VEGETATION

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Vegetation and flora of the Pannonian region

To the southeast of Central Europe's temperate deciduous forest zone, in the region enclosed by the Carpathians, Alps and Dinarides there is a marked change in the vegetation pattern. Surrounded by beech and oak forests a new vegetation type, the forest steppe appears. These vegetation zones form a roughly concentric pattern 1. The Pannonian region or Pannonicum is practically outlined by the Turkey oak forest zone encircling the forest-steppe zone 1. Embraced by the Carpathians dominated by beech (blue) and spruce (grey) forests, the Pannonicum is one of the unique biogeographic units of Europe. In its natural state it would be covered by Turkey oak forests, dry forest-steppe forests, grasslands and floodplain vegetation.

The flora of a certain area includes the plant species living there; vegetation refers to the communities of plant species. In a given landscape each area has its own flora while several different vegetation types forming zones or mosaics can be found in the same area.

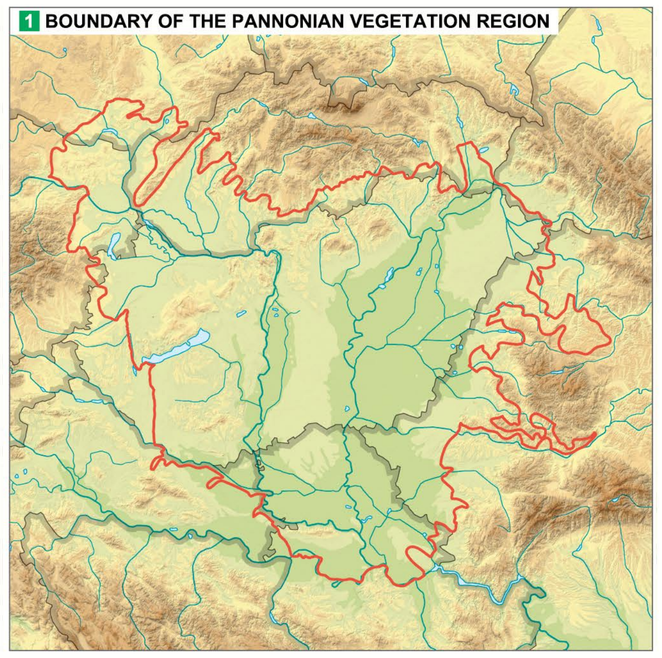
The Pannonian region is shaped by various biogeographic influences and so floristic elements characteristic of different sub-regions of Eurasia come together in uneven abundance to form a richly patterned vegetation. This floristic diversity is especially obvious when compared with the diversity of arctic, boreal and oceanic regions of Europe.

To assess the importance of a given floristic element its presence must be weighted by its distribution within the region. Considering the prevalence of forest-steppes, grasslands and dry oak forests in the region there is a remarkably high percentage of Sub-Mediterranean, continental, Pontic and Balkan species, not only in the lowlands but also in the hills and the submontane belt. This is even more apparent if compared with neighbouring regions to the North and West. Separation, however, is not complete: Eurasian elements are dominant in almost every Pannonian plant community. The presence of endemic species is, however, more important than the particular spectrum of flora as they are unique to the Pannonian region. Sub-endemic species have larger ranges most of which still lie within the Carpathian Basin.

The Carpathian Basin is not just a 'melting pot' of species and communities from various parts of Europe or Eurasia but a place where features from neighbouring areas are 'creatively' combined and transformed. Holocene climate changes brought about the repeated disintegration and reorganization of communities. These communities may have been non-analogous to present-day communities. Apparently, the transitional nature of the climate of the Carpathian Basin and the diversity of ecotones intensify these reorganizational processes and, in so doing, facilitate the survival of relicts (remnants of earlier climatic periods). The biogeographic integrity of the Pannonicum, its distinction from neighbouring regions, is justified by both the endemic species and subspecies and the endemic communities evolving there. Most of the endemics live in saline, sandy and rocky grassland habitats. Other communities are special because of their unique, region-specific species composition and richness.

A special feature of the Pannonian vegetation is that communities forming the regional vegetation mosaics not only have diverse species composition but also diverse physiognomy (stand structure). Where microclimatic and edaphic conditions change quickly and significantly, ecotones appear often bearing a distinct character (e.g. shrub or tall herb fringes). Mosaics of zonobiomes (large continuous zonal ecosystems) close to biome boundaries are formed on a large scale, i.e. patches are large. In the Ukrainian and Russian forest-steppe zone closed-forest patches are surrounded by meadow steppes. Edges are confined to the boundaries between the large forest and grassland patches. Conversely, in the Pannonian pubescent oak forests or forest-steppe forests, ecotones formed by clonal tall-herb species may appear not only around major vegetation transitions but also in highly intricate patterns associated, for instance, with small clearings and canopy gaps 2. Hence, the Pannonian forest steppe with its Sub-Mediterranean features is fundamentally different from its large-scale continental or Central European counterparts.

1 BOUNDARY OF THE PANNONIAN VEGETATION REGION



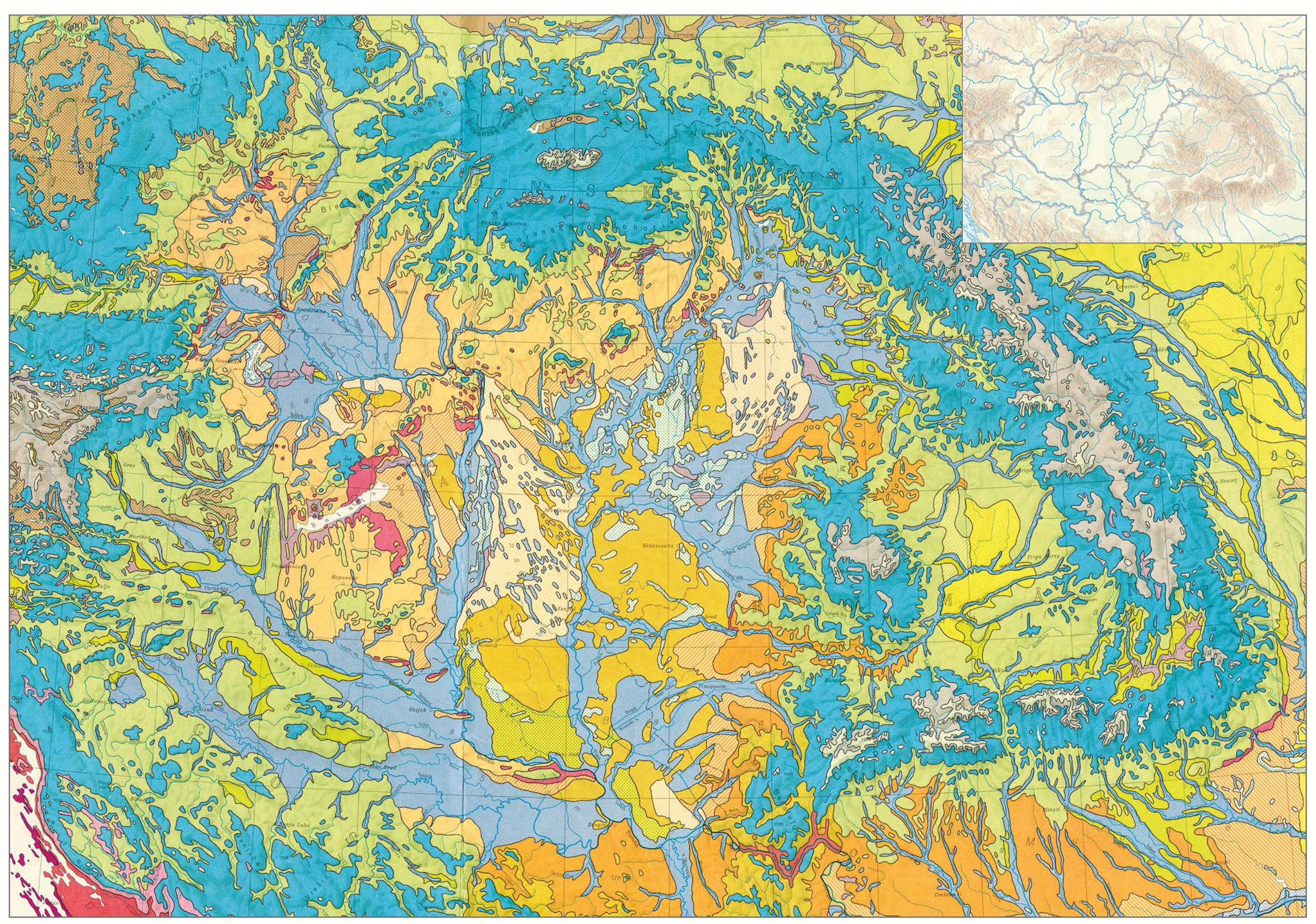
History of the Pannonian vegetation region since the Würm glacial maximum

The main factors influencing the evolution of the Pannonian vegetation were climate changes, i.e. a succession of warming and cooling events over the last 2.6 million years. During the glacials of the last 800,000 years, temperate species survived in southern, and in some cases northern, refugia and recolonized from these refugial areas during interglacials. The present-day vegetation of the Pannonian region is a result of these glacial cycles. During the mild warming periods preceding the maximum of the Würm glaciation, the Carpathian Basin was characterized by coniferous forests, mixed forests, forest steppes and continental steppes 2a. Saline vegetation had already appeared 3. In this highly heterogeneous landscape mountains were covered by spruce and Swiss pine mixed with temperate deciduous species like lime, elm, hornbeam, beech, oak and hazel in warmer areas. During the last glacial maximum (LGM, between 27,000 and 19,000 BP) cold continental steppe and in wet areas tundra steppe was the dominant vegetation. Characteristic tree species were the Scots, Swiss and dwarf mountain pine, larch, birch and juniper 2b. The continuous presence of temperate deciduous tree species in the Carpathian Basin has not been proved yet, but for a few species (elm, European ash) molecular genetic evidence suggests that it is highly probable. Several herbaceous species (like dog's tooth violet, primrose) have also survived the LGM. Based on population genetic evidence, their primary refugia were the Transylvanian Plateau, the Apuşeni Mountains, Southwestern Transdanubia and the Southern Alföld (Great Hungarian Plain).

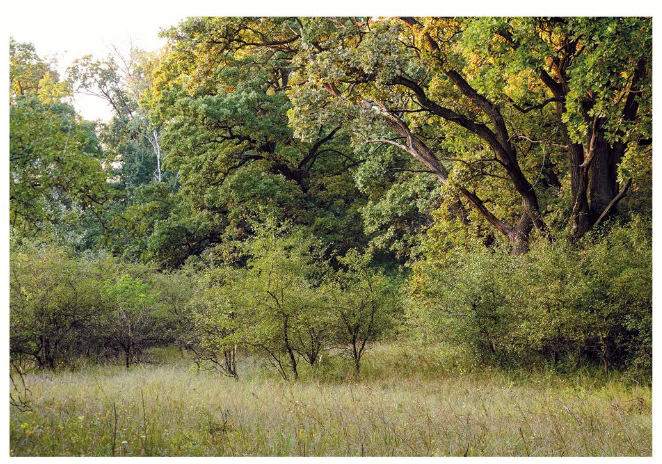
Following the LGM, during the so-called Late Pleniglacial (19,000–14,700 BP) cold continental vegetation alternated rapidly with warm continental, even semi-desert steppe vegetation characterized by grasses and wormwood 2c. These glacial steppes provided habitat for a number of large herbivores (mammoth, auroch, steppe bison, and wild horse) which subsequently died out by the end of the Würm period. Palaeogenetic studies prove that these large herbivores were sustained by the high ratio of tall herbs, grass and sedge species in the steppe, in other words by the high biomass production of the region. Grazing herds maintained a low ratio of wooded areas and the high nitrogen content of their dung played an important role in nutrient cycling and maintaining the productivity of the vegetation. The proportion of wooded vegetation (primarily deciduous mixed forests 2d) began to increase about 16,000 years ago. The frequent and intensive fires accompanying these changes probably contributed to the rapid transformation of vegetation/habitats. Later the coniferous forests of the mountains were replaced by deciduous woodland.

The Early Holocene (11,700–8,300 BP) was characterized by a rapid expansion of hazel and elm reaching its maximum abundance 2e. The Alföld has never been completely wooded in the Holocene. In the Early Holocene the typical vegetation was the open forest steppe with mixed oak forests of low-growing trees. Southern Transdanubia and the mountains north of Lake Balaton were still covered by mixed deciduous forests. In the Middle Holocene (8,300–5,800 BP) oak forest-steppe vegetation 2f reached its maximum distribution in the Alföld. This era, also known as the Holocene Climatic Optimum is characterized by the spread of oaks, elms, maples, ashes, limes and hazel in the forests of the North Hungarian Range, and beech and oak replacing Scots pine in Transdanubia. Hazel was abundant throughout. By that time the floodplain zonation characteristic of the Alföld today had already established. Between 5,800 and 3,000 BP hornbeam expanded its range both in the Alföld and the North Hungarian Range, whilst beech spread in the North Hungarian Range 2g. The extent of forest on the Alföld increased somewhat during this period. It is estimated to have reached 50% cover in the middle parts of the plain and 70% at the edges. In the mountains oak-hornbeam and beech forest zones developed. Hornbeam expanded in Transdanubia as well and in the hilly regions beech declined at the expense of advancing oak whilst Scots pine was still present. Spruce and Swiss pine were typical at higher elevations and on the Alpokalja (Eastern Alpine Forelands).

