LANDSCAPES

Péter Csorba, Szilvia Ádám, Zsombor Bartos-Elekes, Teodóra Bata, Ákos Bede-Fazekas, Bálint Czúcz, Péter Csima, Gábor Csüllög, Nándor Fodor, Sándor Frisnyák, Gergely Horváth, Gábor Illés, Gábor Kiss, Károly Kocsis, László Kollányi, Éva Konkoly-Gyuró, Nikolett Lepesi, Dénes Lóczy, Ákos Malatinszky, Gábor Mezősi, Gábor Mikesy, Zsolt Molnár, László Pásztor, Imelda Somodi, Sándor Szegedi, Péter Szilassi, László Tamás, Ágnes Tirászi, Mária Vasvári

Landscape research is a geographical discipline aiming at synthesis. The geographical landscape is a complex phenomenon determined by several physical and human factors. Also in Hungary landscape study has been dominated for a long time by the purely physical geographical approach dating back to the works of Alexander von Humboldt. Today, however, cultural landscapes are addressed which function and appear as joint products of physical potentials and the societal transformation of the environment 1. In the present conception the landscape is a detail of the Earth's surface which is distinct in appearance and functioning from neighbouring areas (landscapes); it is a functional unit the natural operation of which is influenced and, at the same time, participated by human society. Human action has become the foremost driver of landscape evolution and in many cases, for instance, in urban areas, human impact is now functionally and visually decisive. Modern landscape research primarily focuses on the issue to what extent societal use is in harmony with the potentials of the landscape modified by humans, particularly in the case of landscapes sensitive to change.

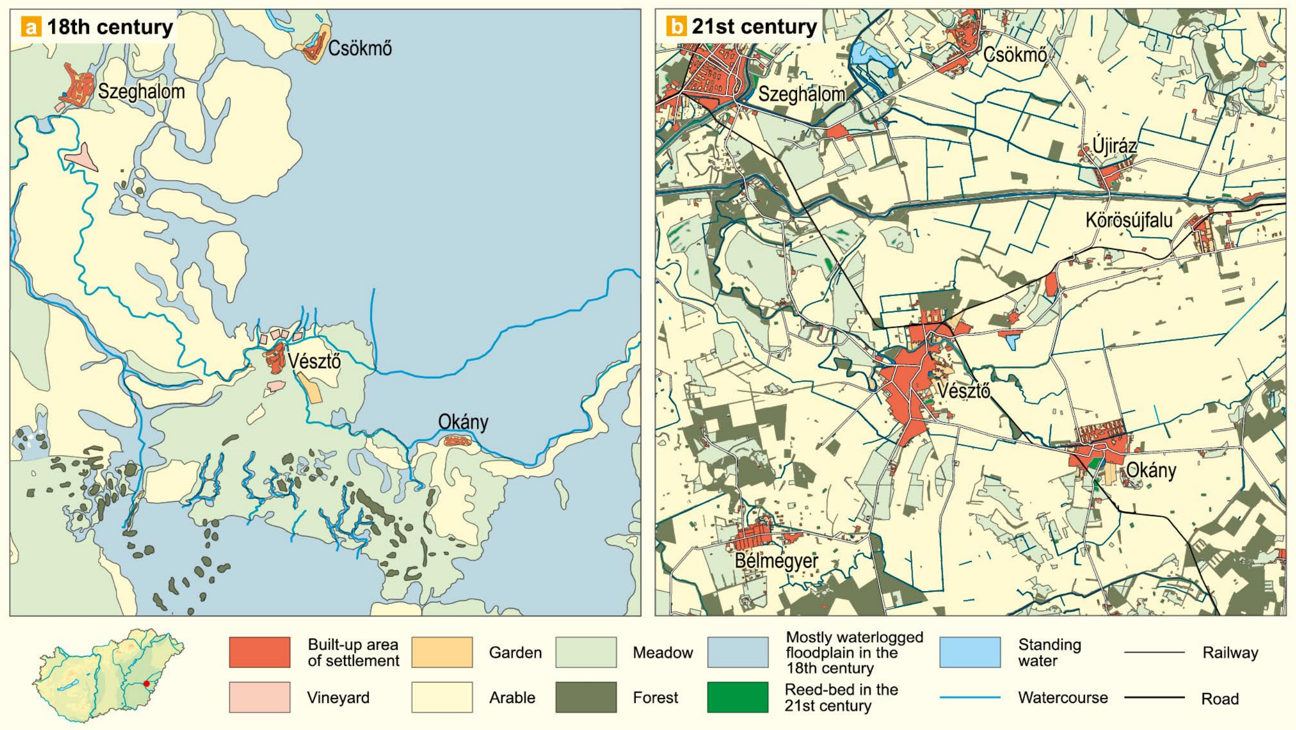
1 The most common type of Hungarian cultural landscape with mixed arable land use in the Hernád Valley (near Boldogkőváralja)

The texts and maps of the chapter on landscape geography touch upon the intricate interrelationships among geology, relief, drainage, soils, biota and landscape history as well as human impact.

Historical landscape types in the Carpathian Basin from the 11th to the 16th centuries

In the Carpathian Basin the first major landscape transformation took place in the Neolithic. Another such period is associated with the people engaged in crop cultivation in the Alföld (Great Hungarian Plain) and in many places the Romans also exerted a lasting impact on the environment. During the Hungarian Conquest the lowlands and hills in the central parts of the Basin were first populated. The Hungarians preferred flood-free natural levees and the margins of loess or blown-sand covered alluvial fans. The occupation of the mountain frame had not been completed before the end of the 13th century. Fords on major rivers and the meeting points of landscapes of different character were favoured or, as it is often expressed, had 'local energies'. At such sites market places of regional goods exchange emerged and were followed by administrative and ecclesiastical centres. They are the core areas of cultural landscapes. An example is the environs of Szeged at the confluence of Tisza and Maros Rivers.

1 LANDSCAPE CHANGE IN THE WESTERN KIS-SÁRRÉT BASED ON THE COMPARISON OF LAND USE IN THE LATE 18th AND EARLY 21st CENTURY



Until the end of the Middle Ages landscape pattern had shown an organic development. The exploitation mode and rate of natural resources did not yet threaten the ecological basis of landscape utilisation. Late medieval evolution was distorted by the Ottoman occupation in the 16–17th centuries, when the population was forced to change land use. Fundamental alterations in landscape utilisation were driven by the modernization of agriculture since the second half of the 18th century, river regulations in the 19th century, industrialization, urbanization and the development of the railway network. A good example is landscape evolution in the Kis-Sárrét region 1.

By the nature and intensity of landscape utilisation, the historical landscape types typical of the Carpathian Basin 2 can be characterized in the following way.

I. Natural conditions – no enduring intervention happened

(1) *Alpine zone, subalpine meadows above the timberline*. The upper limit of coniferous forests was located at 1,500 m in the northern section of the mountain frame (in the Tatras), at 1,600 m in the eastern mountains (Maramureş, Gurghiu/Görgény, Vrancea/Háromszék Mts.) and at 1,800 m in the south (e.g. Făgăraş and Retezat Mts.). Above the treeline (at summer shelters of farms in the valley) humans settled sparsely and only temporarily. Even with complete economic utilisation by the end of medieval times, the landscapes remained in natural conditions.

II. Mostly natural conditions – weak, point-like interventions into the landscape

(2) *Medium-height mountain zone between 1,000 m altitude and the timberline; closed mountain oak, beech and coniferous forests*. This zone was utilised by the sparse population through mountain grazing, forestry, in the valleys and basins through fodder cultivation as well as mining and metallurgy. In the huge woodlands mining centres emerged at large distances from one another, for instance, in the Štiavnica, Slovak Ore Mountains (Slovenské rudohorie) and Metaliferi Mountains in Transylvania.

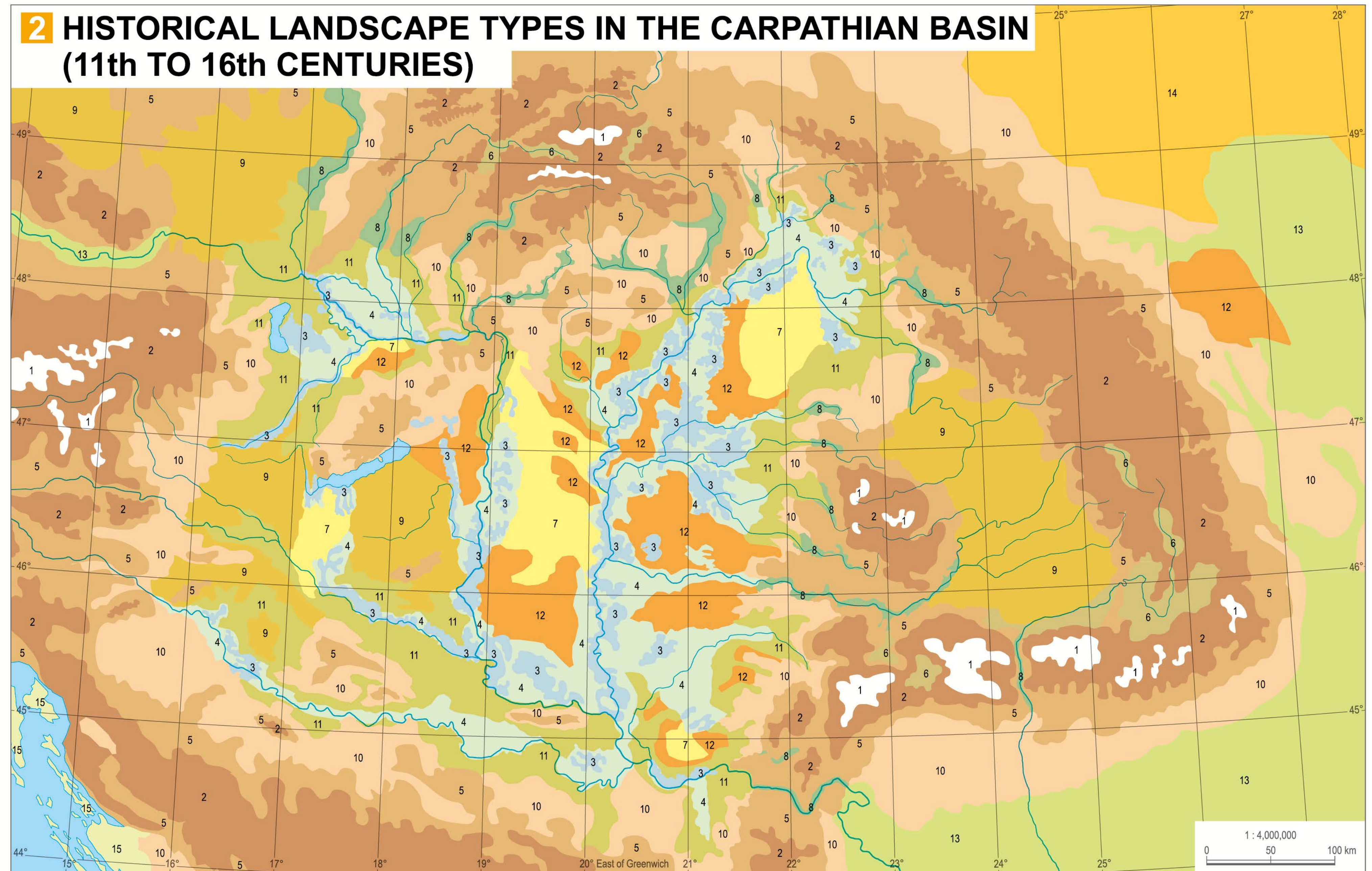
III. Mostly close-to-natural conditions – landscape utilisation in equilibrium with natural changes in the environment

(3) *Low floodplains, bogs and swamps with frequent waterlogging, sparse human settlement on floodplain margins*. The lowland sections of the Danube, Tisza and the major tributaries were accompanied by bogs and swamps in 60–70 km width, e.g. in the Szigetköz, Bodrogköz, Taktaköz, Kis- and Nagy-Sárrét regions. In these low floodplains and waterlogged areas fishery, hunting, gathering and reed and tree-cutting were the main occupations 2.

(4) *High floodplains, floodplain forests, meadows, saline areas with waterlogging and flood-free natural levees suitable for human settlement and crop cultivation; small sand islands and floodplain economy also extending to bogs and swamps*. The Hungarians settled in large numbers both on the outer margins of and on terrains rising above floodplains. Animal husbandry was founded on the animal feeds of grasslands and forests and since the early Árpád Age (11th century)

2 The Bodrogköz region at Zalkod. During the Hungarian Conquest the low and high floodplain surfaces along rivers were occupied first

2 HISTORICAL LANDSCAPE TYPES IN THE CARPATHIAN BASIN (11th TO 16th CENTURIES)



I. LANDSCAPE IN NATURAL CONDITIONS
- 1 Alpine zone, subalpine meadows above the timberline

II. LANDSCAPE IN MOSTLY NATURAL CONDITIONS
- 2 Medium-height mountain zone between 1,000 m altitude and the timberline

III. LANDSCAPE IN MOSTLY CLOSE-TO-NATURAL CONDITIONS
- 3 Low floodplains, bogs and swamps with frequent waterlogging
- 4 High floodplains, floodplain forests, meadows, saline areas with waterlogging and flood-free natural levees

IV. CULTURAL LANDSCAPE OF PATCHY PATTERN
- 5 Low, heavily dissected medium-height mountains, mostly with closed oak forests
- 6 Basins enclosed by mountain frames
- 7 Alluvial fan plains of blown sand with sand pusztas, sand oak forests

V. PARTIAL CULTURAL LANDSCAPE
- 8 Intermountain, mostly terraced river valleys with waterlogged meadows
- 9 Independent hilly regions in basins
- 10 Hilly regions on mountain margins and between mountains

VI. EXTENSIVE CULTURAL LANDSCAPE
- 11 Partially forested areas on lowland margin with elevated alluvial fans
- 12 Loess-mantled alluvial fan plains with loess pusztas and loess oak forests

OTHER GENERAL LANDSCAPE TYPES OUTSIDE THE CARPATHIANS
- 13 Fluvial plains, river valleys
- 14 Uplands
- 15 Coastal plains and marine islands

it was linked with cultivation, floodplain vineyard and orchard economy, fishing and hunting. This kind of economy was in balance with the environment and only involved minor changes in the long-term conditions of the landscape.

IV. Cultural landscape of patchy pattern – sporadic land utilisation

(5) *Low, heavily dissected medium-height mountains, mostly with closed oak forests*. In the Middle Ages isolated and sporadic settlements existed on the mountain margins, in broader sections of river and stream valleys as well as in small basins. Along with animal husbandry and forestry, crop cultivation was subordinate.

(6) *Basins enclosed by mountain frames*. In the continuous forests human settlement typically concentrated on the clearances of basin margins. In spite of their higher (600–800 m) elevation and cool climate, the major intra-Carpathian basins (e.g. the Spiš, Maramureş, Ciuc/Csík and Braşov/Brassó Basins) among mountain ranges were occupied early. Mixed farming with low yields occupied the banks of rivers and tributaries following the axes of basins.

(7) *Alluvial fan plains of blown sand with sand pusztas, sand oak forests*. This type represented sparse settlement, extensive grazing and subordinately field cultivation and horticulture (e.g. Kiskunság, Nyírség, Deliblato Sands and others).

