BfN-Skripten 297, 107–115, Bonn-Bad Godesberg

Beech forests in Hungary – their status and researches on their biological values

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Introduction

This paper provides a brief overview on Hungarian beech forests. It shortly describes the potential and actual area of beech forests, their history, management and conservation status. Examples of recent and ongoing researches on composition, structure and function of unmanaged reserves compared with managed stands are also shown. Then a few potential threats that Hungarian beech forests have to face are discussed.

General description of Hungarian beech forests

Hungary is located in a transition zone between humid and semiarid climates, hence continental forest-steppe and broadleaved deciduous forests are the two major zonal physiognomic vegetation types. The former occurs mainly in the Great Hungarian Plain, and in some Transdanubian lowlands. It is a spatially fine-grained mosaic of closed, dry grasslands and open forests dominated by pedunculate oak (*Quercus robur*). The mountains and lower hills in northern Hungary and Transdanubia belong to the climatic zone of closed deciduous forests, where the main zonal forest communities include the mixed oak forests dominated by sessile oak (*Quercus petraea*) and turkey oak (*Quercus cerris*) at lower elevations, mixed sessile oak – hornbeam (Carpinus betulus) forests at mid elevations, whereas beech (*Fagus sylvatica*) forests dominate the highest mountains in Hungary. The potential forest cover in the country is estimated as 85 % (including the zonal and the edaphic riparian forests, BARTHA 1995), however the actual forest cover decreased to 11.8% in 1920. Since then it has continuously grown up to 20.6% (MGSZH 2008).
Unfortunately, as a result of intensive human land use in the past millennia, both tree species composition and stand structure have changed dramatically even in the remaining forested area. As Table 1 shows, almost half of the forested area is covered by plantations of exotic tree species like locust tree (*Robinia pseudoacacia*) or poplar cultivars and different pine species (*Pinus nigra, P. sylvestris*). However, the magnitude of this anthropogenic modification shows a decreasing trend with elevation, which is illustrated by data on estimated habitat loss of major Hungarian forest communities: beech forests still thrive on roughly one third of their potential habitats, whereas almost 100% of lowland riverine forests and woodland of the forest-steppe zone are lost (data from BARTHA in STANDOVÁR 2006).

Table 1. Proportion of different tree species in Hungarian forests, based on the area occupied (MGSZH 2008). [1]Including mainly *Quercus robur, Q. petraea and Q. pubescens*; [2]Including mainly *Pinus sylvestris, Picea abies* and *Pinus nigra*.

Tree species	Proportion (%)
Oaks[1]	20.6
Turkey oak	11,3
Beech	6.0
Hornbeam	5.3
Conifers[2]	12.6
Robinia	23.2
Poplar clones	7.0

Most Hungarian beech forests belong to the *Asperulo-Fagetum* beech forests (9130, COUNCIL 1992), but *Luzulo-Fagetum* beech forests (9110, COUNCIL 1992) and Medio-European limestone beech forests of the *Cephalanthero-Fagion* (9150, COUNCIL 1992) also occur with low coverage. Phytogeoraphically the Hungarian beech forests create a transition between the Illyrian-Dinaric and the Pre-Carpathian beech forests (BOHN et al. 2004), there are many phytogeographically different phytosociological associations described from the country (*Eu-Fagenion: Aconito-Fagetum, Melittio-Fagetum, Daphno laureolae-Fagetum, Cyclamini purpurescentis-Fagetum; Cephalanthero-Fagenion: Fago-Ornetum, Seslerio hungaricae-Fagetum, Epipactio atrorubentis-Fagetum; Aremonio-Fagion: Vicio oroboidi-Fagetum, Helleboro odori-Fagetum, Doronico austrici-Fagetum, Leucojo verni-Fagetum*; BORHIDI 2003).

Although, present day beech forests are dominated by native tree species, the structure of the forest stands have been modified considerably by land use activities in the past and recent forest management. Similarly to West and Central Europe, practically all of the Hungarian forests were cut in the past (BARTHA and OROSZI 1995). Until the end of the XIX. century the utilization of beech wood was not solved for timber, while oak wood was very merchantable as timber for constructions and railway industry. Beech was used mainly as firewood, and many beech stands were exploited for potash, lime and charcoal production. The preferences of the wood market resulted, that in many potential beech forest sites oaks (mainly *Quercus petrea*, partly *Q. cerris*) were planted. Secondary forest usages, such as grazing or pannage (seasonal practice of feeding pigs on acorns), were also important, but their effects were more pronounced in the zone of oak forests. However, the remaining area occupied by beech forest has been mainly utilized as forest, i.e. other land use activities (arable field, meadow) had not been practiced, therefore the continuity of these forests is long, much longer than in Central and Western Europe.