During the last 3 millennia, i.e. from the start of the Late Holocene, vegetation changes have been mainly driven by human activities. Surprisingly, in the floodplain forests of the Alföld beech has begun to spread while hornbeam has declined. The area of beech has also expanded in Transdanubia where mixed oak-beech and oak-hornbeam forests have developed. Clearances have sometimes been occupied by Scots pine. The proportion of hazel and elm decreased in this



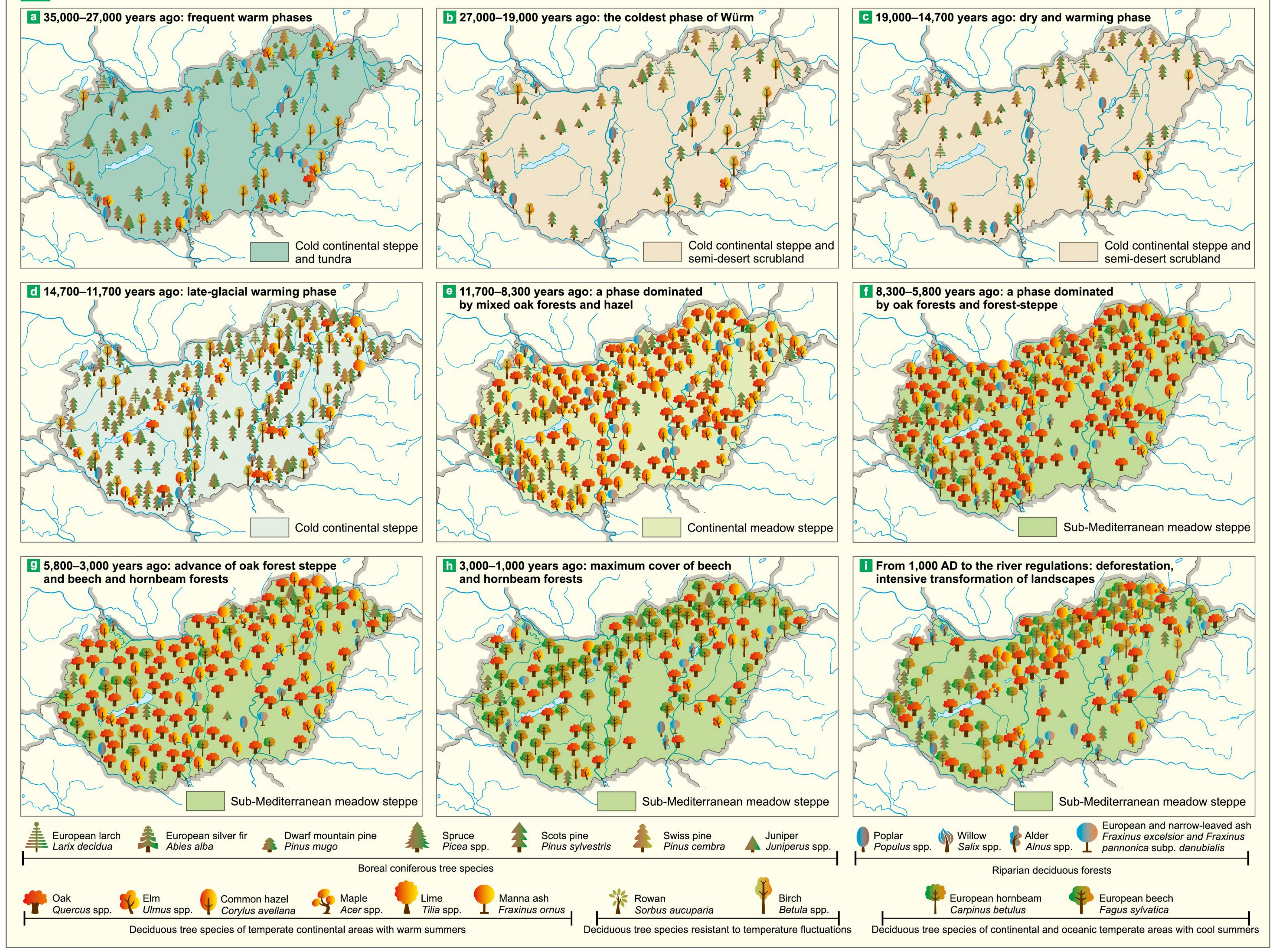
1 *Natural vegetation of the Carpatho–Pannonian Area*



2 *Sand oak steppe forest is a unique vegetation mosaic of the Hungarian landscape*

3 *Saline steppe is the most extensive of Hungarian ancient vegetation types*

2 HISTORY OF VEGETATION IN THE LATE PLEISTOCENE AND THE HOLOCENE



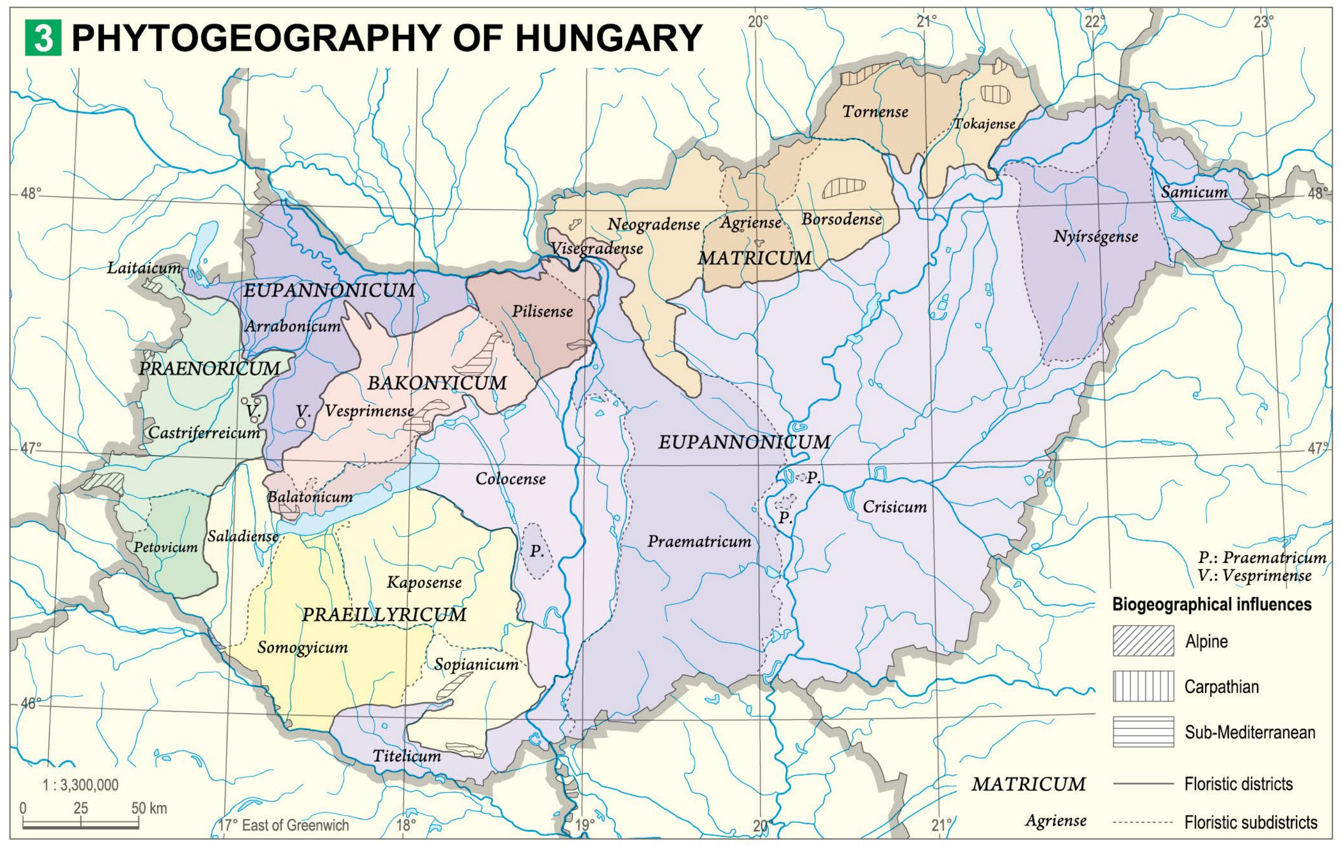
period 2h. Forest cover on the Alföld, however, significantly decreased with the appearance of nomadic people in the Bronze and Iron Age. This process continued throughout the 9th and 10th century. By the Early Middle Ages the forest cover of the Alföld had been reduced to less than 50% at the edges, and barely 25% in the central part. Primarily it is the area of pastureland that has increased. River regulation has also brought substantial changes. Vast areas of floodplain forests and meadows have been ploughed and the area of forests has decreased to less than 20% 2i. The disappearance of beech from the floodplain forests was also a by-product of river regulation.

Floristic division and floristic elements of Hungary

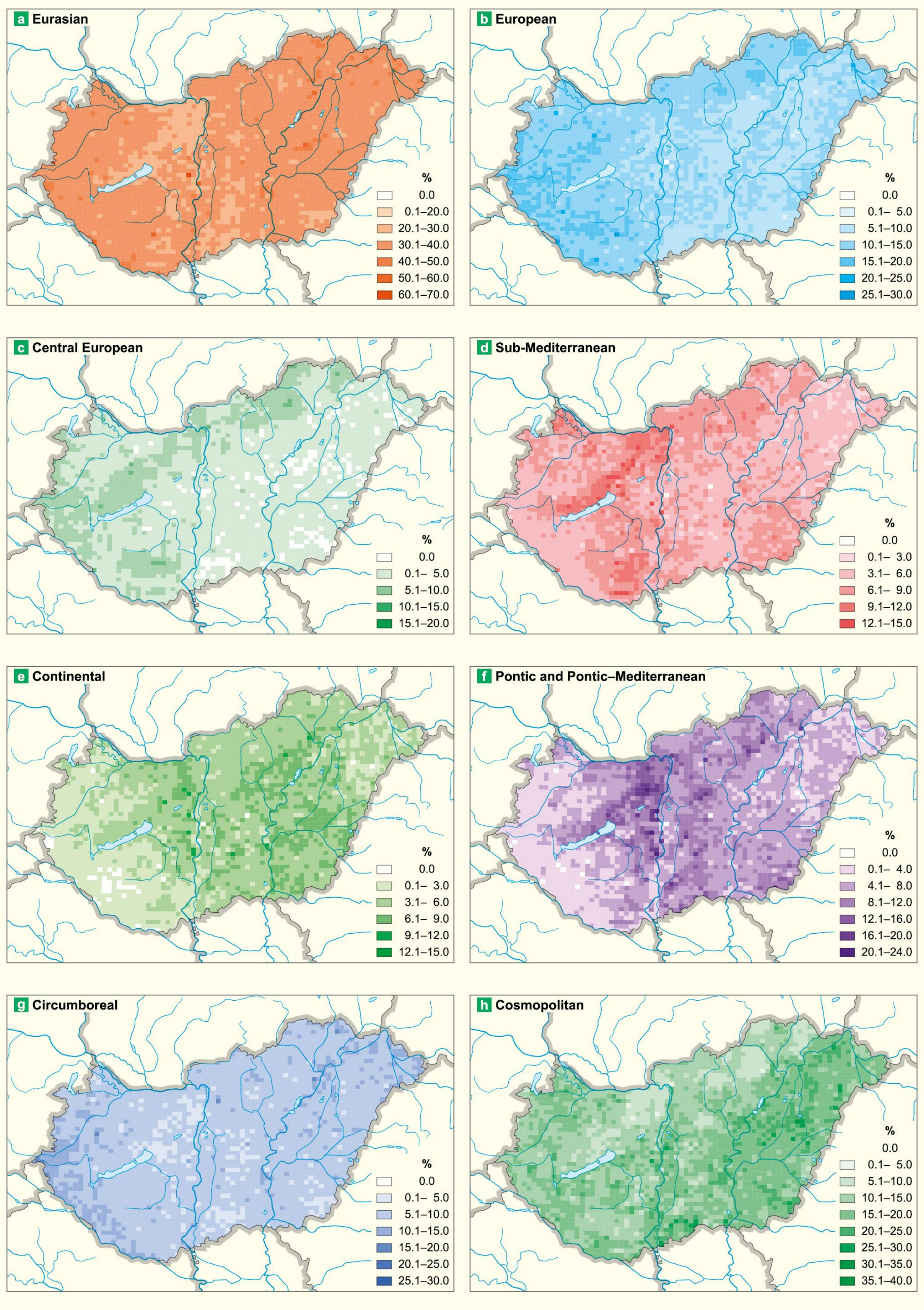
Based on the present and past composition, evolution and migration routes of its flora, any area (continent, geographic region) can be divided into biogeographic units. The largest units are floristic kingdoms which are subdivided into regions and provinces. Nearly all of Europe belongs to the Holarctic kingdom with Hungary lying in the Central European region. The inner parts of the Carpathian Basin mostly belong to the Pannonicum (Pannonian province) surrounded by the Alpicum, Carpaticum, Moesicum and Illyricum provinces. The latter two belong to the Sub-Mediterranean region. Botanists studying the Carpathian Basin have developed a hierarchical system of biogeographic units based on the flora and vegetation of the different landscapes with provinces being divided into districts and subdistricts 3. The criteria used, however, have been quite subjective and as a result there are several versions and interpretations of the system. This system is unique and without parallels in Europe except for Slovakia and Czechia. The boundaries of biogeographic units are not set in stone; even under natural circumstances they have transition zones and may change continuously. In several places, especially in the Alföld, the natural vegetation cannot be reconstructed precisely due to human-induced changes in ecological conditions.

