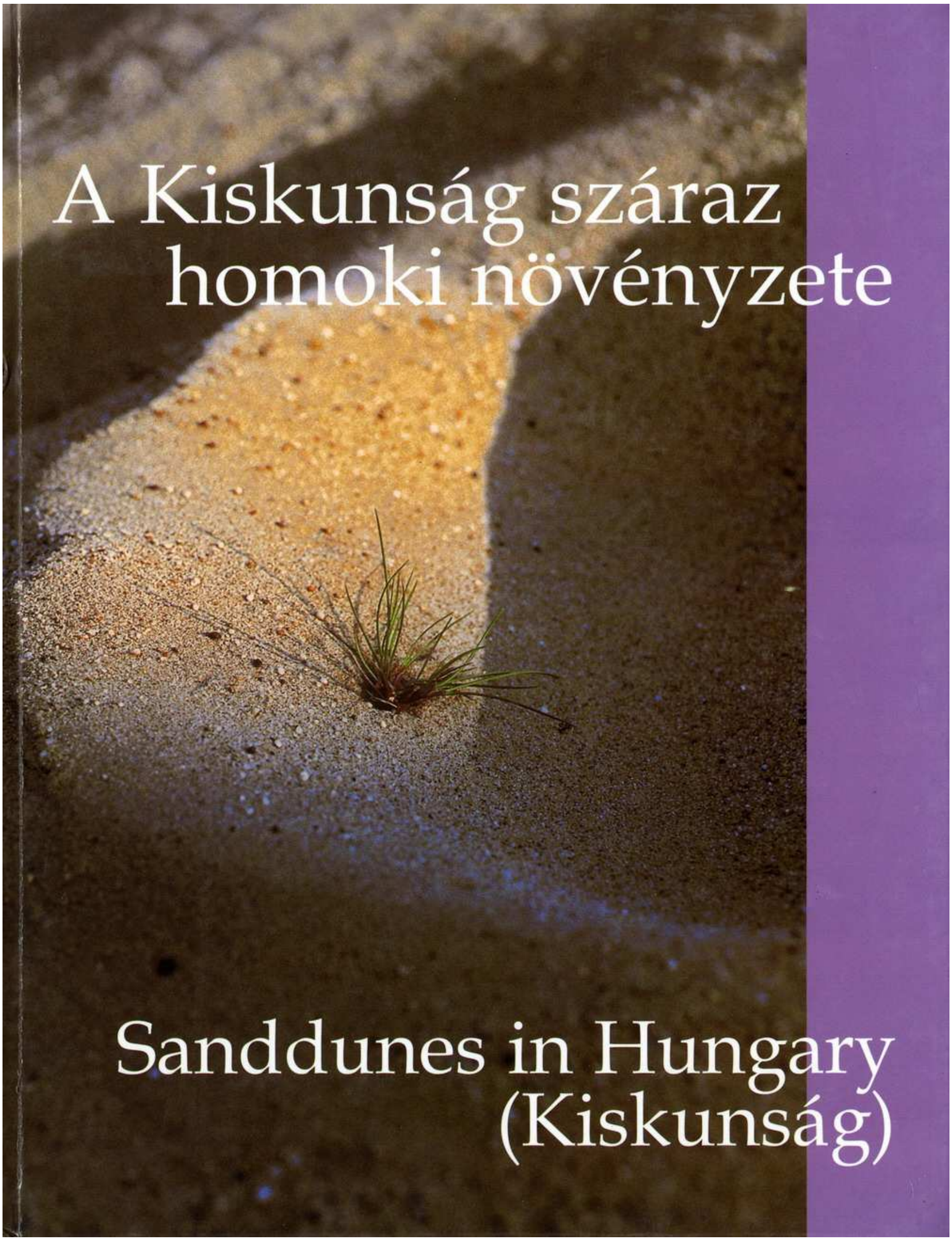

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Dry sand vegetation of the Kiskunság

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Recommendation

Undoubtedly the greatest of the current challenges in nature conservation lies in whether the natural values of the Carpathian Basin can be protected in the long run parallel to the enormous economic development processes. This question is outstandingly up-to-date concerning the Duna-Tisza köze, especially in the Sand Ridge Area, where the smaller or larger valuable areas harbouring geomorpholoigcal, landscape and biological diversity are separated by "deserts" of sand arable land, vineyards and pine forest plantations.

What remains after thousands of years of land use can be found within the Kiskunság National Park (Peszéradacs meadows, Fülöpháza, Bócsa-Bugac, Orgovány meadows) and in smaller protected areas which are managed by the Park. When planning protective and developmental management measures – right at the very beginning – the definition of “ideal aims and state to be achieved” presents a series of tricky questions nature conservationists have to face. Is there a need only for passive protection – simply to conserve and to fence off harmful effects from the surroundings – or rather is there place for intervention, local nature conservation management actions, and if yes, what measures have to be taken?

During the 30 years of existence of our national parks many lessons have been learnt, among others, that the best healer of disturbed natural systems is nature itself: intervention is not necessary everywhere and in everything. We also know that areas should not be assessed according to their present state, even if we have been watching and walking among them for several decades already. For the present understanding and future planning it is essential to acquire the possible deepest knowledge of the landscape’s past.

This thinking is reflected in this book, which – on one hand – gives a snapshot of the present vegetation and flora of the Kiskunság sand areas drawing on historical and land-use roots, on the other hand it raises questions which urge all of its readers to take part in a responsible common thinking about the future of these areas.

In a matter of years sand areas harbouring the dry sand vegetation of the Kiskunság will be part of the NATURA 2000 network uniting outstandingly valuable protected areas of the European Union. The Directorate of the Kiskunság National Park alone – isolated from other institutions – is not going to be able to sort out the long-term maintenance and the desirable expansion of these areas.

Therefore I hope that this book is going to be of value not only to nature conservationist, botanists and zoologists. I recommend those parts of the book which stimulate discussion and encourage action to locals, farmers of the sand hill areas, to colleagues working at local authorities, forestry and water-management services and to all who love and would like to conserve the remaining natural values of the Kiskunság.

Gábor Szilágyi
Director, Directorate of the Kiskunság National Park

Forward

“ *The shifting sand does not, incidentally, always tolerate the rule of the plant world easily . It resists the imposed shackles, wrestles and struggles courageously for its freedom and independence. (...) During its struggles it finds a powerful and ready friend in the storm winds, which whirl up sand masses often enough, ravaging and covering the green land that surrounds the island of sand, burying the established plant world, and thus the boundaries of the drifting sand areas are altered a good distance”* A. Kerner (1865) [1]

Sand dunes and shifting sand areas are considered one of the most endangered habitats in Central Europe. If at the beginning of the 20th century sands habitats with sparse vegetation cover were still extensive, now they have been reduced dramatically in size through stabilizing measures, intensive agricultural and forestry use, along with mass tourism.

The sand dunes give shelter to an exceedingly interesting animal and plant world, which is made up almost exclusively of habitat specialists. Many of the species that appear here are categorized on the red lists as “extremely endangered” or “threatening to become extinct”. Due to their continental character the Pannonian Sand-Dunes take up a special position among sand habitats. Many of the animal and plant species that appear here are extremely rare in the rest of Europe, some of which are even endemic.

For this reason the EU has put the Pannonian Sand-Dunes on the list of “priority habitats”. The member states of the EU have committed themselves to preserve such habitats and are supported by specific programs. Within the framework of the program, LIFE-Nature supports measures, which serve the preservation and restoration of natural habitats for animals and plants. This program should contribute to the improved application of the EU Fauna-Flora-Habitat Guideline and the Bird Protection Guideline and to the support of the organization, Natura 2000, the European Nature Reserve Network.

At present a “LIFE-Nature Project” is being carried out in Austria, which should develop and permanently secure the last remains of the Pannonian Sand-Dunes and was also able to support the drawing up of the publication at hand. Similar studies on sand areas in Slovakia and Yugoslavia will follow. The goal of which is to cooperate more closely in the future in the area of nature protection and to intensify the exchange of information since nature protection does not obey any national borders, but is a general matter of concern for all nations.

At present Hungary is still blessed with wonderful sand habitats: Kiskunság, Nyírség, Somogy and Dél-Mezőföld are just a few examples. But even here time has not stood still. The afforestation of valuable sand locations, extensive land use, the building of streets, and spreading of neophytes threaten sand habitats increasingly.

Against the background of Hungary’s aspiration to join the EU, the sand-dunes offer a valuable potential for the future as a priority habitat and its preservation is of European interest in its entirety. In order to secure and develop these valuable habitats, it is necessary to find an appropriate management form of natural space. For Hungarian sand areas, this also means a strengthening of ecologically adapted economic methods and of soft tourism.

[1] A. KERNER (1865): Das Pflanzenleben der Donauländer.

If there is success in preserving the sand-dunes with their characteristic fauna and flora through long-term caring measures, we will not only win ecologically valuable areas. The sand-dunes are considered to be one of the most beautiful landscapes of our cultural landscape. Already at the end of the 19^{th} century, the botanist and scientist for forestry, J.Wessely[2], wrote about the sand-dunes in the Pannonian region: *"... if the tidings of this remarkable piece of earth had made their way out beyond the circle of shepherds there, nature researchers as well as tourists would already have been planning pilgrimages there for some time."*

Heinz Wiesbauer
Coordinator of the LIFE-Nature Project "Pannonian Sand-Dunes"

[2] J. WESSELY (1873): Der europäische Flugsand und seine Kultur.

> “Nature is not a machine that can be taken into pieces, readjusted or repaired. Nature can only be altered at its own pace and with its own methods.”
>
> Daniel. B. Botkin

INTRODUCTORY THOUGHTS

In today’s world finding the cultural, national and family roots becomes more and more important. Moving the Hungarian Holy Crown from the museum into the Parliament, the castle restoration programme are all part of the same process, as the realisation that the current vegetation of our land is not only a part of our natural heritage. They also trace the marks left by the cultures of the disappeared communities, inhabitants, thus making it into parts of our cultural heritage too.
The principal question for any society is how to exploit its natural resources: in this case, the landscape and habitats such as sand dune areas. The question has been answered in several ways through history: through extensive grazing, arable field and vineyard cultivation, forestry, or by leaving the site uninhabited. Today, however, in our fast changing world, these answers must be re-evaluated. The role sand dunes play in the survival of local people, in the profits of foreign investors, the entertainment of urban society, and their delivery or rather return to nature should be reconsidered.
The purpose of the present book is to help elaborate the above question. It is aimed at amateur and professional conservationists, rural development managers, mayors, farmers, biology teachers, students and anyone else interested, in Hungary and the European Union.
Besides examining strategies and management plans, the book is designed to give the deepest possible insight into the present state and dynamics, and even the history of the vegetation, to help readers formulate their own opinion.

Why write about dry sand vegetation? The semi-desert Pannonian sand hills are considered one of the most characteristic landscape types in the Alföld (Hungarian Great Plain), occupying huge areas primarily in the Kiskunság (about 14-15,000 ha). Furthermore, this continental sand landscape is unique within the boundaries of the European Union (except for some small patches in Austria), so it will become a Hungarian speciality (and a Priority Habitat) following the country’s accession. The uniqueness of this habitat in Europe was noted earlier by western travellers: the Kiskunság was referred to as the European Sahara 200 years ago when most dunes were still shifting. The region’s flora and fauna are likewise special: isolated from other “similar” Eurasian landscapes, local plant and animal species have evolved on their own, creating endemic species or subspecies, including such curiosities as *Dianthus diutinus, Epipactis bugacensis, Colchicum arenarium* and *Festuca vaginata*.

The landscape is extremely varied: eastern continental semi-desert like dune tops, saline lakes full of birds in spring, dried snow-white in summer, sedge fens not unlike those of western and northern Europe, together make up the species-rich, impressive, protean Alföld.
Travellers crossing this landscape by train see nothing but arable fields, vineyards, orchards, black locust and pine plantations, for the remnants of primary, semi-natural vegetation lie isolated and hidden, far from roads.

The region is full of plants which have developed extraordinary strategies to survive the sweltering heat and tormenting drought. Roots may delve as deep as several metres (even those of plants only 10-20 cm high), or linger near the surface to utilise subsurface morning dew. To reduce evaporation some plants hide their stomas behind hairs, while others have narrow, glaucous, very thick leaves. Some species retain water by utilising a special type of photosynthesis, others bear flowers and fruit well before the dry season to tide over hard times as seeds. Most plants keep micro-fungi on their roots (called mycorrhizas) that assist nutrient and water uptake. There are certain moss species that look lifeless under the sun, but are able to revive, "opening up" in 5-10 seconds when watered.

