

THE INVENTORY STATE AND ASSESSMENT OF HUNGARY'S NATURAL HABITATS IN TERMS OF ECOSYSTEM SERVICES



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**Ferenc Horváth*, Zsolt Molnár, Bálint Czúcz, Katalin Mázsa,
Borbála Balázs, Gábor Ónodi, Miklós Kertész**

Institute of Ecology and Botany of the Hungarian Academy of Sciences

2163 Vácrátót, Alkotmány út 2-4.

*E-mail: horvfe@botanika.hu

1. Introduction

In 2006 humanity's ecological footprint was 1.4 times larger than the current carrying capacity of Earth. Our footprint in the beginning of the 1960's was only the area of 0.6 Earth, but for the last 50 years it has been constantly rising, indicating the alarming trend of consumption. Hungary's index, like that of every other country in Europe, is also higher than 1; in 2006 it was 1.25 (*Ewing et al. 2009*). Humanity's living conditions and the production of world economy inseparably depend on the natural renewal capability (maintenance), and the functioning of ecosystems (*MEA 2005*). The overuse of the living natural environment's ecosystem services means an increasing threat to human well-being at both global and local scale. Their maintenance and the protection of their functioning capability is a vital question, and not only in terms of nature conservation.

The facilities of different regions, countries and lands are very diverse (*Kocsis and Schweitzer 2011; Pásztor et al. 2010*). The pattern of ecosystems and their utilisation are not uniformly distributed. From this point of view the results of program MÉTA provide new and fundamental knowledge about the country's ecological state (*Molnár et al. 2009*).

The objectives of program MÉTA (Landscape Ecological Vegetation Mapping of Hungary) are:

- comprehensive assessment of the current state and patterns of natural, semi-natural vegetation of Hungary,
- understanding the land use and risk factors, which determine the state and survival of vegetation,
- scientific assessment of our heritage of natural, semi-natural vegetation,
- developing our landscape ecological approach and knowledge.

With this new, comprehensive information, the maintenance of ecosystems and optimal, more conscientious land use patterns becomes possible. We could also stand to gain protection of our natural heritage and its value. In this study, we provide views of the inventory of our vegetation, and we examine the possible use of ecological knowledge in landscapes by evaluating ecosystem services nation-wide. We broadly present local examples, illustrate the concept of relationships between land use, habitats, and ecosystem services and present two long-term research programmes that give a perspective on a more accurate evaluation of ecosystem services.

2. Land use and ecosystem services

The condition and functioning of ecosystems –the quality and quantity of services they provide – basically depends on the ecological characteristics of landscape, and on the extent and nature of land use. Figure 1. shows general trends of relations between land use and ecosystem services. Extensive use of the landscape changes the functioning of different services, what leads to higher total value for human population. Intensive land use (primarily market-farming) alters the general nature of the landscape to high-level supplying services, while other services of agroecosystems dramatically relapse (*Braat and Ten Brink 2008*). Building-up an area, severely reduces the level of services, since maintaining cities, towns and human infrastructure is very costly, and usually at the expense of near-natural areas and rural services. Several different compromises and aspects of optimization are possible in land use: in space and/or time; private landowner and/or community point of view (*EASAC 2009*).