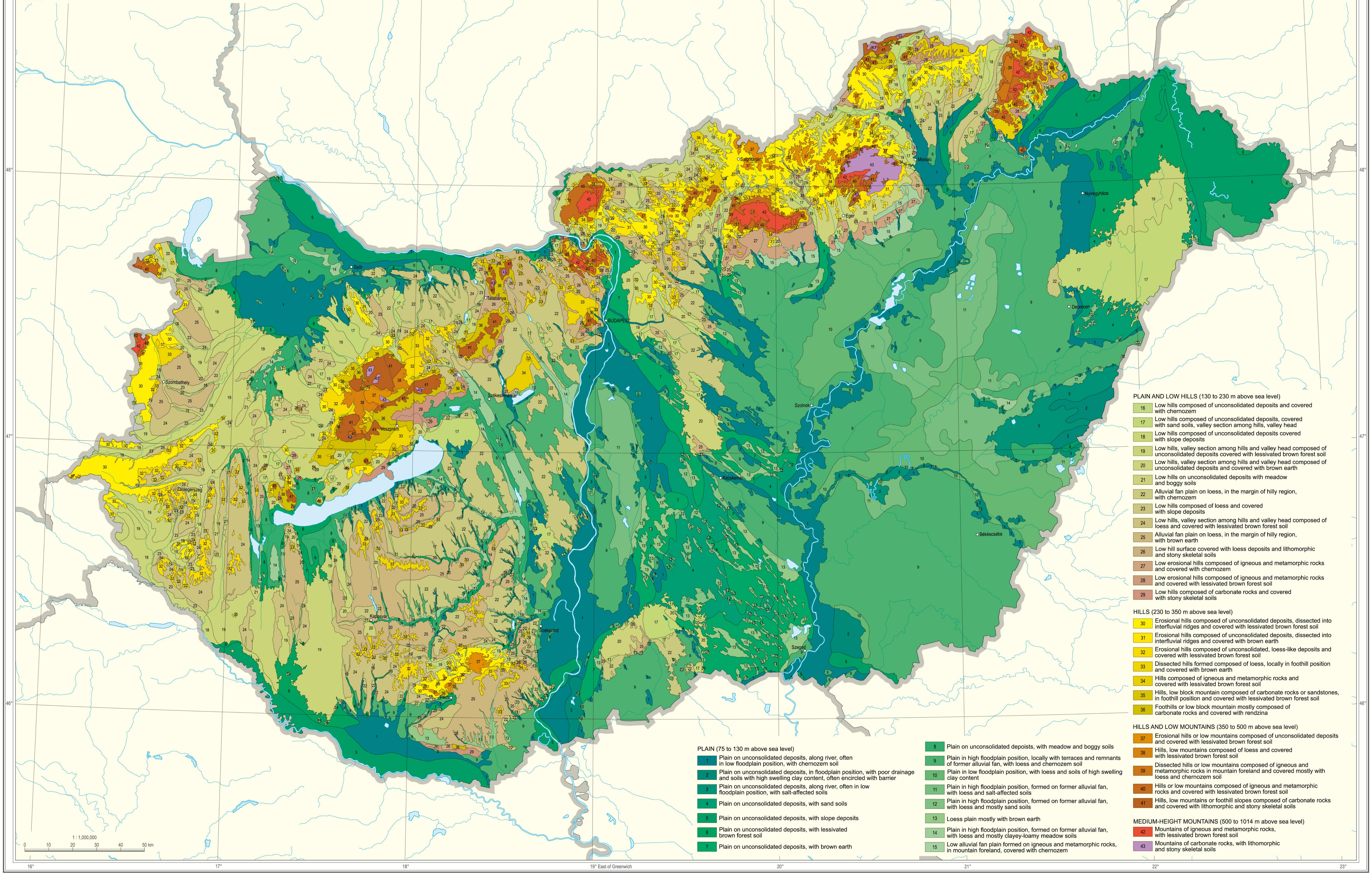
V. Partial cultural landscape – land utilisation concentrated in valleys with enduring characteristics of a cultural landscape

Little Ice Age in Europe

Climate shows centennial fluctuations between optima of favourable climate and unfavourable cold spells. In Europe the last irregularity was the Little Ice Age (LIA) between the 14th and 18th centuries. In centuries preceding the previous turn of the millennium, due to favourable climatic conditions, the population of Europe increased to about 80 million people. Agriculture took maximum advantage of technological progress to serve this population. The delicate equilibrium was easily upset by even a minor alteration in climate. It was first in the 1310s that cool and wet summers caused a serious nutritional crisis in Western Europe and, after a short break, another 'time of the lean kine' followed in the 1340s. Between 1347 and 1353 masses of the undernourished people fell victim to epidemics of the plague. Because the marine ports as foci of infection were remote, the settlement network was sparse and climate probably less extreme, the Carpathian Basin was not seriously affected by the epidemics.

In Hungary extremely cold winters and hot summers began to become common only in the early 16th century and an unambiguous turning-point can be dated to the 1560s. The consequence was that the inhabitants of the Alföld managed to survive the first decades of the Ottoman Occupation with minor losses of life. To the divided country the demographic disaster came later, between 1580 and 1610. The growing season got shorter and famine became almost permanent. Viniculture declined, rivers were frozen over in every five or six years. Spells with more favourable climate only followed a century later, but even then LIA returned for decades. Meteorological observations, which started at that time, indicate that the last years with extremities were recorded between 1810 and 1850, when mean temperatures in March were low and July precipitations very high.

3 GENETIC LANDSCAPE TYPES



©Geographical Institute, MTA CSFK www.nationalatlas.hu, Budapest, 2018

X.

(8) *Intermountain, mostly terraced river valleys with waterlogged meadows.* Waterlogged meadows, riparian willow and poplar forests, further away elm, ash and oak forests on valley floors served animal grazing, while flood-free terraces, valley sides and foothill surfaces were the terrains of human settlement and arable farming. The valleys were also of decisive importance as routes of transport, particularly those of the Váh (Vág), Hron (Garam), Sajó (Slaná), Hernád (Hornád) as well as of the Szamos (Someș), Maros (Mureș) and Olt.

3 Dissected loess hills with brown earth (landscape type 33, 3). Hills along the Koppány Stream near Somogyacsa

(9) *Independent hilly regions in basins.* In the Transdanubian Range 3, the Transylvanian Plateau the elevations in basin margins were covered by closed (oak) forests and in the valleys mosaical land use developed. The forests on hill summits and interfluvial ridges were also included in the complex operational system of farms. Human settlements emerged in broad terraced valleys, arable fields on terraces and footslopes, while meadows and pastures with subordinate forestry were located on valley floors.

(10) *Hilly regions on mountain margins and between mountains.* In the broader valley entrances human settlement was concentrated and centres of the settlement network emerged. The patches of cultural landscape around valley settlements were not yet interconnected. Land use types were arranged in stripes along valleys and physico-geographical boundaries. Where conditions were suitable, viniculture, demanding considerable landscaping, was practised (e.g. in the Balaton Uplands, Bükkalja, Tokaj-Hegyalja and others).

VI. *Extensive cultural landscape – landscapes of flood-free loess areas and inner basin margins with dense drainage and fertile soils*

(11) *Partially forested areas in lowland margin with elevated alluvial fans.* In such landscapes, including, for instance, the Rábaköz, Tápió Region and the Borsodi-Mezőség dense settlement networks developed and arable farming with animal husbandry was common. Grasslands and clearances were converted into extensive cultural landscapes. In early medieval times a water management system with the purpose of flood control, drainage of excess water and irrigation was established in the Rábaköz.

(12) *Loess-mantled alluvial fan plains with loess pusztas and loess oak forest.* The dense population of these regions, among them the Mezőföld, the Bácska (Bačka) Plain, the Titel loess plateau, the Hajdúhát and the Körös–Maros Midland, turned loess pusztas and loess oak forests into arable fields with corn cultivation as early as the end of the 13th century.

Landscape typology and landscape character analysis

Aimed at the classification of landscapes by function, utilisation or visual appearance, typology is central to landscape geography. Although no two landscapes are perfectly identical in pattern and appearance, there is some degree of kinship in these aspects (pattern, utilisation and appearance) among the individual landscapes. Types can be formed employing several factors: primarily relief and vegetation cover (indirectly soil).

There is no internationally accepted standard method for landscape typology. Like the German, Danish or Dutch approaches, previous Hungarian experimental typology was based on geomorphology (landforms) coupled with land use and the hydrological properties of soils.

Landscape types according to the origin of the surface

The map of genetic landscape types of Hungary 3 is based on three factors: relief (elevation above sea level), surface rocks (lithology), and the prevailing soil type 4. The relief classes were created using the statistical method of 'natural knickpoints'. Information on surface rocks derived from the AGROTOPO database, while soil data were imported from the WRB classification (see chapter on *Soils* 4 7) through merging its elements. On the overlays of the maps edited on the basis of the above factors 44 types (of at least 1 ha area) could be identified 3.

Landscape types according to function

When classifying landscapes by their function, also three factors were considered: relief and surface rocks (as above) and, as a third, soil moisture regime 5. Following the above technique of typology, the types produced through the overlay of maps are indicated by colours and three-digit codes on the map:

- the first digit refers to relief class in Table 4;
- the second digit marks surface rock class in Table 4;
- the third digit shows the class of soil moisture regime in Table 5

The functional typology of landscapes is illustrated by a detail of the map of Szekszárd Hills 6 4.

4 A GENETIC SYSTEM OF LANDSCAPE TYPES

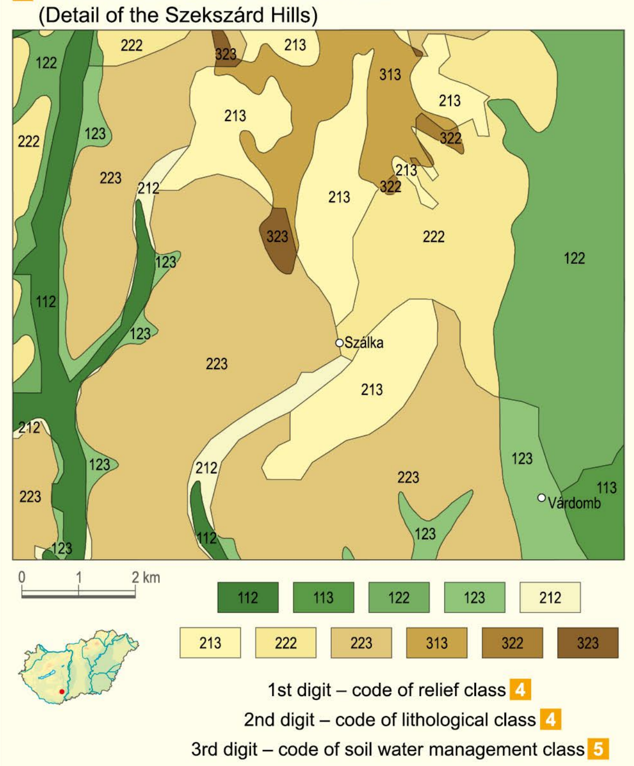
Landscape factors	Classes	
Relief (elevation above sea level)	1	<130 m
	2	131–230 m
	3	231–350 m
	4	351–500 m
	5	>501 m
Surface rocks (lithology)	1	Alluvial deposits
	2	Loess deposits
	3	Slate, phyllite, granite, porphyrite, andesite, basalt, rhyolite
	4	Limestone, dolomite, sandstone
Soil (WRB soil types)	1	Chernozem, phaeozem
	2	Vertisol
	3	Solonchak, solonetz
	4	Arenosol
	5	Fluvisol
	6	Luvisol
	7	Cambisol
	8	Gleysol
	9	Leptosol

5 CLASSIFICATION OF SOILS BY MOISTURE REGIME

1	Soils with poor water retention
2	Soils with good water retention
3	Soils with medium infiltration capacity and hydraulic conductivity
4	Soils with unfavourable moisture regime
5	Soils with extremely unfavourable moisture regime

4 The Szekszárd Hills near Szálka. The reservoir represents landscape type no. 212 and the neighbouring hills no. 223 6

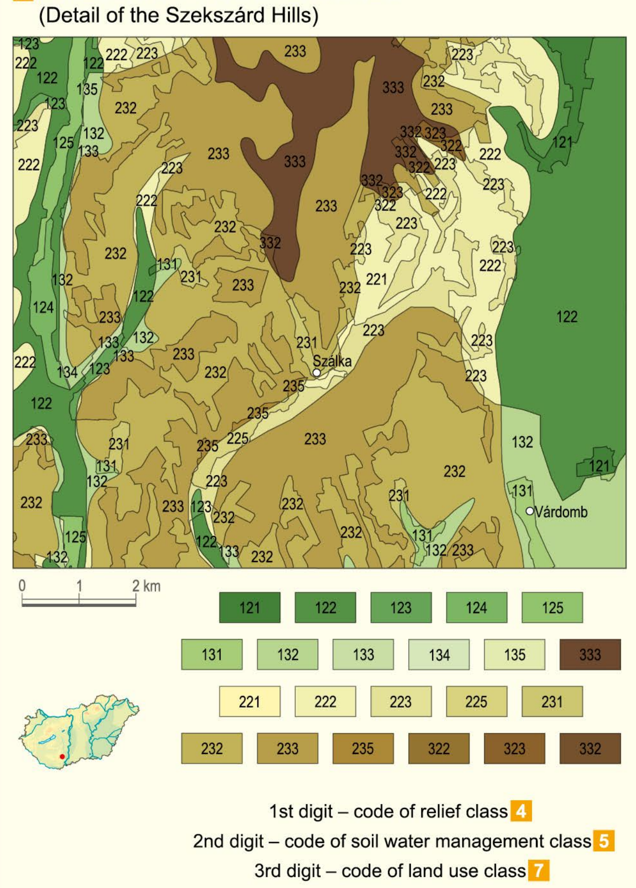
6 FUNCTIONAL LANDSCAPE TYPES (Detail of the Szekszárd Hills)



7 CLASSIFICATION OF THE TERRAIN BY LAND USE

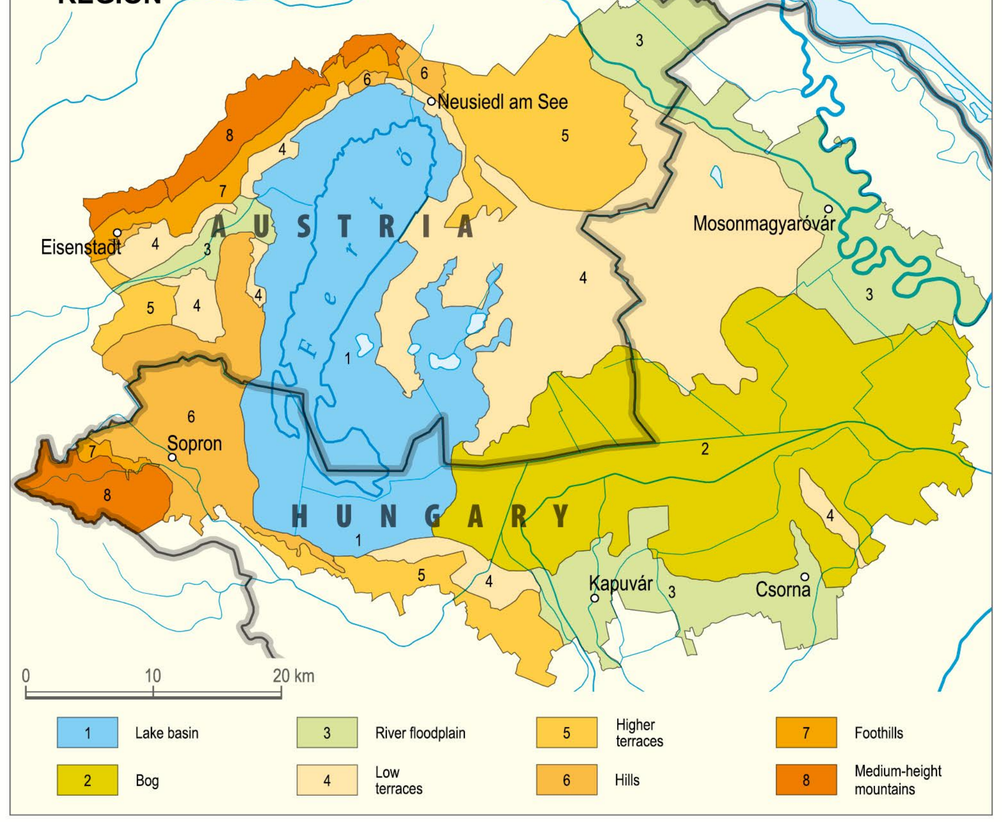
1	Artificial surfaces
2	Agricultural areas
3	Forests and close-to-natural areas
4	Waterlogged areas
5	Water surfaces