The landscape is highly steady and at the same time very dynamic. It is steady because the vegetation has been semi-desertlike steppe woodland with more or less moving dunes at least for the past 10,000 years, since the Ice Age. At a finer scale, however, the landscape is highly dynamic: grasslands become forested, dense juniper woodlands burn down in a day, interdune depressions get buried under as much as 10 metres of wind-blown sand in a few years. Grazing prevents the regeneration of woody species, but as soon as it ceases, poplars and junipers regenerate vigorously. Semi-natural vegetation may recover on abandoned arable fields surprisingly fast, in as little as 20 years.

Sand vegetation dynamics is renowned for the fact that one of the most important features of vegetation, the succession of plant communities, was first recognised here by Anton Kerner in the 1850-60s.

Owing to their uniqueness, the long-term conservation of sand dunes is a priority aim of nature conservation in Hungary. The present book contributes to this aim by:

- introducing the sand hills of Hungary, and their history,
- exploring the most important natural values,
- emphasising their rapid destruction and the most dangerous threats,
- outlining possible conservation and management strategies.

Although there are more general and more specific conservation problems, there is no such thing as a "typical" sand dune, and nor is there a "single optimal" management strategy. This fact should always be kept in mind when designing management plans.

SAND REGIONS IN HUNGARY

Wooded-steppes on sand

The major part of the Alföld is covered by wooded-steppe where vast salt, loess and sand steppes, open and closed woodlands alternate with meadows, marshes, fens and floodplain vegetation. Wooded-steppe in the Alföld is partly of southern (sub-Mediterranean) character, and partly of eastern (continental) character. The most typical habitats are found on sand dunes built from wind-blown sand. Species of or related to eastern or southern distribution areas (continental-Pontic, Pontic-Mediterranean, sub-Mediterranean) are frequent in every habitat type, ranging from the sparse vegetation of wind-blown sand to the open sand steppe oak woodlands. Endemic species of the Alföld are most abundant in the sand regions. These endemic species are found exclusively in the Alföld and the Carpathian Basin. Pannonian sand steppe woodlands are unique due to the transitional (continental-sub-Mediterranean) character together with the endemic species.

Although dunes have now stopped moving, the landscape looks deserted by Central European standards: dune tops are covered by sparse, semi-desert vegetation, on the sides half-closed grasslands grow with dwarfed ("magpie-trampled" - folk expression) poplars, interdune depressions are characterised by steppes and salty meadows, and even sedge fens were present

30-40 years ago. This recurrent pattern of vegetation is chiefly caused by the rhythmic alteration of leeward and windward sites, making the landscape so variable.

Wind-blown sand

In Hungary large areas are covered by sand, mainly by wind-blown sand (Map 1.). The most prominent wind-blown sand areas of the country are: the Duna-Tisza köze sand ridge (including the Tápióvidék and Tiszazug), the Nyírség, the sand regions of Somogy, Kisalföld, Tengelic and Jászság. Although there are other patches of wind-blown sand, e.g. near Fenyõfõ, Igrici, Nagykanizsa, Balatonlelle, etc., they are all very small and lost their natural vegetation (Map 2., Table 1. and 2.).

The sand in Hungary is mostly of fluvial origin (except for the sand region of Somogy, where sand was produced by tectonic cleavage and weathering). Therefore sand in the Nyírség, Duna-Tisza köze sand ridge, Jászság and Tengelic forms characteristic alluvial fans. Dune ranges, the characteristic relief forms of sand alluvial fans, are found emerging from the surrounding fields of agricultural lands. They usually start with gentle, low dunes that merge into higher, more indented, and wider sand hills.
Besides phytogeographic effects, sand vegetation is strongly influenced by macro- and microclimate, and by the quality of sand. The sand regions of Somogy, Fenyõfõ and the Nyírség belong to the Central European woodland climate zone. The rest of the sand regions in Hungary lie under the steppe woodland climate. The acidity of the sand is another important factor. It contains chalk and therefore is basic in the Duna-Tisza köze sand ridge, the western part of the Jászság, the Kisalföld, and the major part of the Tengelic sand region, while the sand is acidic in the Nyírség, the north-eastern part of the Duna-Tisza köze, the eastern part of the Jászság (Heves county), the margins of the Tengelic sand region, and the sand regions of Somogy and in the great part of Fenyõfõ. The physical properties of sand depend on the degree of weathering – grain size, fineness or coarseness – and the quantities of minerals, especially silicates, in the sand. Loess content improves the fertility of sand. The humus and organic matter content, as well as the presence or absence of buried older soil layers, are crucial considering the water regime and nutrient supply of sand soils.

The palette of sand forms

According to historical botanical, forestry, local historical and ethnographical documents the dune regions can be divided into the following landform types: dunes, outblown-sand, high plain, “semlyék” and “zsombos”. Dunes can be high, medium and low. High dunes close to each other is the high-sand. Outblown-sand is a sand surface freshly eroded, not high enough yet to be called a dune. It can be initiated by the treading of animals and wind. The high plain is an area undulating due to the usually parallel running sand dune ridges with dry interdune flats. The “semlyék” denotes the wet interdune flats which are covered with water primarily in spring and in autumn. The “zsombos” is a interdune depression usually water-covered for the majority of the year, with sedges.
Geologists and soil scientists describe the diversity of sand forms in the following way. The sand dunes of different height, the sand forms were built and formed by the wind. Strong winds carried away sand - rolled, saltated and flew - the sand grains, denudated the sand surface, most often deepened, eroded, sometimes elevated it. As the wind died away, it stacked the sand up in ridges.
The basic form of outblown-sand is the wind-groove (see Figure 1.). This is a windward depression with the sand blown out of it is stacked into an emergent pile. The coarse grained sand remaining at the base of the wind-groove is of low fertility but if buried meadow soil

comes to surface at the bottom of the groove then a more diverse and more closed vegetation can establish itself. Small, arheic drainless wind-grooves are called basins. These small depressions by providing a shelter from the wind and by collecting precipitation can help the settlement of more water demanding plants among the sand dunes (steppe-meadows, dry *Molinia* swards, oak patches). The piles during their further development open out and take on the shape of a croissant opened windwards, sometimes shifting further on the surface of the sand. This form is referred to as the parabolic sand-dune. The nude piles and the moving parabolic sand-dunes provide a poor site for growth, however, after the sand movement stops, conditions on the outer, leeward side become more favourable and even trees can take root. The dying winds drop the carried sand-grains and arrange them into elliptical, convex, shield-like ridges, the so-called whale-humps. The coarse sand of the windward side of whale-humps (and generally of all sand-dunes) and of the dry and windy dune-tops is a poor habitat, whereas on leeward escarpments, especially on fine-grained sand of their lower parts closed vegetation can establish itself. Whale-humps as they develop further become the barchans. This croissant-shaped form is the opposite of the parabolic sand-dune: its leeward arms encircle a more fertile, often very deep, wind-protected bay. Sheet-sand covers large areas, it is relatively shallow, influencing rather the grasslands than woodlands. Its original vegetation is not known since it has completely disappeared (presumably some sort of sand steppe-meadow).

Types of dunes
Classification of the sand dunes is based on their relative hight, wideness of the top, steepness of their side, lenght of the dunes and the position of the soil water table (Figure 2.): I. the undulating Adacs-type, II. the highly diverse Bugac-type, III. the variable, long shaped Nyírség/Terézhalma-type, IV. and the flat Ásotthalom-type. The distribution of the types in regions is shown in Table 2.

Sand soils
The soils of sand dunes were once classified into three groups: loose sand (wind-blown sand), semi-fixed sand (more fixed, moderate sand), and fixed sand (the highest quality of sandy soil, rich in humus). Today, the following major sandy soil types are recognised (considering only the soils of dry stands): wind-blown sand, slightly humous sand, chernozem-type sand soil, rust-coloured brown earth, and brown earth with clay stratum ("kovárvány").
Wind-blown sand has no, or only sparse, vegetation cover, therefore soil maturation is a slow process. The humus layer is either missing or confined to the 5-10 cm thick, light grey humous topsoil. Below this is a 1.5-2 m thick, loose, homogeneous layer of sand. Wind-blown sand is devoid of vegetation, or is sparsely covered by perennial or open annual sand grassland.
Fixed soils are covered by more or less closed vegetation, resulting in the formation of "true" soils as organic matter mixes into their topsoil. The first step is the thickening of the surface humus layer. In slightly humous sand this layer is only 25-30 cm thick with 1% humus content. Buried humous or loamy layers are frequently found at various depths. Fixed sand is characterised by open perennial sand grasslands and open sand steppe.
Chernozem-type sandy soils are formed by the undisturbed maturation of slightly humous or calcareous sand soils over hundreds or rather thousands of years. The thickness of the surface humus layer can reach 25-30 cm with 2-3 % organic matter content. The vegetation is usually closed sand steppe or oak grove (the latter only where the ground-water is near the tree roots).
Rusty and "kovárvány" brown earths are present in the sand region of Hungary wherever conditions favour the formation of woodland soils. The profile layers are thick, the rusty

accumulation layer being acid even on calcareous sand. On non-calcareous sand, brown earths often have thin embedded clay layers ("kovárvány"). These clay layers improve the water capacity of the soil. The characteristic vegetation is closed oak woodland.

The sand regions of Hungary are characterised by the so-called multi-layered soils or soil combinations (Figure 3.). Such soils have humus-rich layers buried deep under as much as 1-2 m of wind-blown sand deposited over the past centuries. These buried layers notably increase the likelihood of multi-layered soils becoming forested. It is not unusual to find black, humus-coloured meadow soil under 2 m of yellow sand.

THE LARGEST HUNGARIAN SAND REGION: THE DUNA-TISZA KÖZE SAND RIDGE (KISKUNSÁG)

The largest sand region in Hungary lies in the centre of the Carpathian Basin, between the Rivers Duna and Tisza. It constitutes a self-contained phytogeographic entity owing to its unique flora and fauna, which differ from those of the rest of the Alföld.

Many authors have attempted the division of the Duna-Tisza köze into regions. The division is especially difficult due to the mosaicity of the land, due to the gradual southward and eastward gradients in macroclimate and grain size. So the Kiskunság, the Kiskunság Sand Ridge and the Kecskeméti Puszta can not be unambiguously defined.

Therefore the following land-classification (based on the semi-natural vegetation) is not the only possible answer. Like often in division based on vegetation patterns this system is a necessity even though it should not be done so. Its creation is justified by the practical and communicational needs.

D-m: along the Duna (the present and past (in the narrow sense) floodplain area and the Duna)

É-DT: the northern part of the Duna-Tisza köze area (from Vác to Tiszaalpár; roundabout the Pest Alluvial Plain, the Pilis-Alpár Sand Ridge and the Gerje-Perje Plain)

DTszi: the saline areas in the Duna-valley and neighbouring areas (the old elevated floodplain of the Duna)

Tu-Õr: the Turján fen area and the fens of Õrjeg, including Lake Kondor

Bá-I: the southern two-thirds of Illancs and Bácska (mosaic loessy-sandy lands)

DTho: the central part of the Kiskunság Sand Ridge (partly the Kiskunság Sand Ridge, but also the northern one-third of Illancs and a part of the Dorozsma-Majsa Sand Ridge)

DTlö: the loessy-sandy ridge around Kecskemét and Kiskunfélegyháza (roundabout the Kiskunság Loessy Ridge)

DK-DT: the so-called South-eastern Kiskunság (largely the Dorozsma-Majsa Sand Ridge)

T-m: along the Tisza (the corresponding areas of the Lower Tisza areas)

The wind-blown sand covering the majority of the Sand Ridge (DTho, DK-DT, DTlö, É-DT, B-I) is the alluvium of the Duna, reworked and sorted, and mingled and sedimented together with the wind-blown glacial loess sediments. On the surface these appear as wind-blown sand, loess or as a mixture of these two (sandy loess, loess-sand, loessy wind-blown sand).