The distribution of the species can be typified and categorized. As these categories (i.e. 'area types') are based on certain geographical formations, biogeographic regions, and evolutionary stages, their proportions can be used to describe the vegetation of an area. Species composition of communities is heterogeneous with species coming from different biogeographical backgrounds. Explanation of the spectrum and proportion of area types observed at a given time is complex as it is the manifestation of consecutive changes in climate and vegetation, and the resultant migration of species. Eurasian 4a elements are dominant in the Hungarian flora and they are present in nearly all plant communities. They form the backbone of dry grasslands, meadows, marshes and several forest communities. In many habitats (e.g. mesophilous forests) the contribution of European 4b and Central European 4c elements to the vegetation is also significant. Sub-Mediterranean 4d elements are characteristic of forest and grassland communities of the Transdanubian Range and Southern Transdanubia. The distribution of continental 4e (including the Pontic and Pontic–Mediterranean 4f) elements is somewhat similar except that it extends to the Danube–Tisza Midland. Bogs and rocky areas of mountains accommodate Alpine and Boreal species, 4g which give a special flavour to the Hungarian flora. They are often relicts of previous colder periods. Trivially, cosmopolitan spe-

3 PHYTOGEOGRAPHY OF HUNGARY

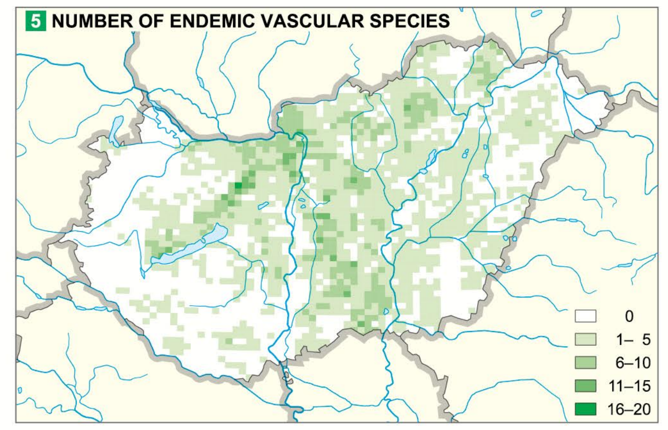


4 PATTERN OF FLORISTIC INFLUENCES IN THE DIFFERENT REGIONS (PROPORTION OF MAJOR CATEGORIES OF FLORISTIC ELEMENT TYPES)

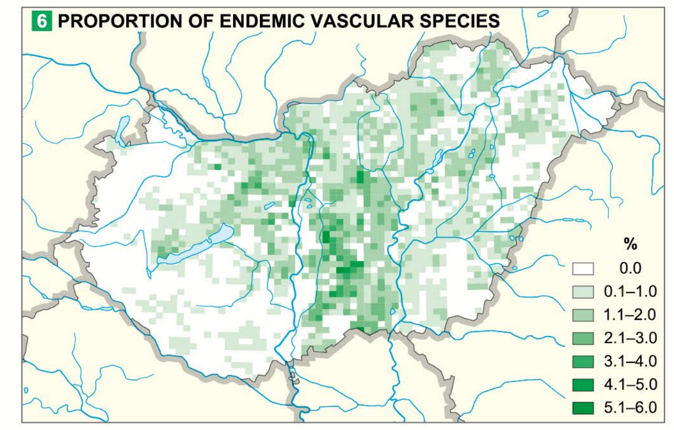


VIII.

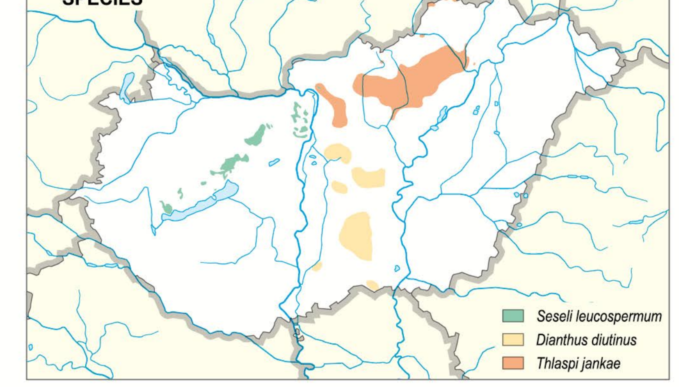
5 NUMBER OF ENDEMIC VASCULAR SPECIES



6 PROPORTION OF ENDEMIC VASCULAR SPECIES



7 TYPICAL DISTRIBUTION PATTERNS OF SELECTED ENDEMIC SPECIES



cies 4h with world-wide distribution are also present in Hungary.

Endemic species

Some plant species are distributed world-wide, others are unique to a small area. The latter are called endemic species. Endemism can refer either to species that were formerly widespread but now restricted to a small area or to new species. These formerly widespread species are also known as 'relicts', their range having been fragmented in the glacial period. For example, the closest relatives of *Linum dolomiticum* (confined today to a single location near Pilisszentiván) presumably live in the mountains of the Balkans, and relatives of *Ferula sadleriana* (confined to six locations in the Carpathian Basin) can be found east of the Ural Mts.

It may be surprising that, sometimes, new species are born before our very eyes relatively quickly by hybridization of related species or by specific genetic events. Evolution and survival of a new species is most likely to occur under heterogeneous geologic and geomorphologic conditions (where various habitats with different exposures and microclimatic conditions occur close to each other) or in extreme conditions (like in saline or dry sandy areas). Most Pannonian endemics come from these types of habitats as anything similar in conditions is far away in the Eastern European steppes or the Balkans. Isolated populations are on their way to becoming distinct species just as happened with *Dianthus diutinus* and other Eastern European pink species. A new species of yarrow, *Achillea horanszkyi* originated by hybridisation of *A. ochroleuca* and *A. nobilis*, which explains its rarity as the distribution areas of the parent species hardly ever overlap.

4 *Seseli leucospermum, an endemic species of open dolomite grasslands*

Only species with a range wholly contained within national borders are considered endemic by some authors, but, from a biogeographical perspective, political boundaries are irrelevant. Species occurring exclusively or largely within the Carpathian Basin are called Pannonian endemics. The number 5 and proportion 6 of endemic species in Hungary is not really high especially if compared with the Balkan Peninsula or the neighbouring high mountains. Pannonian endemic species (e.g. *Seseli leucospermum* 4) are mainly concentrated in the warm and dry habitats of the Transdanubian and North Hungarian Ranges, and the Danube–Tisza Midland 7.

Regularities, deviations and unique features of the Pannonian vegetation

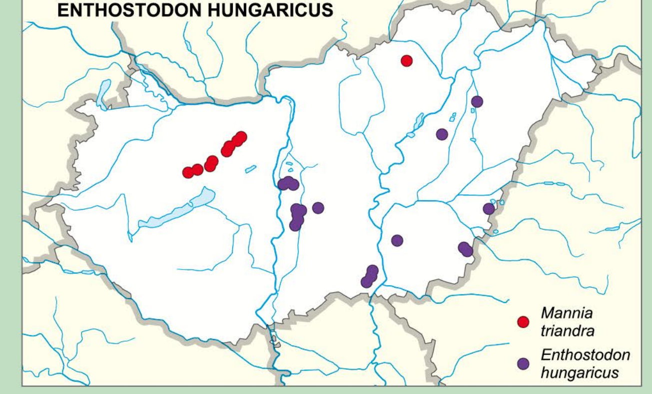
The former natural vegetation of areas in Hungary covered today by plantations, arable land and urban areas has been reconstructed by examining surviving vegetation fragments, local climate and soil in conjunction with historical maps and written documents. According to these reconstructions, hills and mountains were typified by open and closed forests (forest-steppe oak forests, Turkey oak forests, oak-hornbeam forests, and beech forests) 5. The zonation of these forest types is more distinct in the North Hungarian Range and less obvious in the Transdanubian Range. Many communities in the mountains are extrazonal 6, others accommodate relict species. The hills and mountains are connected by an extensive, uniquely Pannonian com-

5 *Mesophilous forest with varied structure and rich herb layer*

Bryophytes

In Hungary there are 659 known bryophyte species living in various habitats ranging from riparian forests and marshes to rocks and dry grasslands. There are no endemic bryophyte species in Hungary but there is a wide range of Sub-Mediterranean, Boreal, Atlantic and Continental elements as well as European temperate species. Mannia triandra 8 is a thalloid liverwort living primarily in high mountains (and it is characterized by a subarctic and subalpine distribution). In Hungary it occurs in mountain recesses of the Transdanubian and North Hungarian Ranges with a boreal or alpine microclimate, especially north facing limestone and dolomite rocks and rocky grasslands. Enthostodon hungaricus 8 is a Continental–Mediterranean element, a characteristic moss species of saline areas. It shows a preference for the special microtopographic 'cliffs' of ancient salt steppes, and thus is an indicator of high nature-value salt steppes 3.

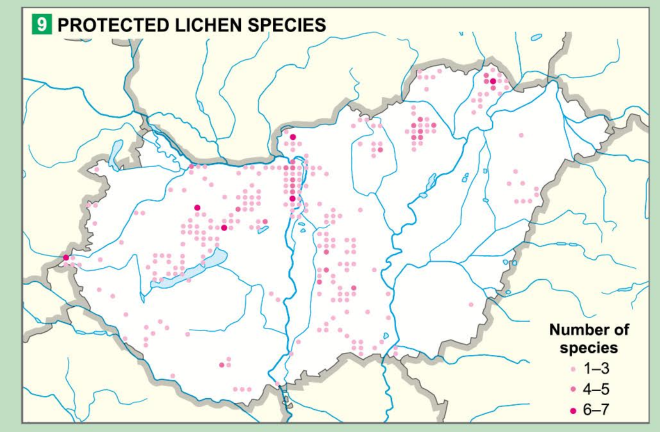
8 DISTRIBUTION OF MANNIA TRIANDRA AND ENTHOSTODON HUNGARICUS



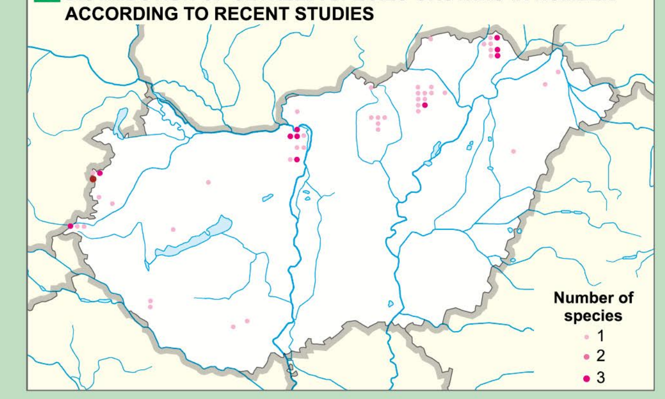
Lichens

Lichens are not considered as a separate phylum any more but groups of fungi living in symbiosis with photosynthetic partners and they are included in the fungal system as lichen-forming (lichenized) fungi. There are about 880 known lichen species in Hungary, and the number is increasing year by year. They live mostly on rock (436 species – 49.5%), soil surface (133 species – 15.1%), tree bark (288 species – 32.7%) and wood (23 species – 2.6%) and their habitats range from dry sandy grasslands to shady cliffs. Since 2005, 17 lichen species have become protected 9. In lichens nearly 1000 biologically active secondary metabolites, so-called lichen substances can be found, most of them are specific to lichens, and indispensable in classification in several cases. With the introduction of new analytical methods the number of known species in Hungary has increased 10. Lichens are important bioindicators and species distribution maps are used to monitor environmental changes, primarily in air pollution and quality.

9 PROTECTED LICHEN SPECIES

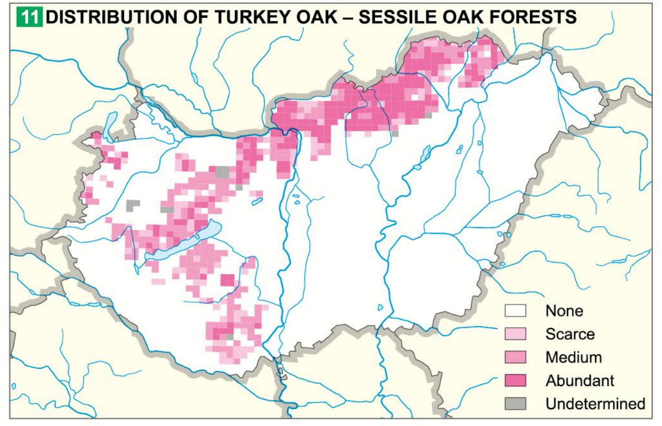


10 DISTRIBUTION OF CETRELIA SPECIES GROWING IN NUMBER ACCORDING TO RECENT STUDIES

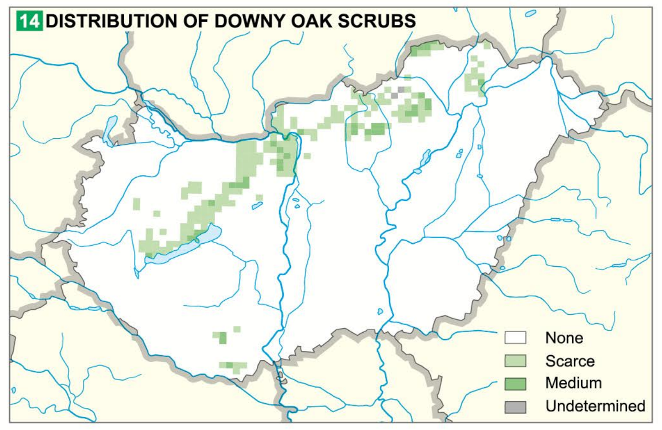


VIII.

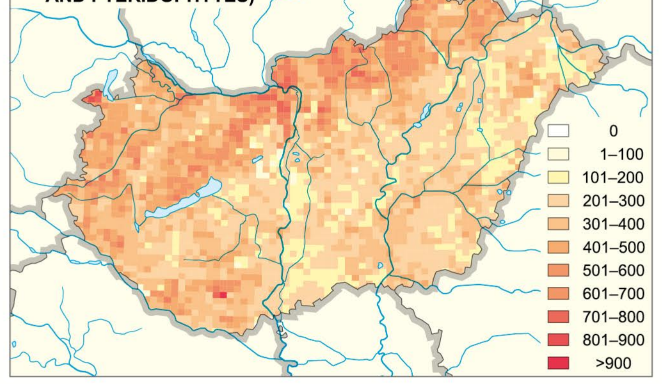
11 DISTRIBUTION OF TURKEY OAK – SESSILE OAK FORESTS



14 DISTRIBUTION OF DOWNY OAK SCRUBS



15 NUMBER OF VASCULAR PLANT SPECIES (FLOWERING PLANTS AND PTERIDOPHYTES)



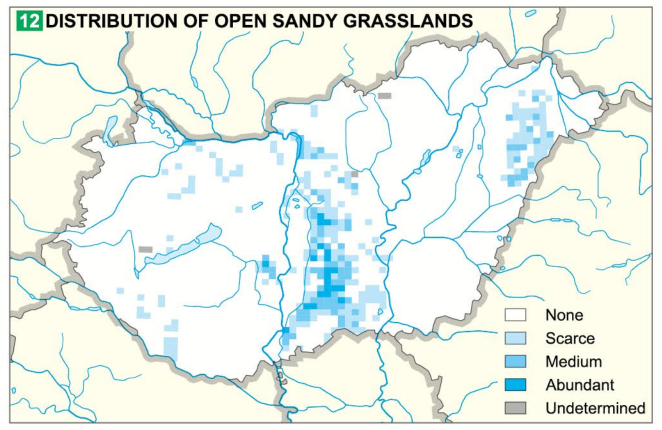
6 *Typical Pannonian landscape with extrazonal submontane steppe meadows and dry oak forests*

munity, the Turkey oak–sessile oak forest 11. The Alföld is dominated by forest-steppe vegetation and although many forest-steppe elements stretch far into Central Europe from the east, the Pannonicum is the westernmost region where the diversity of the forest-steppe communities and their species richness is fully exhibited. The Pannonian lowlands are characterized by a fine-patterned vegetation mosaic of sand dunes, saline steppes, floodplain forests, meadows, marshes and fens. An open sand grassland habitat dominated by *Stipa borysthenica* 12 is a typical Pannonian community with several endemic plant and animal species. Like other forest-steppe forests, sand oak forests 13 have become rare.