8 LANDSCAPE TYPES BY LAND USE (Detail of the Szekszárd Hills)

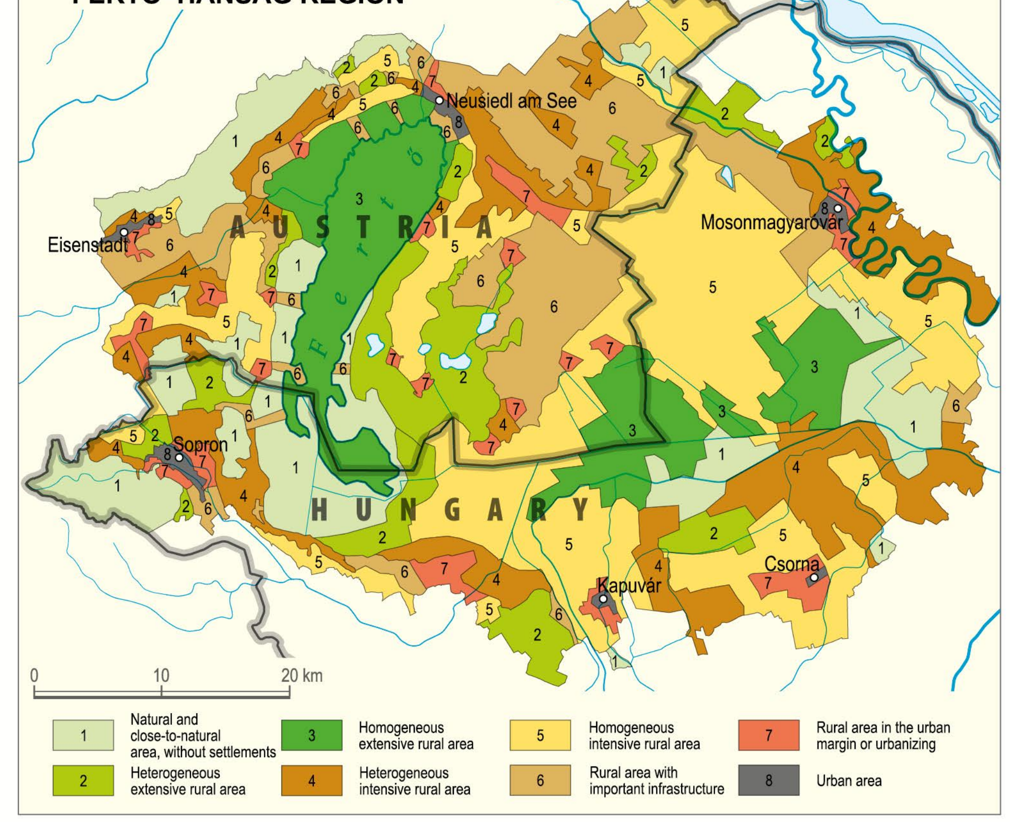


Landscape types according to land use

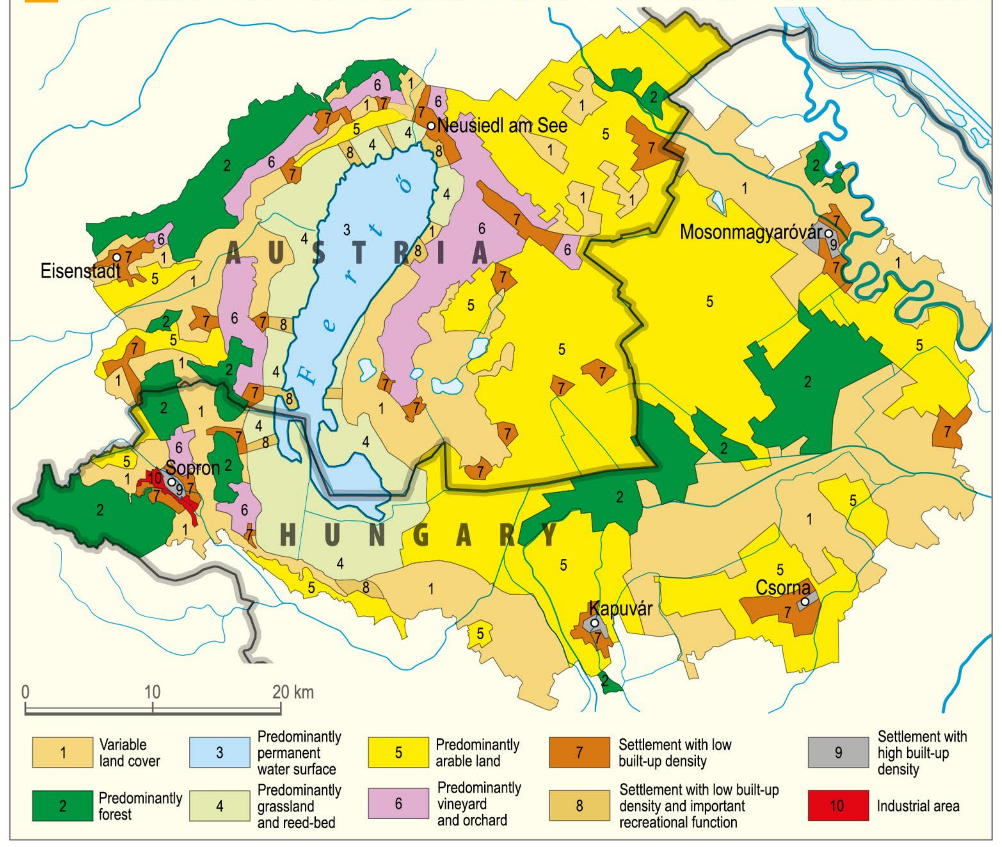
In the classification of landscapes according to land use, two of the three factors considered were the same as above: relief and soil moisture regime with land use type added 7. The types derived from map



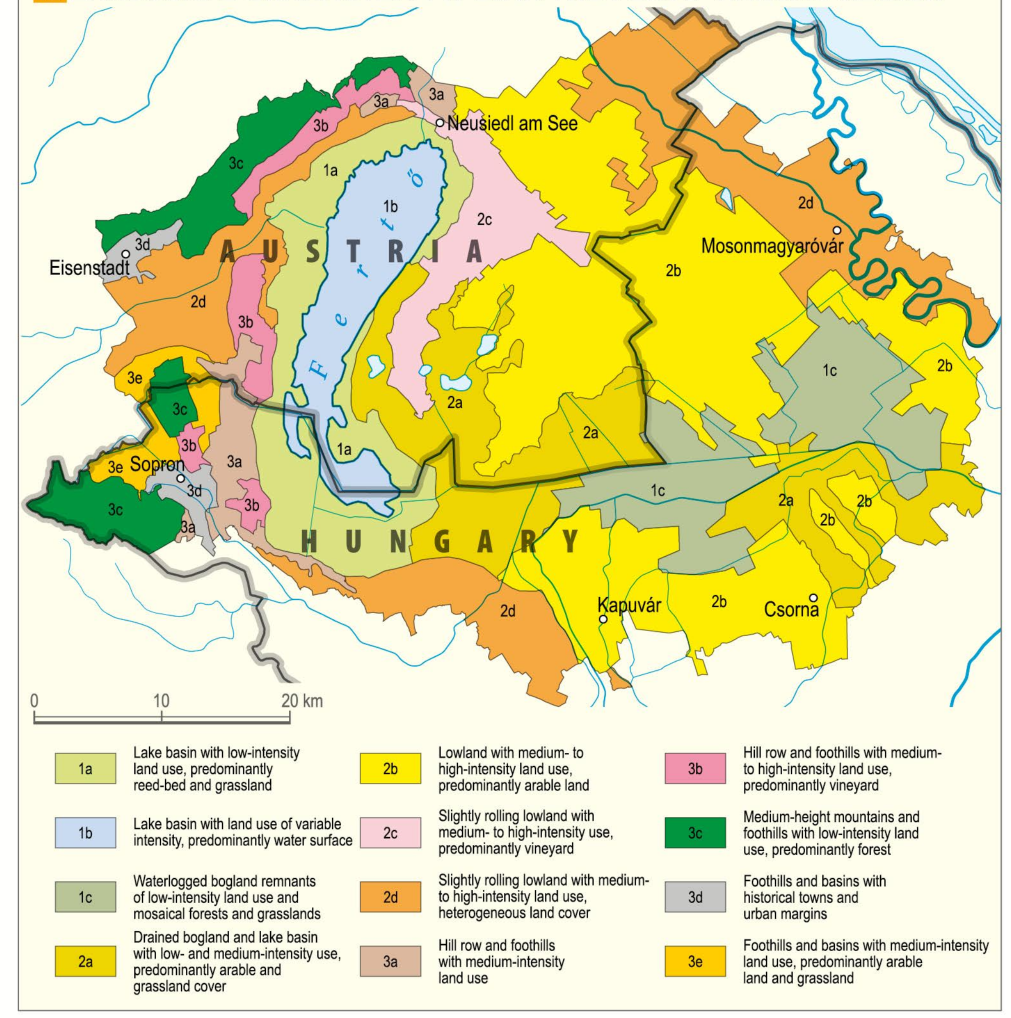
9 MORPHOLOGICAL TYPES OF LANDSCAPES IN THE FERTŐ–HANSÁG REGION



10 ANTHROPOGENIC CHARACTER OF LANDSCAPES IN THE FERTŐ–HANSÁG REGION



11 LAND COVER OF THE LANDSCAPES OF THE FERTŐ–HANSÁG REGION



12 LANDSCAPE CHARACTER TYPES IN THE FERTŐ–HANSÁG REGION

overlay are also shown in this map with colours and three-digit codes:

- the first digit refers to relief class in Table 4;
- the second digit marks the class of soil moisture regime as identified in Table 5;
- the third digit shows land use class according to Table 7.

To demonstrate landscape types by land use the same detail of the map of the Szekszárd Hills is presented 8.

Recently, the utilisation of the landscape has become an important criterion of typology. If in analysis we focus on the origin of the landscape, the indicators outline a general trend in the evolution of the physical environment. If landscape functioning is emphasized, typology based on landscape history promotes country planning, the recognition of land use conflicts, relief transformation and water management. Landscape typology of aesthetic or land use approach can be useful for landscape planning and tourism.

Landscape character analysis

In the last decades of the 20th century, along with traditional physico-geographical landscape delineation and description, demand arose for the identification of landscape character and its methodology was elaborated. The approval of the European Landscape Convention – to which Hungary joined in 2008 – accelerated this process. In the formulation of the Convention: '*Landscape* means an area, as *perceived by people*, whose character is the result of the action and interaction of natural and/or human factors.' A novelty in methodology was the inclusion of visual characteristics into the investigation. Landscape character is the result of a particular combination of natural and anthropogenic elements. For humans it represents a level of organisation higher than that of habitats, i.e. the landscape, which is an organic entity. Landscape character is not merely functional-territorial unit, but the impact of human culture superimposed on the basement of the assemblage of natural elements. It also reflects human identity.

In the method of landscape character analysis (LCA) Alexander von Humboldt's pursuit of synthesis – 'Totalcharacter einer Erdgegend' – is rediscovered. The character of the landscape is determined by an organic fabric, special combination and pattern of landscape factors (landforms, drainage, soils, vegetation cover, settlement and road networks). LCA involves both objective (measurable) and subjective (sensible) information. It was in the United Kingdom that natural science (quantitative) and aesthetic (qualitative) characteristics could be first linked within a national survey.

Landscape character types in the Fertő–Hanság region

Since the peace treaties at the end of World War I, the Fertő–Hanság Basin and the Sopron region is divided by the Austrian–Hungarian border. After establishing the border, due to contrasting political and economic drivers, the evolution of these landscapes of similar physico-geographical conditions took different directions in Austria and Hungary (especially after 1955).

For LCA three complex indicators, suitable to identify individual character, were designed:

- relief types: an indicator which combines relief and geological conditions 9;
- anthropogenic character: a comprehensive indicator of the intensity of human impact and its manifestation in landscape pattern 10;

5 *The lowest lying, reed-covered section of the Fertő (Neusiedler See) Basin and the lakeshore zone with the mosaic of grasslands and arable fields*

6 *Open water surface of Lake Fertő (Neusiedler See) with decisively recreational use*

• land cover factor: presence or absence of a prevailing land cover 11.

Based on the combination of the three indicators, homogeneous *units of landscape mosaic* are created. Landscape character type, however, is not homogeneous but a particular composite of two to four landscape mosaic types, and invariably comprises a detail which is predominant and decisive in the visual appearance of the landscape. The boundaries of the type are marked by the size, shape, arrangement and spatial rhythm of insular patches of the mosaic type and the surrounding subordinate patches 12.

Some landscape character types different in Austria and Hungary:

a) Lake basin with low-intensity land use, predominantly reed-bed and grassland 5

The open landscape in the southern section of Lake Fertő (Neusiedler See) in Hungarian territory is encircled by gentle hills, while in the east by a broad plain. Its individual character lies in the reed zone and grasslands of the shallow saline lake, the westernmost steppe and alkali habitats in the Pannonian Basin. In the monotony of the reed-beds visual diversity is provided by the arborous vegetation appearing in patches or strips disrupting the grassland. Human-built structures are rare in the landscape.

b) Lake basin with land use of variable intensity, predominantly water surface 6

The northern, mostly Austrian, portion of the Fertő (Neusiedler See) region is dominated by open water surfaces encircled by reed-beds of variable width, to which joins a zone of diverse land cover composed of grass strips, arable fields and built-up areas on the lakeshore. The modern lakeshore resorts which belong to settlements built on higher terraces are of small-town character. The 'Sea of Vienna', as it is popularly called, is important for water and bicycle tourism. The expansion of settlements resulted in the development of an agglomeration.

c) Hill row and foothills with medium-intensity land use and diverse land cover 7

This landscape character type with high relief and land cover diversity is represented by the Balf–Rust Hills. A marked vertical zonation of land use is typical. In the northern margin of the lake basin, settlements are surrounded by grasslands and arable fields, while at higher elevations of the hillslopes vineyards and gardens form a mosaical pattern and the summits are covered by deciduous forests. Since Roman times stone quarrying is practiced. In the Fertőrákos and Sankt Margarethen quarries theatres enrich the landscape with cultural and touristic functions.

d) Hill row and foothills with medium- to high-intensity land use, predominantly vineyard 8

This predominantly vineyard landscape type is present in Austria, in the northern Balf–Rust Hills, on the slopes of the Leitha Mountains. The rolling hills, vine rows and roads adjusted to relief, plots of various size, tree groups and sporadic solitary trees create a diverse landscape. The series of urbanising small settlements with historical core are harmoniously nested in the footslopes. The access roads are lined with wine-cellars and wine-shops.

7 *The Balf–Rust Hills and the slopes of the Leitha Mountains*

8 *Vineyards on the southern slopes of the Leitha Mountains, looking onto Lake Fertő (Neusiedler See)*

e) Medium-height mountains and foothills with low-intensity land use, predominantly forest

This type is represented by low mountains and hills covered with deciduous forests both in Austria and in Hungary. The Sopron (Ödenburg) Mountains is the easternmost outlier of the Alps, where the closed woodlands once rich in game used to be favoured by the hunting companies of Vienna, Bratislava and Sopron. In the 20th century the natural oak forests were replaced by spruce stands at many sites.

Land cover changes

Landscapes are changing with time. Satellite images provide data on landscape changes in Europe over several decades. Mapping followed the same methodology in the European Union since the 1980s. The 1 to 100,000 scale CORINE database refers the patches larger than 25 ha area and more than 100 m diameter into 44 land cover classes (27 in Hungary). Changes in the proportions of the individual classes fundamentally influence the processes taking place in the landscape. When a land cover class changes into another, major landscape ecological transformations can be induced and intricate chain reactions can be launched among the landscape factors.

Causes of land cover change in Hungary

Land cover change is to lesser and lesser extent due to physical causes but increasingly to social reasons and economic policy 13.

There is an increasing tendency in the rate of land cover change in Hungary 14. Since 1990 land cover has been modified over 10% of Hungary, which is above the average for Europe. Among the reasons the agricultural policy of the EU can be cited along with the designation of Natura 2000 and World Heritage areas and of nature and geoparks, alterations in climatic conditions as well as profound changes in social demands (e.g. the expansion of recreation areas, residential districts, motorways, etc.).

Through a GIS overlay operation of the CORINE maps from different dates and the selection of areas where no change occurred over the three studied periods, the terrains with stable land cover between 1990 and 2012 for Hungary are obtained 15. Such are the medium-height mountains, the western hills and some Alföld landscapes under nature conservation (e.g. Hortobágy, Borsodi-Mezőség).

Within the 22-year interval, 72% of the territory of Hungary, lowlands and low hills, were under continuous agricultural utilisation. The chernozem soils in the Mezőföld, Hajdúság and the Southern Tiszántúl Region are extremely favourable for arable use and the extension of ploughlands has hardly decreased here.

9 *Nyírség landscape with declining stability of land use – in spite of protection. Mosonta-kert, Létavértes*

13 MAIN DRIVERS OF LAND COVER CHANGE

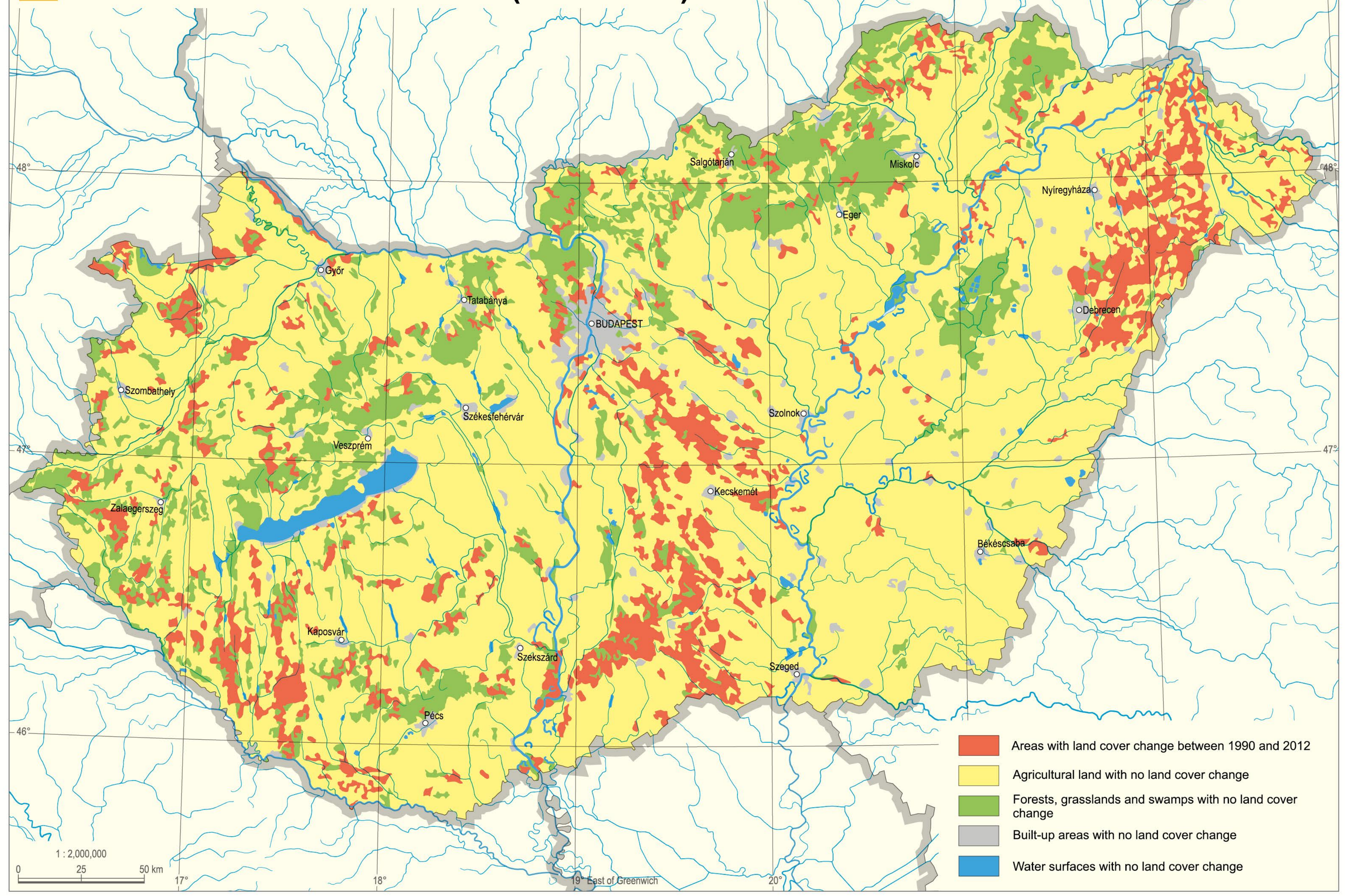
Local drivers	Nature of land cover change
Decisions in economic policy at settlement level	Industrial areas spreading at the expense of agricultural fields (greenfield investments)
Population growth in settlements	Expansion of residential areas at the expense of arable and abandoned fields
Poor accessibility of agricultural areas or low productivity of soils	Growth of meadows, pastures and forests at the expense of arable land
Physico-geographical processes: susceptibility to soil erosion and landslides, presence of excess water, drought hazard, etc.	Growth of meadows, pastures and forests at the expense of arable land, orchards and vineyards

In the sand areas (e.g. in the Nyírség and on the Danube–Tisza Midland), however, changes in the past decades allow the prediction of rapid and variable alterations in land cover in the future, too 9. The transformation of land use is also of considerable scale and rate in the environs of large urban centres and highlighted resort areas (on lakeshores). A foremost goal of landscape protection here is the maintenance of the landscape ecological network, further strengthening the system of corridors and patches.