PAST SAND MOVEMENTS

The most characteristic landscape formation in the Kiskunság is the sand hill area. The last three stages of sand movement that created the present landscape are summarised after Borsy as follows. The movement of wind-blown sand on the alluvial fan of the Duna River intensified 25-26,000 years ago in the cold, dry period of the last Ice Age. It may have lasted until the end of the Ice Age, except where a loess mantle formed. Sand movement ceased about 9000-10,000 years ago and soil formation started. Not much later, in the dry and warm hazel period, sand started to move again. However, no sand movement occurred on dunes covered by a loess mantle (e.g. the loess ridge at Bácska) or where there was a higher groundwater table and thus more closed vegetation (e.g. south-east Kiskunság). As dunes gradually became forested some 5-6,000 years ago, the rate of sand movement decreased and finally ceased. Recent sand movement is the result of human disturbance (18-19th century). Owing to sand movement, a major part of the Ridge consists of a variety of sand hill formations. Each of the three movement phases resulted in different dune sizes and there are notable differences even between sand hills formed in the same. In the interdune depressions where ground-water is high fens are formed, while between regions of dune systems wet depressions, alkali meadows and temporary saline lakes are found.

THE VEGETATION OF THE DUNA-TISZA KÖZE

Before we would start discussing the vegetation and the history of vegetation of the sand areas, it would be useful to have a look at how the vegetation of the Duna-Tisza köze – incorporating the Kiskunság Sand areas – has changed in the past. The vegetation data for the distinguished regions can be seen in Table 3.

Map of the presumably last natural vegetation

Map 3. depicts the last – several thousand years old – presumed natural vegetation of the Duna-Tisza köze. Under continental climate conditions the widespread method of vegetation reconstruction using pollen analysis has limited applicability, therefore former vegetation was inferred from the present pattern of soils. Obviously, this approach offers a restricted scope, and its thematic and spatial resolution is often too coarse, but at the moment no other method gives a better result. Thus, neither the fine scale alteration of woodland and steppe patches in steppe woodland habitats, nor the explicit reconstruction of woodland and marsh vegetation in floodplains is represented. However, the dry sand areas, the loess steppes, the saline basins and fens of the Ridge, the fens on the western border (Turjánvidék and Õrjeg), the floodplains, and the alkali meadows on the former elevated floodplains of the Duna and Tisza Rivers are clearly visible on the map.

Vegetation at the end of the 18th century

The first map suitable for the large scale reconstruction of the vegetation patterns in the Duna-Tisza köze was prepared at the end of the 18th century (1783-85: First Ordnance Survey). Despite the fact that this map was used almost exclusively for military purposes (it was classified top secret for 60 years), it provides a great deal of information about the former vegetation. The task of the 24 surveyors was to depict the state of woodlands and water bodies, the quality of meadows and pastures, the state of roads, and the relief at 1:28,800 scale, and to describe them in the accompanying appendix (the so-called Country Description). The height of the dunes was depicted by lines and their vegetation coverage by different colours (green and yellow).

It is apparent from Map 4. that large extensions of woodlands remained only along the lower segment of the Duna River; the Ridge had become nearly treeless by the end of the 18th century. Arable fields occupied huge territories, especially in areas of loess steppes. Many marshes were found, although surveyors are known to have described dried temporary wet meadows sometimes as steppes, on other occasions as marshes.

The landscape was for the most part covered by dunes. Their pattern and characteristics showed certain tendencies:

- from the north towards the south (until Jánoshalma) the height of the dunes, the area of open sand dune areas and patch-size increases,
- towards east the area of open sand dune areas and patch size decreases,
- the plains (dry and wet) between sand hill areas are the largest in the south-eastern part,
- the majority of the sand dunes areas have scarce vegetation,
- the extent of the high and low dunes with scarce vegetation is about the same,
- low, steppemeadow covered dunes can be found primarily in the northern and southern parts, they are rare between Dabas and Izsák.

Map 5. shows the central part of the Kiskunság as depicted on the First Ordnance Survey map.

Vegetation at the end of the 19th century

The 3rd military survey maps were used to reconstruct the vegetation of the 19th century. Map 6., 7., 8. and 9. shows a landscape dominated by fine scale agriculture with small farm systems created after 1848, the Liberation of Serfs.

The afforestation of dry sand areas started (see angular-shaped forest patches). As extensive grey cattle grazing ceased, the spontaneous regeneration of forests started on sand dunes (irregular shaped, small woodland patches).

Vast pastures existed particularly on dry sand regions. The pattern of arable fields on the highest quality soils was just as it is today, as loess steppes had almost completely disappeared by this time. The hydrography of marshes was intact, although most side-arms were cut off the main channel. Most of today's salt meadows were wetter and therefore fresher, less saline.

Map of destroyed vegetation

Map 10. shows the parts of the landscape which, at least at the scale of the map, are devoid of semi-natural vegetation today. Present arable fields, vineyards, orchards, plantations, settlements, roads and railways were typified according to their soils, and past vegetation (the vegetation of thousands of years ago) was estimated. Comparison between this map and the map of the last natural vegetation shows clearly how some vegetation types have survived better than others. Loess steppes, floodplain meadows, sand steppes in the north and semi-natural woodlands have almost completely disappeared, while there remain sizeable patches of salt steppes and saline lakes on sites under extreme conditions, of fens, and of the driest sand areas. Obviously, these patches have not preserved the primary vegetation, but thanks to their continuity with primary steppes, woodlands and fens, they have preserved some characteristic features.

The map of present vegetation

The map of the present vegetation was prepared by using field data together with botanical evaluation (interpretation) of satellite images (for further description on the applied methods see Appendix). Map 11. depicts about 150 000 hectares of semi-natural and about 110 000 hectares of disturbed habitats with 47 000 points (GIS database). The map contains every semi-natural area larger than 1 hectare.

Looking at the map, it is surprising that huge areas are still covered by semi-natural vegetation, and that other areas do not contain a hectare of remnants of former vegetation. For instance, along the Duna and Tisza hardly any floodplain meadows or marshes remained (about 2 400 hectares) and their total area is less than that of oxbow lakes. Fens can be found not only in the Turján Region and Õrjeg (25 000 hectares) but also in the South-eastern Kiskunság (20 000 hectares). The total area of *Pannonian Pucinellia* meadows has exceeded our expectations (11 000 hectares), and there is more of it than of Artemisia steppes (8 400 hectares), for instance. (In saline areas east of the Tisza however this ratio inverts.) It can also be noted, that around Budapest and Kecskemét the landscape is much more degraded and "empty" than average.

This map can also be used for estimating how well does the vegetation pattern of a well known area represent the landscape it is found in. Visibly the Turján-s of Ócsa do not resemble the other areas of the Turján Area (richer in woodlands), and the Tiszaalpár meadow is not like the area along the Tisza at all (it is no single larger semi-natural floodplain area).

The most important thing is that the present habitat map – according to our observations – is an important source for nature conservationists, biologists, politicians and local residents as well. The information about a habitat: how much is there, in how big patches, in what neighbourhood, can be accessed easily. We can also show which are the protected and non-protected sand areas (see Map 12.). The naturalness pattern of the vegetation of the Duna-Tisza köze, the habitat diversity of given areas can be estimated, the neighbourhood of protected areas and the possibilities of ecological corridors can be assessed.

This map helps with regional scale vegetation dynamical, phytogeographical, landscape ecological researches conducted in the Duna-Tisza köze, as well as in the regionalisation of local research results and in selecting representative sample areas. This also provides an opportunity to compare Hungarian landscape with other lands in Europe and the world, and that the similarities and differences in the landscapes, the degree of uniqueness of the Hungarian landscape can be more objectively evaluated.

VEGETATION OF SAND DUNE AREAS IN THE KISKUNSÁG

The flora

As it was mentioned formerly, the dry sand flora contains many unique elements. These species are not evenly distributed in the landscape: there are richer and poorer sand dune areas. Ádám Boros has already noted this in the middle of the 20th century: "Today the majority of the sand areas are cultivated, natural vegetation remained however on the largest sand dunes unsuitable for agricultural purposes and thus they resist even reforestation attempts. Though overgrazing leads to the spread of weeds of the unploughed sand dunes, significant areas remain – especially where the forests are indicated in public administration – where the original vegetation of the sand dunes is to be found."

The most prominent members of the vegetation are the endemic plant species, which have developed isolated from the related species. In many cases they are to be found only in relatively small areas and are very much bound to the environmental factors which have brought them to life. There are endemic sand species that have special requirements and occur only in the Duna-Tisza köze area on calcareous sand (the number of such species is small, but they are counted among the most precious plants), however the majority of the species can be found under similar environmental conditions in other plant-geographical areas as well, e.g.: other parts of the Great Plains, the whole area of the Pannonic Floraprovince, or even further than that (subendemic species). This means that not all endemic species insist on growing on sand, but they appear in rock grasslands, steppes, etc… According to their present distribution, the sand endemic species, and those, which also appear on sand, can be grouped as follows:

Endemic species of the Duna-Tisza köze area: Dianthus diutinus Epipactis bugacensis Epipactis atrorubens subsp. borbásii
Endemic species of the Great Plains area: Centaurea arenaria subsp. tauscheri Centaurea arenaria subsp. pseudorhenana Tragopogon floccosus Dianthus serotinus
Pannonic endemic species: Sedum sartorianum subsp. hillebrandtii Linum hirsutum subsp. glabrescens Thymus degenianus Centaurea sadleriana Gypsophila arenaria Festuca × wagneri Festuca javorkaea Onosma arenaria
Pannonic subendemic species: Colchicum arenarium Festuca vaginata Seseli osseum
Carpathian-Pannonic endemic species: Dianthus pontederae subsp. pontederae

The most prominent sand endemic species common to the Duna-Tisza area and the Deliblát area is *Dianthus diutinus*. This plant was first described by the most distinguished Hungarian botanist, Pál Kitaibel. Its typical locality (locus classicus) is in the middle of Hungary, in Csévharaszt, the Pótharaszti-wood. Árpád Degen drew the attention to the fact in 1895 already, that the most rare and beautiful *Dianthus* species of Hungary ”belongs to those rarities that are swept away in huge waves by the expanding civilisation so that it finds refuge only in a few, isolated sand areas, and even there only for a short time...” The worries of Degen have proved fortunately premature. As more information has been collected about the plant, it became clear that it is not rare in the open sand grasslands of the Kiskunság. However the majority of the localities of the plant have been destroyed and the plant is now in threat of dying out.

The most well-known plant of the sand dune areas is juniper. It is an evergreen gymnospermous shrub, rarely developing into a tree. For year thousands medical properties have been attributed to this plant. The different parts of the plant have been used often in traditional medicine, and even today it is an important drug and herb. The ripe blue and resin-smelling, fleshy berries are the basic material of gin, the national drink of England and of the drink the Slavs call Becherovka. It is widespread across the whole temperate climate zone, from the boreal polar tundras to the Mediterranean. In Hungary juniper is a typical member of the juniper-poplar areas of the dry sand areas of the Great Plains, but is also often found on pastures, clear-cuts, dry oak woodlands and pine forests of the mountain regions.

Linum hirsutum is a rare inhabitant of the clearings among juniper bushes, developing into a sub-shrub. The original form is hairy, however the endemic subspecies living on the sand of the Kiskunság is completely hairless. The sky-blue, violetish, short-lived flowers bloom in the morning hours. Its interesting, that pollination can take place under the unopened petals even in prolonged cloudy weather.

Colchicum arenarium is a mysterious endemic plant of the open sand grasslands. In autumn only the flowers appear without leaves, the leaves come out and the plant bears fruit in spring. In August, September, especially after rain, thousands of fragile pink flowers appear on the open sand surface. The seeds are dispersed by ants. In undisturbed open sand surfaces the population size can reach several ten thousand individuals.

Southern warm, dry dune-sides provide for a dwarfed shrub of Mediterranean origin, *Fumana procumbens*. With its spiky leaves and its roots reaching more than a meter deep, this plant has adapted well to this extreme environment. The horizontally spreading shoots bear the great golden-yellow flowers, which open only in sunshine. The tiny size of the plant does not mean that certain individuals have not taken root more than a lifetime before. Lichens can colonize the finger thick trunk and branches.

Once, from July onwards the steel-blue round inflorescences of *Echinops ruthenicus* were collected in masses. These flowers, which appear even in the poems of the Hungarian poet Sándor Petõfi (see the picture), have durable flowers that retain their original colour even when dried, therefore they are often used in dry and fresh bouquets. Due to its protected rank, mass collection has declined in the past years.

