvatica* L.). The beech is endemic to Europe and beech forests are limited to Europe (Gömöry et al., 2011). Such forests therefore share the fate of all deciduous forests of the northern hemisphere´s nemoral zone. They have been exposed to an enormous development pressure (settlement, utilisation) for centuries so that natural forests have become scarce (Britz et al., 2009). Beech is one of the most important elements of forests in the Temperate Broad-leaf Forest Biome and represents an outstanding example of the re-colonisation and develop-

ment of terrestrial ecosystems and communities after the last ice age, a process which is still ongoing (Knapp, 2011). Forest communities built up and dominated by the beech are widespread across major parts of Central Europe. Potentially forming the predominant zonal vegetation in Western and Central Europe in terms of area, they are found at the montane level of the South European mountain ranges. They show the widest amplitude of soil trophic levels and altitude distribution, of all deciduous forests in Europe potentially occupying the largest area (Bohn and Neuhäusl, 2003).

The European beech forests stand out due to an exceptional variety of types. According Bohn and Neuhäusl (2003), a total of 86 different biocoenotic units of the beech and mixed beech forests are found in the beech forest area, subdivided according to trophic and altitude levels as well as geographical and local forms. Of these units, 14 cover more than 50% of the potential natural range, with as many as eight units being also widespread in Germany with significant proportions of the overall area. A total of 28 biocoenotic units, which roughly equals one-third of all European units, are widespread in Germany, which emphasises Germany´s particular responsibility for the preservation of the beech forests worldwide (Britz et al., 2009). The European beech forests show a decline in vascular plant species numbers from glacial refuges in Southern Europe to the north and northwest, in which directions they were advancing. Their centres of diversity lie in the Eastern Carpathians, the Dinaric Alps, and the Pyreneans (Dierschke and Bohn, 2004). The particular evolutionary connection clearly reflects in the entire Central European Flora.

The different beech forest types are home to 20% of the terrestrial fauna in Central Europe – 7,000 to 10,000 animal species (Otto, 1994) that have mostly adapted their rhythm of life to the seasonal cycle. Alongside with the plants, fungi, and microorganisms, they are the determining factors in the beech forest system.

The history of the beech forests is closely linked with the history of European civilisation (Bennett, 1994; Britz et al., 2009). The post-glacial colonisation of the landscape by the beech tree ran in paralel with the establishment of communities by mankind and the formation of more highly organised forms of society. That is why the beech is deeply rooted in European culture (Pichler et al., 2007a).

## Material and methods

The beech ecosystem research which has been the basis for elaborating on the World Heritage Nomination Project was carried out in two regions: in the Carpathian Mts and in the German Lowlands.

The complete ecological research of the mountain Primeval Beech Forests of the Carpathians started in the first half of the 20th century due to the famous Czech botanist and forest ecologist Professor Alois Zlatník (Zlatník, 1934, 1935, 1936; Zlatník and Hilitzer, 1932; Zlatník et al., 1938). Valuable knowledge concerning ongoing ecological processes in the Carpathian primeval beech forest ecosystems has been obtained after Second World War during the past years (Leibundgut, 1978; Jaworski et al., 1994a, 1994b; Korpeľ, 1989, 1995; Kricsfalusy et al., 2001; Commarmot et al., 2000; Bublinec and Pichler, 2001; Saniga, 2011; Saniga and Schütz, 2002; Stoyko et al., 1982; Stoyko and Tasenkevitch, 1993; Stoyko, 2002; Brändli and Dowhanytsch, 2003; Vološčuk, 1992, 1994, 1995, 1999, 2003; Hamor and Commarmot, 2005; Commarmot et al., 2000; Pichler et al., 2007b) and utilized for practical forest and conservation management (Vološčuk 1994, 1995; Pichler et al., 2007a). The phytocoenological releves (stationary plots) were decribed according to Zlatník (1976) and geobiocoenoses were classified according to Zlatník (1959). In Primeval Beech Forests of the Carpathians prevail the group of forest types Fagetum pauper, Fagetum typicum, Fagetum tiliosum, Abieto-Fagetum and Fageto-Aceretum.