14 MAIN TENDENCIES AND MAGNITUDES OF LAND COVER CHANGE (1990–2012)

Main tendencies of land cover change	1990–2000	2000–2006	2006–2012
Changes within forests: clearcutting or forest regeneration	forest area growth 55.2 km²/year	forest area decline 20.7 km²/year	forest area decline 45.2 km²/year
Conversion of arable land to forests and close-to-natural areas	13.6 km²/year	46 km²/year	66.5 km²/year
Conversion of pastures to forests	8.1 km²/year	17.8 km²/year	11.1 km²/year
Conversion of pastures to arable land or of arable land to pastures	growth of arable land at 19.1 km²/year at the expense of pastures	growth of arable land at 11.8 km²/year at the expense of pastures	growth of pastures at 19 km²/year at the expense of arable land
Change of agricultural areas into water surfaces	2.5 km²/year	3.9 km²/year	1.1 km²/year
Conversion of agricultural areas to artificial surfaces (e.g. quarries, industrial plants, motorways, residential areas, etc.)	10 km²/year	25 km²/year	11.1 km²/year
Total area affected by change	417 km²/year	443 km²/year	464 km²/year

15 STABILITY OF LAND COVER (1990–2012)



The intensity of landscape transformation by human activity (hemeroby)

On Hungarian territory no landscapes are virtually free from the impact of human activities. The forest stands, forest reserves, which are declared 'non-affected' by human intervention can only be regarded hardly disturbed habitats only since the late 19th century, but they are also influenced by other human impacts (e.g. air pollution).

The degree of transformation of landscapes due to human action is called hemeroby in scientific terminology. The level of hemeroby is important information for nature conservation and ecological landscape planning since it allows us to estimate the scale and complexity of measures necessary to reach environmentally desirable conditions and, last but not least, the financial sources required.

The concept of 'hemeroby' which appeared in the professional literature in the mid-1950s was at first used to express the extent of human impact on plant communities and later it was extended to the comprehensive assessment of the dimensions of human 'disturbance' in the landscape. Among landscape factors, the difference between the former natural and the present-day conditions can only be numerically presented in the case of vegetation and certain soil properties (e.g. the ratio of invasive species or soil contamination with heavy metals). At present, for other factors – rocks, relief, climate and drainage – the hemeroby level can only be described in relative classes.

In the international literature generally seven hemeroby levels 16 are distinguished, but four-, five- or ten-grade scales also exist.

X.
©Geographical Institute, MTA CSFK www.nationalatlas.hu, Budapest, 2018
X.

16 DESCRIPTION OF HEMEROBY LEVELS BASED ON THE INTENSITY OF HUMAN INTERVENTION, GROUPED BY LANDSCAPE FACTORS

Hemeroby level	Relief	Drainage	Soil	Vegetation	Land cover
Ahemerobic (natural)	Negligible	Negligible	Negligible	Natural vegetation	Initial surfaces free of anthropogenic influence
Oligohemerobic (close-to-natural)	Negligible, local	Negligible, local	Slightly modified nutrient supply, no soil erosion	Slightly disturbed communities, modified species composition	Close-to-natural deciduous forests, meadows, swamps, bare cliffs, lakes and streams
Mesohemerobic (managed, regularly disturbed)	Negligible, local	Negligible, local	Altered water and O2 supply from soils, negligible soil erosion (in pace with soil formation)	Plantation of tree species alien to the landscape, spontaneous spreading of introduced species	Coniferous and mixed forests, meadows, pastures
β – Euhemerobic (cultivated)	Minor terrain modification	Small-scale landscaping (channel sealing, locally with artificial materials)	Medium soil erosion, slight change of pH, soil compaction in lowlands	Crop cultivation, emergence of arable and ruderal weeds	Arable land
α – Euhemerobic (intensively cultivated)	Terraced vineyards, railway and motorway embankments	Large-scale landscaping (dykes, sluices, spurs, etc.)	Strong soil erosion, major change in pH	Intensive crop cultivation, spreading of ruderal and arable invasive species	Vineyards, orchards
Polyhemerobic (intensively transformed)	Major engineering structures, mining areas, spoil heaps	Major water management structures (pumping stations, sluice systems, power plant)	All soil properties change, soil compaction, intensive soil erosion	General spreading of allergenic and invasive plants, in residential areas horticultural plants	Urban green areas, disposal sites
Metahemerobic (very intensively transformed)	Dense build-up, landscaping, spoil heaps, opencast mines	Fully regulated stream channels of trapezoid cross-section	Pollution, acidification	Vegetation-free, bare, artificial surface	Continuous build-up, industrial plants, railway and road network, mining areas

On the map of hemeroby levels 17 the disturbances of the following landscape factors were assessed.

• The naturalness of relief was referred into classes through considering motorways, opencast mines and spoil heaps as well as terraced vineyards.

• The degree of transformation of watercourses and standing waters was assessed according to the naturalness grades defined by Water Framework Directive of the European Union.

• Soil disturbance was assessed by two parameters: for medium-height mountain and hill regions soil erosion rate estimated by the *USLE* model was used for the classification, while for lowlands soil compaction was regarded as the marker of anthropogenic transformation of soils.

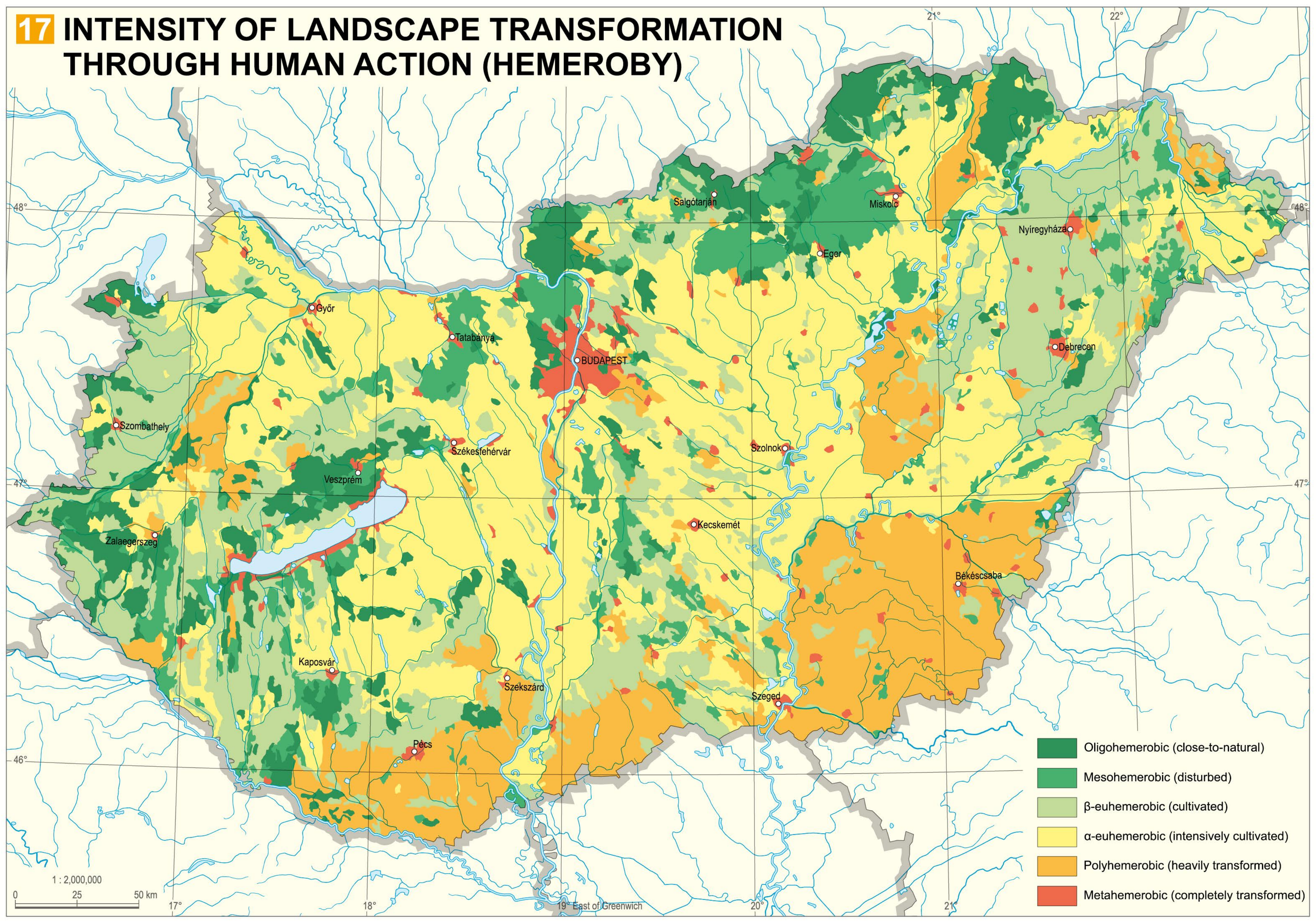
• Vegetation naturalness was assessed with the help of the Natural Capital Index (see the chapter on *Vegetation* 36).

The above indicators received equal weights and were averaged for the land cover patches of the 2012 version of the CORINE database.

The highest, metahemerobic, levels of transformation in Hungary are observed in the Budapest agglomeration and other major towns as well as in areas of opencast mining 10. Other intensively transformed (polyhemerobic) areas include the almost continuously built-up shore zones of Lakes Balaton and Velence. Intensive arable farming causes high level of human disturbance in the landscapes of Alföld with excellent productivity on chernozem soils. Other lowland and Transdanubian landscapes are characterised by medium or lower levels of hemeroby. Lowest hemeroby is represented by the rest of the riverine and medium-height mountain habitats 11.

In summary, it can be claimed that the anthropogenic transformation of Hungary is somewhat higher

17 INTENSITY OF LANDSCAPE TRANSFORMATION THROUGH HUMAN ACTION (HEMEROBY)



10 *Metahemerobic landscape detail caused by opencast mining near Gyenesdiás, Keszthely Mountains*

than of medium level. Most of the landscapes belong to the two euhemerobic (23% and 39%) and polyhemerobic (17%) categories. The oligohemerobic and mesohemerobic classes make up 9–9% each of the area, while 3% falls into the metahemerobic type. Mostly on the margins of large towns conflict areas, intensively transformed landscapes and areas with high naturalness levels are found next to one another.

11 *Close-to-natural, oligohemerobic landscape along the Tisza, at Gergelyiugornya*

The zones where protected areas are in contact with terrains of high hemeroby level, for instance, the Balaton Uplands National Park or the Buda Protected Landscape, are particularly sensitive to disturbance. When land use is planned, the hemeroby level has to be investigated in more detail for these regions than nationally.

Landscape protection

Legal background to landscape protection in Hungary

In Hungary it has been possible to declare natural objects, 'landscape details or entire landscapes' nature reserves or protected landscapes since the approval of Act IV of 1935 on forests and nature conservation. At first, legal protection covered natural monuments of small extension and local significance, for instance, in the Nagyerdő (Great Forest) of Debrecen (1939). The first Protected Landscape was the Tihany Peninsula (1952) and the first National Park the Hortobágy (1972).

Today the legal framework of landscape protection in Hungary is regulated by Act LIII of 1996 on nature conservation. It formulates the basic principle of landscape protection, i.e. the compulsory adjustment of measures to landscape character.

The European Landscape Convention and the protection of landscape character

The European Landscape Convention (Florence, 2000) is the first international agreement that expressedly concerns the landscape. Paragraph 6 of the Convention states the tasks of the participating countries:

• preparation of an inventory of the landscapes in the area;

• analyses of their characteristics and the influencing driving their changes;

• recording the changes;

• assessment of the inventoried landscapes considering the values attributed to them by stakeholders and the population affected;

• finally, definition of objectives of qualitative development.

It is to note that the classification of landscape character is not a tool of resistance against changes in the landscape, but a step of decision support which promotes the understanding of landscape evolution (based on history and functioning), the recognition of key factors in landscape appearance and the direction of predictable landscape change.

In Hungarian landscape protection the *National Landscape Strategy* for 2017–2026 was an important achievement in 2017. The related Government Decree 1128 of 2017 summarizes the main tendencies, principles and objectives in physical landscaping and landscape planning.

Landscape protection in practice

'Landscape view is a visually sensed, perceptible assemblage of living and non-living landscape elements characterised by shapes and colours, stretching to the horizon.' Visual landscape assessment for scientific purposes dates back to the end of the 20th century, but well-elaborated and widely accepted methods are still missing. This can be explained by the difficulties of defining landscape, which has a double meaning in most languages: partly a locality or area, partly the view opening from a site. While by the end of the 20th century protection for natural objects, areas and cultural monuments had been well identified and classified, with the techniques of protection described, the necessary institutions established, the concept of visual landscape protection is not yet adequately formulated, its legal regulation and institutional network is poorly developed. At the same time, public opinion is increasingly sensitive to changes in the visual environment, the appearance of the landscape. One of the consequences is that protest against the visual damage made to the landscape by basalt mining in the Balaton Uplands began as early as the 1970s. Today the concepts of liveable settlement and harmonious environment unambiguously include landscape aesthetics.

The proposal for the protection of landscape view, prepared for the National Spatial Plan (OTrT), is based on the integration of thematic maps depicting the following factors: relief roughness and visibility, land cover, forests and vineyards, surface waters, density of marked edges of land use patches (forest margins, boundaries of built-up areas, etc.), diversity of land use, protected areas in different categories as well as the frequency of occurrence of point-like elements

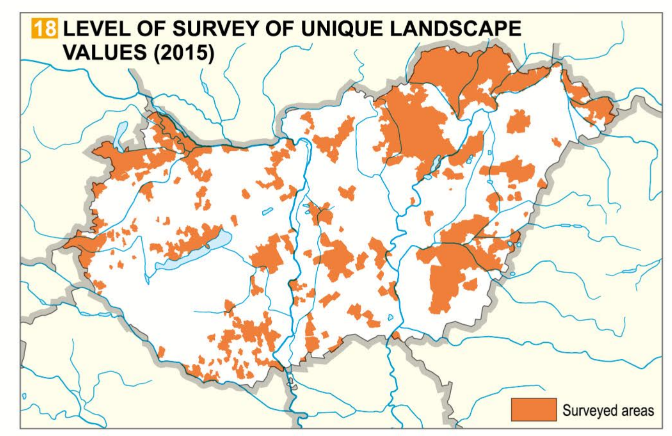
Unique landscape features and their protection

Unique landscape feature is a special category in the Hungarian legal system, defined in Act LIII of 1996 on nature conservation: 'A unique landscape feature means a natural value or natural formation characteristic to a particular landscape or a man-made yet inherent element of the landscape which has natural, historical, cultural, scientific or aesthetic significance for society.'

The determination and registration of unique landscape features are the tasks of the National Park Directorates (see chapter on Nature conservation 6 19). The regional plan shall contain an inventory of the unique landscape features in the settlement. The data have to be stored in the Nature Conservation Information System. By 2015 the inventory of unique landscape features has been prepared for 950 settlements (one third of all) 18 and includes data on 22,580 unique landscape features.