For many decades the management of the Hungarian beech forests has mostly followed the uniform shelterwood system (DANSZKY 1973) resulting in more or less pure and even-aged subcompartments of 3-15 ha in size. Average rotation time is 80-120 yr. After the final cut, regeneration is mostly based on natural regeneration, but large regional differences can be found in the proportion of artificial regeneration. In the young (less than 30 yr old) stands cleaning (negative selection), while in older (30-90 yr) stands thinning (positive selection) activities assure the establishment of high quality timber. In this system the length of regeneration period in the old stands is 10-30 yr using two or three cuttings: preparatory cutting, seed cutting, removal cutting (final cutting). According to the present regulations, the forest authority can prescribe a maximum five percent of the timber retention. District and subcompartment scale forest management plans are produced by the Forestry Directorates of the Central Agricultural Offices (former State Forest Service) for each ten year period, which can assure sustained yield. 56.5% of the Hungarian forests are managed by the 22 state owned Forestry Enterprises, but this proportion is considerably higher in the case of beech forests (83.6%, MGSZH 2008). Considering primary function, only 36.2% of beech forest is dedicated to timber production, while the rest has other, mainly protection functions (nature conservation, soil protection), however in practice most of these stands are also managed by a similar shelterwood management system, though they occur in nature conservation areas, and/or Natura 2000 areas. Conservation measures are often limited to the prescription of longer rotation and regeneration period, higher proportion of tree retention, and of maximum size for cutting units, or temporal (seasonal) restrictions are given for forest operations. Real non-intervention policy is applied only in the core areas of forests reserves and in some strictly protected areas and in extreme sites (mainly very steep slopes). On the other hand, promising changes have taken place among both private forest owners and state forest enterprises towards the introduction of silvicultural techniques resulting in continuous forest cover on the long run. The reasons for this change are multiple: in addition to economic considerations (continuous production, absence of regeneration costs, higher proportion of high quality timber), the pressure from conservation and raising public awareness about the status of semi-natural forest all play a role. Pro Silva Hungaria – an NGO founded in 1999 by representatives of the forestry sector and a few ecologists – took the lead in this process (PRO SILVA 2000a,b, www.prosilva.hu).

In Hungary there are 63 Forest Reserve, representing the (best possible) natural references of different forest types.

The core area of the reserves – where all management activities are prohibited – is between 30-100 ha each (total 4786 ha - 0.26% of forest area, MGSZH 2008). The core area is surrounded by a buffer zone (total area 8393 ha, MGSZH 2008), where the management activities are limited (only "close to nature" forestry is allowed), however there are many examples where this rule was not followed. Forest reserves provide an opportunity to study and observe stand level natural processes of forest dynamics. Researches in forest reserves are carried out both by local research projects and by a national monitoring programme (HORVÁTH & BORHIDI 2002, www.erdorezervatum.hu). Because of the relatively good conservation status of the beech forest zone in the country, it is overrepresented in forest reserve network, 23 reserves occur in this zone. However, most of these reserves located in extreme forest sites (on steep slopes, deep valleys and ravines). Most of them were managed in the past, their history is very heterogeneous, however, many of them are without any intervention for decades, representing an old-growth forest structure.

Comparative studies of natural reference and managed stands

Hungarian beech forests were studied from many different aspects: growth, mortality and regeneration of trees (STANDOVÁR & KENDERES 2003); phytosociological description of associations (BORHIDI 2003); floristical and faunistical investigations; ecological demands of different organism groups, etc. In this short review we mainly show examples of comparative researches between natural reference and managed beech stands. Comparisons of stand structure, diversity and composition of different organism groups are in our focus.

There are two intensively studied forest reserves that served as reference sites in many studies. Kékes Forest Reserve is located on a steep north facing slope of the Mátra Mountains (North Hungarian Mountains), elevation ranges from 700 to 950 m, the bedrock is andesite. The size of the core area is 63 ha (including a young subcompartment of 15 hectare), which was never managed for timber production in the past (CZÁJLIK 2009). The other site is the Bükki Őserdő Forest Reserve located on the karstic plateau of the Bükk Mountains (North Hungarian Mountains), the range of elevation is between 800-900 m. It is a small stand (core area 25 ha) left for free development in the past 60 yr, the age of the dominant trees are 150-200 yr.