The ecological research in Ancient Beech Forests of Germany (lowlands) was carried out during the past 40–50 years (Assmann et al., 2008; Dörfelt, 2008; Plachter et al., 2008; Knapp, 2011; Britz et al., 2009).

## Characteristics of the localities

The World Natural Heritage „Primeval Beech Forests of the Carpathians“ is situated in the biogeographic region „Carpathian beech forests“ (Brändli and Dowhanytsch, 2003) with a centre of diversity in the Eastern Carpathians. It is a part of the Inner Carpathians, which form a continuous mountain range over 1,300 km in length, 100 to 350 km in width, and up to 2,600 m in height. In the periphery and the montane-altomontane zone, large portions of this richly wooded mountain range are characterised by specious beech and mixed beech forests. The potential natural range of the beech forests therefore comprises an area of approx. 92,000 km$^2$ throughout the Carpathian centre zone, which corresponds to roughly one-tenth of the pan-European beech forest area. These areas, located in mountainous and sub-alpine altitudes (400–1,940 meters a.s.l.), are primarily representative of mountain beech forest. The geographic coordinates of Primeval Beech Forests of the Carpathians are: N 47°–49°, E 22°–24° (Table 1).

The last extensive primeval beech forests can now only be found in the Carpathians. This is the only place where there can still be experienced the uninterrupted dynamics of the coming and decline of beech forests since the last Ice Age. The great biodiversity of the

Table 1. Location and area of the component parts of the Primeval Beech forests of the Carpathians

| Component parts | Country | Core area ha | Buffer zone ha | Elevation a.s.l. m |
|---|---|---|---|---|
| Chornohora | Ukraine | 2,476.8 | 12,925.0 | 640–1,550 |
| Kuzyi-Trybushany | Ukraine | 1,369,6 | 3,163.4 | 420–1,087 |
| Maramorosh | Ukraine | 2,243.6 | 6,230.4 | 600–1,470 |
| Svydovets | Ukraine | 3,030.5 | 5,639.5 | 720–1,500 |
| Uholka – Shirokiy Luh | Ukraine | 11,860.0 | 3,301.0 | 400–1,350 |
| Stuzhitsia – Uzhok | Ukraine | 2,532.0 | 3,615.0 | 600–1,221 |
| Stužica – Buk. vrchy | Slovakia | 2,960.0 | 11,300.0 | 512–1,210 |
| Havešová | Slovakia | 171.3 | 63.9 | 442– 741 |
| Rožok | Slovakia | 67.1 | 41.4 | 440– 789 |
| Vihorlat | Slovakia | 2,576.0 | 2,413.0 | 517–1,076 |
| Total area ha | | 29,278.9 | 48,692.7 | |

beech forests has managed to endure here. The World Heritage Site „Primeval Beech Forests of the Carpathians“ represents the beech forest of the mountain range in ten component parts. Four areas are located in the Slovak Republic, six are located in the Ukraine. The smallest area is 67 hectares in size, the largest approx. 12,000 hectares. They are located in the Eastern Carpathians, one of the most unspoilt habitats in Europe. All the component parts are remnants of primeval forests which are embadded in beech forests that are extensively managed.

Germany is at the centre of distribution of the beech forests. If nature had its way they would cover approx. two thirds of the land area of Germany extending from the Alps over high and low mountains ranges and down to the lowlands at the sea coastlines. Now only approx. seven per cent of this surface is covered with beech forests due to deforestation and forest conversion. Larger contiguous forest areas are rare. The remaining forests are used in the forestry industry and beeches of approx. 120 years of age are harvested. The senescent and decay phases of a lifecycle that is naturally of more than 300 years duration are absent and thus also the living spaces that emerge in these phases as tree hollows and dead wood with their typical biocoenosis. Primeval beech forests have long since disappeared barring a few miniscule remnants and with them also species that are dependent upon them.

The Decision of the 35th Session of the World Heritage Committee, Paris 25 June 2011, approved the extension of the Primeval Beech Forests of the Carpathians (Slovakia and Ukraine), to include the Ancient Beech Forests of Germany, and becomes the Primeval Beech Forests of the Carpathians and the Ancient Beech Forests of Germany (Slovakia, Ukraine and Germany), on the basis of criterion (ix): outstanding examples representing significant on-going ecological and biological processes in the evolution and development of ecosystems and communities of plants and animals. The German extension in 2011 is another major step towards protecting this unique ecosystem for the long term.