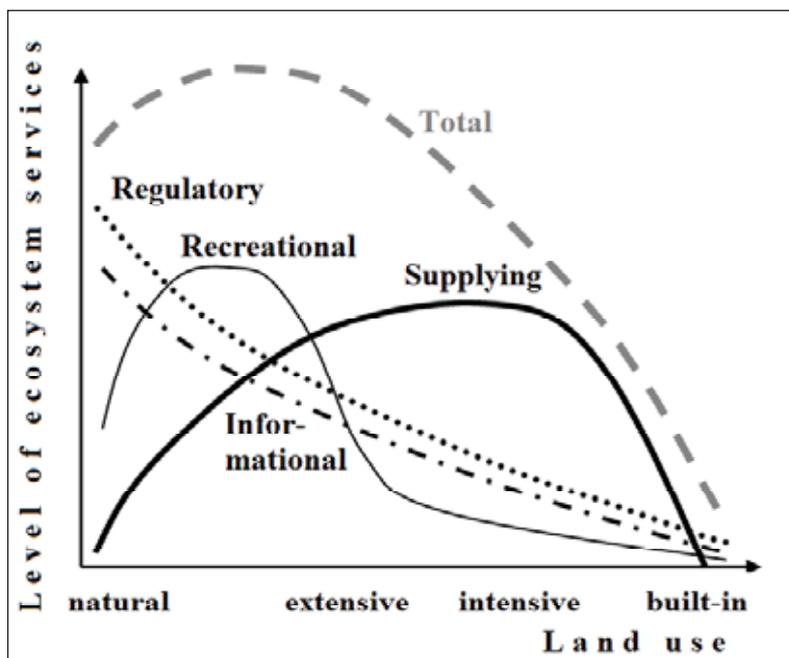


Figure 1: Rate and run of the main types of ecosystem services in the light of land use intensity (based on Braat and Ten Brink 2008).

3. The inventory of Hungary's natural habitats, their conditions and landscape patterns

Program MÉTA provides data primarily about natural, near-natural or extensively used lands, but since the landscape pattern and the pattern of land use are patchy and mosaic, a large area of the country is affected directly. 62% of the units covered by Program MÉTA (Bölöni et al. 2007, Molnár et al. 2007) still consists remnants of vegetation, while 38% of them are covered only by plantations, agricultural, industrial or urbanized lands. In their area with radius of 335 metres nothing has remained from original ecosystems (Horváth et al. 2008).

In terms of our vegetational heritage we distinguish 86 habitat types (Bölöni et al. 2007) that we classify into 18 habitat groups (Molnár et al. 2008). Since these groups can be interpreted easily as ecosystem-types, their nationally aggregated extents have been chosen as a basis of the inventory. For reviewing the status of the habitats we use naturalness and the Natural Capital Index (NCI_{lin}), which is especially capable to be an universal, quantitative indicator of different regulatory ecosystem services (such as carbon sequestration, soil forming, micro-climate developing, or maintaining the populations of natural enemies, regulators of agricultural pests) (Czúcz et al. 2008; Czúcz et al. 2011). The landscape patterns are introduced on maps.

3.1. National inventory of habitat groups

In Hungary, based on the survey of program MÉTA, the total area of natural, near-natural and degraded vegetation is about 1 800 000 hectares, and it covers 19.4% of the country (www.novenyzetiterkep.hu – national data). Within that, 1 200 000 hectares show the characteristics of the near-natural vegetation, 600 000 hectares were degraded featureless by the recent changes. The present vegetational heritage of Hungary is seriously degraded in 17.3%, and 46.8% of the national territory is intermediately degraded, 32.6% is near-natural, only 3.3% of it is natural (Bölöni et al. 2008). Besides the loss of a part of habitats, and the deterioration of the remainings (loss in the stock of species, degradation in the composition of species and the structure of associations) contributed to the decay of natural heritage. Concerning all these effects on one stock, we express it by the vegetation-based Natural Capital Index (NCI_{lin}), which is currently 9.9%. It means that, only 1/10 of the natural ecosystems

Habitat groups (Á-NÉR 2003 codes)	Extent in the country (hectare)	Natural Capital Index (%)
Euhydrophyte habitats (A1 - A5)	9 730	0.07
Marshes (B1 - B6, BA)	117 170	0.74
Flushes, transition mires and raised bogs (C1, C23)	14	0.00
Rich fens, eu- and mesotrophic meadows & tall herb communities (D1 - D6)	100 670	0.59
Colline and montane hay meadows, acid grasslands and heaths (E1 - E5)	29 330	0.16
Halophytic habitats (F1 - F5)	202 060	1.30
Dry open grasslands (G1 - G3)	11 970	0.07
Dry and semi-dry closed grasslands (H1 - H5)	95 820	0.52
Non-ruderal, pioneer habitats (I1 - I4)	380	0.00
Shrublands (J1a, J3, P2a-b, M6 - M8)	70 200	0.37
Riverine and swamp woodlands (J1b, J2, J4 - J6)	66 220	0.40
Mesic deciduous forests (K1a, K2, K5, K7a-b)	346 740	2.17
Closed deciduous woodlands (L1, L2a-b,x L4a-b, L5)	204 690	1.21
Rocky woodlands (LY1 - LY4)	8 600	0.06
Open steppe (oak) woodlands (M1 - M5)	6 050	0.04
Coniferous mixed woodlands (N13, N2)	1 320	0.01
Other, non-woody habitats (OA, OB, OC)	265 240	1.06
Other woodlands and woody habitats (RA, RB, RC, RD, P45, P7)	263 800	1.13
TOTAL	1 800 000	9,9