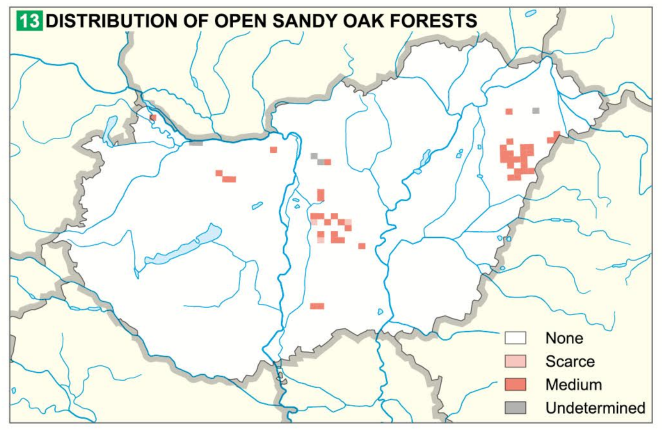
Vegetation reflects the openness of the Carpathian Basin from the south. The influence of three different forest zones can be determined. First, the forest-steppe zone expands somewhat discontinuously from Oltenia to the Pannonicum. Second, there is the impact of the Northern and Eastern Balkans which can be likened to a fork. On one side the arid and semi-arid Eastern Balkan forests stretch to the north along the eastern edge of Pannonian forest steppe. On the other side species rich and diverse Balkan forests – such as the oak-lime forest – expand to the southeastern parts of Transdanubia. Third, the influence of the Western Balkans can be detected in the oak-hornbeam and beech forests of Western and Southern Transdanubia. In the eastern part of the Balaton Uplands between the closed oak forests of Outer Somogy and the forest steppes of Mezőföld – uniquely in Central Europe – closed xerotherm Sub-Mediterranean Pubescent oak forests appear 14. Pubescent oak forests have a Balkan distribution. They are special in having a relatively open canopy layer consisting of tree species with a southern distribution and a herb layer rich in eastern steppe elements. This southern influence can also be observed in the vegetation of the Alföld especially in the Danube–Tisza Midland and explains why the Pannonian, Sub-Mediterranean forest steppe is different from the so-called continental forest steppes of Eastern Europe.

The character of the Pannonian vegetation can be described by three criteria 20. *Regularities* are the repetitive spatial patterns of vegetation both at local and regional scales. *Deviations* are departures from this pattern where vegetation types appear unexpectedly without conforming to the regular distribution. This is usually a result of vegetation history, and mesoclimatic and habitat conditions. The *uniqueness* of the Pannonian vegetation is given by vegetation types characteristic of the region, and scarce or non-existent in the neighbouring Alpine, Carpathian and Balkan regions.

12 DISTRIBUTION OF OPEN SANDY GRASSLANDS



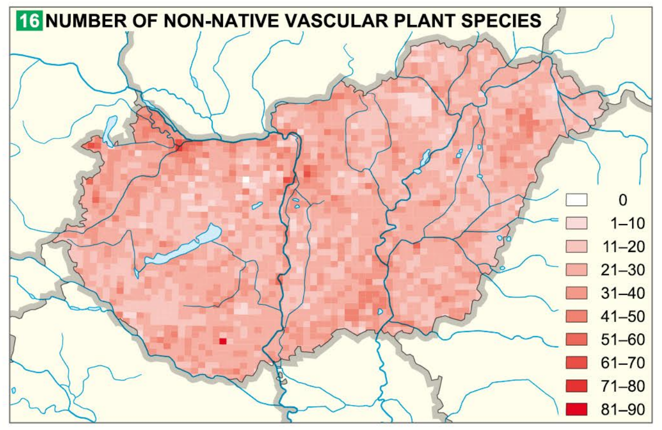
13 DISTRIBUTION OF OPEN SANDY OAK FORESTS



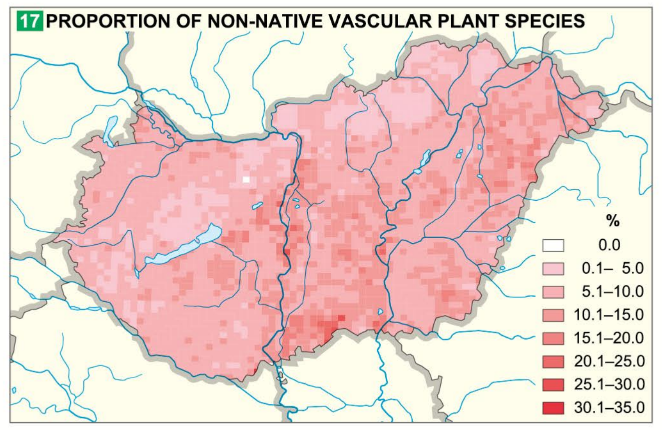
The current state of flora and its changes over the last centuries

Even under natural conditions the *flora* of a particular area changes continuously along with changes in environmental conditions. Even though these natural processes are still going on today, in the last few millennia human impact has become the most important factor in the development of the European flora, including in Hungary. The major drivers are change and loss of habitats and formation of new habitats, although in case of certain species, collection or eradication, and even planting and cultivation might play or have played a significant role. In addition to advancing or declining *native* species, *alien (adventive)* species originating in distant regions (often from outside Europe) become dominant in some situations. These alien species of real or assumed economic advantage present ecological, environmental, economic and social risks. The exact number of these species present in the Hungarian flora is hard to determine because there are differing scientific approaches (e.g. definition of species) and the flora is continuously changing. Former estimates are continually revised based on new scientific findings (e.g. species descriptions). Altogether there are about 2,400 species of vascular plant in Hungary. Seven hundred of them are non-native, of which 70 species are spreading rapidly. These latter are called *invasive alien species*. Our montane regions are more species rich as a result of diversity in environmental and habitat conditions, and less intensive land use 15. Non-native species primarily occur in secondary habitats and spread into the wider landscape from these loci. Their prevalence is lower in montane regions and higher in the Alföld (especially in intensively cultivated areas) 16 17. Invasive species are present throughout the country but are fewer (both in number and proportion) in regions with greater cover of semi-natural vegetation 18 19. There are several factors supporting their easy spread like

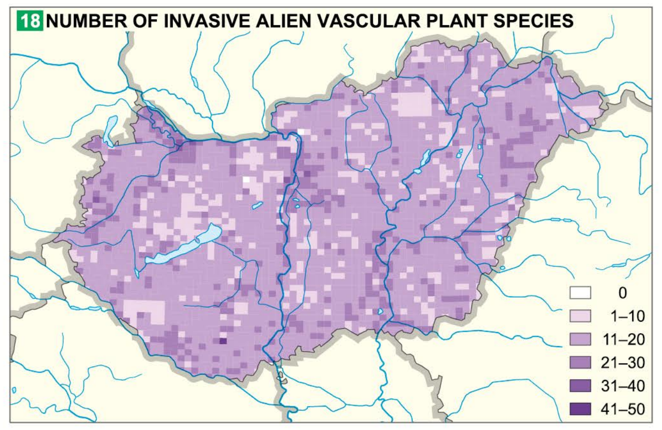
16 NUMBER OF NON-NATIVE VASCULAR PLANT SPECIES



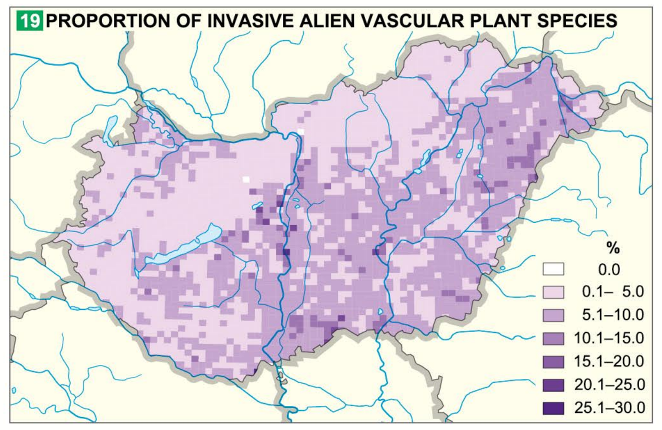
17 PROPORTION OF NON-NATIVE VASCULAR PLANT SPECIES



18 NUMBER OF INVASIVE ALIEN VASCULAR PLANT SPECIES



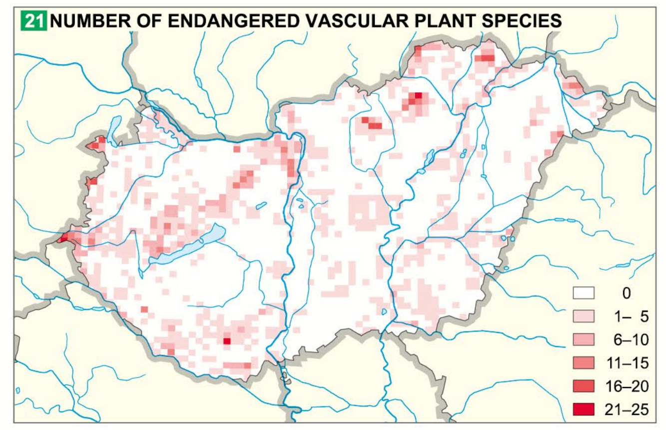
19 PROPORTION OF INVASIVE ALIEN VASCULAR PLANT SPECIES



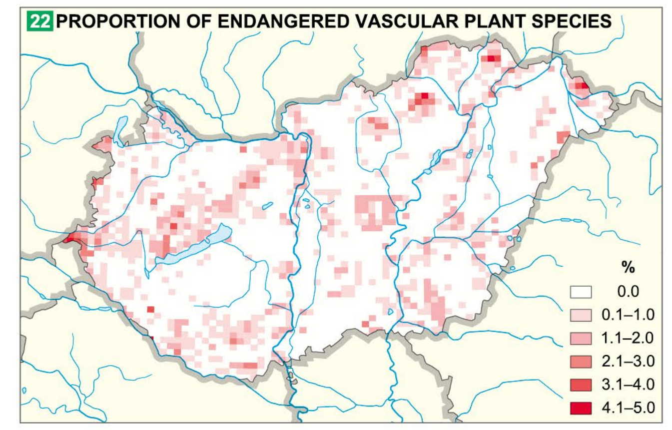
20 CHARACTERISTICS OF THE PANNONIAN VEGETATION

Phenomena	Typical regions	Explanation of phenomena, other notes
REGULARITIES OF VEGETATION PATTERN		
Spatial pattern of vegetation belts: altitudinal gradient of communities from forest steppe to beech forests	North Hungarian and Transdanubian Range	Gradient of mesoclimate with altitudes, and change of macroclimate from northeast to southwest (towards northeast, vegetation belts gradually shift upwards in the mountains)
Spatial pattern of vegetation zones: horizontal gradient of communities from east to west	Transdanubia	Increasing oceanic influence from the Danube towards the west
Gradual disappearance of Sub-Mediterranean communities in the mountains towards the northeast and continental communities towards the southwest	North Hungarian and Transdanubian Range	Gradual change in macroclimate from Sub-Mediterranean to continental, from the southwest towards the northeast
Circular vegetation pattern in the Alföld with closed forests on the edges and forest-steppe zone inside	Alföld	'Basin-effect': macroclimate becomes drier towards the centre of the basin
DEVIATIONS FROM THE REGULAR VEGETATION PATTERN		
Mixed deciduous–coniferous forests (Scots pine and broad-leaved trees)	Western Transdanubia (Őrség)	Presumably a combined result of vegetation history, several hundred years of forest use, mesoclimatic (Sub-Atlantic climate) and edaphic factors (acid gravels)
Scots pine forests of cool-continental forest steppes	Edge of Kisalföld	Presumably a combined result of vegetation history, local climatic and edaphic factors (dry sand)
Deciduous forests of cool-continental forest steppe	Gödöllő Hills	Mesoclimatic and edaphic factors to a smaller extent
West Balkan (Illyrian) zonation of vegetation belts	Bakony, Balaton Uplands	Early postglacial advance of beech and climate-induced decrease in the vitality of subcontinental forests
of vegetation belts with certain vegetation zones missing	North Hungarian Range	Early postglacial advance of lime (even before beech), competitive superiority of lime over beech on specific rock outcrops
Lime-ash oak forests surrounded by beech forests	Northern Alföld, North Hungarian Range	Vegetation history, mesoclimatic factors, Alföld: also edaphic factors (oxbows of meandering rivers on acidic substrate, oligotrophic groundwater)
UNIQUE FEATURES OF VEGETATION		
Forest-steppe forests on loess	The edge of the Alföld, Kisalföld and the edge of mountains	These forests represent the Sub-Mediterranean forest steppe with a species combination typical of the region (oaks and their hybrids)
Oak scrub forests with Quercus pubescens and Fraxinus ornus	North Hungarian and Transdanubian Range	Canopy is composed of trees of southern distribution, herb layer is rich in steppe elements
Forest-steppe forests and tall-herb meadow steppes on saline soil	Alföld (eastern part), Kisalföld	An extremely rare forest type, the community of forest glades is the westernmost outpost of an intrazonal vegetation type distributed from Siberia to Eastern Europe
Forest-steppe forests on sand	Alföld, Kisalföld	On the continental Alföld forests close to the lower tree line are refugia of montane and forest species
Vegetation mosaic of dry perennial *Festuca vaginata* grasslands with juniper-poplar forests on sand	Alföld, Kisalföld partly	Edaphic grasslands composed of many endemic species and species of Pontic and Pontic–Sub-Mediterranean distribution
Fine-scale mosaic of *Artemisia* and *Achillea* steppes with *Puccinellia* and *Camphorosma* swards and salt lakes	Alföld, Kisalföld	Presence of numerous Pannonian endemic species and rare species with Pontic–Pannonian and Irano-Turanian distribution ranges
Open dolomite grasslands	Transdanubian Range	An exclusive habitat for several Pannonian endemics and specialists showing a southern distribution
Beech forests on dolomite rocks, unique dolomite vegetation	North Hungarian and Transdanubian Range	Ecotone-like community with isolated occurrences of species of distant zones and belts

21 NUMBER OF ENDANGERED VASCULAR PLANT SPECIES



22 PROPORTION OF ENDANGERED VASCULAR PLANT SPECIES



degradation of habitats, abandonment of arable fields or too intensive cultivation. In the last two decades nearly 100 new species have been reported from Hungary. About half of these are non-native species; others are newly recorded native species. At the same time 50 native species have disappeared from Hungary over the last century and nearly 400 further species are *endangered* to some extent 21 22. The decline of species unique to Hungary or the Carpathian Basin along with species of high historical, biogeographical and ecological value is especially alarming. Endangered species are more frequent in 'good', that is species-rich, areas as they still provide favourable habitats for these sensitive species. This fact emphasizes the importance and urgency of conserving these areas.