The German part includes selected forest regions of the National Parks Hainich in Thuringia, Kellerwald-Edersee in Hesse, Jasmund and Müritz in Mecklenburg-Western Pomerania, and the forest of Grumsin in the Schorfheide-Chorin Biosphere Reserve in Brandenburg. These are the most valuable remaining examples of large, undisturbed beech forests in Germany. These German sites with their beech forests in the lowlands and central uplands are a perfect component to the mountain beech forests located in the Carpathians. This component part of the World Natural Heritage represents the characteristics and the natural processes of European beech forests under various ecological conditions.

The development history of beech forests since the Ice Age, the enormous competitiveness of beech *Fagus sylvatica* and the diversity of geographical, geological and ecological beech forest variations are a unique global phenomenon. The Ancient Beech Forests of Germany are indispensable to documenting the postglacial colonisation by *Fagus sylvatica* from south to north, from east to west, and spanning the entire spectrum of altitudinal zones from the sea-shore, to the lowlands and the submontane belt, to the upper timber line in the mountains (Knapp, 2011). German´s component parts are the most outstanding examples worldwide of the respective beech forest types. Each component part has its own specific characteristics and local peculiarities that make it unique and irreplaceable.

**Jasmund:** size 492.5 ha, buffer zone 2,510.5 ha, N 54°32´53´´ E 13°38´43´´ (0–131 a.s.l.). Jasmund is

a representative of the beech forest of the lowlands type. Half of Jasmund´s property border follows to coastline. Although this border is subject to very slow natural dynamic changes based on the denudation of the steep coast, it is clearly identifiable by distinctive habitat limits at any given point. Jasmund represents the beech forests of the lowlands on lime and boulder clay. Beech forests, chalk cliffs and sea form a fascinating backdrop. The harsh coastal climate and the interaction of topography and climate lead to a broad range of different beech forest communities which are interspersed with streams and moors. Rare orchids, the great horsetail and the coral root are typical here.

**Serrahn:** size 268.1 ha, buffer zone 2,568.0 ha, N 53°20´24´´, E 13°11´52´´ (67–124 m a.s.l.). The best structured lowland beech forests in Europe. Demarcation in Serrahn has produced a compact core area of beech-dominated forests. In the Serrahn part the forest of the Müritz National Park lowland beech forests grow on sands from the Ice Age. In the midst of an extended forest and lake landscape this old beech forests help us to imagine what the German beech forests once looked like. Lakes and mires enrich the forest landscape, create a rich diversity of habitats and form the basis for a great amount of biodiversity. The beech forest of Serrahn is consequently documenting moisture-related distribution limits in an outstanding manner.

**Grumsin:** size 590.1 ha, buffer zone 274.3 ha, N 52°59´11´´, E 13°53´44´´ (76–139 m a.s.l.). Grumsin represents the beech forests of the lowlands on glacial sands and clay. The demarcation of the Grumsin component part largely follows the core area border of the Schorfheide-Chorin Biosphere Reserve, which was designated in 1990. Minor marginal zones which predominantly consist of pine woods rather than near-natural deciduous forests and were likewise abandoned to natural development in 1990 have been assigned to the buffer zone. Water and forests are closely linked in Grumsin. Lakes, forest marches and moores in deep valleys interchange with marked ridges and conjure up atmospheric forest images in the ancient beech forests. These different structures in the most confined spaces form the basis for an exceptionally rich range of animal and plant species. The area represents an exceedingly textured young moraine landscapes with altitudes of between 60 and 140 m above sea level and all the typical elements in a unique fashion.