Table 1: Inventory of Hungary's habitat-groups, based on program MÉTA's results: their estimated extension in the country, and their percental contribution to the national Natural Capital Index (NCI_{lin})

once covered the country has remained. In a functional point of view, we lost 90% of the capacity of regulating ecosystem services (while the supply service of agricultural ecosystems is high). The total extent of habitat groups in Hungary and the value of Natural Capital Index (NCl_{lin}) they represent are summarized in Table 1.

The numbers of Table 1 show that the highest Natural Capital values belong to the mesic deciduous forests (2.17%), the halophytic habitats (1.3%) and the light-rich, closed deciduous woodlands (1.21%) – because of their extent and their more natural status. We can find (about 529 000 hectares) degraded habitats (categories like: other, non-woody habitats; other woodlands and woody habitats) on very large areas, their average naturalness is lower, and because of this, they give an important, but still lower proportion of natural capital (1.06% and 1.13%).

3.2. Inventory and status of landscape vegetation

The landscape pattern is also an important feature of vegetation. For reviewing this, Király et al. (2008), partially based on the results of MÉTA database, compiled Hungary's vegetational landscape. However, MÉTA database is not only suitable for comparing a priori-defined landscapes, but also for separating independent landscapes, and for marking vegetation-based landscape borders. Csaba Molnár and his colleagues divided the country into 95 areas, in terms of natural vegetation, most uniform „vegetation-based landscape regions” (Molnár Cs. et al. 2008). For introducing the vegetation heritage of these landscape regions, we made a summary, (in the form of a map) of near-natural vegetation and Natural Capital Index per landscape (Figure 2, 3).

As we can see in Figure 2, especially the forested parts of our mountains, and the larger grasslands and wetlands of Hortobágy are covered with vegetation, while the larger regions of Alföld and Kisalföld (and the foothill zone of the northern mountains) lost almost completely their near-natural character. The least vegetation cover (lower than 5%) can be found at Érmellék, Hegyalja, Győr – Tata terrace region and Igmánd – Kisbér plain, Mosoni plain, Felső-Bácska, Hajdúság and Mezőföld regions, where the value of NCI is only about 1-2% (Figure 3). Coverage exceeds 50% only in landscape units of summits, North-Börzsöny, Visegrád Hills, Vértes and Gerecse, South-Vértes and the South-Bakony. Natural Capital Index exceeds 30% in each of the case in these landscape units. Otherwise, that index was higher than 40% only in case of summits (51%) and North-Börzsöny (42%).

Figure 2: Average vegetation cover of our vegetation-based landscape regions.