The conservation of certain declining native species cannot or can scarcely be successful without the conservation of their habitats. Correspondingly the fight against invasive species cannot be successful without improvement and restoration of natural habitats. The dominant role of habitats is signified by the fact that loser and winner species of human-induced changes can be clearly determined, and most easily categorized, by habitat type. Species of loess and forest-steppe communities, forest edges and bogs 23 are declining significantly, while marsh, meadow and forest species with wide tolerance ranges (e.g. the invasive American waterweed, and the native fragrant agrimony) are advancing 24 25. These changes, however, must be analyzed on a long-term basis as the abundance of species in a given habitat might fluctuate considerably from year to year depending on environmental conditions (e.g. the amount of precipitation).

In the last two decades modern agricultural techniques, the use of herbicides and fertilizers and the spread of invasive alien species have drastically transformed the weed vegetation of our arable fields. In less than a century after its introduction, the common ragweed has become the most abundant weed species on our arable lands and due to its allergenic pollen, the most dangerous as well (see chapter: *Natural hazards* 29). On the other hand, several typical arable weeds, like

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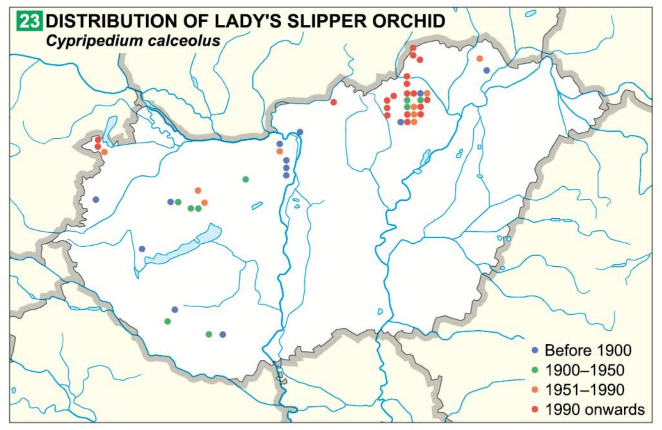
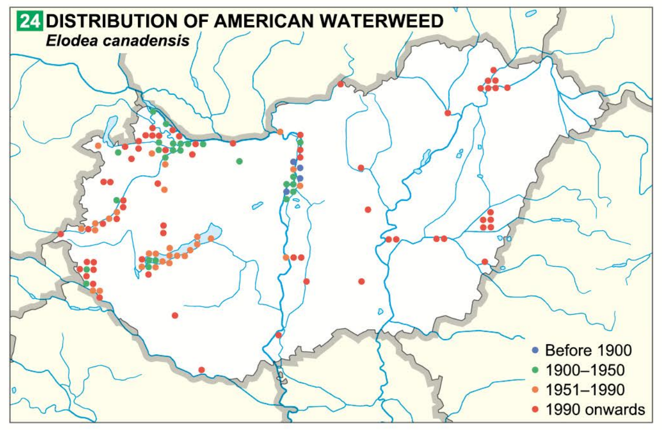
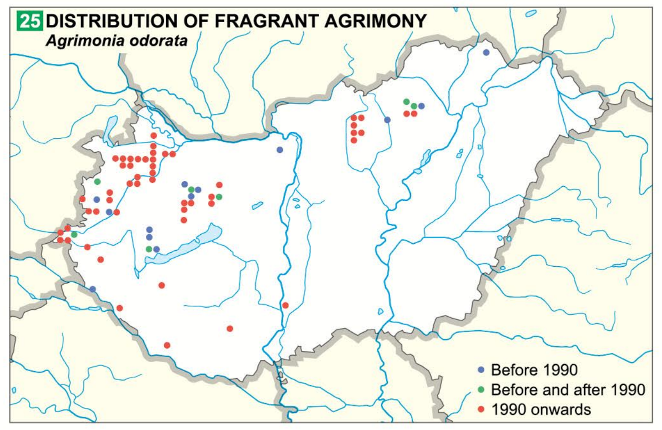


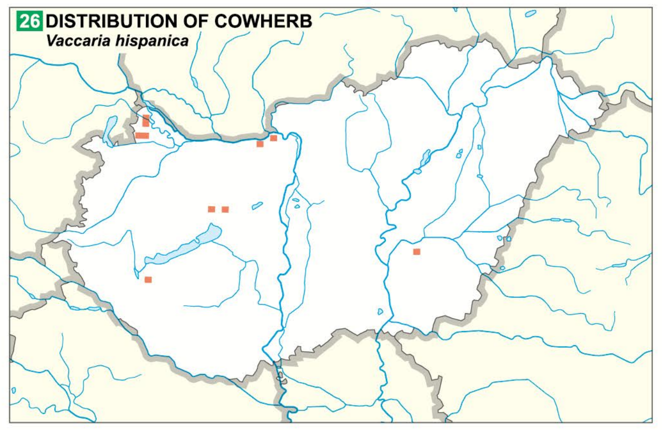
23 DISTRIBUTION OF LADY'S SLIPPER ORCHID *Cypripedium calceolus*

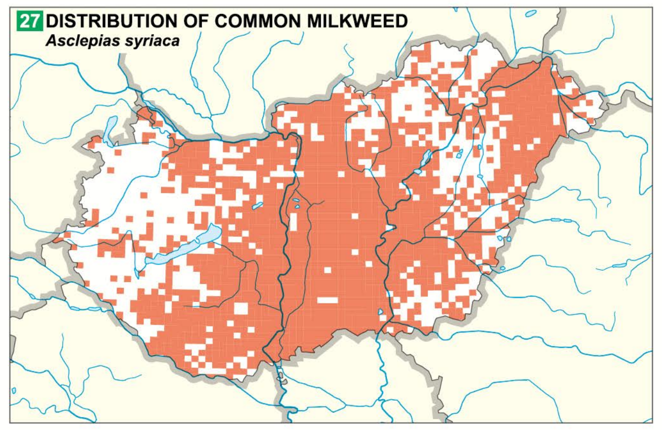


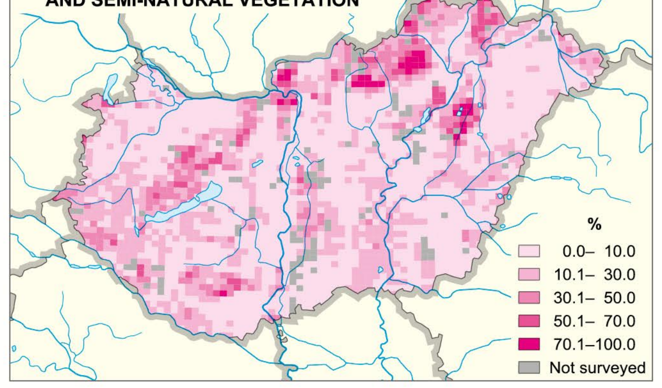
24 DISTRIBUTION OF AMERICAN WATERWEED *Elodea canadensis*



25 DISTRIBUTION OF FRAGRANT AGRIMONY *Agrimonia odorata*


26 DISTRIBUTION OF COWHERB *Vaccaria hispanica*


27 DISTRIBUTION OF COMMON MILKWEED *Asclepias syriaca*



28 PROPORTION OF AREAS COVERED BY NATURAL AND SEMI-NATURAL VEGETATION

corn cockle *(Agrostemma githago)* and cowherb *(Vaccaria hispanica)* 26 7 have considerably diminished by the introduction of intensive agricultural techniques. Simultaneously the development of agriculture has transformed the lifestyle of farmers as well. With the traditional animal husbandry of village households gone and the gardens and streets organised and 'tidied-up', certain ruderal species (typical in disturbed areas) like the stinking goosefoot *(Chenopodium vulvaria)* have declined. Modern land use has facilitated the dramatic advance of certain invasive species even in relatively undisturbed habitats. The floodplains and alluvial forests of the western part of the country, for instance, are brimming with tall goldenrod *(Solidago gigantea)*, originally introduced as a decorative plant. The common milkweed *(Asclepia syriaca)* formerly a cultivated plant now produces massive self-sown stands in sandy areas and has become a hazard to native species by occupying their habitats 27 8. During the last few decades several other alien species have invaded various habitats. Black locust *(Robinia pseudoacacia)* is spreading in one third of our mesophilous forests and in two thirds of our forest-steppe oak forests. One third of our alluvial forests are endangered by non-native aster species (*Aster* sp.) and the desert false indigo *(Amorpha fruticosa)* and more than half by the American ash *(Fraxinus pennsylvanica)* and boxelder *(Acer negundo)*.


7 Cowherb (*Vaccaria hispanica*) has almost disappeared because of modern agriculture


8 The massive advance of an alien invasive species, the common milkweed (*Asclepias syriaca*) in a sandy habitat

The current state of vegetation and its transformations over past centuries

As a result of land use changes a substantial part of the Hungarian landscape is covered by transformed habitat types. The original vegetation has been replaced by arable fields, plantations, settlements and transport infrastructure. Our surviving natural heritage, and the distribution and diversity of habitats, however, is still significant 28, even at the European level. The diversity of habitats can be analyzed at different spatial scales. If the base unit is the vegetation region 29 then our mountainous and hilly regions and the northern part of the Alföld are the most diverse areas. However, if the number of habitats per 3,500 ha 30 is counted, certain hilly regions are outranked by some floodplain and saline areas. At an even finer scale of analysis – with the base unit being 35 ha 31 – our most intricately mosaicked landscapes, like saline grasslands, near-natural floodplains 9 and some of our mountain regions, are seen to exhibit the highest habitat diversity.

Two different approaches can be used to demonstrate the spatial distribution of our vegetation heritage: the first is based on the naturalness of the entire landscape (including arable fields and settlements) 32; the second is based on the state of surviving vegetation patches 33. The difference between the two maps clearly shows that it is not irrelevant whether a landscape is evaluated based on its surviving vegetation or if the original, already destroyed vegetation is also taken into account. Even though loess steppes originally covering certain landscapes have disappeared, the latter approach gives high value to these loess ridges because the remnant vegetation in the depressions is highly natural (salt steppes). There are two habitat types worth mentioning in the section as they are hardly ever noticed but shelter significant natural values. In loess areas, vegetation fragments between arable fields and on kurgans (burial mounds) provide habitats for the last remnants of natural loess flora and fauna (e.g. Nagykunság, Heves Flat, or the Körös–Maros Midland). The last or largest stands of several rare steppe species (like *Adonis volgensis* and *Salvia nutans*) subsist in such places and their conservation and maintenance is therefore critically important. Another special habitat is provided by temporarily waterlogged areas. In the vegetation of their mud several rare plants, such as species of *Elatine*, occur. In dry years these areas are covered by cultivated plants, but in wet years these species reproduce and spread successfully.

The vegetation of forested mountainous and hilly regions, and the large continuous marshy and saline areas in the lowlands have been less transformed, while the loess ridges of the Alföld and the drier hilly regions have been impoverished by cultivation. The naturalness of our vegetation heritage is higher in the mountains and forested hills, and in the saline areas of the Alföld.

The naturalness of Hungarian forests is very heterogeneous 34. These days forest management is generally expected to maintain or even enhance forest naturalness. This is necessary, as two thirds of present-day forested areas are covered by completely or considerably transformed stands. Only one third of the forest stands can be considered near-natural having less intensive management history and natural species composition 35. The origin and silvicultural management of forests considerably influence the species-richness of the canopy layer, the age-class structure (whether trees of different ages are present), the proportion of standing and fallen dead wood – which are top priority micro-habitats for many species – and the overall state of naturalness.

In general, the naturalness of forests in landscapes with low forest cover and more fragmented forest patches tends to be lower. The naturalness of forest stands dominated even by native and non-native tree species is the highest in the mountainous regions and in Western and Southern Transdanubia, where the climate is favourable for forests. Likewise, large near-natural forests occur only in the mountains, Southwestern Transdanubia and the inner parts of Southern Transdanubia, and are scarce in other regions. In most areas with forests with high levels of naturalness, there has been continuity of forest cover throughout history. These forests are characterized by natural regeneration and typically managed on long felling cycles. In the plains where the climate is drier and vegetation is considerably modified and fragmented, extensive secondary forests and forest plantations are typical, created on areas formerly used as arable land or pasture.