Stipa species are defining elements of sand grasslands. Their structure has much simplified due to the adaptation to the dry environment. Taxonomic identification is a requiring job. All hairy *Stipa* species are protected in Hungary. These species were once used to decorate hats, later they were bound into bouquets.

Alkanna tinctoria is a typical sand species. Its common and scientific name both refers to the well-known fact, that this plant has been widely used traditionally for painting. The bark of the several ten centimeters long rhizome containes great quantities of red pigments (alkanin and anhuza) which were extracted using alcohol or petroleum. Depending on the concentration of the pigments a whole range of colours - from yellow to dark red – could be prepared. The alkanin dye produced from the two red pigments were used to colour tinctures, wood and paper, hides, food, cosmetics. This dye was even used in traditional husbandry to mark geese, rabbits, pigs and sheep. This function is remembered in the folk-name of the plant: it is called ”sheep-redder”. The role of the alkanin dye has decreased as synthetic pigments appeared.

Ephedra distachia is a reminder of past geohistorical periods, its smaller or bigger branching shrubs might remind us of horstail. Once it was thought of this dioecious plant that the Hungarian populations consist almost entirely of male specimens and only some localities had both female and male individuals. In the past years only from the Duna-Tisza köze area several mixed populations have been reported.

The earliest bulbous bloomer of the sand flora is *Bulbocodium versicolor*. Due to its lilac flowers it is very similar to the *Colchicum* species. Depending on the weather they open from the end of February, beginning of March, and after flowering the fruit emerges on a some centimeters tall stalk among the leaves. Smaller or larger populations can still be found on the southern parts of the Duna-Tisza köze area, near Ásotthalom. On the other side of the border, it occurs near Szabadka and in the Érmellék region. It is an endangered species, due to the fact that agriculture and silviculture has destroyed completely the sand oak woodlands, where it has long dwelled. The majority of the Hungarian population mainly lives in black locus plantations.

Another member of the early spring geophyton aspect is *Crocus reticulatus*. The white or light violet coloured flowers bear lilac stripes – that is why the folk-name: variegated saffron. The protruding orange stigma hardly contain any pigments in contrast to real saffron. This flower opens in end of March, beginning of April, in the same time and sometimes in the same place with *Bulbocodium versicolor*. Once these were the inhabitants of the sand and loess oak forests, but today they open mostly in sand or loess grasslands, black locust plantations, which have taken the place of the former oak forests.

Adonis vernalis opens its conspicuous yellow flowers 3-7 centimetres in diameter in March and April. This flower has grown rare in the Great Plains, but in the hilly areas of Hungary it is still relatively frequent. It inhabits dry sand and loess grasslands, steppes, and clearings of dry oak forests. It is a well-known herb, its extracts are used in the production of cardiovascular medicaments. Its rarity can be accounted for its medical effects, for it was once collected in great quantities. Today "plantations" are sustained for medical purposes.

Jurinea mollis is an eye-catching element of sand steppes. The leaves are soft, hairy on the backside (that is why the Latin name: mollis). The Hungarian folk-name (ant-thistle) refers to the fact that ants can always be found on the inflorescence, participating both in pollination and seed dispersal.

It is a rare and unexpected occasion when in such an exceptionally well-described and investigated area, like the Carpathian Basin a new vascular plant is described. This was the case in 1990, when Karl Robatsch, an Austrian scientist has described a new orchid species from Bugacpuszta, named after the region where it was found, *Epipactis bugaciensis*. For a long period of time only one locality was known with a dozen individuals. With the intensification of research efforts in the Kiskunság, more than twenty localities – especially in poplar plantations – have been described. This orchid has proved to be an exceptionally valuable member of the sand flora, since it was not found anywhere outside the Kiskunság. Its origin is still debated.

Epipactis atrorubens subsp. *borbasii* is a much more common orchid, which was believed to be the only endemic Hungarian orchid. As for the former flower, this plant was also found only in the Kiskunság, on the same localities. The poplar forests with hardly any herb-layer planted onto drier sand ridges have played an immense role in the survival of this species together with the natural poplar forests.

On the dry clearings, margins of the remnants of the sand oak woodlands *Anemone sylvestris* can be found growing. Its rare white beauty inspires people to collect them, that is why it has become important to declare this a protected plant. This peril unfortunately is not real in the Duna-Tisza köze area, since it is very rare. The reason behind is the drastic decrease of sand oak woodlands.

The number of unusual and rare steppe species is relatively high in the sand areas of the Duna-Tisza köze. These include *Teucrium montanum, Thalictrum aquilegiifolium, Dictamnus albus, Aster linosyris, Helichrysum arenarium, Scorzonera purpurea* which are the typical species of calcareous and dolomite rock grasslands and steppes. *Lychnis coronaria, Dictamnus albus* and *Salvia glutinosa* are typical of the hillier mountain areas. They are disappearing from the Alföld today. Their distribution is of plant-geographical importance.

In the arable lands of small farm systems, especially in less dense rye stands and in abandoned fields, Agrostemma githago has become a widespread weed again. This plant was a common and dangerous cereal weed until the middle of the century. Due to the new seed purification process and to the efficient herbicides, this plant has almost become extinct from the arable lands of Central Europe. After the changing of the agricultural system in the 1990's slack plant protection has opened ground for its massive redistribution.

The degraded secondary sand grasslands composed mainly of annual species represent apparently no value as a degradation state. However several annual sand plants e.g. *Colispermum* spp. prefer open, disturbed, moving surfaces. They live in huge quantities on the open surfaces of dry ploughed soil, especially in abandoned fields, vineyards, orchards, old fields, sand mines, young tree plantation and on the disturbed surfaces of tracks, roads, and railway-lines.

Protected plants of the sand flora

The list of the plants to be protected (43 species) was compiled in 1941 by the distinguished scientists of the Nature Protection Committee, and it was handed over to the Minister for Culture and Public Education without any further result. A law to enforce the protection of Hungary's plant species was not made for a long period of time. Order No. 4, issued in 1982 about the Protection of Nature was the first to define the set of protected plants. Table 4. and 5. contain the date of protection and the value of the protected plants of the sand flora. In the 1982 order, from the 310 species on the list of protected plants 21 plants came from the sand flora of the Kiskunság, whereas in 2001, from the several times modified list of 617 species 58 originated from here.

Extinct species

In the past 50-200 years more than 30 native plant species have disappeared from the Hungarian flora. Sand flora was no exception in this aspect. The exact number of extinct species is not known, but there is evidence that more than a dozen species have disappeared in the Kiskunság.

One of the most interesting extinct plants is Spiraea crenata. Pál Kitaibel described it from Pusztavacs, Kerner refers to his data, he even collected it from the nearby Tatárszentgyörgy area. However, nobody has seen it since the middle of the 19th century in the Duna-Tisza köze region. No herbarium specimens exist, even though it was described in Kitaibel's diary as a common plant. Both data remain a mystery.

Another extinct rarity of the sand regions is *Dracocephalum austriacum*. László Hollós noted in the 1890's that there were plenty of it on some sandy hills of Nyíri-wood in Kecskemét. The plant beared 4-5 centimetres large, blue-lilac, violet flowers on the top of the stalk and was named after the inspiring shape of these flowers. Due to Hollós's report, several researches visited the site and have collected specimens until 1920. From this on the population has disappeared without a trace. In Hungary, until the middle of the 20th century eight localities were described, from the Great Plains, the Bükk Mountains and the Aggtelek Hills. Due to agricultural production on these localities only one small population has remained in the Aggtelek Hills which is also threatened by dying-out.

Depending on former investigations on sand areas, deductions can be made concerning the impoverishment or perhaps the enrichment of the flora. From the 19th century till the middle of the 20th century only a few, but well researched sand areas were known from the Kiskunság. These included the formerly mentioned Nyíri-wood near Kecskemét, investigated by the sharp-eyed László Hollós in the last years of the 19th century. Based on the species-lists it can be deduced that this was the only known locality of the saprophytic orchid *Limodorum abortivum*, which is sporadic in the dry oak woodland of the hilly areas. Ádám Boros has reported a hybrid of *Orchis tridentata* and *O. ustulata* from a clearing of this woodland in the 1920's. These two species appeared only in the Rákos-plain in the Great Plains apart from the Nyíri-wood, but no hybrid was observed there. And an *Iris variegata* variant from the Nyíri-wood of uncleared lineage has disappeared for ever from the Hungarian flora, which had white veins on its flower instead of the usual brown ones.

There are no known population of the following steppe species in the Kiskunság: *Pulsatilla grandis* and *Echium russicum*, and of the following woodland species: *Asarum europaeum* and *Epipactis purpurata*.

The succession of sand plant communities

One of the most striking features of sand vegetation is its dynamics. That is why it is not suprising that succession, one of the most general properties of vegetation was discovered in

this vegetation type. This is especially interesting that it was recognised here in the Kiskunság, by Anton Kerner, an Austrian botanist in the middle of the 19th century.
Sand succession has been investigated by several authors, on one hand it helped the afforestation, on the other hand it was an interesting research topic of plant ecological investigations.

Primary succession
Several theories exist concerning primary succession (the development of vegetation on the parent material, fixing the bare, plantless surfaces of the sand dunes). One reason is that one lifetime is not enough to observe the whole process beginning with the settling of the first plants on the bare sand surface till the formation of woodlands. Therefore our knowledge is based on several deductions.
According the Anton Kerner, Rezsõ Soó and his followers succession starts with annual and cryptogamic species, then perennial plants settle, slowly the grassland becomes closed, then the first woody plants appear, and finally closed woodland is established. During the succession the following habitats follow each other:

1. *Bromus*-type open annual grasslands
2. *Fesctuca vaginata – Stipa* open perennial grassland
3. closed sand steppe
4. poplar-juniper steppe woodlands
5. *Convallaria majalis* - oak woods

Foresters looking at the soil side (Pál Magyar, Imre Babos, István Szodfridt) have drawn the attention to the point that this sequence can not be justified by the evolution of soil (wind-blown sand, slightly humous sandy soil, chernozem-like sandy soil, slightly humous sandy soil, rust-coloured brown earth). The steppe and the oak woods do not fit into the series since the conditions necessary for the formation of their soil is not given in a sand dune area (e.g.: high ground water, fine-grained sand-base).
The succession series which took into account the above aspects was drawn up by Gábor Fekete. This includes the vegetation types of the sand hills, whereas the more closed and fresh grasslands were removed from this sequence. This is not a sequence anymore rather a net. Moreover the succession begins not with annual grasslands but with the *Festuca vaginata* grasslands, and ends not with the closed oak woodland but with the semidesert-like poplar-juniper groves. This latter type is thus the climax community (see Figure 4.).
Due to the variety of the environmental and historical factors the succession series on sand are even more complex. Investigations should include the side-branches when loess or fine-grained sand is mixed with sand (from open sand steppes towards closed sand steppes and oak groves). And it should not be forgotten that the accelerated vegetation dynamics due to the new sand surfaces emerging from the 18th-19th century sand movements and to the changing land-use can conceal several phenomena that are crucial to a better understanding of the natural sand succession.

Secondary succession
Succession goes on differently if it starts on an area where soil formation has already partly taken place and soil contains seeds. Here – even though the surface is bare - the development of the vegetation does not start from “nothing”, the “heritage” greatly influences the happenings of at least the first years. This type of succession is called secondary succession.
Nowadays investigations on secondary succession have become increasingly important since it would be advantageous to know what kind of vegetation is expected to develop on abandoned arable fields and vineyards, how fast will these regeneration processes take place

and what are their limits. According to our experiences the processes are surprisingly fast. Research on fallow lands of different age have proved that close to natural sand areas, even in 10-30 years grasslands and groves semi-natural in their species composition and state can develop. In locations far from sand dune areas (some kilometres away), sand grasslands often formed on abandoned vast vineyard areas are characterless and the ratio of alien species is higher.

Momentarily the opinion is that the primary succession of the sand hills and the secondary succession of abandoned lands are embedded in each other, secondary succession, which is richer in states and transformations, contains primary succession. Thus the investigations on the dynamics of fallow land serves the better understanding of primary succession.