The collection of unique features by a community as a method allows a more intense utilisation of local knowledge and may occupy an important place in the preservation of everyday 'small treasures' in the landscapes of Hungary. Landscape heritage is cherished by the cooperation of communities giving rise to such initiatives as the establishment of nature parks, geoparks and greenways.

18 LEVEL OF SURVEY OF UNIQUE LANDSCAPE VALUES (2015)

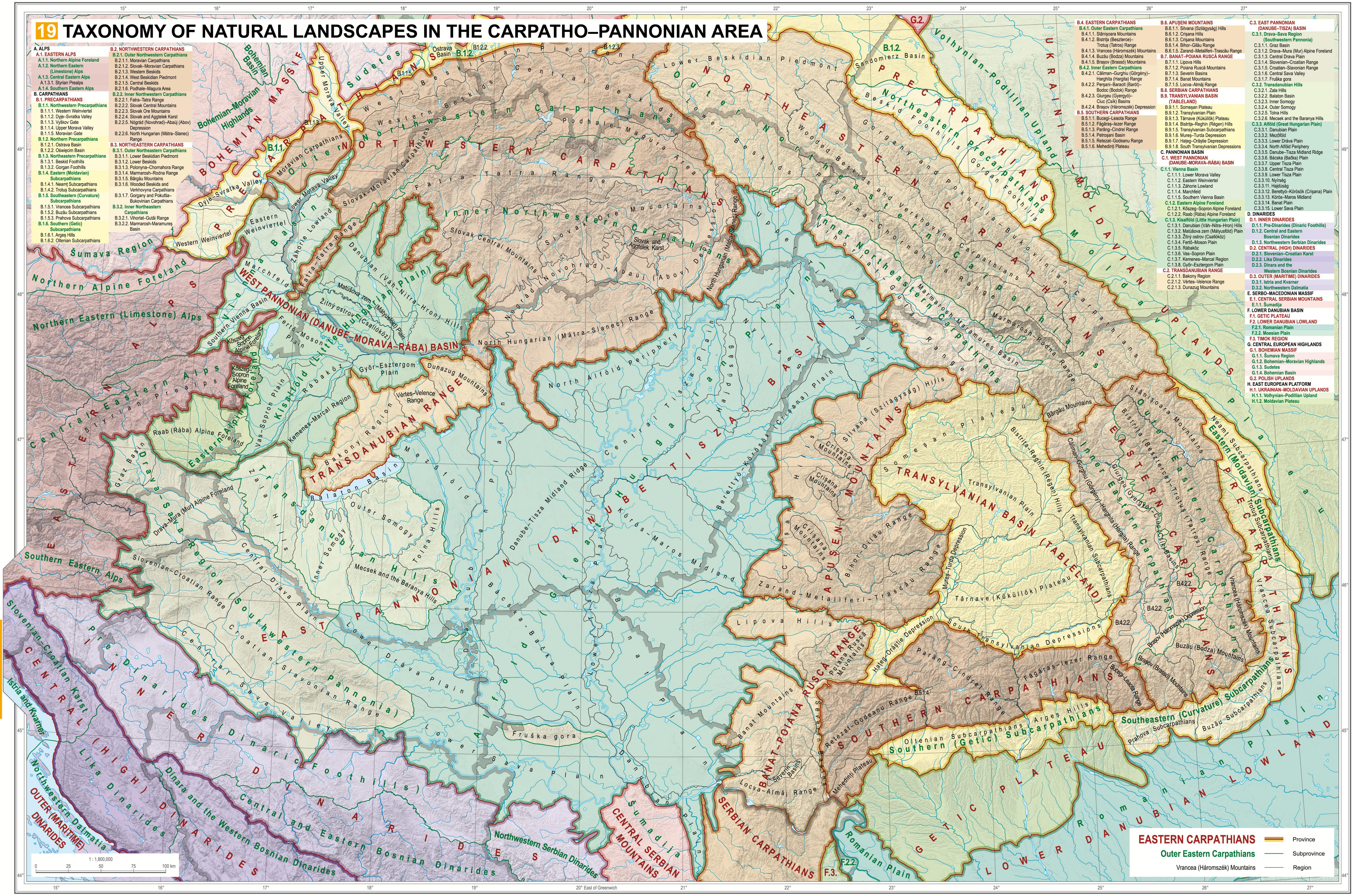


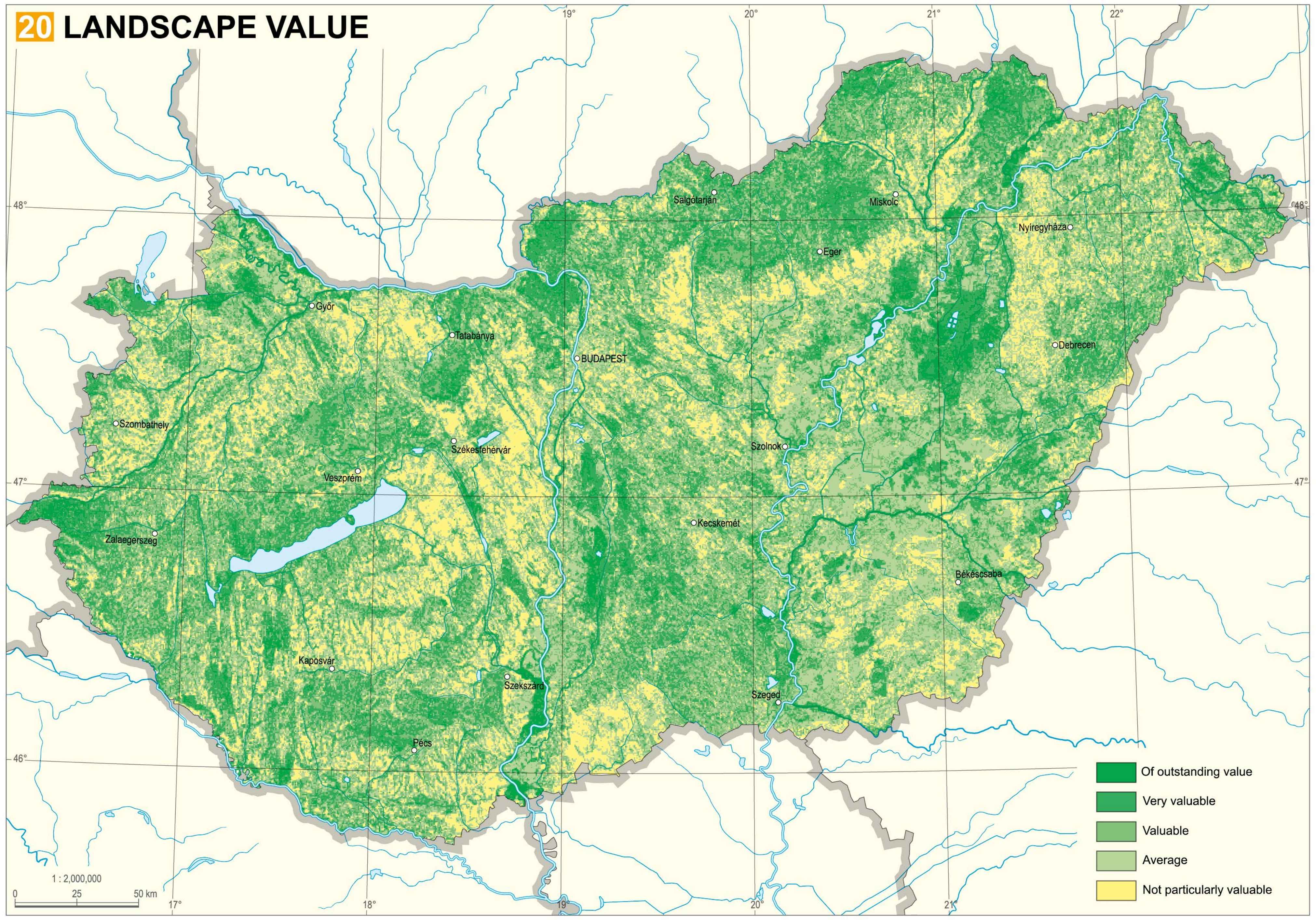
What is the Hortobágy landscape worth?

Mass tourism turned attractive landscapes into marketable goods. The question arises: why is one landscape worth more than the other? How to enhance demand for a landscape? The market value of a geographical landscape can be expressed in monetary terms: how much are visitors ready to spend on travelling and staying there? Since in tourism it is usually recorded from where guests arrive, travel costs are relatively easy to estimate. Statistics on the number of guest nights is also available. In Hungary it is the Hortobágy to which the statement best applies that the visual appearance 12 is a primary motivation for a trip. Hortobágy is visited on average by 35,000–40,000 guests from Hungary, mostly day-trippers, and about 15,000 from abroad, who spend several days on the puszta in their majority. Official estimates put the costs of a trip to Hortobágy to HUF 20,000 on average in the case of a Hungarian tourist and to HUF 60,000 in the case of foreigners. Accordingly, visitors give out about HUF 1.5–2 thousand million in a year to see this extraordinary landscape.

12 *Typical landscape with saline berms in Hortobágy*

19 TAXONOMY OF NATURAL LANDSCAPES IN THE CARPATHO–PANNONIAN AREA





13 *The visual value of the landscape is strongly influenced by actual vegetation cover and the even more variable weather conditions. Landscape before storm near Tiszaörs (Central Tisza Plain)*

of the cultural landscape (fortresses, castles, calvaries, etc.). The weighted integration of thematic data in a cell grid leads to a national map depicting visual landscape value 20. It is clear that the most valuable landscapes equally include lowlands (e.g. the Hortobágy), mountains and hills as well as some larger contiguous water surfaces or riverbank zones 13. At the same time, structures damaging the view can come into conflict with beautiful landscapes located next to them 14.

14 *Landscape conflict in the environs of the Visonta power plant (Mátraalja)*

Landscape rehabilitation

Landscape rehabilitation means the procedure of making landscape details degraded by natural or human-induced processes, which cannot be restored to their initial state, suitable for re-utilisation. Habitat restoration is a kind of rehabilitation with the purpose of recovering former conditions of a damaged ecosystem. Recultivation is a special case of landscape rehabilitation when the target is to return fertile land to agriculture and forestry. In a broader sense, recreation and nature conservation as well as the establishment of demonstration sites for education and science popularisation are also part of landscape rehabilitation 15. After implementation local climate is improved, erosion hazard is reduced and the aesthetical value of the landscape is increased. Landscape reconstruction is performed if a previous state of a degraded landscape detail can be brought back.

Main types of landscape rehabilitation in Hungary

Like elsewhere, also in Hungary opencast extraction of raw materials leads to the heaviest destruction of the landscape. There are around 15,000 such sites in the country, mostly clay, sand and gravel pits in villages or stone quarries operated to meet local demand. Transport networks also exert an outstanding impact on the landscape. The sealed zones of public roads and railways and edifices cannot be restored to conditions prior to construction. It is at most possible in the 'accompanying zones', which were also damaged during building activities. Degraded landscape sections are also due to water management interventions.

Landscaping of mines

The Act XLVIII of 1993 on mining ensures the provision of financial resources for landscaping from taxes levied on mining activities. Over the period of the national programme of 'non-transferrable landscaping after mining' (1994–2003) about 1100 spatial plans were prepared in cooperation between landscape architects and mining engineers. Within an interval of ten years the rehabilitation of 425 mining sites was completed and almost 2,000 ha of degraded land were affected. In the case of some stone quarries with natural and cultural values of national significance, geological demonstration sites were established (Ság Hill of Celldömölk, Kálvária Hill of Tata). In the Alföld several old clay pits turned into wetlands and elsewhere fishponds and construction areas replaced them.

15 *Former mine landscaped and afforested and now safe to visit: Bauxite Geological Park near Gánt*

In Hungary the largest-scale mine rehabilitation takes place for the lignite mining district in Mátraalja, over about 5,000 ha area. Physical landscaping here includes afforestation of pits and spoil heaps in the environs of former shafts and their utilisation for tourism purposes 16. A good portion of mine pits and spoil heaps at Visonta are fully landscaped and returned to agricultural companies or local governments for use. Most of the pits are afforested with birch, poplar, oleaster and black locust, while moister lakeshore areas are overgrown by willows. In the vicinity of the lake areas for leisure activities and a nature trail were formed. At Abasár and Visonta, where the diversity of wine and delicatessen grapes is the highest in Hungary (more than 150 varieties), a vinestock reproduction site was established. There is also energetic utilisation, partly of the biomass of tree plantations on spoil heaps, partly through the largest solar plant of Hungary, installed in 2015.

16 *Landscaped former pit of abandoned opencast lignite mine near Ecséd (Mátraalja)*

Next to the wine-growing district of Tokaj-Hegyalja, part of the UNESCO World Cultural Heritage, the landscaping of the spoil heaps of the andesite quarry at Tállya in 2015 primarily aimed at improving the visual appearance of the landscape. A total of 177,000 m^3 waste was moved, followed by physical landscaping and the plantation of native tree and shrub species.

Rehabilitation of surface waters

The rehabilitation of the Kerca Stream took place within the Slovenia–Hungary–Croatia Neighbourhood Programme in the period between 2004 and 2006. In the mid-20th century parts of the grasslands along the stream were ploughed and the bends were straightened. During the rehabilitation the water was conducted back to the old channel and three dams were built to help four dead arms to develop into living watercourses. By way of impoundment some discharge is retained during drought.

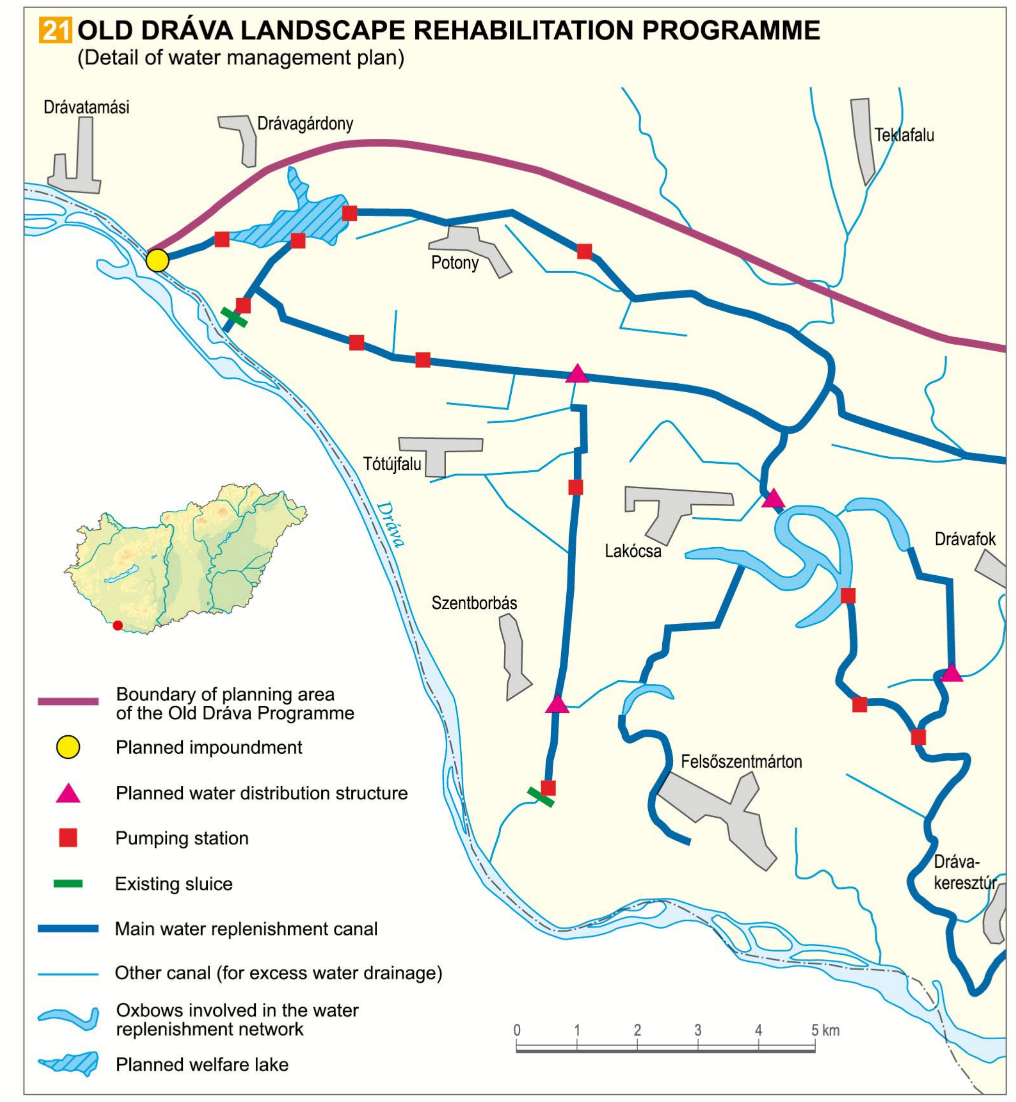
Rehabilitation of road environments

Road constructions destroy the landscape in a broad zone. Therefore, along the roads there is a need for large-scale rehabilitation. Over the past 50 years about 1,600 km of motorways were built in Hungary and almost 5,000 ha of damaged area affected by construction were restored using measures for improving ecological and visual endowments of the landscape (physical landscaping and plantation), in harmony with the requirements of landscape design.