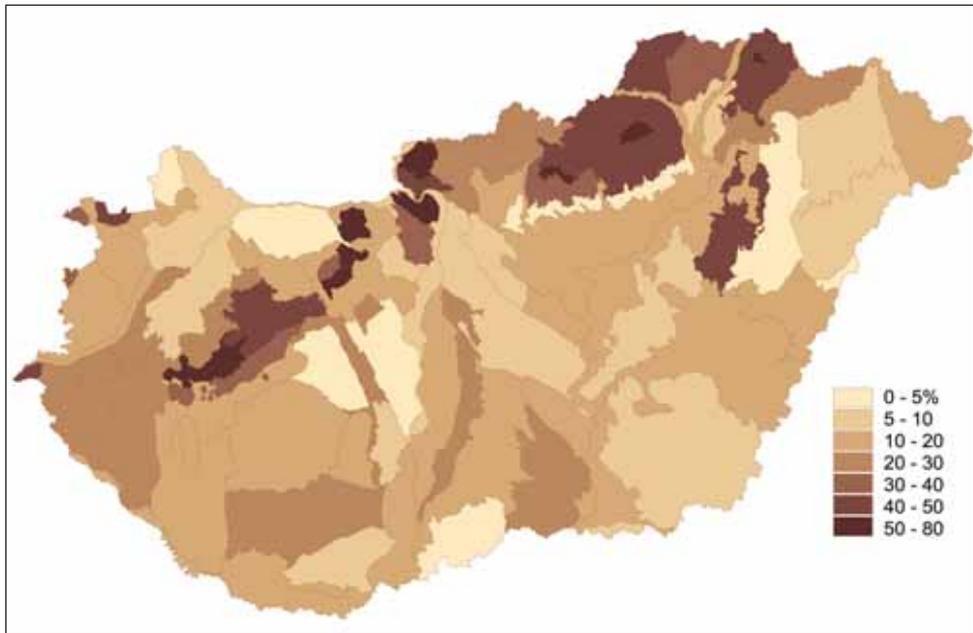


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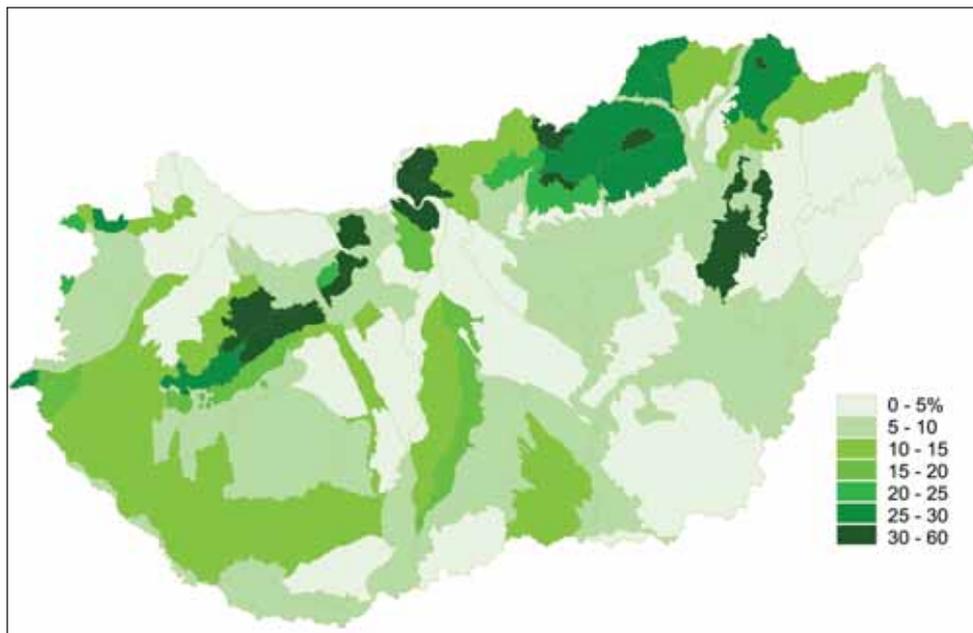


Figure 3: Natural Capital Index of our vegetation-based landscape regions.

3.3. Examples for the main types of land use

Below we list some typical examples of the main categories of land use from Figure 1.