Vegetation changes of the yearly – decade scale

Although several decades are not enough for a sand succession series to be completed, it is enough for substantial changes in the sand vegetation to take place (see later). Grasslands become richer or poorer in species, woody plants can burn down or grow stronger, the ratio of *Festuca vaginata*, *Stipa borysthenica*, perennial dicotyledons can change, certain sand species (e.g.: *Centaurea arenaria*, *Dianthus serotinus*, *Salsola kali*) or alien species become more abundant. These changes are a consequence of the inner dynamics of the grasslands, of human and animal activity (grazing, digging) or of climate changes (drought), and partly – e.g.: in the case of fallow land - a consequence of age, in ancient grasslands of the time spent from abandonment from grazing, but the scale of changes are in the range of the scale of nature conservation.

This is the reason why the research on dynamic changes and their causes - with long-term observations, experiments, landscape historical investigations - is so important. Today we know too little to confidently prepare management plans for the sand hill areas of different state.

The vegetation changes taking place since the Ice Age (so-called secular succession)

The longest-term changes in the vegetation – the secular succession – should not be left out either. Unfortunately little is known about the last 10 000 years of sand hills. The cause for the absence of historical reconstruction is the recent and complete destruction of the peat fens among the sand hills. The history hidden in the peat has gone forever.

Due to the lack of facts we can only rely on the general vegetation history of the Alföld and the present habitat-vegetation patterns of the sand hill areas. The assumption is that since the Ice Age till present times the sand hills were dominated mostly by open dry sand grasslands, with groves, in the interdune areas with closed grasslands, fresh meadows, sedge fens or fresh poplar and oak woodlands.

The deeper understanding of the several thousand year history by utilising better historical resources (e.g.: soil) would be an important research aim. The past thousands years basically do not influence directly the present vegetation dynamical processes but its better understanding would give a general framework for the interpretations of the changes on a finer time scale, even when considering the possible nature conservation strategies, especially in the cases of the shifting sand dunes, grazing and juniper-poplar areas.

The most important sand habitats

As early as the 19th century, florist botanists and foresters observed and described plant communities, or “formations”, as they called them, based on co-occurring plant species. These communities are listed here with their present names in parentheses: *Festuca* formation

(*Festuca vaginata* subtype of the open perennial sand grassland), *Stipa* formation (*Stipa borysthenica* and *S. capillata* subtype of the open perennial sand grassland), *Bromus* formation (open annual sand grassland), Pollinia formation (sand steppes with *Chrysopogon gryllus*), *Holoschoenus romanus* formation (interdune dry fen with *Salix rosmarinifolia*), Dwarf shrub and Juniper formation (junipers, "magpie-trampled" – dwarfed poplars), Poplar formation (juniper-poplar steppe woodlands, poplar patches of oak steppe woodlands), Oak formation (oak steppe woodlands). The syntaxonomical (phytogeographical) names of the Hungarian sand vegetation is shown in Table 6.

Open perennial sand grasslands

All open perennial sand grasslands in the Duna-Tisza köze belong to the same community (*Festucetum vaginatae danubiale*) since their species composition is highly characteristic and repetitive. Plant cover in this habitat is usually low, 60-70%. Spaces between tussocks are either bare or covered by mosses and lichens. The dominant grass species are *Festuca vaginata* and *Stipa borysthenica*.

Historical sources mention two types of *Festuca vaginata* grasslands (however this is not well documented due to the uncertainties in old species lists): the highly open grassland just starting to fix sand is well distinguished from the more closed and mature stands. *Stipa* stands are regarded by early literature as a phase of sand fixation following *Festuca vaginata*, on semi-fixed sand. They are never referred to as pioneer sand fixing phases. *Stipa* stands are also described as poor pasture – unlike *Festuca vaginata* stands – that sheep do not graze, but only trample down.

Several subtypes may be distinguished within open perennial sand grasslands, based on the dominant species and the accompanying dicots. These form a dynamic relationship controlled by local disturbance, the abundance of the dominant species, population dynamic factors and the impacts of neighbouring vegetation.

Grasslands may further be grouped according to their origin, soil, surrounding landscape and management. Most stands are primary (or at least several hundred years old), few were formed on sand dunes stabilised in the last 50-100 years. The regeneration of abandoned fields has started creating old-fields.

The soil is coarse-grain sand on high dunes, fine-grain sand on gentle slopes or level surfaces, and loessy near loess areas. In the latter case steppe species appear more frequently (e.g.: *Dianthus pontederae*, *Odontites lutea*, *Seseli osseum*). Grain size varies between the leeward, windward and interdune parts of sand hills, as is reflected by the cover and species composition of grasslands. On level or gently sloping ground *Festuca vaginata* and *Stipa borysthenica* dominate the grasslands, on dune tops the *Fumana* type is more abundant, on leeward valleys the *Stipa capillata* type is frequent. Sand grains get finer towards the River Tisza, since only these small grains could fly so far with the north-westerly wind, and thus the size of the *Festuca vaginata* swards decreases.

Formerly all sand grasslands were grazed. Today the palette is diverse: some dunes have not been pastured for 40-50 years (Tázlár and Bugac areas), while others are frequently overgrazed (e.g.: Sarlósár and Bodoglár areas).

The surroundings of open perennial sand grasslands can be diverse, but they are generally surrounded by arable fields, old-fields, plantations and juniper woodlands. The landscape mainly affects microclimate and the spread of alien species but eventually influences land use as well (clearings barred from grazing).

Bromus-type open annual sand grasslands

"As loose sand fixed by perennial grasses turns into wind-blown sand owing to sheep trampling, *Festuca vaginata* is replaced by annual weeds which are alien or only distantly related to the original flora of the primary sward: *Secale sylvestre, Apera spica-venti, Bromus tectorum, Medicago minima*." – reported Lajos Thaisz in 1921. Thus, this initial association formed chiefly of annual weeds is described as a weed community exploiting temporal humus enrichment, established after heavy disturbance caused by ploughing, digging or overgrazing. Nevertheless, the community is often regarded as the pioneer phase of succession. It was Gábor Fekete who confirmed that the initial stages of primary and secondary succession differ: *Festuca vaginata* swards bind wind-blown sand, while *Bromus*-type open annual grassland establishes itself on denudated sand.

On young abandoned fields, open surfaces of afforestations, trampled roads, abandoned mines, around small farms annual sand grasslands establish themselves. Due to the disturbance, Secale sylvestre and Bromus tectorum decrease in number or disappear completely, and their place is taken by foreign weeds, like the North American *Asclepias syriaca*, *Erigeron canadensis* and *Cenchrus incertus.* Even though apparently annual grasslands do not harbour natural value as a degradation type, still some protected annual species, like *Colispermum* spp. benefit from the open surfaces produced by continuous disturbance and thus they can be found predominantly in these degraded places.

The so-called "black spots", a type of annual grasslands rich in mosses, present another difficulty. These are formed, especially in trough-like depressions, probably from perennial sand grasslands. Swards thinning for reasons not fully understood become flooded with annual plants and mosses (the "black spot" name derives from the dark colour of dried moss). In a couple of years perennial grasses return, and the grassland apparently regenerates. This vegetation type may play an important role in the natural regeneration processes of sand grasslands.

Sand steppes

Sand steppe was the most common grassland community of plain sand areas in the Duna-Tisza köze. It covered – judging by the present soil pattern – some 280,000 hectares, of which less than 1000 hectares (0.3 percent) are left. At least 99% of these areas occupy secondary, non-typical stands (see below), therefore it is almost impossible to reconstruct the characteristics of former steppes, for example as they were 200 years ago. Three localities of "typical" (so-called zonal) steppes are known at present, altogether amounting to less than one (!) hectare.

The vegetation cover of sand steppes is nearly 100%. There are many steppe specialist species, while species characteristic of open sand grasslands and fresh meadows are generally missing. Besides drought-tolerant species, wide-leafed grasses and dicots also appear. Sand steppes gradually merge into loess steppes near loessy areas. Their species composition is often the same, although today some species only appear (e.g. *Cytisus austriacus*) or become abundant (e.g. *Thalictrum minus, Fragaria viridis, Filipendula vulgaris*) on loess parent material. Stands dominated by *Chrysopogon gryllus* were frequent at the time of Anton Kerner, in the middle of the 19th century. Other dominant grass species of sand steppes are *Poa angustifolia, Festuca x wagneri* (and *Festuca rupicola*), and the plants of degraded areas: *Dactylis glomerata, Botriochloa ischaemum, Cynodon dactylon* and *Festuca pseudovina*.

There are several factors that have affected the present diversity of sand steppes. Origin, site-conditions, landscape, age and management greatly vary among the stands. Some patches are primary, others have been formed on oak clear-cuts, dried meadows or abandoned fields, still others have grown in the shadow of trees. Humous sandy soils and chernozem-like sandy soils

are typical sites for sand steppes. The majority of sand steppes, however, are not found on typical steppe sites. They have formed on drier or wetter areas that gradually became steppe-like: wind-blown sand that was heavily shaded and therefore had a better water regime, or drained meadow soil. Once steppes occupied large areas of the Duna-Tisza köze, today they form only small patches and have became enclosures thus their secondary stands may be surrounded by several different kinds of habitats and since these stands are usually young, the influence of the nearest landscape as recent propagulum source is of great importance. Woodland and open grassland species might appear, but if the landscape is poor in steppe species, secondary stands remain species-poor as well (rich applies to the Pirtó area, poor for the Fülöpháza stands).
The majority of the sand steppes used to be part of a sand or meadow pasture, some were rather mowed. Sand steppes were mostly unmanaged in the past decades.

Transitional sand steppes with Festuca wagneri
This vegetation type is worth mentioning since this is the transitional stage between open sand grasslands and sand steppes. The majority of the biomass is produced by the species of open sand grasslands, whereas in the species list more species are from the closed dry grasslands. Phytocoenologists call the communities *Festucetum wagneri*, but do not always distinguish them from open grasslands or steppes. In many ways open sand steppes represent a transition between open sand grasslands and closed steppes, e.g. in the humus content of the soil, or the quality of sand. However, certain species tend to stick to this community: *Festuca x wagneri, Iris arenaria, Peucedanum arenarium* and *Achillea ochroleuca*. Further species are those of open sand grasslands (e.g.: *Festuca vaginata*, *Stipa borysthenica*, *Euphorbia seguieriana*, *Alkanna tinctoria*, *Carex liparicarpos*), steppes (e.g.: *Poa angustifolia*, *Galium verum*, *Eryngium campestre*, *Asperula cynanchica*, *Chrysopogon gryllus*, *Carex humilis*, *Falcaria vulgaris*, *Helianthemum ovatum*), and the common species of open grasslands and steppes (e.g.: *Teucrium chamaedrys*, *Scabiosa ochroleuca*, *Potentilla arenaria*, *Botriochloa ischaemum*, *Asparagus officinalis*).
The origin of open sand steppes is uncertain. They may have evolved out of open sand grasslands on still sand surfaces thanks to humus accumulation, they may be the result of the overgrazing of closed steppes, the partial erosion of humus or the opening up of closed steppes, or they may have formed on the clear-cuts of dry sand steppe oak woodlands or other steppe woodlands.

Closed interdune grasslands
Interdune areas are most often occupied by open sand grasslands. However, on better (leeward, humus rich) sites closed grasslands, or even fens might appear if the ground-water rises.
Some interdune areas are covered by closed grasslands, especially those near Tatárszentgyörgy and Kiskunhalas. These were probably steppes or meadow steppes even before the drainage of the area. They are relatively species-rich with the dominant species *Chrysopogon gryllus, Carex humilis*.
Fen-like interdune meadows with closed grasslands, and the species *Salix rosmarinifolia* and *Molinia coerulea*, that have dried out and turned into steppes are quite common. They contain water-demanding species (*Holoschoenus romanus, Salix rosmarinifolia, Molinia coerulea, Agrostis stolonifera, Carex flacca, Thalictrum simplex*), open sand grassland species (*Festuca vaginata, Stipa spp., Fumana procumbens*), and steppe species (e.g. *Ononis spinosa, Poa angustifolia, Helianthemum nummularium*). As they have always lacked typical meadow species (which explains why they are not classified under the typical fen meadow category)

they are likely to have dried out regularly or become buried by sand. Buried meadow soils are also an indication of this process. Interdune depressions could have formed by wind erosion, as dry sand was blown away and the surface sank towards the groundwater table, which favoured the establishment of water-demanding plant species. This may explain the low number of meadow species and the mixed species composition.