9 Natural floodplain communities are confined to some unregulated river segments

Impact of agriculture

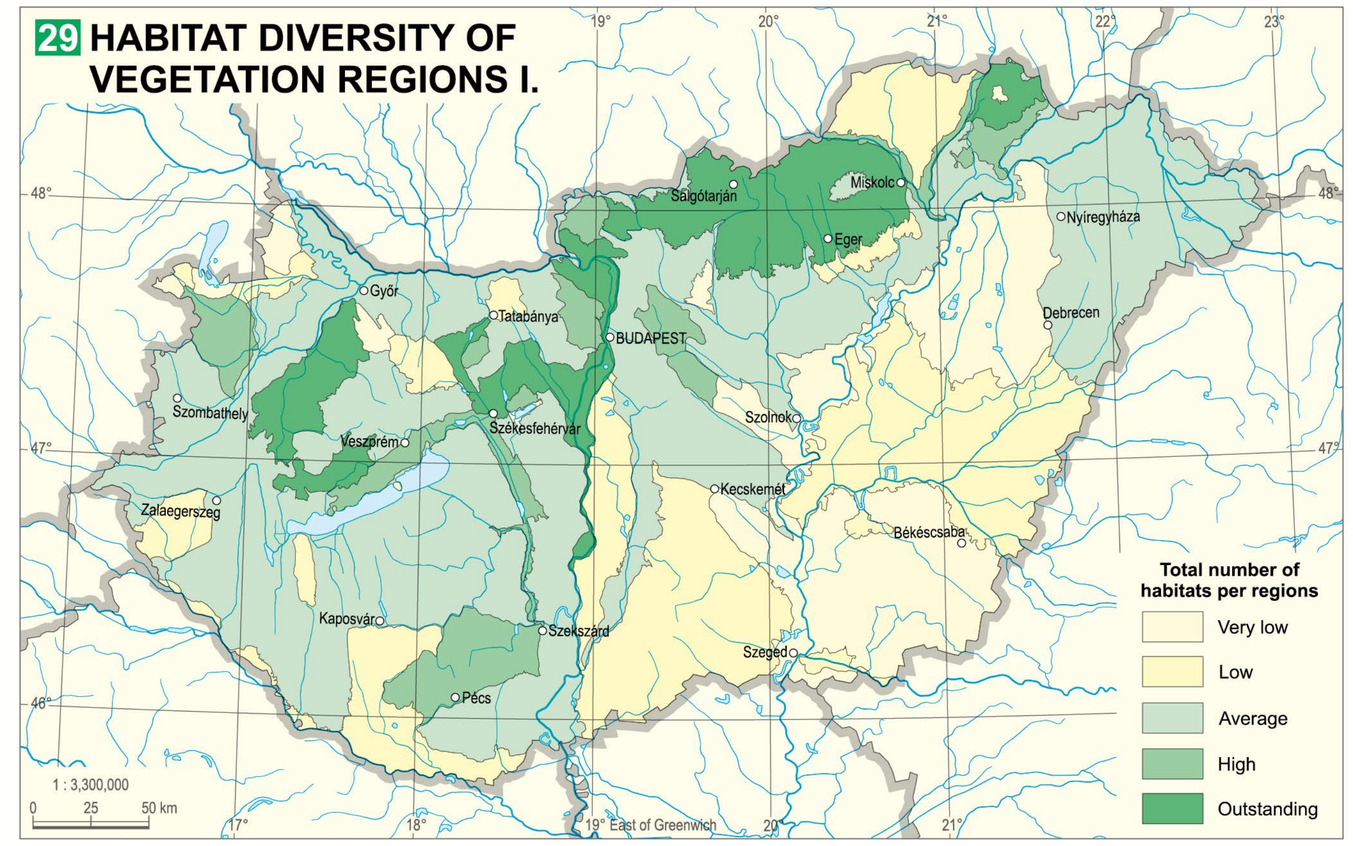
In the last 200 years vegetation changes have been driven by the continual intensification of agricultural land use. In the 20th century traditional small-scale farming and other extensive land uses were replaced by large-scale farming with increasing mechanization and more and more application of chemical pesticides and fertilizers. In some other areas, rather than intensification, the abandonment of fields has led to degradation. The decline of different habitat types has not been uniform because the potential for economic land use in some habitats is limited. Hence, a larger proportion of saline and rock grasslands have survived whilst most of our marshes, floodplain meadows and loess steppes have disappeared. The regenerative capacity of habitat types and the ecological neighbourhood of transformed patches are also of great importance. Drained fens cannot be re-established in a short time, while rock grasslands can regenerate rapidly. Degradation was slower in our mountainous regions than in the plains.

Currently the most important threats to our vegetation heritage are the transformation of habitats (e.g. by drainage and/or ploughing of grasslands), discontinuation or change of traditional management practices (e.g. cessation of, or inappropriate, mowing and grazing), intensive management homogenizing habitats and communities (e.g. monocultural forest plantations), invasion of alien species and overgrazing by game species. Forest-steppe forests, alluvial forests dependent on natural rivers and floodplains, bogs and marshes that require special water conditions (e.g. tussock beds, alder and willow fens and marshes), extensively managed meadow orchards, wood pastures, loess cliffs, *Molinia* meadows and mountain meadows are the most endangered habitats.

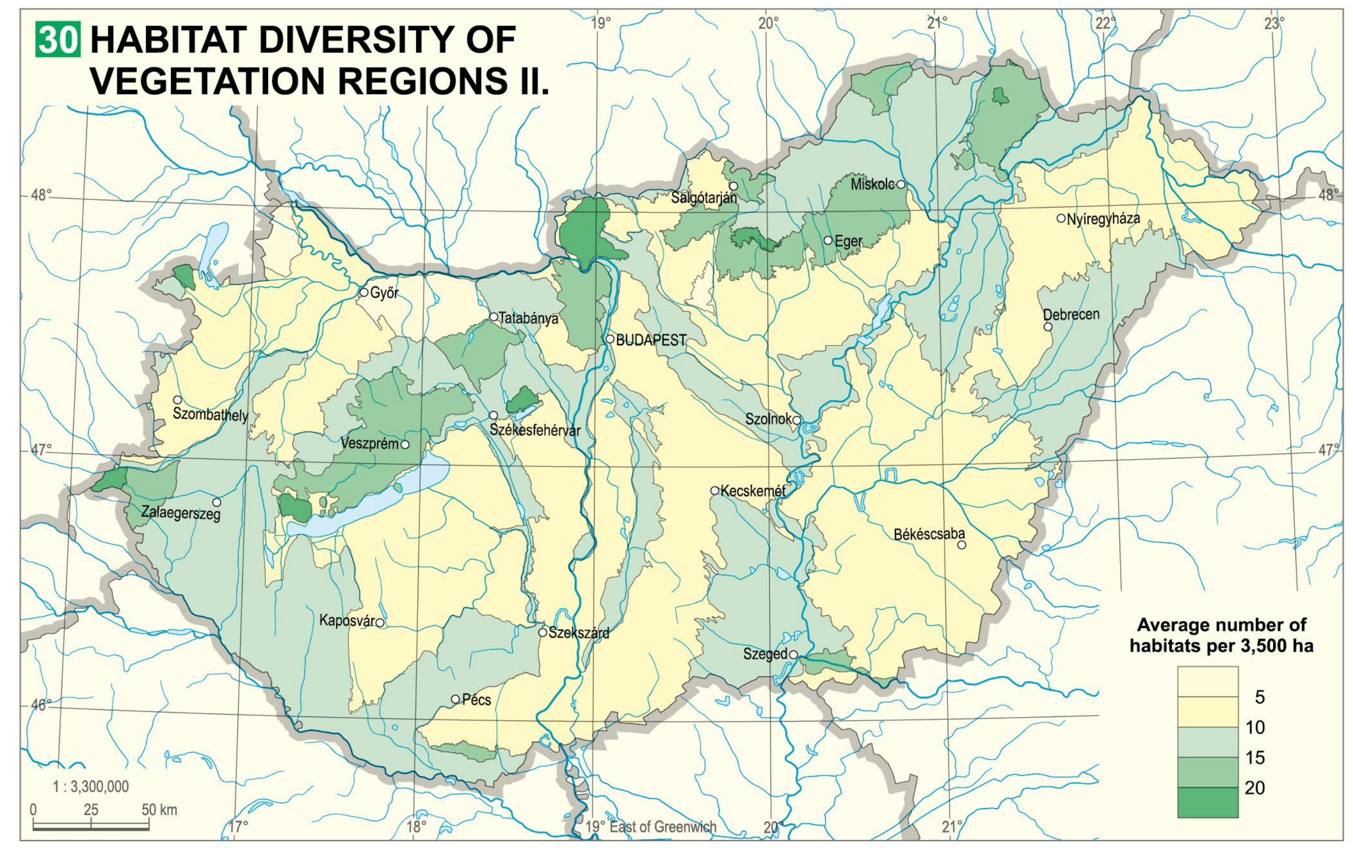
As mentioned above, another driver of change is the abandonment of formerly cultivated areas. In the first decade of the 21st century, in addition to abandoned pastures and hay meadows, the proportion of abandoned arable land increased. At national level it is 4% but in the North Hungarian Range, especially in its lower regions, it has reached 7.8%. There was less abandoned land in the Transdanubian Range whilst its proportion in the Alföld and Western Transdanubia was near average. It was less than average in the Transdanubian Hills and lowest (1.3%) in the Kisalföld 37. In some places the regeneration of vegetation on abandoned fields and pastures has begun, but in other places the change in management has resulted in the loss of native species and the spread of invasive alien species 10.


10 Hilly landscape with cultivated areas, regenerating habitats and spreading invasive species

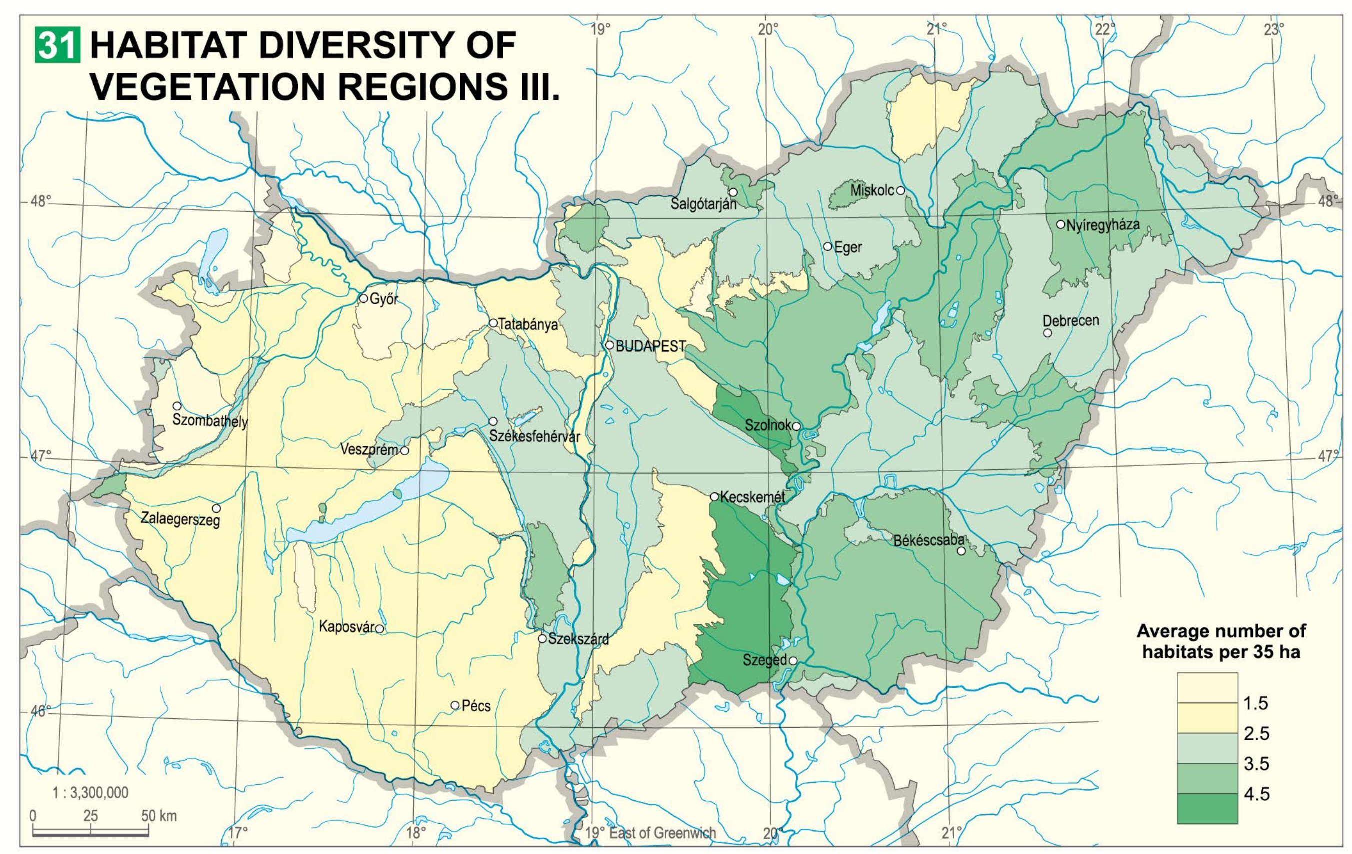
29 HABITAT DIVERSITY OF VEGETATION REGIONS I.