- A near-natural landscape, Bükk-plateau – The vegetation is mainly dominated by mountain beech forests. Diverse rock forests have formed on the rocky ridges. On the southern rock formations open rocky grasslands and steppes are dominant. Planted coniferous woods are significant in scope (spruce mainly). As a result of century-old traditional land use and human activity (hay making) extensive, rare species-rich mountain meadows have been preserved. The number of plant species is between 1000-1200; the number of protected plants is more than 120; the number of invasive species is very low, and their role is not significant (*Vojtkó 2008*).
- An extensively used landscape, Bugac region – This is a cultivated sandy landscape, its level of modification is varying, and its farm culture is declining. Its vegetation cover is small or medium, natural or semi-natural. Poplar woods, oak woodlands, and sandy grasslands can be considered as the remains of the former forest steppe woodlands. Between the arable fields, orchards and abandoned areas, *Molinia* meadows, high reed beds, tussock sedge communities are lying in the low-lying parts mosaic of wet meadows with the occasional fragments of surviving willow swamps, swamp forests, salt lakes, dense and tall *Puccinellia* swards, salt marshes, and meadows. Many rare and unique species enrich the flora. The total number of plant species varies between 600-800; number of protected plants is between 80-100. Invasive weeds spread mostly in secondary sandy habitats and disturbed wetlands; their number is high and their effect on these ecosystems is significant (*Vidéki and Máté 2008*).
- An intensive agricultural farming utilized land, Bácska Loess Plain – Due to its excellent soil, this is a mostly plowed and intensively farmed landscape. On the sandy margins, significant areas are covered by species-poor fallows and plantation forests of mostly alien species. The remaining fragments of natural vegetation are determined by the transitions of different proportions of loess and sand. Many of the salt

lakes have been drained, their basin is filled with salt meadows. The annual salt pioneer swards have mostly remained in their natural state. The previously dominant loess grasslands, except for one or two remnants, are pushed back to the basin-walls of former salt lakes and to the balks between the arable lands. Only a little stock of the forest-steppe meadows and the vegetation of loess-walls remained, continental deciduous steppe-thickets are almost completely gone. The original sand vegetation has been almost completely eliminated. Only little bits of *Molinia* marsh meadows have remained. The vegetation of brooks and the marsh meadows supporting them are generally in a favorable natural condition. Infections of invasive species are primarily significant in sandy areas; the regenerative capacity of the landscape is weak, except for the aquatic or halophytic habitats. In addition, the number of plant species is quite high, namely between 800 and 1000, however, the number of protected species is low varying between 20 and 40. The number of invasive species is high, and their impact is sometimes significant (*Csathó 2008*).

- A heavily built-up landscape, Vác–Pesti Duna plain – The largest part of the landscape is dominated by agricultural areas, plantations, planted forests, sand- and gravel mines, and towns or different buildings – primarily in Budapest and in its agglomeration zone. Natural or near-natural vegetation remains only in a small part (5-6%). A significant part of the landscape is floodplain, and although the pioneer vegetation of the reefs, and the entire river zonation (mostly willow, soft wood- and hardwood groves) are present, there are only fragments remaining of the latter. Willows and poplars are in a better state, but they are degraded in many places, and in other places they have been replaced by cultivated poplars. At the edges of the groves we find floodplain meadows, marsh meadows, and rarely moorlands. In the small branch of the Danube, islands with natural state have developed. In some areas, fragments of opened sand grasslands and closed steppe grasslands can be found. Sometimes sandy oak woodland inclusions can be detected between black locust, pine and poplar plantings. The estimated number of the remained plant species is between 400 and 600, number of protected plants varies between 40 and 60, the number of invasive species is high, and their effect is significant (*Csomós 2008*).

4. Habitats or ecosystems?

Both habitat and ecosystem approaches have their own justification. Although our approaches are different, usually we talk about the same things, from a different perspective. Habitats, according to Fekete et al. (1997) can only be interpreted in terms of organism or a group of organisms, and separate classification could be created for each organism. The National Habitat Classification System used in program MÉTA was formed according to plant associations appearing at similar or at same conditions (*Á-NÉR, Fekete et al. 1997; Bölöni et al. 2003; Bölöni et al. 2007*). In the ecosystem-based approach, function of these systems (flow of mass and energy, production) is under consideration, but the diversity of species that build up and operate the system is pushed into the background. It is rather difficult to capture „natural entity”, which has a temporary and undefinable nature. Operational units are used, like in habitat mapping (*Takács and Molnár 2009*), or land cover mapping and classification (*Büttner et al. 2001*). For determining of operational units, it is very beneficial if they can be „put together” by aggregating well-defined components. For example, the ecological footprint-calculations are linked to a very broad range of land use types (agricultural cultivated fields, pastures, fishing areas, forest management areas, built-up areas). To determine them, databases working with more detailed categories are used (*Ewing et al. 2009*). In case of Hungary, for example, the CORINE Land Cover database (*Büttner et al. 2001*) or the Kreybig Soil Information System (*Szabó et al. 2007*) databases are used.