**Hainich:** size 1,573.4 ha, buffer zone 4,085.4 ha, N 51°04´43´´, E 10°26´08´´ (290–490 m a.s.l.). Hainich National Park encompasses what is, at present, the largest unmanaged deciduous forest area in Germany. Hainich represents the best reference area for the specious eutraphent beech forests of the European collinesubmontane zones with their ground vegetation rich in geophytes and the exceedingly attractive floral display in early spring, representing the seasonality of Central European deciduous forests in a unique manner. The most valuable beech forests that offer a very rich range of species grow on the central mountain ranges on limestone. It impresses through its extensive range of tree species and reveals lime beech forests of a magnitude, unspoilt nature and form that you will be unable to find in any other area. The demarcation in Hainich follows the distribution of the best-preserved beech forests with old growth stands. The buffer zone comprises the core area of the national park. The Hainich beech forest is unique proof of the currently ongoing ecological processes associated with the present climate change.

**Kellerwald:** size 1,467.1 ha, buffer zone 4,271.4 ha, N 51°08´43´´, E 8°58´25´´ (245–626 m a.s.l.). The acidophilous beech forests of the lower mountain ranges grow on slate and geywacke in the Kellerwald. No roads and no settlement cut through the exceptionally old, extensive forests of the Kellerwald in which unique primeval forest relics have survived. The beech reaches its natural forest boundary at the rocky and scree slopes and forms a bizarrely formed forest landscape. More of than 500 of the purest springs and streams form additional valuable habitats. In Kellerwald, the border was established taking into account the specific qualities of the component part, such as the high relief energy, the disjointed occurrence of small primeval-forest like steep slopes, and the spatial distribution of valuable beech forests. A coherent complex of valuable old-growth beech forests has been included. The demarcation of buffer zone follows the national park border. No buffer has been designated in a very small plot located on the northern border in order to integrate one of the primeval beech forest slopes into the property. Kellerwald contains the largest protected area of oligotraphent and mesotraphent beech forests, where undisturbed ecological and biological processes occur and is a perfect illustration of acidophilous beech forests.

## Results and discussion

Specific peculiarities of the Carpathian forests include the richness in endemic species, the occurrence of Europe´s largest population of predatory mammals with some 8,000 brown bears, 4,000 wolves and 3,000 lynxes as well as the most significant large-scale primary forest on the periphery of the European beech forests´distribution range. Representing its remaining primeval forests, the World Natural Heritage „Primeval Beech Forests of the Carpathians“ is an essential part of these unique beech forests landscapes. These undisturbed, complex temperate forests exhibit the most complete and comprehensive ecological patterns and processes of pure stands of *Fagus sylvatica* across a variety of environmental conditions. The Carpathians Primeval Forests show a broad range of possible forest development stages from rejuvenation to decay (Pichler et al., 2007a).

Ukraine and the Slovak Republic have taken on a pioneering role with the inscription of the Primeval Beech Forests of the Carpathians in the World Heritage List in 2007. The Carpathian Mountains are home to the last remaining large-scale primeval beech forests in Europe. Since the end of the last Ice Age, the forests here have been able to develop undisturbed. Mightly beech trees up to 50 meters high dominate the structurally rich forests (Brändli and Dowhanytsch, 2003; Vološčuk, 2003). The dynamics of the primeval beech forests, the natural comings and goings, are able to play out entirely free from anthropogenic influences here. Globally endangered species of fauna, fungi and flora have been able to preserve their natural gene pool.

The model of the main natural successional phases occuring in Central Europe (Korpeľ 1995, Pichler et al., 2007a): growing-up stage, optimal stage, decaying stage. In the growing-up stage, trees are found in all three layers – upper, middle and lower, and the crown closure is dense. As there is low mortality in trees of this age, there is little dead wood. At the end of phases, however, the competition between individuals is so great that strong dying off of juveniles occurs. In the following optimal stage, the maximum timber stock is reached, but the number of trees per area unit is low. With the lack of an understorey, the attainment of maximum height and a closed canopy, the forest in this phase is known as „hall-forest", being reminiscent of the interior of a cathedral or great hall, and also bears some resemblance to a commercial forest. During the transition to the decaying stage tree vitality decreases and the proportion of dead wood increases considerably. In this phase, the number and size of gaps between tree clusters increases and regeneration of climax tree species starts again.