The stands structure was investigated in detail in the Kékes Forest Reserve and compared with surrounding managed stands of different ages with similar site conditions. In the reserve a heterogeneous structure could be observed, the tree size distribution followed a negative exponential function, where enormous number of regeneration (diameter at breast height 0-10 cm) and some extremely large trees (diameter at breast height larger than 100 cm) also occurred (GÁLHIDY 1999, STANDOVÁR et al. 2003). The size distribution of managed stands of different ages followed a more even, close to normal distribution. The regeneration showed a particular pattern (maximum of aggregation is circa 20 m) following the distribution of gaps (GÁLHIDY 1999). The proportion of gap area in the reserve was 5-7% (at any time during 30 yr of observation) their mean size was 100 m^2 (STANDOVÁR et al. 2003). A similar phenomenon was observed in the Bükki Őserdő Forest Reseve (MIHÓK et al. 2007, KENDERES et al. 2008). In these natural reference stands the amount of dead wood exceeded 100 m^3/ha, and the proportion of large logs (DBH > 40 cm) were overrepresented (ÓDOR & STANDOVÁR 2001, CHRISTENSEN et al. 2005). In managed stands the canopy was closed, and the amount of dead wood was low, mainly below 30 m^3/ha, also in the old stands the logs were thinner than 30 cm (ÓDOR & STANDOVÁR 2001).

The species richness of vascular plants is relatively low in beech forests, and compared to other vegetation types they are also poor in red listed and protected species. The differences between natural reference and managed stands are better expressed by the diversity measures reflecting richness in spatial patterns (STANDOVÁR 1998, STANDOVÁR et al. 2006). In the Kékes Forest Reserve these beta diversity measures (e.g. number of realised species combinations, spatial variance) were higher than in managed forests at all studied spatial scales and increased considerably with increasing sampling unit size. This different spatial response of herbs was closely connected to the differences in stand structure and related light pattern in natural versus managed stands. There were also considerable differences in the functional (plant trait) composition of herbs (KENDERES & STANDOVÁR 2003). In the reserve the following plant trait were overrepresented compared to managed stands: early flowering, short flowering duration, short life span of the leaves (from spring to autumn), large seed size, high plant height. These characteristics were adapted to more competitive, crowded, and resource rich conditions of gaps, while small seeded plants with little rosettes were more appropriate in spatially homogenous disturbances of managed stands.

Concerning bird assemblages, both their abundance and species richness was approximately two times higher in the Kékes Forest Reserve than in the surrounding old managed stands (BALCZÓ 2005). Especially, hole nesting birds preferred the more natural stands. These differences were explained by the higher amount of dead wood, especially large snags, and by the presence of large cavity trees in the reserve. Richness in dead wood caused by natural disturbances in the beech forests of the Börzsöny Mts. had significant effects on the occurrence of the protected white-backed woodpecker (SZEKERES 2010).

In contrast to vascular plants, the diversity of fungal assemblages in old-growth beech forest is extremely high, and they are peculiarly rich in saproxylic species. Investigating 200-200 dead beech logs in two Hungarian forest reserves (Kékes and Bükk Őserdő), 227 species were recorded, and the mean species richness of logs was 13 (ÓDOR et al. 2006). The proportion of species of conservation concern was 11%, much higher than in the reference stands in the Atlantic region (The Netherlands, Belgium). Comparing the fungi community of the Bükk Őserdő with an old managed beech stand, the number of saproxylic species was two times higher in the reserve, but it was poorer in mycorrhiza species (SILLER 1986).

In Hungary the zone of beech forest is important for the conservation of bryophytes. A considerable proportion of the Hungarian local populations of European endangered species occurred in beech dominated forests, mainly on shaded cliffs, dead logs or trunks (PAPP 2008). Although these are special microsites, the survival of these populations considerably depend on the natural status of the forests. The diversity of bryophyte communities was higher in the Kékes Forest Reserve than in the managed stands (ÓDOR & STANDOVÁR 2001). A key structural element for bryophyte diversity was the presence of dead wood, especially large logs. It created microhabitat for epixylic species, and the accumulation of woody debris could increase the bryophyte diversity of epilithic assemblages (ÓDOR & STANDOVÁR 2002). Similarly to other organism groups connected to dead wood, there was a clear succession in bryophyte assemblages during decay: the species composition of logs of different decay stages was unlike (ÓDOR & VAN HEES 2004). This means that dead wood continuity and the simultaneous presence of differently decayed logs considerably increase the stand level diversity of bryophytes. In Hungarian beech forest the occurrence of specialist epixylic bryophytes is limited not only by dead wood availability but also by climate. In deep valleys, ravines and north facing slopes the potential species pool of epixylic bryophytes is higher than in zonal stands.