Several dunes are known to have had sedge fens in their interdune depressions (e.g.: Pirtó, Csévharaszt). Today, they are all steppe sites. The fen-like character is only apparent from the shoots remnants of *Carex elata* and Carex *acutiformis*, or the monodominant, dense *Molinia* swards. All species preferring fens or meadows have become extinct leaving only a few stems of *Lysimachia vulgaris*.

Poplar-juniper steppe woodlands

The poplar-juniper steppe woodland is the most conspicuous sand dune community. It gives a scenic view with the ever changing shapes of junipers (*Juniperus communis*), and poplars (*Populus* spp.) standing crookedly alone, in bunches or “magpie-trampled” - dwarfed.

The composition of these communities varies widely: some consist almost exclusively of juniper and are so dense that they are hardly accessible and it is easy to get lost in them; in other places juniper is missing for unknown reasons and hawthorn replaces it. In other locations poplars form a tall canopy and a shrub layer with hawthorn (*Crataegus sp.*) and wild privet (*Ligustrum vulgare*). Leeward, interdune areas have more closed stands with more poplars, while windward, warm slopes are covered by more open stands with more grass and juniper. Among junipers and dwarfed white poplars open or partially closed sand grassland patches can be found. When juniper-covered dunes are surrounded by plantations, particularly dense thickets are formed, probably due to the lack of grazing and strong winds. The dunes at Bugac and Jakabszállás are of this type.

The forms of sand poplar forests were described by István Szodfridt and Imre Babos. A special form of the white poplars is the “valley-type”, which always appears on the leeward, very steep northern or eastern sloping troughs. The poplars in the interdune depression can reach the ground water and the offshoots creep up the dune side, even up to the crest. Under the white poplars a rich shrub layer develops predominantly with *Ligustrum vulgare* and *Rubus caesius*, but juniper, hawthorn and sloe appears also.

The other special form of poplar forests is the so-called “trough-type”, based on the shape of the relatively shallow (1.5-3 m deep) and small (10-15 m in diameter), undrained trough. The sand dunes are surrounded by open sand grassland or juniper from the outside. The canopy of the white poplar gradually closes, juniper dwells in the lighter patches between the trees, later it can only occupy the margins. The lack of light due to the closed canopy allows only a few plants to survive in the herb and shrub layer, e.g.: *Molinia coerulea*, *Ligustrum vulgare*, or it is also possible that the undergrowth is missing completely.

The pioneer type of white poplars appears on sand dune tops, severely dry ground, among smaller or larger juniper patches, on bare or hardly covered sand. The undergrowth of the juniper-poplar patches contains the typical species of an open sand grassland: *Festuca vaginata, Stipa borysthenica, Euphorbia seguieriana* and *Linum hirsutum*.

In the past few years and decades large juniper stands have burnt down (e.g. at Bugac, Bócsa, Tatárszentgyörgy, Orgovány). In these stands poplar regeneration is vigorous, while junipers have so far failed to regenerate (see later).

Even though this formation is highly characteristic, easy to recognise, spectacular and much investigated, its origins, naturalness is still hotly debated. According to a theory the felling of deciduous forests in the Middle Ages have helped the undemanding juniper bushes (undemanding, except for light) to win ground. Wind blown sand is an extreme environment and under such water regimes only white poplar can compete with juniper (oak can not grow in such conditions). Grazing animals preferred the soft shoots and bark of deciduous trees to the pricky needles of juniper, which mean a further advantage for juniper which continued to spread at the expense of poplars and so almost homogenous juniper stands without any poplars have formed (e.g. Bugac, Jakabszállás, Monostor). Later, as grazing decreased, the explosive spread of the oppressed species (e.g. poplars) was noted. The spread of poplars and the closing of the canopy above the junipers have caused the retreat of the junipers. With the spread of poplars, moving sand surfaces have become inhabited.

Today another theory has gained wider acceptance, which proposes, that the climax formation of the driest sand areas was similar to the present juniper-poplar forests.

It was proved that several stands (e.g. in Bugac) were completely treeless 200 years ago, thus these stands can not represent a degraded state – on the contrary – this regenerative state is several hundred years old. Unfortunately there is absolutely no data available about sand juniper and poplar stands from 250 years earlier. Even the existence of juniper covered dunes in the Kiskunság before the 19th century is in question (due to the lack of historical data).

Most poplar-juniper steppe woodlands were grazed by sheep and cattle 50 years ago. Today, fewer stands are grazed (mainly by sheep), nevertheless, there are overgrazed patches. Rabbit overpopulation often “substitutes” for earlier grazing.

Small oak woods in the sand dune areas

This habitat probably consisted of small woods of hairy oak (*Quercus pubescens*) and pedunculate oak (*Q. robur*) (and their hybrids), open sand grasslands and some steppe. Only two localities of this type are known today: at Csévharaszt and near Jánoshalma, at the Hármashatár described by Ádám Boros. Here, “hundred-year-old” hairy, pedunculate and Turkey oaks (*Quercus cerris*!) alternate with open sand grasslands. These apparently natural patches of a few hectares lie in a plantation of pine (*Pinus sp.*) and black locust (*Robinia pseudo-acacia*). The old oak trees are believed to have been planted either 60-80 years ago, or after the Turkish Occupation (in the 18th century), or are thought to be native. Closed steppes are rare among the oak, poplar and open sand grassland patches, and the woodland margins – where the wooded-steppe species should enrich – are surprisingly species-poor and characterless. The explanation to this phenomenon is not known.

The Buckás wood at Csévharaszt must have been surrounded by extensive closed oak woodlands (lowland oak-hornbeam and closed sand steppe oak woodlands, sedge fen patches) with a hillier and much drier island where an area of oak-poplar-juniper woodland is found today. The speciality of this habitat lies in the 5-12 metres tall hairy and pedunculate oak (and hybrid) trees growing on the sides and tops of the hills. The undergrowth is steppe-like with woodland species such as *Convallaria majalis* and *Polygonatum latifolium*. The principal question is what kind of woodland does this oak-poplar-juniper woodland originally derive from? According to one theory it has evolved from more closed sand oak woodlands as a result of overgrazing and the spread of juniper, but this is contradicted by the size and poor condition of the trees. Another theory argues that the site has never been good enough for the development of closed oak woodland, therefore small oak woods must have been surrounded by pioneer shrubs and trees (e.g. juniper and poplar) and open sand grasslands. The continuity of grasslands is indicated at Csévharaszt by the presence of rare, poorly spreading, light-demanding species, such as *Dianthus diutinus*. Unfortunately, the interdune fens have dried out, their peat has oxidised and the site history "encapsulated in pollens" has been lost. Thus, one has to rely on the careful study of the soil, exploring the origins of the humus and the buried soil strata.

Dry open oak woodlands

Open steppe oak woodlands are the “gems” of the dry sand vegetation in the Kiskunság. Rare as they are in sand dune areas today, they are thought to have occupied large stands in the close vicinity of dunes. Unlike poplar-juniper steppe woodlands and the above mentioned small oak woods, dry open oak woodlands are “true” woodlands. The canopy layer is dominated by pedunculate oak, other characteristic species are hairy oak, white poplar (*Populus alba* and *canescens*), common pear (*Pyrus pyraster*), etc. In the shrub layer hawthorn and wild privet are frequent but *Colutea arborescens* and *Viburnum lantana* might appear. In the herb layer, closed woodland species mix with steppe clearing species, but the so-called wooded-steppe species are the most characteristic: the specialists of open woodlands and woodland margins (e.g.: *Dictamnus albus, Melampyrum cristatum, Hieracium umbellatum*, *Anemone sylvestris*).

Unfortunately, only a few primary stands of open sand steppe oak woodland have survived in the Kiskunság. According to historical maps some patches were already grove-like 200 years ago, while others were formed by the closing of more open oak woodlands or the opening up of more closed oak woodlands. The size of the remaining stands is gradually decreasing (it covers only some tens of hectares now) therefore the impact of neighbouring stands (margin effect) increases, as seen in the black locust invasion.

All stands were managed and in terms of the technology of regeneration they were coppices. Since the first half of the 20th century clear cutting and deep ploughing systems have spread and resulted in species-poor, characterless oak stands. The last open oak woodlands are either unmanaged strict woodland reserves or are first thinned for sanitary purposes to “save” the quality wood material and then clear felled, resulting in the destruction of semi-natural vegetation.

Dry sand arable fields

Only the major features of this habitat will be discussed to point out its most characteristic properties. They were created out of necessity to scrape a living in sand hill areas in the 19th and 20th centuries. Even the worst dunes had 5 x 5 m kitchen gardens, quarter-hectare fields of rye and vineyards. All these farmland enclosures and larger dune-side fields received extensive cultivation. The abandonment of these arable fields has started decades ago and still continues.

Sand vineyards and orchards

Large areas of sand vineyards and orchards in sand dune areas and their margins were also cultivated out of necessity. The species that were planted were deep-rooted enough to reach the ground-water (unlike today), which made it possible to cultivate them where field crop farming was uncertain. Large stands are to be found in areas covered by blanket sand, small patches on the margins of dunes.

Sand plantations, black locust “cemeteries”

The main questions of sand afforestation will only be outlined here: further details are provided in the chapter on landscape history. Plantations have fixed vast sand areas, thus relieving the landscape from the sand storms which used to cause serious damage and hardship to local people and which were known as yellow rain. However, sand afforestation continued even after this aim had been achieved, that is, after sand stopped moving. As these plantations are worthless their continued planting on sand hills causes serious damage from both economic and nature conservation viewpoints.

Due to poor site conditions, some of these forests have never closed, or self-thinned soon after planting. Such plantations are referred to as black locust “cemeteries” (however the terms such as “pine cemetery”, “poplar cemetery” are not used even though these tend to grow just as poorly as black locust). In clearings sand vegetation can regenerate well. Similarly, high, non-afforested dunes (surrounded by a sea of plantations) also offer refuge for the natural vegetation. These areas may act as species sources for the future regeneration of the habitat.

Old-fields, abandoned vineyards and orchards
Assuming that the abandonment of arable fields continues at the same rate as in the past decades (as is likely following the country’s accession to the EU) these heterogeneous habitats will constitute the majority of sand grasslands. Their total area is around 50-100,000 hectares or even more (precise data are not available). The habitats include *Asclepias* and *Ambrosia* fields as well as apparently highly “natural” grasslands. If these habitats are situated near semi-natural grasslands, ancient-like grassland may develop. An example is Fülöpháza, where all local sand grassland species (except *Ephedra distachia*), but especially *Sitpa borysthenica, Festuca vaginata, Euphorbia seguieriana, Koeleria glauca* and *Equisetum ramosissimum)* are found in vineyards and arable fields abandoned 5-15 years ago.
Most old-fields have a gently undulating or smooth surface, and wind-blown sand or slightly humous sandy soil. Their size ranges from less than one hectare to several dozen hectares. Older ones were abandoned by small farmers, more recent ones belonged to large scale agricultural enterprises. They may be surrounded by dunes, earlier old-fields or plantations. Some are grazed by sheep, but most old-fields are left unmanaged.

A GLIMPSE INTO THE PAST
THE LANDSCAPE HISTORY OF THE DUNA-TISZA KÖZE SAND HILL AREAS IN THE PAST 250 YEARS

(Marianna Biró)

The goal of this historical reconstruction is to probe into the past of sand dunes in order to understand their present, predict their future and provide food for thought for the nature conservation actions. Relying on available sources we have been able to explore the history of the past 250 years. Although earlier historical data would be of great importance, information is limited from that time. We believe that any investigation of earlier times have to be conducted more carefully in the case of sand hill areas than usual since it can not rely on the information conserved in fens (see before).
The history of dry sand hills over the past 250 years - based on landscape management type, the intensity of sand movement, the intensity of afforestation, and the transformation of vegetation - can be divided into four quite different phases. The 4 phases may be merged into two major periods. Before the 1940s most of the sand was moving, and grasslands were open due to overgrazing. Later, due to sand fixation - primarily through afforestation - sand movement stopped, the intensity of grazing gradually decreased, and as a result grasslands closed and the landscape became forested. The present landscape, thus, is characteristic mainly of the last 50 years. In the age of earlier great Hungarian botanists (e.g. Pál Kitaibel, Anton Kerner, Vince Borbás and János Tuzson), conditions were different: extensive, homogeneous, unwooded, more or less moving sand regions were common with open vegetation maintained by grazing.