30 HABITAT DIVERSITY OF VEGETATION REGIONS II.



31 HABITAT DIVERSITY OF VEGETATION REGIONS III.



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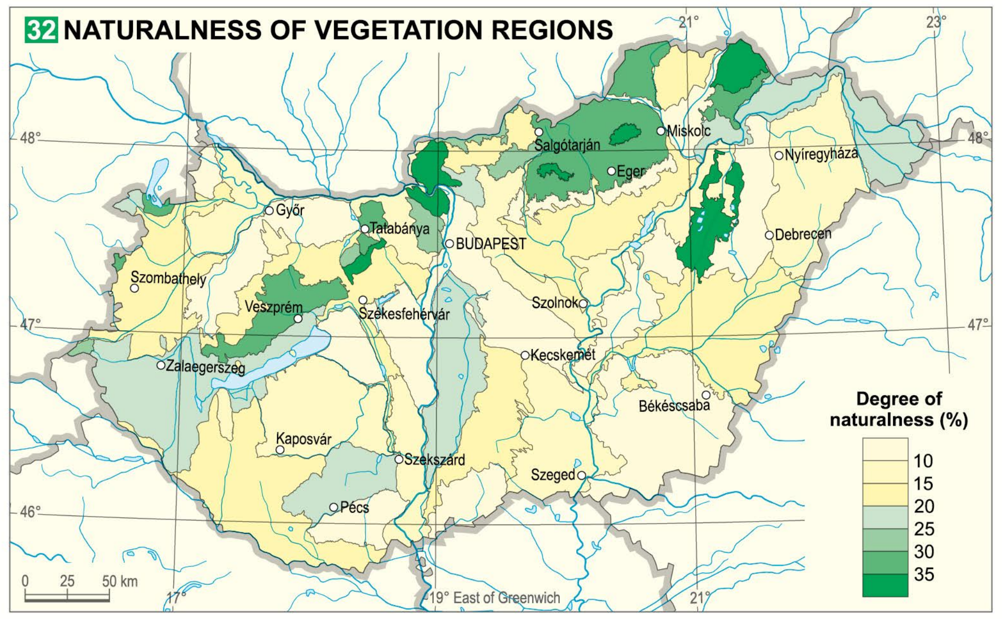
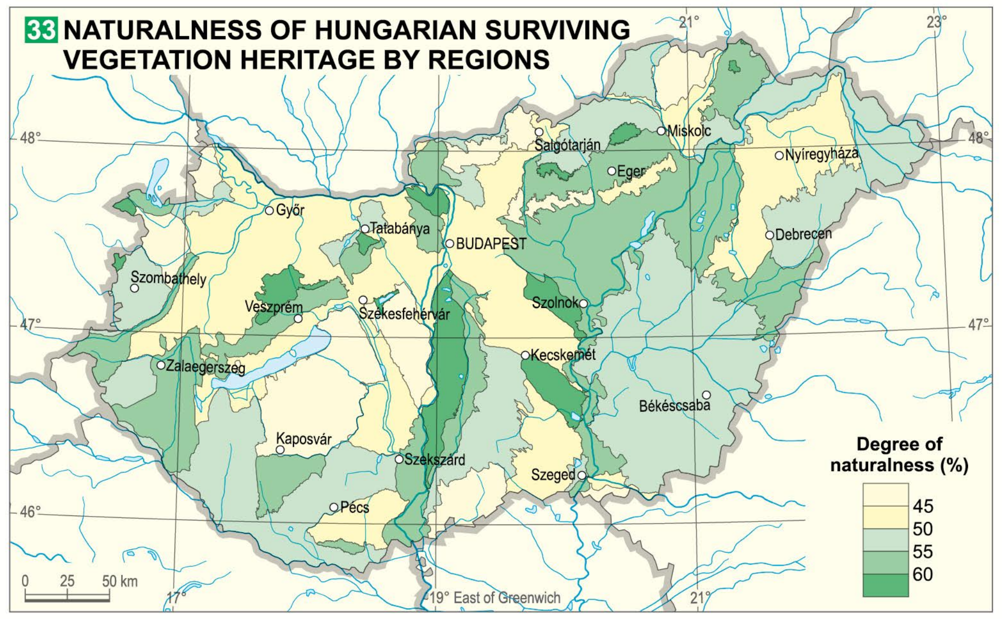
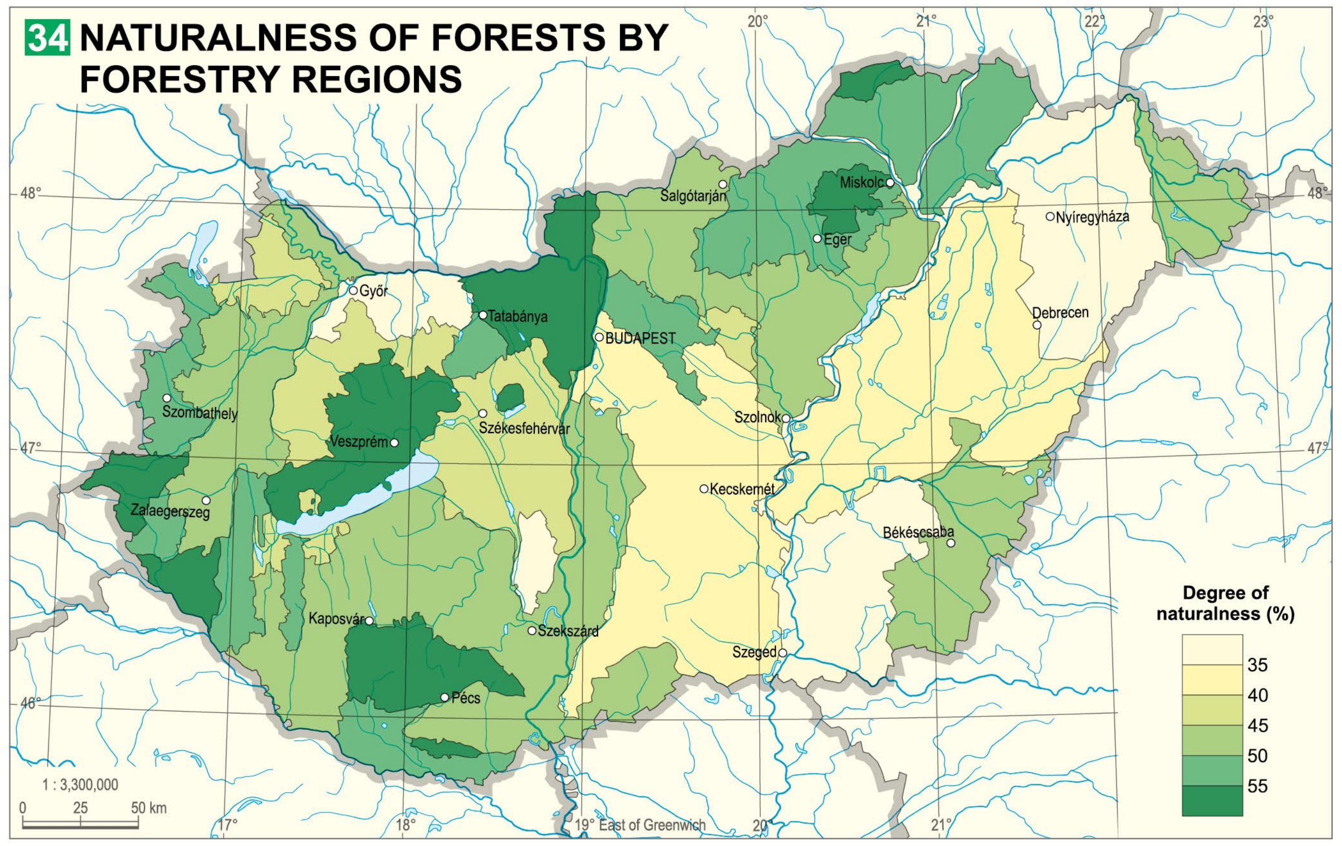