In the framework of a project titled „Assessing forest naturalness in Hungary" (2001-2004) a survey was completed in 3000 subcompartments representative for Hungarian forests in terms of main forest community- and climate types. Stand scale naturalness values (between 0 to 100) were derived during a hierarchical process based on 51 indicators (observed in the field). Detailed description of the methods used for the field survey and calculations can be found in BARTHA et al. (2006) and at http://ramet.elte.hu/~ramet/project/termerd/index.htm.

From the many analyses here we show only two. Comparison of the average total naturalness of zonal forest community types supported the above mentioned trend, i.e. beech forests have the highest naturalness value (Table 2, BARTHA et al. 2005). A comparison was also made to test if the beech forests in different types of conservation areas had higher naturalness values then stands primarily used for timber production. As Figure 1 shows, there is no significant difference between the groups of stands studied (STANDOVÁR et al. 2005). This has important implications for the need to increase the conservation efforts in protected beech forest areas.

Table 2. Average total naturalness values of different zonal forest community types in Hungary (BARTHA et al. 2005).

Forest community type	Naturalness value (%)
beech forests	59.7
sessile oak – hornbeam forests	58.3
sessile oak – turkey oak forests	57.7
forest steppe woodlands	50.6

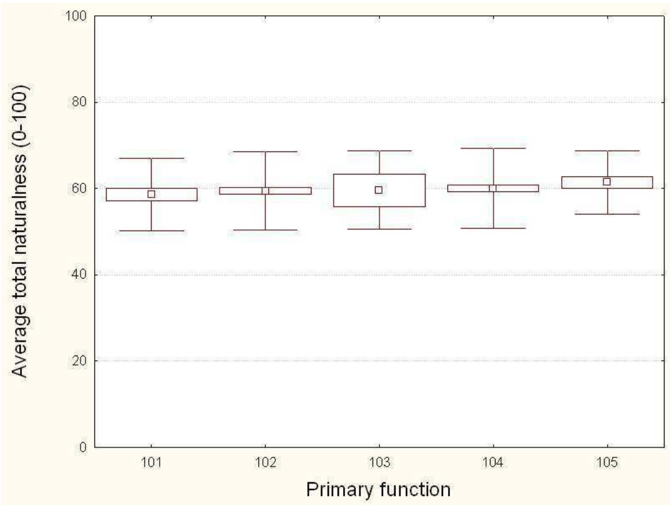

Fig. 1. Comparison of average naturalness of beech stands representing different primary functions. 101 – protection forest; 102 production forest; 103 - other, 104 – protected forest; 105 – strictly protected forest; Square - mean; box – standard error; whiskers – standard deviation (STANDOVÁR et al. 2005).

Potential threats of beech forests in Hungary

The potential area of beech forest is not continuous in Hungary, in eastern and central part of the country it is restricted to higher elevations and northfacing slopes of the mountains (hills), and the occurrence of this vegetation type is limited by climate (Fig. 2). It is supposed that beech forests are very sensitive to climate change, and based on different climate scenarios, its area will considerably decrease, and regionally disappear (GÁLHIDY et al. 2006). Especially, in the south-western part of the country, where beech forests occur at lower elevations (200-400 m) on gently slopes of the hills, considerable changes are expected. Forest management can buffer these changes by maintaining high tree species diversity in the stands, and by applying silvicultural regimes that support continuous forest cover.

In Hungary the climatic changes are expressed not only in the mean values of climate variables, but also in their higher within and between year variance, and the more common occurrences of disturbance events. In the Börzsöny mountains 4830 ha was hit by ice break in 1996 and a windstorm in 1999. The analysis of the sensitivity of forest stands to these events concluded, that relatively old, beech dominated stands occurring above 500 m a.s.l., on steep east facing slopes were the most sensitive to these disturbances (KENDERES et al. 2007). A practical consequence of these events and investigations, was that the local forest management tried to increase the structural heterogeneity of the sensitive beech stands introducing a group selection cutting system that maintain a continuous forest cover.

A major threat to the regeneration and conservation of Hungarian forests is caused by the very high density of browsing game species. Between 1960 and 2010 the estimated number of roe deer and red dear increased 5.5 times, while this increment was 12.8 times in the case of wild boar (Fig. 3). This high game density is a potential obstacle against the introduction and widespread application of more nature-based forestry techniques by impeding natural regeneration.

Nowadays, there are five power plants in Hungary that use biomass as primary energy resource, and a considerable part of this biomass is wood. The present biomass plantations can not fulfil the firewood demands, which lead to the utilization of native tree species (e.g. oak and beech) as biomass. Although forestry plans prohibit the overexploitation of native forests by assuring sustained yield of timber, however this economic driving force prevents the application of higher levels of live and dead tree retention, which could be very important from a conservation viewpoint.