An alternative view (Holling, 2001) suggests that the complexity of living systems of people and nature emerges not from a random association of a large number of interacting factors rather from a smaller number of controlling processes. These systems are self-organized, and a small set of critical processes create and maintain this self-organization. „Self-organization" is a term that characterizes the development of complex adaptive systems, in which multiple outcomes typically are possible depending on accidents of history. According to Holling (2001) there are three properties that shape the adaptive cycle and the future state of a system: wealth, controllability, and adaptive capacity. The adaptive cycle includes 4 phases: (1) long period of slow accumulation and transformation of resources, and (2) conservation (growing-up stage and optimum stage according to Korpeľ, 1995), (3) shorter period of collapse that creates opportunities for (4) innovation (from release to reorganization), or decaying stage with regeneration phase according to Korpeľ, 1995).

The European natural beech forests stand out due to a highly peculiar natural dynamism which is determined by the cycle of growth and decay of one single tree species, which is the beech. Old beech stands will regenerate with the crowns of individual trees gradually dying back to allow more light to the ground. Either there already is young beech wood that will now emerge, or the next generation of saplings will close the void within a period of a few years. The beech once again forms the upper crown canopy later on, thus resetting the cycle, which has been described as the small development cycle (Zukrigl et al. 1963, Leibundgut 1978, Korpeľ 1989, 1995). In the wake of major disruptions, however, the cycle may also involve the formation of an early successional forest made up of pioneer species such as pines, birches, goat willows or rowans, which is later on infiltrated by medium-shade and shade tree species. This big successional cycle may take several decades longer than the small one. Variation incorporating elements of both big and small cycle are possible. This endogenous cycle of development meets the diversity of sites resulting from the glacial and postglacial periods, producing the considerable structural variety as basis for the species-rich, complex system. Rooted in the beech´s enormous ecological plasticity, the high ecological stability results in a biodiversity-promoting continuity of the forest´s character, which makes the dynamics of the beech forest persistently „predictable" for the forest dwellers. Old beech forests are, for example, home to a multitude of flightless ground beetles that would drop the ability to fly due to the habitat being continuously available or changing only at a small scale (Britz et al., 2009, Plachter et al., 2008).

A significant feature of the beech forests is decline in floristic diversity, which is a result of the history of flora and vegetation, from the former glacial refuges in Southern and Southeastern Europe up the northern and northwestern subterritories. Old beech trees can form a highly diverse habitat for fauna. The beech is a key species which creates its own internal forest climate and crucially influences soil formation, regeneration cycle, food chains and structures and reveals stonishingly specific diversity of plants, vertebrates, insects, molluscs and fungi. This diversity is described in terms of its ecological role in the ecological processes of beech forest ecosystems – trees and shrubs, mycorrhizae, geophytes, other herbaceous plants, lianas, herbivores, carnivores, dead wood inhabitants, destruens, etc. (Assmann et al., 2008).

As opposed to the climatic patterns of tropical rainforests, the climate of the temperate zone is distinguished by its seasonal changes together with the phenological floral cycle involved. From a physiognomic perspective, the most striking feature of deciduous trees is the fall of leaves, which will further accentuate the seasonal differences and conditions of the biotopes respectively. However, the foliage changing with the seasons does not take place abruptely. In pure beech forests this process is accompanied by unique changes in

colour (Knapp, 2011). The most dramatic consequence of leaf fall is the light climate´s periodicity. This sets deciduous forests apart from all non-deciduous forest types, permitting the intermittent occurence of a herb layer that shows different specific adaptations. Spring geophytes exploiting the brief warm spring period prior to leafing for development are particularly well adapted and transform the soils of richer beech forests into a carpet of flowers. The association that has given rise to geophyte-rich beech forests is a result of ecosystemary continuity as well as the inner functional and structural differentiation of the development cycle of deciduous forests. In this particular shape, it is without paralel in the world (Knapp, 2011).