Extensive grazing (from the Middle Ages till the mid-19th century)

Man has started changing the landscape during or even before the early Middle Ages migration period (5-8th century): deforestation started, ever larger pieces of land were cultivated, and extensive animal grazing became widespread. As a result of the long history after the Turkish period the area of the Duna-Tisza köze, this “central treeless desert”, was characterised by overgrazed or bare sand dunes. Partly due to overgrazing and trampling (especially by grey cattle and sheep), and partly to lack of protection from the wind, sand had started moving by the 18th century.

Pál Magyar wrote: “Wind-blown sand destruction became catastrophic in the 18th century. Huge arable fields were covered by sand and made partly or completely barren.” This process was further worsened by the unusually hot and dry years between 1779 and 1797, and by continuous gales which caused a state of emergency in unprotected barren sand regions. The area of wind-blown sand was 20,000 cadaster acres at 12 square miles from the town of Kecskemét in 1792, growing to 60,000 cadaster acres from 1805 to 1806, while it reached 300,000 cadaster acres in the county of Pest-Pilis-Solt-Kiskun.”

The containment of wind-blown sand had become a crucial question by the 19th century. Decrees, books and forestry articles all called for afforestation to be started as soon as possible. However, the process was quite slow owing to the lack of sufficient knowledge and expertise, and was restricted to small areas until the 1860s. Although many tree and shrub species, both native and exotic, were tested, it was the black poplar (*Populus nigra*) that gave the main stand volume in the initial forests of new sand plantations. The source material for black poplar was obtained by the father of István Vedress in 1793 from the River Maros flood plain (from the Csipkés-erdõ, Kiszombor, planted in the era of Maria Theresia). Periodic droughts and gales gave a new impetus to irregular afforestation.

Small farm systems (from the mid-19th century until the 1940s)

In the second half of the 19th century, due to the repopulation of the landscape and the parcelling out of vast plains, more and more arable fields became established and cultivated. Peasants who laboriously tilled dry sand areas were called the “heroes of the sand” by Vince Lakatos.

The ratio of arable fields in the Duna-Tisza köze was 26.5% in 1789, 37.9% in 1855, 53.6% in 1895 and 56.6% in 1956. Most lowland pastures were tilled for arable field cultivation, fodder growing or stubble pasture. Viticulture and horticulture thrived on gentle dunes, especially after the phylloxera epidemic that had destroyed colline vineyards at the end of the last century. Since at the beginning only the best quality soils were tilled, the area of sand steppes shrank rapidly and eventually almost disappeared. On steep sand hills extensive grey cattle grazing was gradually replaced by small farm sheep grazing. This period is characterised by grasslands dominated by *Stipa borysthenica* and *Euphorbia seguieriana*, herbs typically avoided by sheep.

In the second half of the 19th century afforestation was given a fresh impetus, this time using (sometimes to extremes) black locust with success. By the turn of the century lowland estates were generally surrounded by rows of trees, and the area of loose-sand afforestation further increased (although it did not reach the desired extent). The obstacle to sand fixation was still extensive animal grazing.

Despite all these facts open sand hills changed only in area, not quality, until the middle of the 20th century. This was because non-afforested dunes were grazed in basically the same way as before, and woodland cover on afforested sand hills was too low to completely fix the sand, thus sand grasslands remained more or less open. It is worth noting that even in 1949 there were 7000 ha of more or less moving sand in the Duna-Tisza köze. Photographs exist of some sand hills, such as the “moving and smoking dunes at Illancs”, the “white Alps at Pirtó” or the white dunes near Kiskunhalas, Zsana and Kunadacs.

Sand afforestation (from the 1950s to the beginning of the 1980s)
In the 1950s, as the liquidation of smallholdings started, the small farm system was gradually suppressed and has disappeared together with its land-management, its landscape forming farms and ancient fruit types. Today's farm-association villages were established in the 1960s (e.g. Fülöpháza, Kunbaracs). This resulted in the migration of 250 000 persons from farms to villages (see Map 13.). Large-scale viticulture thrived, and vast areas of dunes were levelled. Following the new wave of plantations in the 1930s, the afforestation of wind-blown sand areas started again from 1947 on.
The No. 1040/1954 order issued by the Ministers Council has made it compulsory for the forestry companies to afforest sand areas which were not suitable for agricultural production. In the 50 years since the issuing of the order ten thousands of hectares declared "unvaluable", but harbouring valuable natural vegetation were forested.
This time black locust was replaced chiefly by Corsican pine (*Pinus nigra*) (and Scots pine (*P. sylvestris*)). The method of planting and regenerating developed as well (with the introduction of power mechanised deep-ploughing and stumping). The forest cover of the Ridge increased from 6.5% after World War II to 14%, chiefly to account of sand dunes. (Forest cover was 4.5% in 1789, 5.0% in 1855, 7.2% in 1895 and 6.5% in 1935 in the Duna-Tisza köze, see Map 14.) Meanwhile the area of natural woodlands decreased form 4% to 1%.
The remnants of the once were sand vegetation are found today mainly in hillier parts in smaller or larger patches, enclosed among locust and pine plantations. On surfaces undisturbed by afforestation the predominance of woody formations is apparent. Only on patches with steep surfaces – which were difficult to access with heavy machinery – could more or less continuous areas remain which exhibit typical dune types and the remains of sand communities.
Large-scale agriculture was most difficult on sand ridges, thus farmsteads and sand grassland grazing remained here, allowing for the delayed closing of open grasslands. However, from the 1960s on, grasslands gradually closed as small farm animal grazing and trampling declined and the ratio of protective forest belts increased. Wind erosion and sand movement gradually ceased. Today, it is hard to maintain wind erosion and wind-blown sand even by artificial means (e.g. at Fülöpháza). As a result of the draining of the Ridge in the 1940s and 1960s, justified by high groundwater tables, interdune marshes and fens gradually disappeared.
Typically in this period were sand hills used for military purposes, as firing ranges and for manoeuvres (e.g. Bugac, Bócsa, Orgovány, Fülöpháza, Pirtó). The military use of dunes had various effects: the intensive trampling caused by military vehicles, large numbers of ditches and pits were dug, the original vegetation was destroyed and environmental pollution (soil contamination, mixed garbage) was left behind. Roads were built, and some areas were made completely barren by fighting vehicles. Fires were regular. In general, land used for military purposes includes a wide range of habitats, from completely destroyed grasslands to relicts of undisturbed grasslands.

The past 20 years
In this period vegetation changes were mainly caused by the meteorological changes, changes in the ground-water level and society. Between 1981 and 1993 the average yearly precipitation decreased by 16.7% (especially in winter). The sinking of the ground-water level began in the 1970's, became crucial in the 1980's (on average the water level sank by 1.7 metres, but on certain large areas it exceeded 3 meters, see Figure 5.). The rainy years since 1997 have partly

reverted these processes. Modelling and other research results have shown that the reasons behind the sinking, apart from the drought, are artesian and ground-water extraction, draining, changes in land use (e.g.: afforestation, intensive farming) and hydrocarbon extraction – therefore even after a possible return of rainy years the regeneration of interdune wet habitats is unlikely. The assumption is that droughts have caused largely irreversible changes in these wet habitats. Water level sinking had no direct effect on the drier parts of the sand hill areas since the highest spring water level used to be below 250 cm. However, with the drying out of the wet habitats the habitat diversity of the landscape has decreased. The saline lakes of the sand ridge have dried out, too. Some, however, – like Kondor Lake near Fülöpháza – have revived since summer 1999.
Partly due to the above-mentioned unfavourable changes, partly because of the transition of the Hungarian economy and society since the end of the 1980's, more and more arable land and vineyards are abandoned, especially on drier areas. The last shifting sand dunes (Fehér-hegy, Fülöpháza) of the Kiskunság stopped moving in this period (mid-1980's). Recent "white hills" are a result of artificial vegetation removal.

MAN'S INFLUENCE ON THE VEGETATION OF SAND HILL AREAS – TODAY

Destructive effects

Even though over the past 150 years the area of sand hills in the Kiskunság has decreased significantly the decline has not stopped completely. At the end of the 1990s the Hungarian compensation system has given lots of people land, but due to the lack of competency they have started agricultural production on these lands. Primarily stands in non-protected areas are destroyed (see Map 15. and Table 7.). The two reasons are: money, since afforestation or sand mining provide income, and sometimes the location itself is used. In the latter case the quality of the sand, the vegetation is not important: a new street or dump site in the vicinity of a settlement, roads, pipelines, new factory buildings have all taken away land from sand habitats.

Direct effects (sand hill area land use)

In the past sand hill areas provided biomass for the community: wood was burnt as fuel, grasslands were grazed, vineyards and orchards provided fruit. Today the importance of these uses is decreasing but does not disappear. The use of juniper as fuel, cattle grazing, the collection of mosses has almost ceased if not completely, but sheep grazing, felling of spontaneously grown trees, hunting and juniper fruit collection still exist.
Juniper is an important herb even today, the most important source is the juniper-poplar woodlands in the Kiskunság. Its collection is not harmful, as long as it is carried out carefully, without damaging the shoots. Since supervision of the collection is impossible, therefore it would be advantageous to discourage its collection in the protected areas.
Hunting causes problems by using unauthorized lands and by sustaining a non-native game stock (red deer (*Cervus elaphus*), fallow deer (*Dama dama*)). The greatest problems are still caused by local overgrazing because it induces the invasive spread of weeds.
Beekepers have appeared only recently on the sand dunes, especially near the great black locust plantations and areas infested with the aggressive alien weed, *Asclepias syriaca*. They have even played an important role in the propagation of this plant and they plan further plantings!

The use of sand hills as scientific experimental areas is another aspect. It is a dynamic, characteristic, unique and beautiful Pannonian habitat with many curiously behaving species and relatively simple vegetation structure.
Nature protection actions have direct effects on sand areas. Even though the assumption is that these intend to do good, it does not mean that their effect is favourable from the aspect of vegetation (e.g.: felling of alien trees and then explosive offshoot-growth). Also, short-term gains can turn into long-term losses. For example, mowing large areas simultaneously on sand steppe inclusions of fresh meadows leads to the disappearance of plant and insect species, even though in the short run it removes the biomass and prevents litter accumulation.
In the past decades the military use of the sand hills has decreased (e.g.: Bugac, Bócsa, Orgovány, Fülöpháza areas) but the Táborfalva-Dabas area might see a major land reconstruction due to Hungary's acceptance into the NATO. Military use results in disturbed, sometimes completely denudated surfaces, but in other cases leads to protected "sanctuaries".
Today sand hills have gained new functions. Tourists and city-dwellers come here for recreation, riding, to explore rare plants, animals, folklore. Movie-makers are looking for "desert" scenes. Hundreds of young people learn in the Educational Centre at Fülöpháza and the Ornithological Camp at Kondor Lake to learn about nature and nature protection. Activities positively influencing public opinion and causing little or no environmental damage are considered worth supporting.
This does not imply for moto- and autocross. They are looking for the tallest, steepest hills, denudating it, driving through even the "sanctuaries".

Indirect effects (changes in the surrounding landscape)
These changes are made not in the sand hill areas but in the surrounding landscape or region, however they do have effects on the sand dunes. Such is the abandonment of neighbouring arable lands, vineyards. As a consequence alien invasive species like black locust, *Asclepias syriaca*, *Gaillardia* sp. multiply. At the same time on the abandoned arable fields more natural grasslands might regenerate which is a favourable for their buffering capacity.
The draining of the surrounding wet areas has been mentioned already, in that respect that these remove the water from below the sand hill areas. And these drastic draining processes still continue…
Certain regional nature protection actions should have positive effects, like the protection of new areas, agricultural environmental programmes and the establishment of the ecological network, thus the isolation of sand hill areas would decrease due to the increase of buffer zones.

PRESENT DYNAMICS OF SAND VEGETATION

This chapter summarises the present vegetation dynamic processes relevant to the conservation and management of sand habitats. Some of the processes have been going on for hundreds of years, others have just begun; some are local, others concern the whole landscape. Certain processes are easy to influence, others are hard, still others are not open to influence at all by nature conservation means.