Landscape rehabilitation along the Drava River

Landscape-scale rehabilitation projects in Hungary are usually associated with former floodplains or sand regions with water deficit. In the 1990s complex water replenishment plans were drafted for Danube–Tisza Midland Ridge, where groundwater levels were dropping. From 1993 on, an ecological programme began to counteract the water deficit in the Szigetköz region, caused by the transfer of the discharge of the Danube to Slovakian territory. Since 2003 several large reservoirs were constructed along the Tisza River to retain floodwater and to spread it on the former floodplains, thus re-creating the close-to-natural ecological system which predated river regulations.

Even more comprehensive landscape management goals are targeted in the ***Old Dráva Programme****, which covers the administrative areas of 43 settlements. One of the main causes of actual landscape degradation here is the lowering groundwater table. The new system of feeder canals which are intended to ensure gravitational water replenishment will follow the revitalized remnants of the old channels* 21*. The set objective is the restoration of side-arms and oxbow lakes as well as other wetlands, protection against floods and excess water, increasing water retention capacity. When water availability is stabilized, the transformation of land use, the reduction of arable land, afforestation, the restoration of grazing lands with sporadic fruit trees, reed economy, the re-introduction of native crops, fruit-trees, medicinal plants, once common domesticated animals, the promotion of fishery and apiculture. Economic growth is also furthered by the establishment of food-processing manufactures, handicraft workshops and the development of transport facilities and catering infrastructure with the purpose of giving an impetus to eco- and heritage tourism. Finally, the Programme also extends to developing the network of bicycle roads, the restoration of churches and authentic village looks.*



Changing climate – changing landscapes

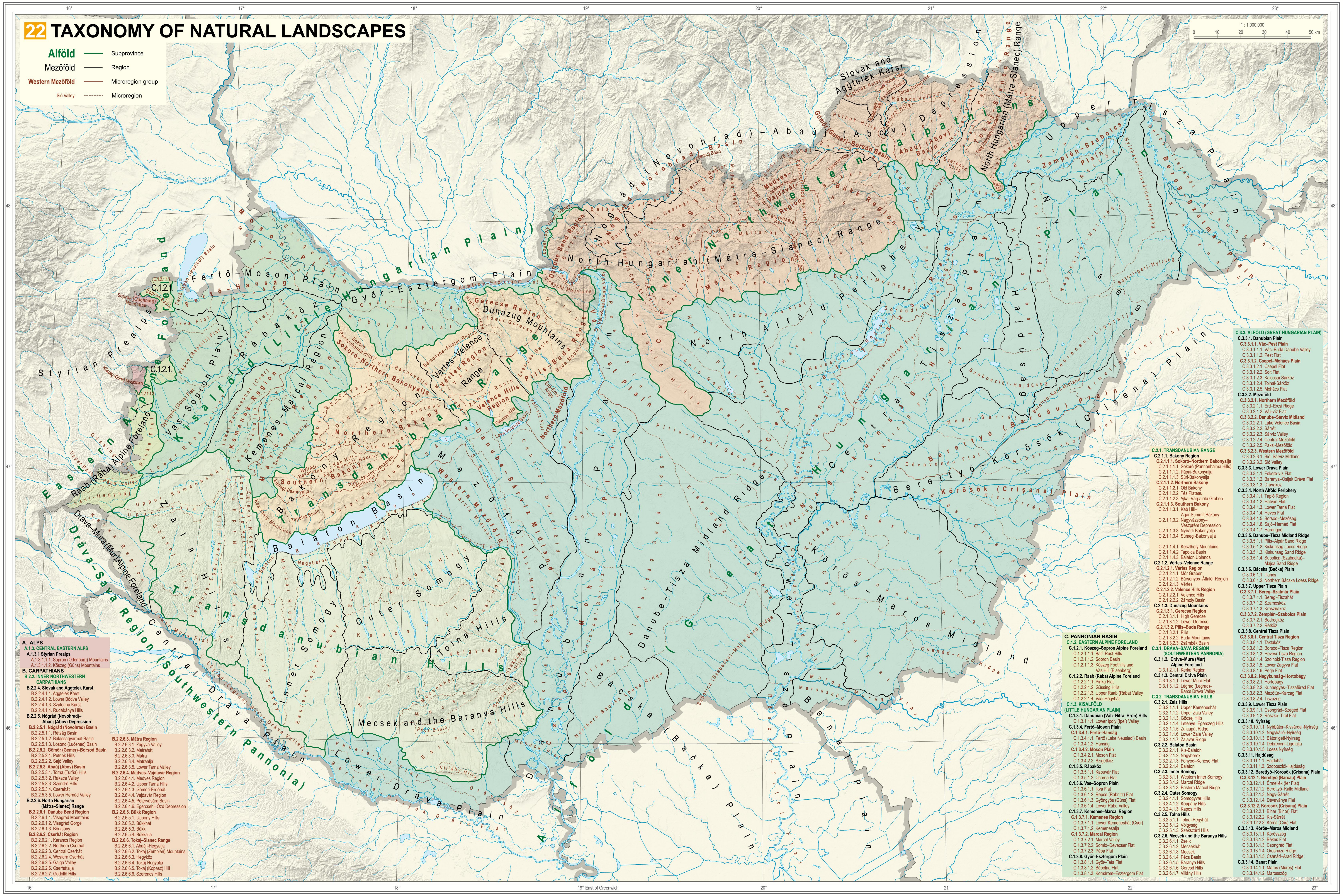
In the early 21th century the most fundamental environmental change seems to be global climate change. In spite of the intricate cause-and-effect relationships and the numerous uncertainty factors, the fact that climate is changing in Hungary, too, cannot be doubted. The survey of consequences and opportunities for adjustment to the predictable effects are studied in disciplines from architecture via health care to nature conservation. The tasks to do are summarized in the *2nd National Strategy for Climate Change (NÉS2)* approved in 2013. This prognostication outlines the steps necessary to prevent or mitigate deleterious socio-economic consequences for the decades until 2050. Since regional planning is increasingly adjusted to the regional strategies of the European Union, which also consider climate change in a complex manner, it is useful to overview the expected tendencies from the aspect of landscape research as well.

In the centre of the Carpathian Basin climate change will be primarily manifested in shifting seasons, increasing summer water deficit and growing frequency of extreme weather events (heat waves, heavy showers and storms). The functioning, appearance and use of particular geographical landscapes will react differently to the change of climate. Although there are some especially sensitive rocks, like limestone, the geological landscape component will be only modified to a small extent. Due to enhancing soil erosion, topographic transformation could be of larger scale, for instance, new landforms may emerge on desiccating sand surfaces.

Prediction of the vulnerability of vegetation cover due to climate change till 2100

The most fundamental changes will be probably associated with vegetation cover. For the estimation of the sensitivity of natural and cultural vegetation to climate, predictable changes in drainage and soils were also considered along with meteorological models (*ALADIN-Climate* and *RegCM*). When preparing the map, the methodology proposed by the *Intergovernmental Panel on Climate Change (IPPC)* was applied, which defines vulnerability as a function of expected climatic impact and capacity for adaptation. The stronger climate change will be, the more vulnerable is the habitat, but the actual impact on vegetation can be reduced by a high capacity for adaptation, i.e. habitat diversity or extended ecological connections (e.g. ecological corridors).

Estimating the climatic vulnerability of *natural habitats*, starting from layers of the *Landscape Ecological Vegetation Database and Map of Hungary (MÉTA)* and environmental factors from the *National Adaptation Geo-information System (NATéR)* (temperature, precipitation, drainage, soils, relief) and applying statistical models, a distribution model for 38 stable


22 TAXONOMY OF NATURAL LANDSCAPES
Alföld — Subprovince
Mezőföld — Region
Western Mezőföld — Microregion group
Sió Valley — Microregion
1 : 1,000,000
0 10 20 30 40 50 km
A. ALPS
A.1.3. CENTRAL EASTERN ALPS
A.1.3.1 Styrian Prealps
A.1.3.1.1.1. Sopron (Ödenburg) Mountains
A.1.3.1.1.2. Kőszeg (Güns) Mountains
B. CARPATHIANS
B.2.2. INNER NORTHWESTERN CARPATHIANS
B.2.2.4. Slovak and Aggtelek Karst
B.2.2.4.1.1. Aggtelek Karst
B.2.2.4.1.2. Lower Bódva Valley
B.2.2.4.1.3. Szalonna Karst
B.2.2.4.1.4. Rudabánya Hills
B.2.2.5. Nógrád (Novohrad)–Abaúj (Abov) Depression
B.2.2.5.1. Nógrád (Novohrad) Basin
B.2.2.5.1.1. Rétság Basin
B.2.2.5.1.2. Balassagyarmat Basin
B.2.2.5.1.3. Losonc (Lučenec) Basin
B.2.2.5.2. Gömör (Gemer)–Borsod Basin
B.2.2.5.2.1. Putnok Hills
B.2.2.5.2.2. Sajó Valley
B.2.2.5.3. Abaúj (Abov) Basin
B.2.2.5.3.1. Torna (Turňa) Hills
B.2.2.5.3.2. Rakaca Valley
B.2.2.5.3.3. Szendrő Hills
B.2.2.5.3.4. Cserehát
B.2.2.5.3.5. Lower Hernád Valley
B.2.2.6. North Hungarian (Mátra–Slanec) Range
B.2.2.6.1. Danube Bend Region
B.2.2.6.1.1. Visegrád Mountains
B.2.2.6.1.2. Visegrád Gorge
B.2.2.6.1.3. Börzsöny
B.2.2.6.2. Cserhát Region
B.2.2.6.2.1. Karancs Region
B.2.2.6.2.2. Northern Cserhát
B.2.2.6.2.3. Central Cserhát
B.2.2.6.2.4. Western Cserhát
B.2.2.6.2.5. Galga Valley
B.2.2.6.2.6. Cserhátalja
B.2.2.6.2.7. Gödöllő Hills
B.2.2.6.3. Mátra Region
B.2.2.6.3.1. Zagyva Valley
B.2.2.6.3.2. Mátrahát
B.2.2.6.3.3. Mátra
B.2.2.6.3.4. Mátraalja
B.2.2.6.3.5. Lower Tarna Valley
B.2.2.6.4. Medves–Vajdavár Region
B.2.2.6.4.1. Medves Region
B.2.2.6.4.2. Upper Tarna Hills
B.2.2.6.4.3. Gömöri-Erdőhát
B.2.2.6.4.4. Vajdavár Region
B.2.2.6.4.5. Pétervására Basin
B.2.2.6.4.6. Egercsehi–Ózd Depression
B.2.2.6.5. Bükk Region
B.2.2.6.5.1. Uppony Hills
B.2.2.6.5.2. Bükkhát
B.2.2.6.5.3. Bükk
B.2.2.6.5.4. Bükkalja
B.2.2.6.6. Tokaj–Slanec Range
B.2.2.6.6.1. Abaúji-Hegyalja
B.2.2.6.6.2. Tokaj (Zemplén) Mountains
B.2.2.6.6.3. Hegyköz
B.2.2.6.6.4. Tokaj-Hegyalja
B.2.2.6.6.5. Tokaj (Kopasz) Hill
B.2.2.6.6.6. Szerencs Hills
C. PANNONIAN BASIN
C.1.2. EASTERN ALPINE FORELAND
C.1.2.1. Kőszeg–Sopron Alpine Foreland
C.1.2.1.1.1. Balf–Rust Hills
C.1.2.1.1.2. Sopron Basin
C.1.2.1.1.3. Kőszeg Foothills and Vas Hill (Eisenberg)
C.1.2.2. Raab (Rába) Alpine Foreland
C.1.2.2.1.1. Pinka Flat
C.1.2.2.1.2. Güssing Hills
C.1.2.2.1.3. Upper Raab (Rába) Valley
C.1.2.2.1.4. Vasi-Hegyhát
C.1.3. KISALFÖLD (LITTLE HUNGARIAN PLAIN)
C.1.3.1. Danubian (Váh–Nitra–Hron) Hills
C.1.3.1.1.1. Lower Ipoly (Ipeľ) Valley
C.1.3.4. Fertő–Moson Plain
C.1.3.4.1. Fertő–Hanság
C.1.3.4.1.1. Fertő (Lake Neusiedl) Basin
C.1.3.4.1.2. Hanság
C.1.3.4.2. Moson Plain
C.1.3.4.2.1. Moson Flat
C.1.3.4.2.2. Szigetköz
C.1.3.5. Rábaköz
C.1.3.5.1.1. Kapuvár Flat
C.1.3.5.1.2. Csorna Flat
C.1.3.6. Vas–Sopron Plain
C.1.3.6.1.1. Ikva Flat
C.1.3.6.1.2. Répce (Rabnitz) Flat
C.1.3.6.1.3. Gyöngyös (Güns) Flat
C.1.3.6.1.4. Lower Rába Valley
C.1.3.7. Kemenes–Marcal Region
C.1.3.7.1. Kemenes Region
C.1.3.7.1.1. Lower Kemeneshát (Cser)
C.1.3.7.1.2. Kemenesalja
C.1.3.7.2. Marcal Region
C.1.3.7.2.1. Marcal Valley
C.1.3.7.2.2. Somló–Devecser Flat
C.1.3.7.2.3. Pápa Flat
C.1.3.8. Győr–Esztergom Plain
C.1.3.8.1.1. Győr–Tata Flat
C.1.3.8.1.2. Bábolna Flat
C.1.3.8.1.3. Komárom–Esztergom Flat
C.2.1. TRANSDANUBIAN RANGE
C.2.1.1. Bakony Region
C.2.1.1.1. Sokoró–Northern Bakonyalja
C.2.1.1.1.1. Sokoró (Pannonhalma Hills)
C.2.1.1.1.2. Pápai-Bakonyalja
C.2.1.1.1.3. Súri-Bakonyalja
C.2.1.1.2. Northern Bakony
C.2.1.1.2.1. Old Bakony
C.2.1.1.2.2. Tés Plateau
C.2.1.1.2.3. Ajka–Várpalota Graben
C.2.1.1.3. Southern Bakony
C.2.1.1.3.1. Kab Hill–Agár Summit Bakony
C.2.1.1.3.2. Nagyvázsony–Veszprém Depression
C.2.1.1.3.3. Nyírádi-Bakonyalja
C.2.1.1.3.4. Sümegi-Bakonyalja
C.2.1.1.4.1. Keszthely Mountains
C.2.1.1.4.2. Tapolca Basin
C.2.1.1.4.3. Balaton Uplands
C.2.1.2. Vértes–Velence Range
C.2.1.2.1. Vértes Region
C.2.1.2.1.1. Mór Graben
C.2.1.2.1.2. Bársonyos–Általér Region
C.2.1.2.1.3. Vértes
C.2.1.2.2. Velence Hills Region
C.2.1.2.2.1. Velence Hills
C.2.1.2.2.2. Zámoly Basin
C.2.1.3. Dunazug Mountains
C.2.1.3.1. Gerecse Region
C.2.1.3.1.1. High Gerecse
C.2.1.3.1.2. Lower Gerecse
C.2.1.3.2. Pilis–Buda Range
C.2.1.3.2.1. Pilis
C.2.1.3.2.2. Buda Mountains
C.2.1.3.2.3. Zsámbék Basin
C.3.1. DRÁVA–SAVA REGION (SOUTHWESTERN PANNONIA)
C.3.1.2. Dráva–Mura (Mur) Alpine Foreland
C.3.1.2.1.1. Kerka Region
C.3.1.3. Central Dráva Plain
C.3.1.3.1.1. Lower Mura Flat
C.3.1.3.1.2. Légrád (Legrad)–Barcs Dráva Valley
C.3.2. TRANSDANUBIAN HILLS
C.3.2.1. Zala Hills
C.3.2.1.1.1. Upper Kemeneshát
C.3.2.1.1.2. Upper Zala Valley
C.3.2.1.1.3. Göcsej Hills
C.3.2.1.1.4. Letenye–Egerszeg Hills
C.3.2.1.1.5. Zalaapát Ridge
C.3.2.1.1.6. Lower Zala Valley
C.3.2.1.1.7. Zalavár Ridge
C.3.2.2. Balaton Basin
C.3.2.2.1.1. Kis-Balaton
C.3.2.2.1.2. Nagyberek
C.3.2.2.1.3. Fonyód–Kenese Flat
C.3.2.2.1.4. Balaton
C.3.2.3. Inner Somogy
C.3.2.3.1.1. Western Inner Somogy
C.3.2.3.1.2. Marcal Ridge
C.3.2.3.1.3. Eastern Marcal Ridge
C.3.2.4. Outer Somogy
C.3.2.4.1.1. Somogyvár Hills
C.3.2.4.1.2. Koppány Hills
C.3.2.4.1.3. Kapos Hills
C.3.2.5. Tolna Hills
C.3.2.5.1.1. Tolnai-Hegyhát
C.3.2.5.1.2. Völgység
C.3.2.5.1.3. Szekszárd Hills
C.3.2.6. Mecsek and the Baranya Hills
C.3.2.6.1.1. Zselic
C.3.2.6.1.2. Mecsekhát
C.3.2.6.1.3. Mecsek
C.3.2.6.1.4. Pécs Basin
C.3.2.6.1.5. Baranya Hills
C.3.2.6.1.6. Geresd Hills
C.3.2.6.1.7. Villány Hills
C.3.3. ALFÖLD (GREAT HUNGARIAN PLAIN)
C.3.3.1. Danubian Plain
C.3.3.1.1. Vác–Pest Plain
C.3.3.1.1.1. Vác–Buda Danube Valley
C.3.3.1.1.2. Pest Flat
C.3.3.1.2. Csepel–Mohács Plain
C.3.3.1.2.1. Csepel Flat
C.3.3.1.2.2. Solt Flat
C.3.3.1.2.3. Kalocsai-Sárköz
C.3.3.1.2.4. Tolnai-Sárköz
C.3.3.1.2.5. Mohács Flat
C.3.3.2. Mezőföld
C.3.3.2.1. Northern Mezőföld
C.3.3.2.1.1. Érd–Ercsi Ridge
C.3.3.2.1.2. Váli-víz Flat
C.3.3.2.2. Danube–Sárvíz Midland
C.3.3.2.2.1. Lake Velence Basin
C.3.3.2.2.2. Sárrét
C.3.3.2.2.3. Sárvíz Valley
C.3.3.2.2.4. Central Mezőföld
C.3.3.2.2.5. Paksi-Mezőföld
C.3.3.2.3. Western Mezőföld
C.3.3.2.3.1. Sió–Sárvíz Midland
C.3.3.2.3.2. Sió Valley
C.3.3.3. Lower Dráva Plain
C.3.3.3.1.1. Fekete-víz Flat
C.3.3.3.1.2. Baranya–Osijek Dráva Flat
C.3.3.3.1.3. Drávaköz
C.3.3.4. North Alföld Periphery
C.3.3.4.1.1. Tápió Region
C.3.3.4.1.2. Hatvan Flat
C.3.3.4.1.3. Lower Tarna Flat
C.3.3.4.1.4. Heves Flat
C.3.3.4.1.5. Borsodi-Mezőség
C.3.3.4.1.6. Sajó–Hernád Flat
C.3.3.4.1.7. Harangod
C.3.3.5. Danube–Tisza Midland Ridge
C.3.3.5.1.1. Pilis–Alpár Sand Ridge
C.3.3.5.1.2. Kiskunság Loess Ridge
C.3.3.5.1.3. Kiskunság Sand Ridge
C.3.3.5.1.4. Subotica (Szabadka)–Majsa Sand Ridge
C.3.3.6. Bácska (Bačka) Plain
C.3.3.6.1.1. Illancs
C.3.3.6.1.2. Northern Bácska Loess Ridge
C.3.3.7. Upper Tisza Plain
C.3.3.7.1. Bereg–Szatmár Plain
C.3.3.7.1.1. Beregi-Tiszahát
C.3.3.7.1.2. Szamosköz
C.3.3.7.1.3. Krasznaköz
C.3.3.7.2. Zemplén–Szabolcs Plain
C.3.3.7.2.1. Bodrogköz
C.3.3.7.2.2. Rétköz
C.3.3.8. Central Tisza Plain
C.3.3.8.1. Central Tisza Region
C.3.3.8.1.1. Taktaköz
C.3.3.8.1.2. Borsodi-Tisza Region
C.3.3.8.1.3. Hevesi-Tisza Region
C.3.3.8.1.4. Szolnoki-Tisza Region
C.3.3.8.1.5. Lower Zagyva Flat
C.3.3.8.1.6. Perje Flat
C.3.3.8.2. Nagykunság–Hortobágy
C.3.3.8.2.1. Hortobágy
C.3.3.8.2.2. Kunhegyes–Tiszafüred Flat
C.3.3.8.2.3. Mezőtúr–Karcag Flat
C.3.3.8.2.4. Tiszazug
C.3.3.9. Lower Tisza Plain
C.3.3.9.1.1. Csongrád–Szeged Flat
C.3.3.9.1.2. Röszke–Titel Flat
C.3.3.10. Nyírség
C.3.3.10.1.1. Nyírbátor–Kisvárdai-Nyírség
C.3.3.10.1.2. Nagykállói-Nyírség
C.3.3.10.1.3. Bátorligeti-Nyírség
C.3.3.10.1.4. Debreceni-Ligetalja
C.3.3.10.1.5. Loess Nyírség
C.3.3.11. Hajdúság
C.3.3.11.1.1. Hajdúhát
C.3.3.11.1.2. Szoboszlói-Hajdúság
C.3.3.12. Berettyó–Körösök (Crișana) Plain
C.3.3.12.1. Berettyó (Barcău) Plain
C.3.3.12.1.1. Érmellék (Ier Flat)
C.3.3.12.1.2. Berettyó–Kálló Midland
C.3.3.12.1.3. Nagy-Sárrét
C.3.3.12.1.4. Dévaványa Flat
C.3.3.12.2. Körösök (Crișana) Plain
C.3.3.12.2.1. Bihar (Bihor) Flat
C.3.3.12.2.2. Kis-Sárrét
C.3.3.12.2.3. Körös (Criș) Flat
C.3.3.13. Körös–Maros Midland
C.3.3.13.1.1. Körösszög
C.3.3.13.1.2. Békés Flat
C.3.3.13.1.3. Csongrád Flat
C.3.3.13.1.4. Orosháza Ridge
C.3.3.13.1.5. Csanád–Arad Ridge
C.3.3.14. Banat Plain
C.3.3.14.1.1. Maros (Mureș) Flat
C.3.3.14.1.2. Marosszög
19° East of Greenwich