Well-documented and broadly applied habitat classification system, and the MÉTA database that appropriately describes the landscape conditions, provide sound bases for the development of an operational ecosystem-classification. Another advantage of this approach is that it establishes a connection between ecosystems, populations and habitats. As in case of each habitat categories we know well the flora and fauna communities building up them, and site requirements (*Babos 1954; Borhidi 2003; Bölöni et al. 2003; Fekete and Varga 2006*).

5. Case studies

If we would like to get a more accurate picture related of the functioning of ecosystems – and of ecosystem services – estimating and measuring basic operating parameters are needed. We are aware of many similar tests and their results (*Jakucs 1985; Précsényi 1970, 1975; Stefanovits et al. 1981*). Here we give a report about two currently running programs, which have results that can be integrated into the conception of understanding ecosystem services.

5.1. The relation between production and diversity of vegetation in a diverse area of Kiskunság

As part of Kiskun LTER (*Kovács-Láng et al. 2008*), there is a 3x3 km research area, mostly belonging to Kiskunság National Park's Orgoványi Meadows. Here they run a monitoring process to follow the production and diversity, especially with regard to the relationship between weather and production (*Kertész and Ónodi 2008*). The main challenge of the investigations is the diversity and mosaic pattern of the area. From poplar-juniper woodlands, through abandoned farm sites to marsh and reed beds almost every kind of habitat can be found at the site, which is typical in case of Kiskunság Sand Ridge. Therefore, a combination of different sampling methods is necessary to conduct landscape-level estimations.

The monitoring began in 1999, with the preparation of an overview map of the site, which was clarified in 2002. The field sampling began in 2000, and the complex sampling method had formulated by 2003. As a result of the monitoring, we can give an annual estimation of the underground and aboveground biomass of more important habitats, and of the Leaf Area Index (LAI). For the estimation, we create a calibrational database for each species with specific leaf area measurement, form yearly 30-35 cut turf samples. Besides, we estimate Normalized Difference Vegetation Index (NDVI) annually on about 120 points with multispectral measurements. In woodland habitats we measure leafage cover on about 60 points with LAI2000 instrument to estimate LAI directly. Based on the measurement data, we create annually an estimation for the underground and aboveground plant biomass and LAI of different land use types, and then assign them to the patches of the habitat map. In addition, in

2004, a representative sampling of plants was carried out in the area in 106 4x4 m quadrats, where we recorded the species, visually estimated the cover of different plant species, and measured leaf area with LAI2000 instrument. As a result, we have a good overview of several ecosystem properties' pattern. As an illustration, we present the 2008 pattern of one of the defining elements of production, the Leaf Area Index (Figure 4).



Figure 4: Leaf Area Index of KISKUN LTER's Orgovány research area in 2008.

Primary production is one of the most notable index of ecosystem services (MEA 2005). Biodiversity, and the species composition - examined by us - have important, but at the same time controversial role at the forming of ecosystems. The diversity is definitely big in case of a low-production opened grassland, while on the meadows with high production it is not larger (Kertész et al. 2008); and in the forests and reed beds it is lower. This is in contrast with the general expectations of the literature, according to which the diversity's maximum should be around the maximum of production (Abrams 1995). The contradiction could be explained by the fact that meadows and wet meadows with potentially larger diversity have been placed into production more times before. The soil preparation has reduced the micro-heterogeneity of the area, and the repetitive regenerations have lead to species compositions less and less rich.