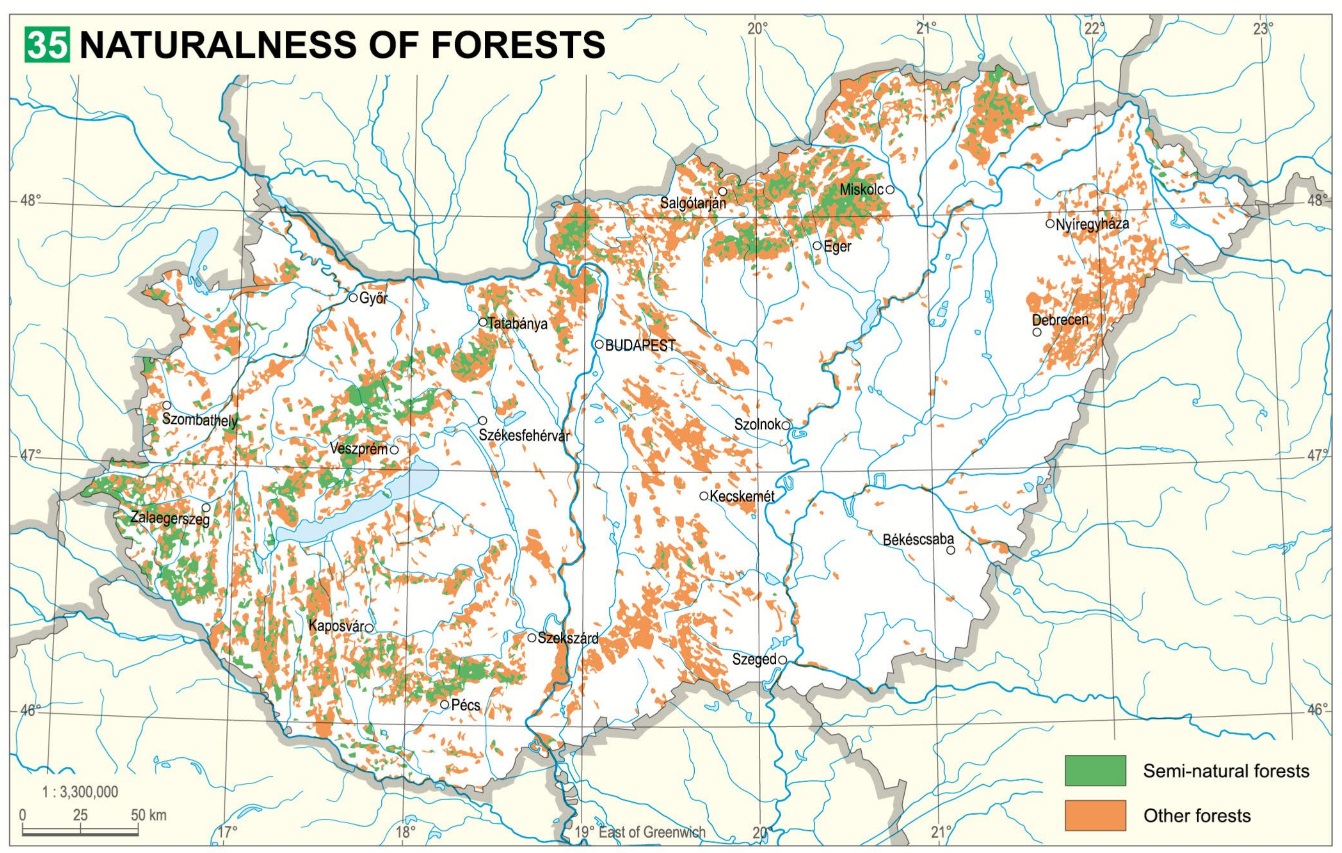
32 NATURALNESS OF VEGETATION REGIONS



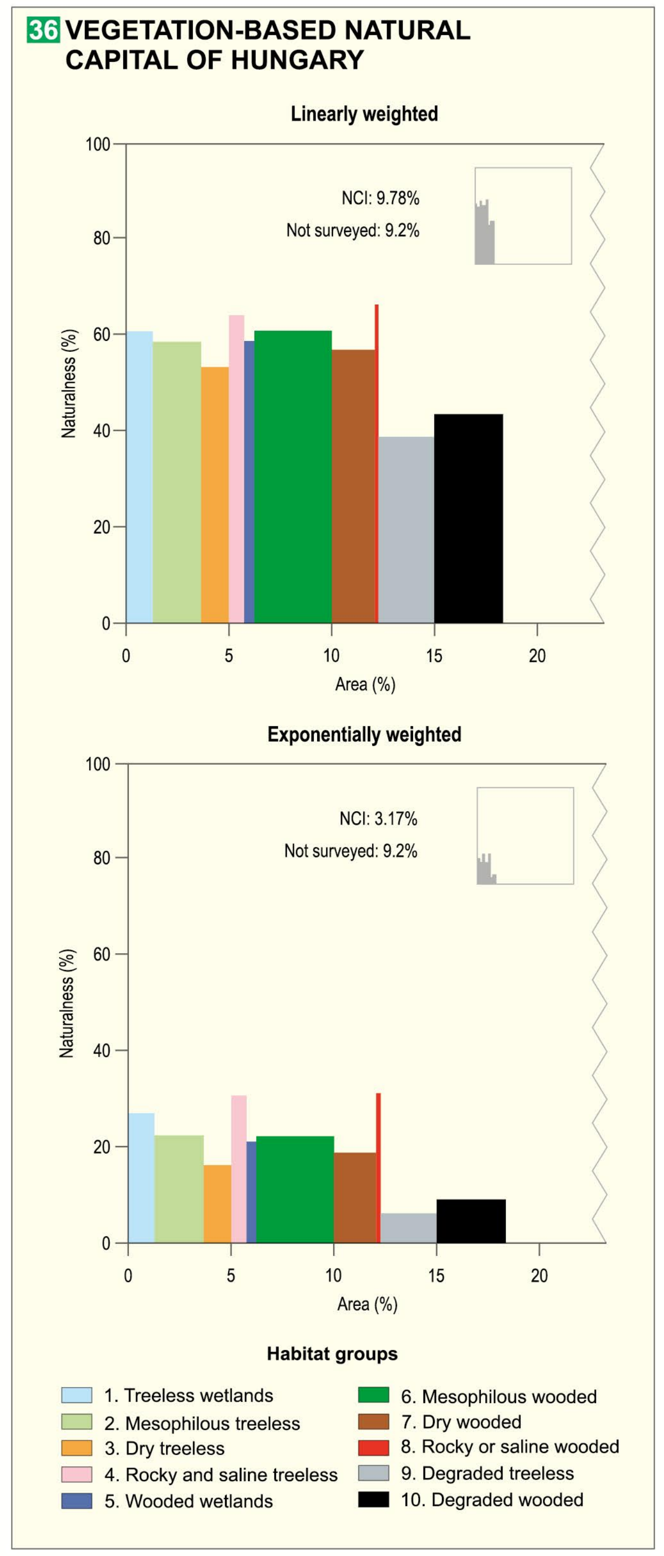
33 NATURALNESS OF HUNGARIAN SURVIVING VEGETATION HERITAGE BY REGIONS



34 NATURALNESS OF FORESTS BY FORESTRY REGIONS



35 NATURALNESS OF FORESTS



36 VEGETATION-BASED NATURAL CAPITAL OF HUNGARY

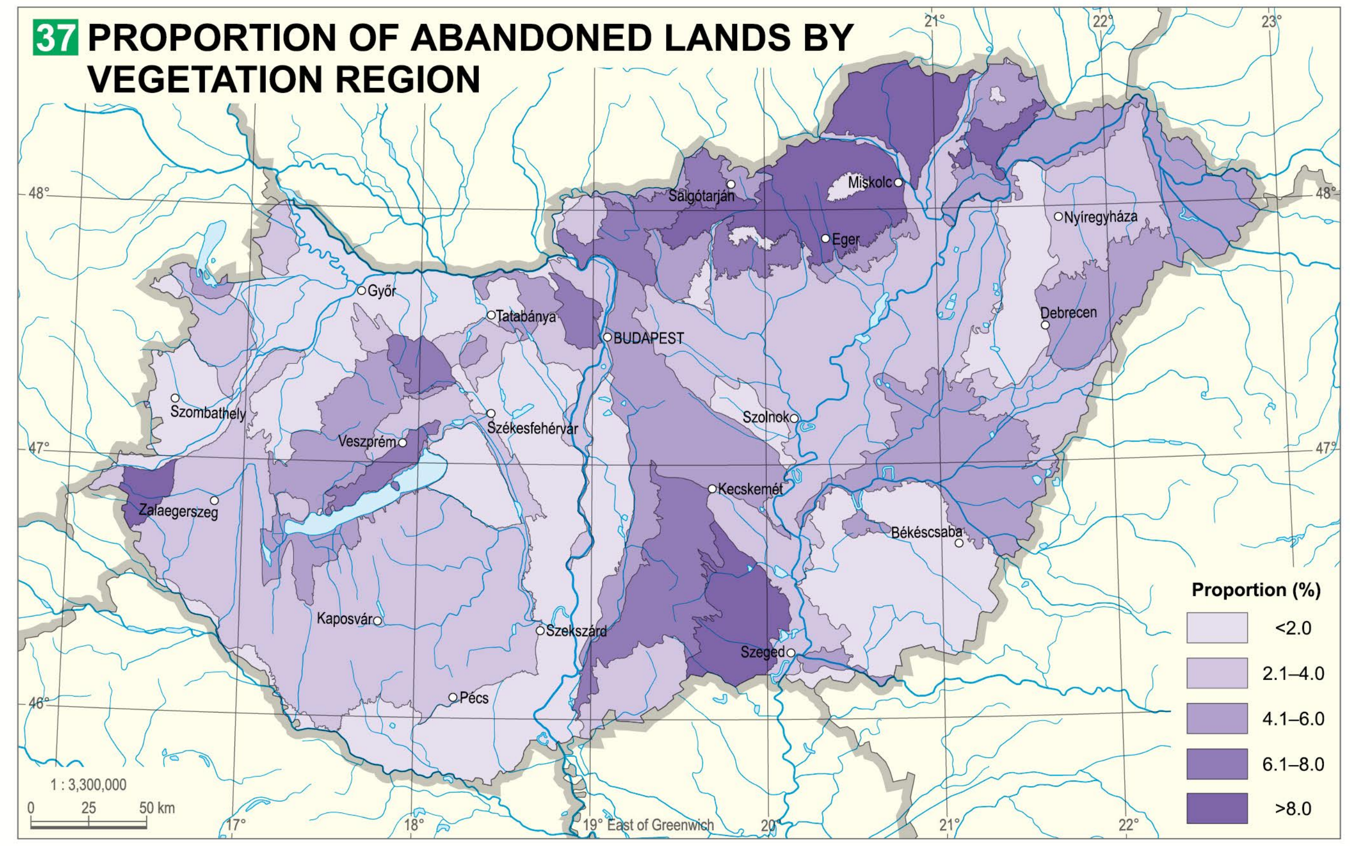
Vegetation-based natural capital

To quantify our vegetation heritage, a vegetation-based natural capital index (NCI) was used. NCI is the product of the proportion of the area covered by vegetation multiplied by its relative naturalness (%). Hungary's vegetation-based natural capital index was calculated in two different ways (linear and exponential estimation) using habitat groups as units 36. The analysis shows that 90–96% of our natural vegetation heritage has already been lost. Conservation of the rest is of paramount importance.

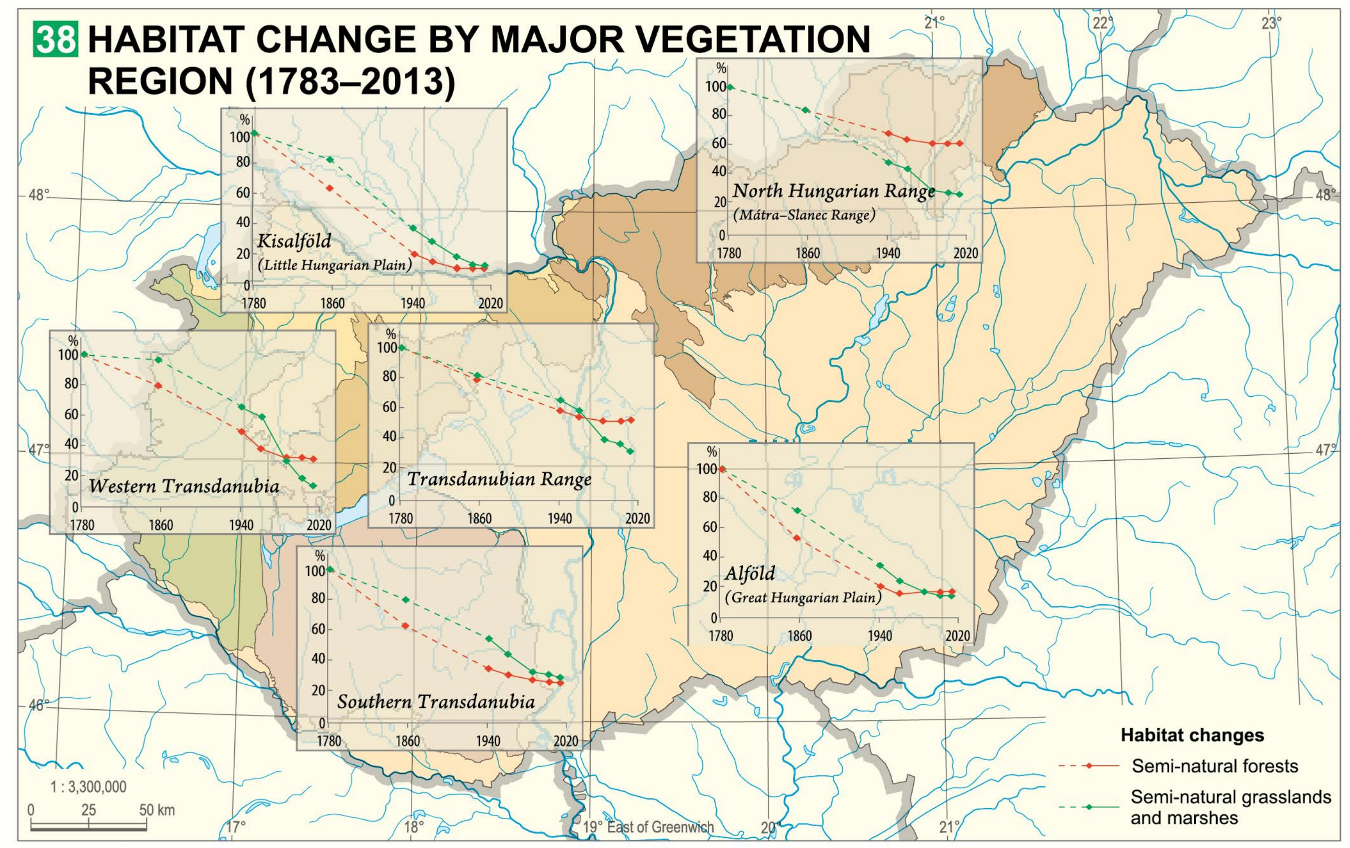
Changes in natural heritage (changes of the area covered by semi-natural habitats) can be traced from the end of the 18th century onwards, as detailed military surveys, maps, and botanical descriptions have become available. The cumulative impact of deforestation and afforestation, river regulations, wetland drainage, arable expansion, grassland 'improvement' and urbanisation has led to a significant decrease in semi-natural habitats, including forests, grasslands and wetlands in nearly every landscape 38. Grassland loss is still happening. (The figure does not show the expanding tree plantations with very low naturalness.)

The regenerative capacity and future prospects of flora and vegetation

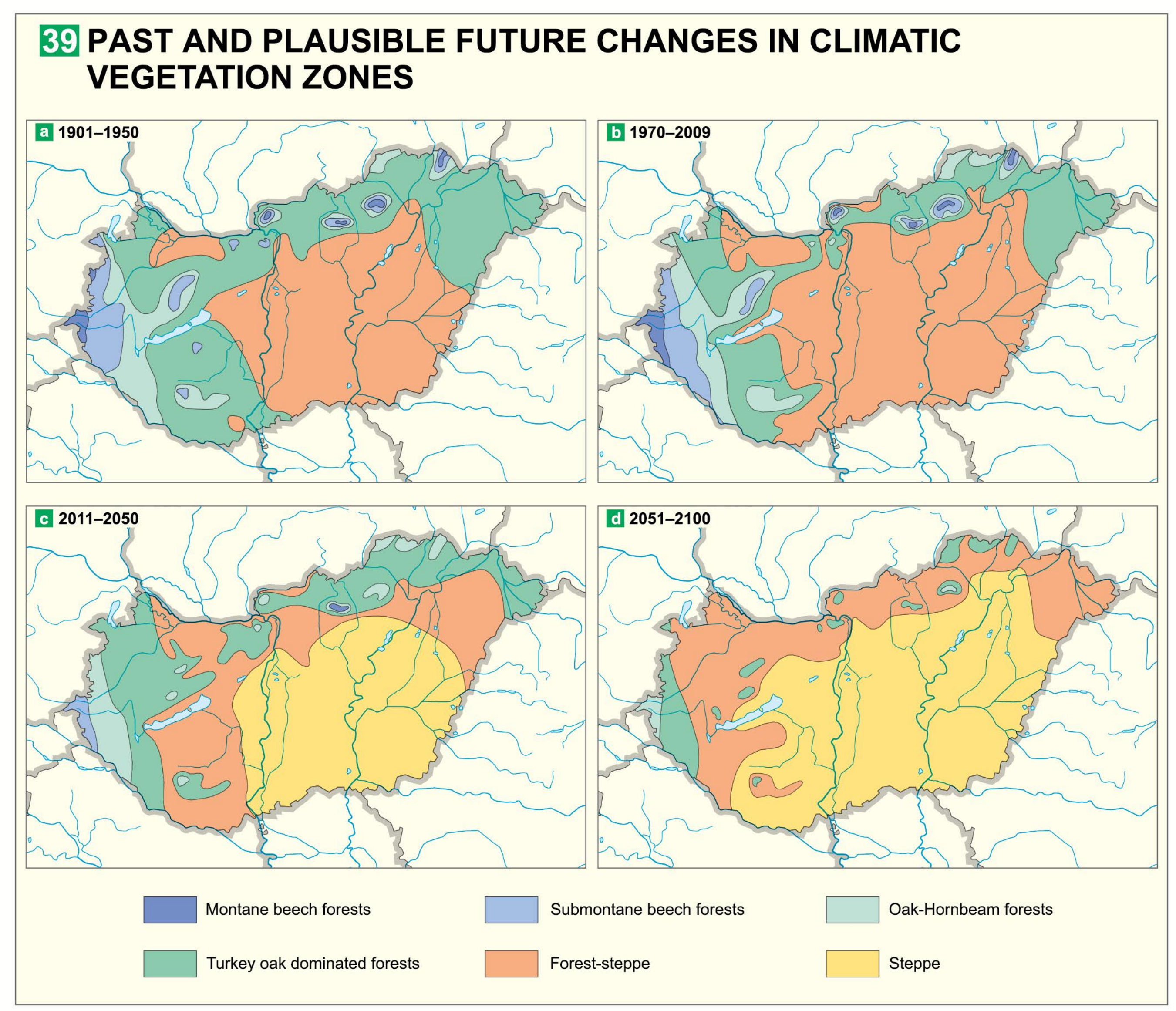
The future of the flora can be considerably different in the different geographical regions. In the mountains and certain hilly and lowland regions where the vegetation cover is still closer to the natural state and species have extensive, viable populations, conservation (that is the maintenance of the current state) has a good chance. In some places even further regeneration is expected. In certain parts of the Alföld where the natural flora has almost disappeared (even at a small scale) chances are poor. Regeneration of the flora requires a network, a certain density of near-natural habitats. If the density is adequate, natural succession and spontaneous colonization can efficiently help restoration.



37 PROPORTION OF ABANDONED LANDS BY VEGETATION REGION



38 HABITAT CHANGE BY MAJOR VEGETATION REGION (1783–2013)



39 PAST AND PLAUSIBLE FUTURE CHANGES IN CLIMATIC VEGETATION ZONES

In the case of species with special needs and fragmented populations human intervention and active conservation management will often be necessary. In some cases huge efforts are required even to maintain the status quo.

The future of vegetation greatly depends on its regenerative, self-healing capacity, or *resilience*: the extent to which a vegetation type is able to recover to its former natural state after degradation or habitat reconstruction. For this reason the *regeneration potential of habitats* is considered to be a functional indicator by which the quality and natural value of a habitat is estimated. Here quality does not describe the current state but its future potential. Most habitats have regenerative capacity; conservation practices are based on that fact. Certain habitats, like saline grasslands or marshes are able to regenerate even in new locations; others like certain fens are not at all. Certain marsh and floodplain habitats, and some closed forests regenerate relatively well in their original location, but are unable to do so, or only very slowly (in 100–200 or more years), in a new location (e.g. on abandoned arable fields).

Plausible future changes are diverse. Perhaps the most important is *change in land use*. In certain regions agricultural production may become further intensified, with high chemical usage, mechanization and large monocultural fields. In other regions the discontinuation of fine-scale extensive cultivation might raise problems. The result of the new initiative, called ecological intensification, is still uncertain.

Climate change is of ever-increasing importance and has a number of secondary negative impacts as well. The diversity of climates has created typical vegetation zones throughout the globe. Hungary is in the subzone of temperate deciduous forests. This zone is divided into several smaller units of climatic forest zones based on the amount of precipitation. These range from dry oak forests, mesophilous oak-hornbeam forests to the more humid submontane and montane beech forests. The transitional areas between the dry and humid climatic zones are covered by forest-steppe including both forest and steppe components, which characterizes large parts of Hungary.

The ecological importance of climate change experienced in the 20th and expected in the 21st century is clearly demonstrated by the shift and transformation of climatic zones 39. So far only the expansion of the forest-steppe zone into the forest zone is shown by a vegetation ecological analysis of data from 80 weather stations. But some regional climate scenarios envisage more substantial changes: most of the Alföld will belong to the steppe zone, the border of forest-steppe and forest zone will shift 100 km to the west in Transdanubia, and the zone of beech forests will practically disappear from the mountains. Finally, the proportion of Hungary's area that falls within the steppe zone is projected to rise to two thirds, and the area covered by the climatic forest zone may fall to below 10%. The prospective changes are not uniform across the country: in the northeast there will be hardly any decrease in precipitation, whereas in Southern Transdanubia or the Alföld a major increase in aridity is expected.

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