X.

natural habitats of Hungary was made. In this way, the numerical probability of occurrence of habitats has been calculated in the function of environmental variables. Then 12 habitats where the influence of climatic variables was the strongest were selected and the model was applied to both future and present conditions. The expectable effect is the difference.

The other factor, capacity for adaptation, was estimated from the present-day pattern of habitats considering three aspects: habitat diversity, naturalness and ecological connectivity. For vulnerability the values of predictable effect indicating unfavourable climatic influence were multiplied by the value expressing the lack of adaptation capacity. On the map geographical mesoregions are characterised by the vulnerability of their most sensitive natural vegetation element.

For *arable crop cultivation* the climatic sensitivity of maize, winter wheat, winter barley, rapeseed and sunflower was studied using the 4M simulation model. Vulnerability was determined from the difference between average yields in the future (2071–2100) and in the reference period (1961–1990). Three classes were established: major (>30%), moderate (10–30%) or insignificant relative drop (<10%) in yields.

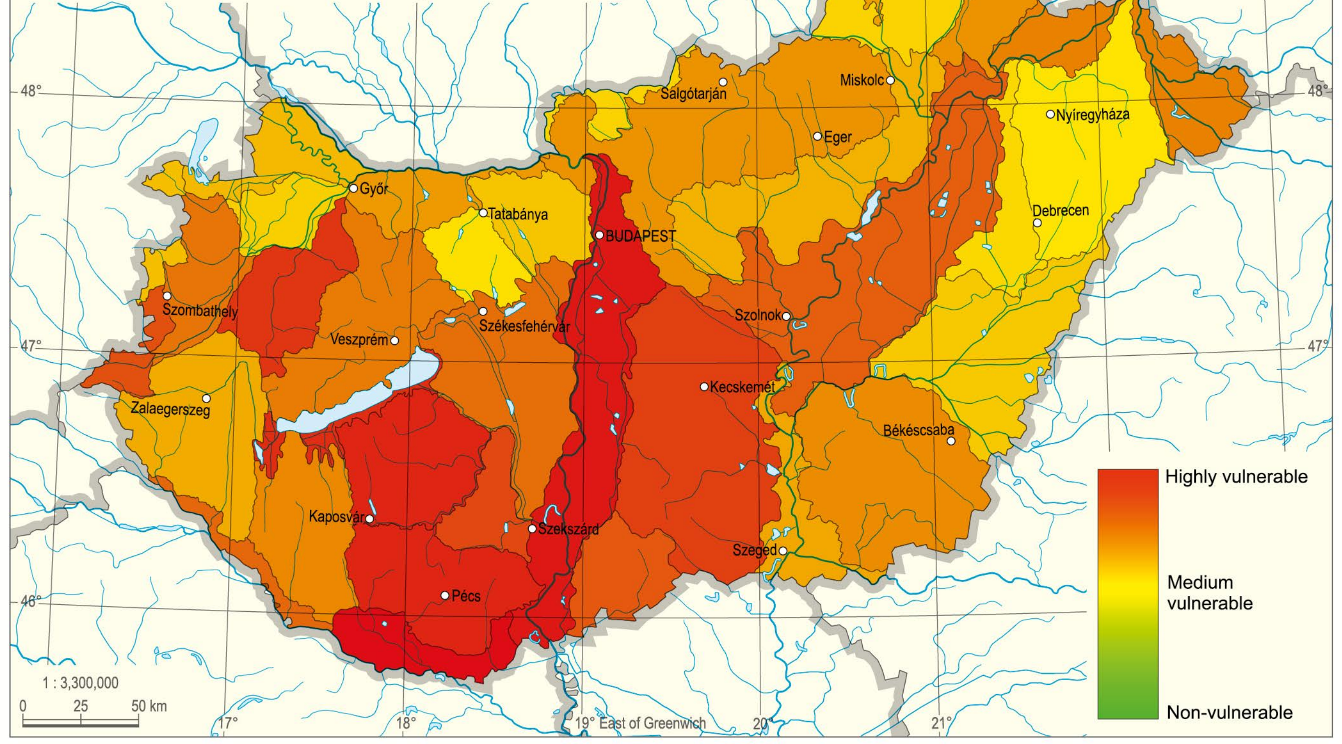
Capacity for adaptation is based on the weighted averages of five factors: the amounts of fertilizers and pesticides applied, productivity, excess water hazard, proportion of areas suitable for irrigation and professional knowledge.

The survey of the vulnerability of *forest cover* sought answer to the question: based on the estimates from the above models, to what extent the four main forest types of Hungary (beech, hornbeam–oak, Turkey oak and sessile oak) as well as the wooded steppe could alter their proportions and how will it affect timber production. Hungary is located in the transitional zone of closed forests and wooded grasslands and, thus, climate change could influence almost half of the forested areas. Climatic variation and the related wood increment data between the intervals of 1961–1990 and 1991–2010 were evaluated for the eight most widespread tree species (black locust, beech, Turkey oak, Scots pine, Austrian pine, sessile oak, pedunculate oak and poplar varieties). The extent of foreseeable alterations was established for the individual habitat groups identified by hydrological class, soil type, soil depth and texture. Forest vulnerability was determined from the total of estimated productivity by tree species in the light of climate change until 2100.

Capacity for adaptation was also deduced from adaptation variables (water retention capacity of soil, degree of species mixing and age structure) and rated. Areas where predictable climate impact will be the strongest and capacity for adaptation is the lowest are referred to the class with highest vulnerability. Finally, vulnerability ratings were weighted with the extension of the individual geographical mesoregions.

The vulnerability of landscapes to climate change was expressed as the arithmetic mean of the values obtained for the above described land cover types 23. It was found that there are no landscapes where climate change would not be a considerable hazard to close-to-natural habitats, forests and arable land. The danger is greatest in the centre and southern half of the country, irrespective of whether there are lowlands, hills or mountains there. It is notable that strongly endangered landscapes will also appear in the western, more humid borderlands. At the same time, in the northern medium-height mountains and in the northeastern lowlands we probably do not have to count with high vulnerability of the natural

23 VULNERABILITY OF LANDSCAPES TO CLIMATE CHANGE (UNTIL 2100)



and cultural vegetation. Wetlands are particularly endangered 17. The scenario presented here does not mean that the appearance of the now forested or agricultural landscape will not remain of the same character. Map rather warns that there will be a strong pressure on decision-makers to change tree species or agricultural crops in some parts of the country.

The delineation and hierarchy of geographical landscapes

Geography is the science of space. Therefore, geographers strive to represent natural and artificial formations, phenomena on maps – even in the case of such an abstract concept as the geographical landscape. It is almost impossible to depict the spatial arrangement of natural landscape factors (landforms, climate, drainage, soil and vegetation types) on maps with an accuracy of one metre. Uncertainty is greatest in the map representation of climate types: the boundaries of oceanic, Mediterranean or continental climates on some maps, for instance, run at several hundred kilometres' distances away from one another. More exact delineation is achievable for soil types and hydrographical units. The landscape is a complex of all the factors, difficult to map individually, and, consequently, to define its limits requires major compromises locally. To handle the problem of transitional zones, a new approach interprets landscapes and fuzzy sets.

Landscape divisions and their exact delineation is only seemingly a theoretical issue. The success of landscape protection, rural development or nature conservation increasingly depends on the implementation of a land utilisation which does not disturb the functioning of the landscape system. To this end, knowledge on the topographic pattern and hierarchical system of neighbouring landscape units is indispensable.

Landscape boundaries on old Hungarian maps and landscape mapping of novel approach

In 1936 Gyula Prinz divided the Carpathian Basin into four major units: Pannonia, Upper Hungary (Felvidék), the Alföld and Transylvania. They were further subdivided into provinces and subprovinces. He represented even the boundaries of major units with dashed lines and often failed to delineate his provinces precisely. The same uncertainty of delineation is observed on László Kádár's (1941) map. To solve the problem, since the 1950s landscape boundaries have been largely adjusted to relief by Béla Bulla (1962).

In the second edition of the National Atlas of Hungary (1989) a three-tier system appears with 6 macroregions, 35 mesoregions and 230 microregions, supplemented with a category of microregion groups. The best known example of experimental landscape divisions in Hungary is the landscape map by József Hajdú-Moharos, Attila Hevesi and Zsolt Horváth (1997).

The map in the present Atlas, getting rid of administrative limitations, follows two basic principles when drawing the map of landscape division:

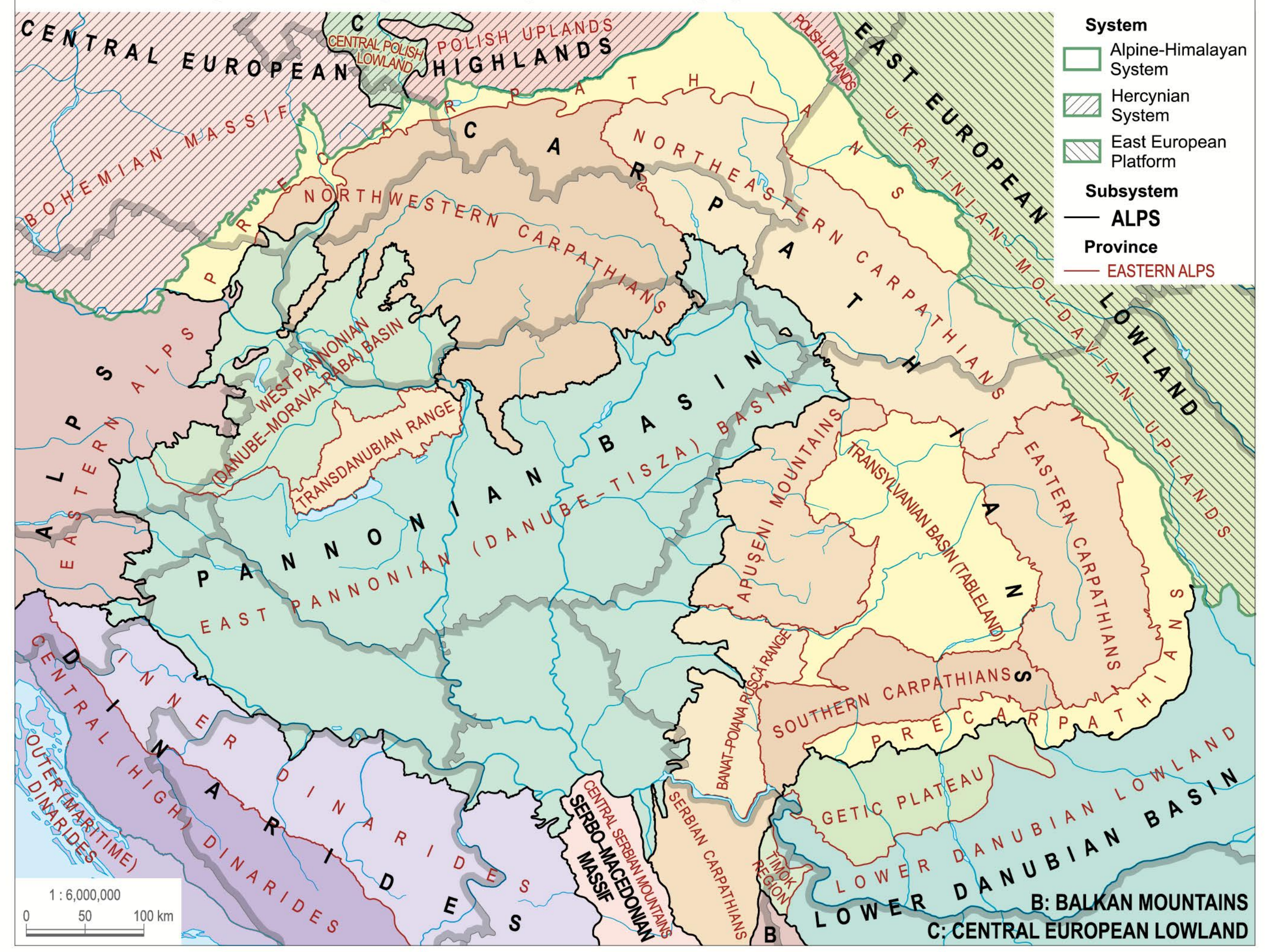
1.) The hierarchy levels should adjust to the major regions of Europe and, if possible, to the taxonomic systems elaborated in the neighbouring countries.