A multitude of fungi are involved in dead wood decomposition, with a number of species being specialised in the metabolisation of specific wood types. The species of the genus *Fagus* are highly mycotrophic; in other words, much of their nutrient supply comes from fungi. Their survival is directly dependent on the mycobionts of ectotrophic mycorrhizae. The dominant mycorrhizal fungi associated with *Fagus sylvatica* are Agaricomycetidae, a subclass of Basidiomycetes (Homobasidiomycetes) from the genera *Amanita, Boletus, Cortinarius, Inocybe, Laccaria, Lactarius, Tricholoma, Russula* and *Xerocomus*. Soil acidity plays an important role in relation to the species spectrum of the mycorrhizal partners of *Fagus sylvatica* (Dörfelt, 2008). Species typical of the beech include *Fomes fomentarius* (wood-inhabiting fungi), *Ganoderma applanatum* (wood decaying), *Neobulgaria pura, Oudemansiella mucida*, which is indicative of extensive matured wood pools, and *Hericium coralloides*, which, although widespread throughout the northern hemisphere and also growing on other trees, is only found in very old, mature beech forests. Dead beechwood is colonised very swiftly by very many lignocolous fungi. Three phases characterise decomposition of beech stups: initial, optimal and final phase. There are more than 10 parasitic biotrophic fungi which infect Europe´s beeches. A very large number of fungi are involved in the decomposition of fallen beech leaves, fruits, mast (cupulae) and twigs (Dörfelt, 2008). An especially important symbiosis has been evolved between fungi and plants in the rhizosphere, which is called mycorrhiza. Forests of the temperate zone are home to fungi that will enter into specific symbioses with one or few tree species (Britz et al., 2009).

Despite the beech´s absolute dominance, the beech forests show outstanding diversification and are unique in function and structure (Pichler et al., 2007a). Nortwithstanding the geologically short time of a few thousand years, a highly characteristic faunistic biocoenosis has been evolved postglacially which is just a globally unique as is the plant community. The fauna can exist in all its diversity, and the postglacial evolutionary processes can take place only if each forest development stage of the natural regeneration cycle is available – which is the case in the Primeval Beech Forests of the Carpathians (Pichler, 2007; Plachter et al., 2008).

**The Principles of Joint Management Plan**

Long-term protection and management of the World Heritage Sites is ensured through national legal protection as national parks or core areas of a biosphere reserve. Effective implementation of the integrated management plan and the trilateral integrated management system is required to guide the planning and management of this World Heritage Sites.

The general objectives of the Integrated Management Plan are (Pichler et al., 2007a):

- To ensure the most effective conservation of the WHS properties with all their abiotic and biotic components, geo- and biodiversity and ecological processes. To secure a lasting homeostasis and self-reproduction of the respective ecosystems and their protection both against anthropogenic factors.
- To maintain and expand the existing, ecologically connected complex of primeval and natural beech forests that encompass and connect (link) the WHS on both the Slovak and the Ukrainian sides – within the corridors connecting the WHS. Supporting the succession of managed beech semi-natural forests.
- To use WHS for scientific research in order acquire knowledge transferable and applicable on the level of sustainable. To use WHS for enhancement of landscape ecological stability.
- To use WHS for enhancement of ecological and environmental education, awareness of primeval forests – chosen to maintain integrity and conservation of the existing sites, to preserve their naturalness and uniqueness.
- To support of traditional crafts, products and ecotourism.

Common elements of an effective management system could include: a) a thoroughly shared understanding of the property by all stakeholders; b) a cycle of planning, implementation, monitoring, evaluation and feedback; c) the involvement of partners and stakeholders; d) the allocation of necessary resources; e) capacity-building; and f) an accountable, transparent description of how the management system functions.

**Conclusions**

Joint World Natural Heritage "The Primeval Beech Forests of the Carpathians and the Ancient Beech Forests of Germany" is indispensable to understanding the history and evolution of the genus *Fagus*, which, given its wide distribution in the Northern Hemisphere and its ecological importance, is globally significant. These undisturbed, complex temperate forests exhibit the

most complete and comprehensive ecological patterns and processes of pure stands of European beech across a variety of environmental conditions and represent all altitudinal zones from seashore up to the forest line in the mountains. Beech is one of the most important elements of forests in the Temperate Broad-leaf Forest Biome and represents an outstanding example of the re-colonisation and development of terrestrial ecosystems and communities after the last ice age, a process which is still ongoing. They represent key aspects of processes essential for the long term conservation of natural beech forests and illustrate how one single tree species came to absolute dominance across a variety of environmental parameters.

Furthermore, it is not enough for a site to meet the World Heritage criteria, but it must also meet the conditions of integrity and/or authenticity and must have an adequate protection and management system to ensure its safeguarding.

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