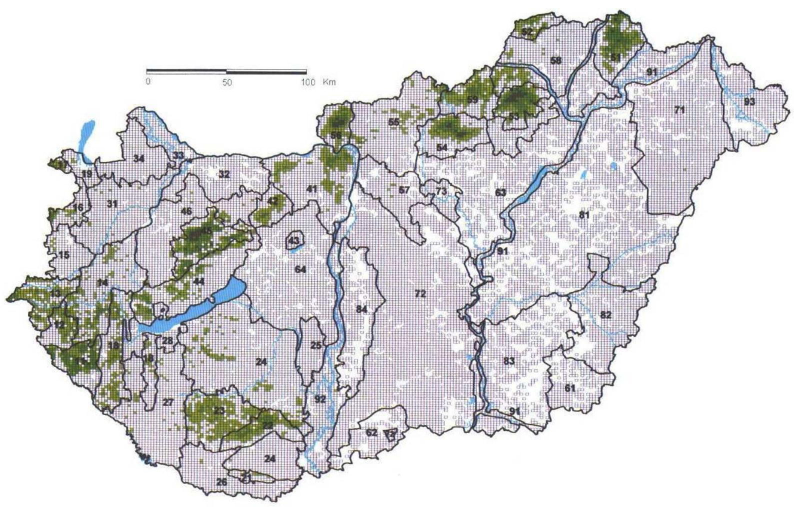

Fig. 2. Distribution of beech in Hungary (MGSZH 2008).

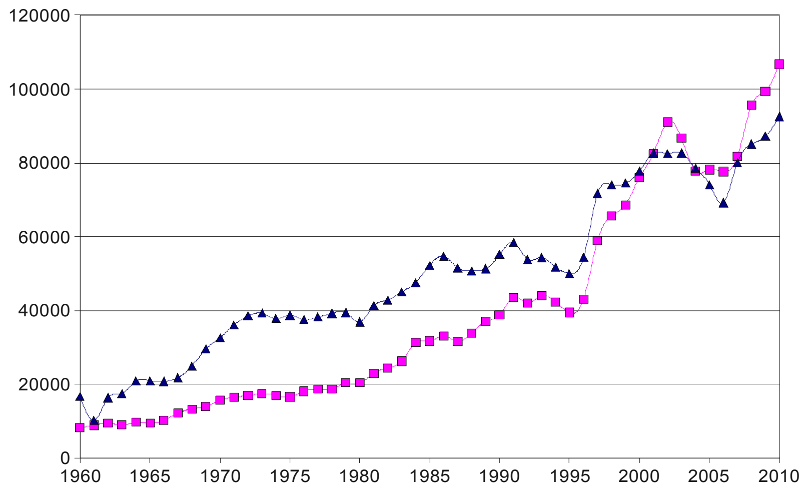

Fig. 3. Estimated population size of different game species in Hungary between 1960-2010 (National Game Management Database, www.vvt.gau.hu). Triangle: roe deer, square: wild boar.

Summary

This paper gives a briefly overview on the distribution, history, management and conservation status of Hungarian beech forests, mentions some research activities focusing on the comparison of natural reference and managed beech stands and emphasizes some potential threats of beech forests in Hungary.

The forest cover is 20% in Hungary, the proportion of beech is 6% in Hungarian forests. As a result of long history of forest use in Hungary, we have practically no virgin forest remnants, however the still existing forests in the beech zone can be characterised by almost unbroken forest continuity. The beech forests are managed mainly by state owned companies using a shelterwood management system.

The stand structure is more heterogeneous, and the amount of dead wood is higher in natural reference stands than in managed ones. The pattern (beta) diversity of herb layer is more sensitive to stand structural differences than its species richness. The distribution of plant traits also differed between natural and managed stands. In case of birds both abundance, species richness and the proportion of hole nesting species were higher in natural reserves. Both in fungi and bryophyte assemblages quantity and quality of dead wood is a key of biodiversity, resulting considerable differences between reserves and managed sites. Assessments of stand scale forest naturalness showed proved that beech forests are the least transformed in the country, but also showed that conservation measure are insufficient in creating protected forests with higher naturalness values than those of production forests.

Nowadays the major threats of Hungarian beech forest are the climatic changes, the high density of games, and the increasing demand for wood as biomass.

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Acknowledgements

This study was supported by the Hungarian Science Foundation (OTKA NI68218, K79158) and the János Bolyai Scholarship of the Hungarian Academy of Sciences.

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