2.) Landscape names and delineations should not be influenced by national borders.

In this new taxonomic system there are seven levels:
- system,
- subsystem,
- province,
- subprovince,

17 *One of the wetlands most exposed to predictable climate change in the Upper Tisza Plain. Boroszló-kert, Gulács*

24 HIGHER TAXONOMIC LEVELS OF NATURAL LANDSCAPES IN THE CARPATHO–PANNONIAN REGION



History of Hungarian toponymy

The oldest of the landscape names in the Carpathian Basin derive from times well before the Hungarian Conquest. The Carpathians, the Szerémség (Syrmia) – as well as the majority of the names of large rivers – are continuations of names used in the Antiquity. The Tatra comes from an old Indo-European root, while Balaton is known from the period of a Pannonian Slavic principality.

One of the first Hungarian words occurring in a written document (Etelköz) is also a landscape name. Its structure, river name + köz (meaning 'interfluve'), such as Csallóköz, Rábaköz, Sárköz, is typical of a large group of landscape names from the Árpád Age (1000–1301). The names of some major landscape units are of medieval origin: Erdély (Transylvania), Szlavónia (Slavonia), as well as those of most of the mountainous-forested regions, such as the Bakony, Börzsöny, Mátra and others. Geographical names like Alföld, Felföld, Erdőhát, Hegyalja, Sárrét denote several landscapes. The morphemes alja, föld(e), hát, mező, mellék(e), rét, sár, szeg, vidék(e) are common in compounds (Érmellék, Kalotaszeg, Mezesalja). Suffixation is another frequent device to create landscape names (e.g. Szilágyság). Similarly to the word Hortobágy, which equally means a river and a riparian landscape today, initially water names in themselves, without adding any suffix or forming a compound, were used for landscapes, too (e.g. Barca, Csík, Kalota, Kölesér).

Beginning with the 16th century more and more new landscape names appear, dozens of them with -ság/-ség suffix. The suffixes are equally common in the group of landscape names referring to natural phenomena (Hanság, Mezőség) or ethnic groups (Jászság, Kunság), both in old (Barcaság, Nyírség, Ormánság) and recently formed names (Hajdúság, Völgység). Moreover, several landscapes borrowed their names from royal counties with names of this structure (Szepesség, Szerémség, Szörénység). Compounds with 'vidék' (Erdővidék, Sóvidék, Kővár vidéke) became general at that time, too.

Although denominations of Hungarian origin occur throughout the Carpathian Basin from the beginnings, some landscape names have been borrowed from the language of other peoples: from Slavic (Kemenes, Vihorlát), Romanian (Retyezát, Vlegyásza) and Latin (Partium) roots. A Cumanian personal name is preserved in Bugac and an old Turkish name in Karancs. Probably the German Vater ('father') word gave the name of the Fatra and mater, matera ('mother') to the Mátra. Of Hungarian origin is the root of the Hanság ('hany' meaning 'bog, swamp'), the Bakony ('bak' meaning 'buck').

Since the last third of the 19th century artificial denominations allowing delineation, unambiguous identification and hierarchical ordering have become typical. Geographical character (Beregi-síkság/plain, Nógrádi-medence/basin), distinction (Borsodi Mezőség), subdivision (Southern Bakony), beginning and end (Tokaj–Eperjes Mountains) were emphasized. Names with zug and mente elements are mostly artificial denominations (Tiszazug, Küküllő mente).

The physical and social factors in the creation of landscape names have never formed a closed system, neither in space, nor in time. Some landscape names disappeared during historical changes, while others (e.g. Kisalföld) are relatively young at historical scale. Certain landscape names, such as the Csallóköz or Erdély survived many centuries, while others changed their form or the denoted region has altered (Kis- and Nagy-Kunság, i.e. Little and Great Cumania first only meant the area where Cumanians settled, but now they are extended contiguous landscape units). It was common that the name of a small geographical unit was extended to a much larger area, e.g. Mecsek was once a single hill, today it is a mountain range. The borders after the Trianon Dictate (1920) changed the meaning of former names like Délvidék ('southern land') and Felvidék ('highland'). The names Kárpátalja/Subcarpathia and Vajdaság/Vojvodina emerged from political considerations.

- region,
- microregion group,
- microregion.

The three highest taxonomic levels are shown in a separate map 24. On the main map 19 provinces, subprovinces and regions are represented. Finally, microregion groups and microregions appear on the map of landscape subdivisions in Hungary 22.

The new hierarchical system is consistent in structure and, in comparison with the basin, applies more taxonomic units for the mountain frame. As a consequence, only the Transdanubian Range have retained their qualification as a macroregion (province). The Alföld and Kisalföld (Little Hungarian Plain), the Transdanubian Range and the Alpokalja (Eastern Alpine Foreland) became subprovinces and the North Hungarian Range is referred to the taxonomic level of mesoregions (region).

The number of regions was reduced from 35 to 31, but 6 'new' regions also appeared on the present territory of Hungary: the Fertő–Moson Plain, the Styrian Prealps, Danubian (Váh–Nitra–Hron) Hills, the Alpine Foreland of the Rába (Raab), the Banat Plain and the Nógrád (Novohrad)–Abaúj (Abov) Depression. The previously independent Győr Basin and North Hungarian Basins are now referred into several mesoregions.

The microregions were affected by the most fundamental changes: instead of the former 230 microregions the new map of landscape divisions contains only 195 of them (and Lake Balaton). The 34 microregions, now not distinguished, were mostly small mountain basins, mountain forelands and sections of hilly regions. New microregions include the Szamosköz, the Lower Rába (Raab) Valley and the Maros (Mureş) Flat. Among the microregion groups and macroregions an almost forgotten historical name, the Vajdavár Region, reappears.

Since in the case of many microregions the area beyond the national border, in a neighbouring country, is more extended, it seemed justified to employ the Hungarian versions of the official names used there (e.g. Németújvár/Güssing Hills, Losonc/Lučenec Basin).

In the revision of terminology topographic concepts are used consistently and the hierarchy of dimensions. We tried to leave out hints to geomorphological features from the landscape names (e.g. floodplain, terrace, alluvial fan and others).

In addition to the terminology, the alignment of landscape boundaries was also revised, but they were only modified where recent research led to considerable shift (at least 8–10 km) in the boundaries. There were, however, few such instances (e.g. the Illancs and the Hortobágy).

National Atlas of Hungary (MNA)
www.nationalatlas.hu

MNA Natural Environment

Volume editors
Károly Kocsis (Editor-in-chief), Gábor Gercsák, Gergely Horváth, Zoltán Keresztesi, Zsombor Nemerkényi

Chapter editors
Zita Bihari, Károly Brezsnyánszky, Péter Csorba, †Gábor Fekete, Gyula Gábris, János Haas,
Gergely Horváth, Attila Kerényi, Gergely Király, Károly Kocsis, Zsolt Molnár, László Pásztor,
Ferenc Schweitzer, József Szabó, Mária Szabó, János Tardy, Gábor Timár, György Varga, Zoltán Varga

Revised by
János Bölöni, Károly Brezsnyánszky, Mihály Dobróka, Ilona Keveiné Bárány, Károly Konecsny,
Zoltán Korsós, Dénes Lóczy, Gábor Magyar, János Mika, V. Attila Molnár, András Schmotzer,
Anna Solt, György Szabó, József Szabó, Zoltán Szalai

English translation by
Zoltán Bálint, Endre Dobos, Gábor Gercsák, Krisztián Klima, Krisztina Labancz, Györgyné Laczkó,
Dénes Lóczy, Richard William McIntosh, Erika Michéli, Brigitta Palotás, László Pásztor, András Schmidt,
Péter Szabó, Tamás Telbisz, Eszter Tímár, Gábor Timár, László Tóth, Zoltán Varga

English translation revised by
Iain Coulthard, Gábor Gercsák, Daniel Kibirige, Richard William McIntosh, Robin Lee Nagano, Philip Sansum

Cover design
Gáspár Mezei – Geographical Institute, MTA CSFK, Ildikó Kuti – Civertan Bt.

Design and typography
Ildikó Kuti – Civertan Bt.

Printing
Pannónia Nyomda Kft. (Budapest)

Publisher: László Szarka (Director general)
Hungarian Academy of Sciences (MTA), Research Centre for Astronomy and Earth Sciences (CSFK), www.csfk.mta.hu

The publication is supported by
Hungarian Academy of Sciences (MTA)
Ministry of Human Capacities (Emmi)

Closing date of editing: 31st October 2018

ISBN 978-963-9545-58-8ö
ISBN 978-963-9545-57-1

NATIONAL ATLAS OF HUNGARY
NATURAL ENVIRONMENT

Authors
Szilvia Ádám
†László Alföldi
Réka Aszalós
György Babolcsai
Zoltán Barina
Dénes Bartha
Judit Bartholy
Zsombor Bartos-Elekes
Teodóra Bata
Ákos Bede-Fazekas
Zita Bihari
Marianna Biró
Attila Borhidi
János Bölöni
Károly Brezsnyánszky
Tamás Budai
Szabolcs Czigány
Bálint Czúcz
István Csepregi
János Csiky
Péter Csima
Péter Csorba
Gábor Csüllög
István Dancza
Laura Dobor
Endre Dobos
Szabolcs Fábián
Tamás Fancsik
Edit Farkas
Sándor Farkas
István Fazekas
†Gábor Fekete
Zita Ferenczi
László Fodor
Nándor Fodor
Sándor Frisnyák
Gyula Gábris
Nóra Gál
Attila Galsa
†Judit Gerhátné Kerényi
Gizella Gombárné Forgács
László Gyalog
János Haas
László Haszpra László
Katalin Homokiné Ujváry
Ferenc Horváth
Gergely Horváth
Gábor Illés
Krisztina Iványi
Gábor Katona
Attila Kerényi
Balázs Kevey
Gergely Király
Gábor Kiss
Károly Kocsis
László Kollányi
Éva Konkoly-Gyuró
Gábor Kovács
Tamás Kovács
Szilvia Kövér
Mónika Lakatos
Ildikó Lázár
Nikolett Lepesi
Ferenc Lesták
Dénes Lóczy
József Lóki
László Lőkös
János Maginecz
Donát Magyar
Enikő Magyari
Ákos Malatinszky
Gergely Mányoki
Gábor Mezősi
Erika Michéli
Gábor Mikesy
Attila Molnár V.
Zsolt Molnár
Péter Mónus
Annamária Nádor
†András Nagymarosy
Gábor Négyesi
Ákos Németh
Csaba Németh
Beáta Papp
László Pásztor
György Pátzay
†Márton Pécsi
Gyula Pinke
Ervin Pirkhoffer
Rita Pongrácz
Péter Prakfalvi
Mária Putsay
Ágnes Rotárné Szalkai
Péter Scharek
András Schmidt
Dávid Schmidt
András Schmotzer
Ferenc Schweitzer
Ferenc Síkhegyi
Anna Solt
Imelda Somodi
Pál Sümegi
József Szabó
Mária Szabó
Szabó Péter
József Szalai
Miklós Szalay
Sándor Szegedi
Árpád Szentiványi
Gábor Szepessy
Gabriella Szépszó
Péter Szilassi
Ferenc Szmorad
Teodóra Szőcs
Gergely Szövényi
Erzsébet Szurdoki
Ágnes Tahy
László Tamás
János Tardy
Tamás Telbisz
Viktor Tiborcz
Gábor Timár
Ágnes Tirászi
György István Tóth
László Tóth
Ákos Török
Zoltán Túri
Orsolya Udvardy
György Várallyay
Gábor Varga
György Varga
Zoltán Varga
Mária Vasvári
József Vatai
Zsuzsanna Vikor
András Voitkó
Tünde Andrea Zagyva
László Zilahi-Sebess
Zita Zsembery

Chief cartographers
Norbert Agárdi
Zoltán Keresztesi
Fanni Koczó
Anikó Kovács
Gáspár Mezei
Zsombor Nemerkényi
Renáta Szabó

Contributors to cartography
Gergely Bagaméri
Éva Balázs
Ádám Barancsuk
Zsanett Butor
Anna Gertheis
Zoltán Gulyás
Réka Kiss
Csaba Szigeti
József Sziládi
Zsuzsanna Veszely

Technical staff
Margit Laczkó
Árpád Magyar
István Poór

©Geographical Institute, MTA CSFK www.nationalatlas.hu, Budapest, 2018

INSTITUTIONS SUPPORTING AND CONTRIBUTING TO THE PUBLICATION OF THE NATURAL ENVIRONMENT VOLUME OF THE NATIONAL ATLAS OF HUNGARY

Eötvös Loránd University (Eötvös Loránd Tudományegyetem, ELTE)
  Faculty of Informatics, Department of Cartography and Geoinformatics (Informatikai Kar, Térképtudományi és Geoinformatikai Tanszék)
  Faculty of Science, Institute of Geography and Earth Sciences (Természettudományi Kar, Földrajz- és Földtudományi Intézet)
General Directorate of Water Management (Országos Vízügyi Főigazgatóság, OVF)
Hungarian Academy of Sciences (Magyar Tudományos Akadémia, MTA)
  Centre for Agricultural Research, Institute for Soil Sciences and Agricultural Chemistry (Agrártudományi Kutatóközpont, Talajtani és Agrokémiai Intézet)
  Research Centre for Astronomy and Earth Sciences (Csillagászati és Földtudományi Kutatóközpont)
  Centre for Ecological Research, Institute of Ecology and Botany (Ökológiai Kutatóközpont, Ökológiai és Botanikai Intézet)
Hungarian Central Statistical Office (Központi Statisztikai Hivatal, KSH)
Hungarian Meteorological Service (Országos Meteorológiai Szolgálat, OMSZ)
Mining and Geological Survey of Hungary (Magyar Bányászati és Földtani Szolgálat, MBFSZ)
Ministry of Agriculture (Földművelésügyi Minisztérium, FM)
  State Secretariat for Environmental Affairs, Agricultural Development and Hungaricums (Környezetügyért, Agrárfejlesztésért és Hungarikumokért Felelős Államtitkárság)
Ministry of Defence (Honvédelmi Minisztérium, HM)
  Zrínyi Mapping and Communication Servicing Non-profit Ltd. (Zrínyi Térképészeti és Kommunikációs Szolgáltató Közhasznú Nonprofit Kft.)
Ministry of Human Capacities (Emberi Erőforrások Minisztériuma, Emmi)
National Agricultural Research and Innovation Centre (Nemzeti Agrárkutatási és Innovációs Központ, NAIK)
  Forest Research Institute (Erdészeti Tudományos Intézet)
National Food Chain Safety Office (Nemzeti Élelmiszerlánc-biztonsági Hivatal, NÉBIH)
  Directorate for Plant, Soil and Agricultural Environment Protection (Növény-, Talaj- és Agrárkörnyezet-védelmi Igazgatóság)
National Institute of Environmental Health (Országos Közegészségügyi Intézet, OKI)
National University of Public Service (Nemzeti Közszolgalati Egyetem, NKE)
  Institute of Disaster Management (Katasztrófavédelmi Intézet)
Szent István University (Szent István Egyetem, SZIE)
  Faculty of Agricultural and Environmental Sciences, Institute of Environmental Sciences (Mezőgazdaság- és Környezettudományi Kar, Környezettudományi Intézet)
  Faculty of Agricultural and Environmental Sciences, Institute of Nature Conservation and Landscape Management (Mezőgazdaság- és Környezettudományi Kar, Természetvédelmi és Tájgazdálkodási Intézet)
  Faculty of Landscape Architecture and Urbanism (Tájépítészeti és Településtervezési Kar)
University of Debrecen (Debreceni Egyetem, DE)
  Faculty of Science and Technology, Institute of Biology and Ecology (Természettudományi és Technológiai Kar, Biológiai és Ökológiai Intézet)
  Faculty of Science and Technology, Institute of Earth Sciences (Természettudományi és Technológiai Kar, Földtudományi Intézet)
University of Miskolc (Miskolci Egyetem, ME)
  Faculty of Earth Science and Engineering, Institute of Geography and Geoinformatics (Műszaki Földtudományi Kar, Földrajz-Geoinformatika Intézet)
University of Pécs (Pécsi Tudományegyetem)
  Faculty of Sciences, Institute of Geography and Earth Sciences (Természettudományi Kar, Földrajzi és Földtudományi Intézet)
University of Sopron (Soproni Egyetem, SoE)
  Faculty of Forestry, Institute of Botany and Nature Conservation (Erdőmérnöki Kar, Növénytani és Természetvédelmi Intézet)
  Faculty of Forestry, Institute of Forest Resources Management and Rural Development (Erdőmérnöki Kar, Erdővagyon-gazdálkodási és Vidékfejlesztési Intézet)
University of Szeged (Szegedi Tudományegyetem, SZTE)
  Faculty of Science and Informatics, Institute of Geography and Geology (Természettudományi és Informatikai Kar, Földrajzi és Földtudományi Intézet)