The plantations consist of mainly alien trees. They greatly contribute to production, but it is well-known that they impoverish and degrade the original habitat. Among these species especially the wood and honey serving black locust (*Robinia pseudoacacia*) and the dense (and so successfully planted) black pines (*Pinus nigra*) (Biró 2008) can be found, which in turn increase the fire danger also for the surrounding natural vegetation (Kertész et al. 2011). The abandoned sandy arable lands can be well characterized with the invasion of honey serving milkweed (Szitár and Török 2008). Despite its high production, this species greatly slows down, almost blocks the regeneration, and threatens the surrounding natural vegetation with further invasion.

Examples show that, biodiversity itself can not determine the possible level of ecosystem services, and at the same time that some introduced species play a prominent role. The greatest value of this varied land is diversity in terms of ecological services. The main interest of nature protection and of broader social environment is that this diversity continues to be maintained.

5.2. Calculating the biomass and modelling the carbon turnover of near-natural forests

Original or natural („old-growth”) forests free from tree cuttings and from other forest use practices contribute significantly to the reduction of greenhouse gases in the atmosphere due to in their unbalanced carbon turnover. In addition, they hold and extract more carbon dioxide from the atmosphere than the intensively managed forests under same circumstances (Luyssaert et al. 2008). Therefore, natural or near-natural forested lands have a great importance in terms of climate change. Today, habitats like these are hardly found in Hungary (a known exception at Czajlik 2009). However, there are reserves of these forests excluded from farming, that are becoming increasingly natural and can serve as good references of the old forests (Horváth et al. 2001; Bartha and Esztó 2001; Somogyi 2002). In this study, we report the case of a forest reserve's biomass and carbon storage capacity.

We conducted our research at South-Bükk, at the 96 ha core area of Felsőtárkány's Vár-hegy forest reserve, where high variety of oak-dominated woods occur, from downy oak woodlands (*Cotino-Quercetum*), through turkey oak (sessile oak and oak), hornbeam habitats to beech forests. Between 2005 and 2009 we surveyed the habitat structure at 406 permanent sampling points of the so called FOREST+n+e+t, stand dynamic and forest ecological observa

tion system (Horváth et al. 2005). In the results we describe the mix ratio and size relations of trees, the volume of living and dead woods. In addition, we revealed the history and age relations of the forest, delineated stands considered as homogeneous units (Mázsa et al. 2008). For the 28 stand patches, we defined tree cohorts based on mixture proportions, size and age relationships. Their development and the volume stored in the forests were calculated with CO2FIX model (Schelhaas et al. 2004; Balázs et al. 2008). On the whole research area the aboveground biomass was averaged as 186 ± 67 tC/hectare (N = 28). The estimated biomass volume for the shrub-dominated low forest was 148 ± 13 tC/hectare (N = 4), the average of turkey-oak – sessile oak woodlands was 188 ± 70 tC/hectare (N = 3), the hornbeam - oak stands showed 228 ± 67 tC/hectare in volume (N = 12).

6. Future perspectives

- A) By the program and database of MÉTA we got an exact documentation and a summarizing inventory of Hungary's near-natural habitat types, their range, quality and pattern. By ecological-based grouping of habitat classes, ecosystem-types can be determined.
- B) Basic plant species inventory of each habitat can be put together based on phytosociological data and evaluation of experts. By this we can make an important step towards understanding the biodiversity characteristics of ecosystem types.
- C) A good method is to use well-characterized indicators for capturing the different types of ecosystem services. One indicator we suggest is the vegetation based Natural Capital Index (NCI_{lin}), for proper description of the extent of regulatory ecosystem services. Another one is net primary production index for provisioning services. Developing further indicators of ecosystem services could open new perspectives.
- D) Thematic classification of ecosystem types and ecosystem services provide a framework for deeper understanding of the two types – functional and structural context – approaches. A contingency table of „types” and „services”, and within it firstly, its qualitative filling and understanding by experts should be our short-term goal (using, and reinterpreting the results of already existing and earlier tests), then our long-term goal could be to quantify elements of the framework system (the contingency table's blocks), based on further investigations.

7. Literature

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