Disappearance of moving sand dunes, closing of open surfaces

The last moving dunes in the Kiskunság stopped moving in the 1980s. Since then, artificial methods (weed control and trampling) have helped to keep dune surfaces moving. (It is important to note that sand dunes have been in motion only for 2-300 years.) Unless some dunes are regularly overgrazed by sheep and cattle, and a wind channel is cut in the surrounding plantations, moving sand hills will disappear in the Kiskunság. In the current landscape, land use and climate, sand areas become covered by grass and the wind can only sparingly blow out the sand from around the roots. This amount of sand however is not enough for the dunes to start moving. Smaller open sand surfaces are being formed even today, primarily due to sand mining and military activity, but also at road sides and due to overgrazing in certain small patches. Regeneration of the vegetation starts soon, however. When the sand is just slightly moving and the surface is grazed and trampled during regeneration then annual sand vegetation (e.g.: *Corispermum* spp., *Salsola kali*, *Cenchrus incertus*) will establish itself. On blown sand surfaces *Festuca vaginata* establishes – almost on its own – pioneer swards. These swards might resemble those sand-fixing *Festuca vaginata* swards characterised in historical descriptions.

Closing grasslands

Grasslands are becoming more closed, and moss cover is increasing, as was unanimously reported by local inhabitants and by researchers with prolonged experience of working on sand areas. The reason is thought to be the lack of grazing.

Grasslands that are grazed at present remain open. However, they are regarded as weedy, disturbed, or simply “ugly” by botanists and conservationists. (Grasslands with considerable non-native rabbit populations also remain open.) Grasslands with *Festuca vaginata* and *Stipa borysthenica* do not seem to close 100% even without “management” under present conditions. These dominant species do survive in the long run (unlike in Austrian grasslands where they become extinct), native species which are alien to the community do not appear, even though some have reported a decrease in species number and population size of sand specialist plants when the grassland was not grazed for decades (e.g.: *Fumana procumbens, Dianthus serotinus, Helichrysum arenarium*). Due to the lack of grazing the grass litter accumulates, does not break up and sometimes thickly covers the surface. The spread of mosses is not inhibited by trampling anymore. The closing of grasslands is not a degradative process however, it is a regeneration, “self-heeling” with which – according to our experience – the biological organisation of the grassland grows.

Spontaneous native shrub and tree regeneration

The spontaneous regeneration of trees and shrubs is also caused by the lack of grazing. The process is the same in every dune area where grazing does not occur, but the rate of regeneration varies. The regenerating woody species may also differ, although they are most often white or grey poplar (*Populus x canescens*). It is important to note that as the climate turned drier, that is, more unfavourable for woodlands, the landscape became more woody! Trees regenerate from offshoots and seeds. Poplars gradually creep up the hills toward the top. How long will this process go on is not known. In the Emlék-erdõ (Ásotthalom) and in other places it was observed that the living and dead poplar offshoots creeping to the sand hill are of the same height. The conclusion is that the spread of woodland has stopped, growth and die-back has reached a dynamic equilibrium. Aerial photographs confirm this assumption. Spontaneous reforestation near Csévharaszt is slow, in contrast with Bugac, Pirtó, Orgovány, where grazing has stopped only several decades ago – here the area covered with trees and shrubs has increased several times. It is known that these areas used to be severely grazed. We assume that under the actual and expected environmental conditions the sand hills will not be completely covered with woodland, for a long period “rather large” clearings will remain and thus grassland species that ought to be protected will survive. Presumably this was the situation for the past 10 000 years as well.

Shading and leaf litter only transforms but does not degrade the sand grasslands. Under poplars *Stipa* disappears, and *Festuca vaginata* forms a well organised, relatively species-rich community. Between the *Festuca* tufts poplar litter completely covers the surface. Under hawthorn and wild privet, in the dark shade of poplar groups – judging by the age of the trees and shrubs – the sand grasslands transforms into steppe, probably due to the improving microclimate and humus accumulation. Obviously this steppe is not as organised, species rich as the ancient zonal steppes once were, but its dominant and accompanying species mainly come from the generalist species of the steppes (e.g.: *Poa angustifolia*) and the specialists of the steppes (e.g.: *Aster linosyris, Trifolium montanum, Carex humilis, Salvia pratensis, Centaurea sadleriana),* even wooded-steppe species can appear (*Thalictrum minus, Anemone sylvestris).* The grassland among the thickening juniper thickets is changing as well: it thins out the number of species decreases, moss cover increases and bare surfaces are not rare, either. Steppe does not form here. It is worth mentioning that on the dark shaded clearings of *Pinus* spp. plantations the species list becomes "steppe-like", but the swards are thin, characterless and species-poor (e.g.: *Poa angustifolia, Melandrum album, Cynoglossum officinale).*
In the small forests that form during the regeneration, generalist woodland species often appear (e.g.: *Viola odorata, Polygonatum latifolium, Brachypodium sylvaticum, Geum urbanum*) but the true woodland flora can not establish itself due to the great distance of the propagalum sources.

Invasive alien species

One of the greatest threats to the semi-natural vegetation of sand dunes in the Kiskunság is the spread of non-native, alien (American, Asian), aggressive invasive plants.
These species are either deliberately planted in or near sand hill areas (e.g. black locust, *Amorpha fruticosa*, *Gaillardia sp.*, Corsican pine, *Cenchrus incertus*, tree of heaven (*Ailanthus altissima*)), or originate from the spontaneous spread of accidentally introduced species (e.g.: *Erigeron canadensis*).
Of all aggressive alien species black locust seems to be the most harmful, and is unfortunately likely to spread further in the future. This tree was originally introduced to fix wind-blown sand. Since its wood can be used for several purposes and it is a good melliferous plant, black locust was a tresure to the farmers who fixed the wind-blown sand. It spreads via its vigorous offshoots, even though it does not survive among the driest sand hills. The main problem is that beneath – due to the nitrogen-fixing bacteria and the accumulating litter – the soil is transformed to such an extent that generalist and nitrophilous species become dominant at the expense of the native species. This process is reversible by felling black locust but it demands a lot of time.
Asclepias syriaca, planted formerly as a melliferous plant, is spreading spontaneously, occupying several dozen thousands of hectares in the country. It often constitutes continuous 100-hectare stands in abandoned arable fields, vineyards, young plantations, and worse still in semi-natural sand grasslands and drying fen woodlands. Its eradication is theoretically possible but is very work-demanding. It is likely that *A. syriaca* decreases as sand grasslands regenerate, turn more natural and closed. Unfortunately we do not have enough data for this process, so it should be observed at different places.
Erigeron canadensis is an old American immigrant. It can be found almost in all sand grasslands and infiltrates even into relatively undisturbed grasslands. Its size decreases in this case and apparently does not cause irremediable problems in the community. Its eradication is not possible, but perhaps it is not necessary.

Gaillardia pulchella is a new spreading species. So far its spreading has been observed only in the Kolon Lake area called Bikatorok where it has conquered not only the road sides and fallow land but the semi-natural grasslands in the sand hills as well.
Ailanthus altissima is a serious “time-bomb”. Fortunately it spreads slowly but its destructive effects can only be compared to that of the black locust. It spreads in vegetative patches, like a frontline, and eradicates everything beneath. In other parts of Hungary the destruction of hundreds of hectares of natural vegetation can be blamed on it, and the extent of devastation on sand areas is getting closer to this number.
Ambrosia artemisiifolia does not threaten closing and undisturbed sand grasslands but on new abandoned fields it reaches such densities that it causes public health care concerns (national pollen maxima are usually detected in Kecskemét). It is unlikely that its stands on sand grasslands can be lowered to such a level such as in Austria. For its suppression the general stabilisation of the habitats would be necessary.
According to some herdsmen the Lord of Baracs had introduced the so-called “Baracs thistle” - *Cenchrus incertus* - which gave good pasture in spring but stopped barefooted herdsmen entering his territory. The plant has continued to spread but is unable to establish itself in semi-natural grasslands, it appears mainly in trampled places.
The *Cleistogenes serotina* is an interesting story. This is a native species, found on the warm, dry extrazonal steppes of Hungary’s hilly areas. In the Kiskunság it was first encountered in the 1950’s near Jakabszállás. Today it has populations near 8 settlements, some contain more than a million plants. It spreads mainly in disturbed grasslands and pine forests, but semi-natural sand hills are no exception where it has gained space at the expense of native local grass species.

Fires

Fires were intrinsic to the wooded-steppe zone even before the appearance of man. Especially after years of great biomass production litter-fires were rather likely. Fires along with grazing animals limited the transformation of grasslands and thickets to woodlands.
In the past years however we witnessed more fire cases in the Kiskunság than average. Large, precious juniper areas were burnt down in Bugac, Bócsa, Tatárszentgyörgy, Orgovány and Ágasegyháza. These fires were all a result of human negligence or bad-will, thus these can not be viewed as part of the natural dynamics even though it resembles that. Fires from this point of view do not destroy the natural values, rather they place an advanced succesional state back into a younger type. On the burnt-down juniper areas the regeneration of sand vegetation has started vigorously.
József Agócs and his colleagues have tracked the changes in the burnt-down juniper areas of Bócsa for 6 years. They found that the greatest destruction took place in the closed juniper and pine forests, in places even the soil was burnt through. In the first year *Salsola kali* and *Erigeron canadensis* became dominant and surviving black and white poplars started pushing up offshoots. From less severely burnt areas lot of seeds have arrived (e.g.: seeds of *Stipa borysthenica*, *Koeleria glauca*, *Alkanna tinctoria*, *Festuca vaginata*). In the second year annual plants were forced back, plants grown from seeds and perennial plants reproducing with stolon became dominant (especially *Calamagrostis epigeios*) and poplar offshoots continued growing. Later the inhabitation of the area slowed down but at the same time more and more species appeared. The plants consumed all the nutrients released from the died roots. In the fifth year *Calamagrostis epigeios* was forced back from the burnt juniper areas, however poplar shoots formed thick stands. Later the thinning of these offshoots - and thus the appearance of junipers is expected. In the sixth year no observable change took place and in the seventh year (2000) the investigation had to be closed for the lack of funding even

though the middle term effects of fires can only be assessed by a continuous monitoring programme. With the Orgovány fire a new observation series was started.

Drying interdune depressions and oak woodlands

Fresh sand dune sites, interdune marshes and fens were once characteristic to the landscape. However, irresponsible water management from the 1940s till today, and drought periods from the beginning of the 1980s to the middle of the 1990s have put an end to them. The stands have dried out, leaving only few fresh habitat demanding species e.g. *Schoenus nigricans* (at Jakabszállás), *Carex elata* (at Pirtó), *Molinia coerulea*, *Lysimachia vulgaris*. The droughts seriously damaged oak woodlands as well. Interestingly, the deepest scars were left not in the driest Csévharaszt, Jánoshalma oak forests but in the closed canopy, so-called *Convallaria majalis*-oak woodlands (e.g.: near Nagykõrös, Pusztavacs). Could it be that oaks from formerly drier areas can adapt better? Or is there another reason? It is especially curious that pedunculate oak and hairy oak regenerates best in the driest sand hills! Near Csévharaszt and Jánoshalma in the poplar-juniper woodlands hundreds (!) of 5-20 year old pedunculate and hairy (and hybrid) oak individuals can be found.
Hungarian foresters (but not all!) have renounced oak as a woodland forming species in the Kiskunság referring to the lack of natural regeneration and the stands with drying shoot-tips. It is agreed that due to the economic expectations it is not a rentable wood species (expensive and time-consuming to regenerate) but the solution is not to clear cut the oak woodlands and replace with black locust! The wooded-steppe oak groves remain wooded-steppe habitats even after the accidental disappearance of oak (the majority of the species will survive), at most instead of/next to the oak poplars, *Pyrus pyraster*, *Ulmus minor* will form the thin canopy (or shrubs will take over the stands). Who knows, perhaps in 50-100-150 years the climate will again favour oak. (Natural vegetation does not stand a chance in ploughed patches planted with alien species.)

Increase and decrease in size

It is a global tendency that natural habitats become islands in the agrarian-urban sea, more or less isolated from each other. (According to experience most non-weeds are not able to explore and colonize habitats which are further than some 100 metres even in centuries.) The decrease does not only mean that the total area of sand hills goes down but also that the remaining patches become more vulnerable (e.g.: the ratio of margins to area increases, the population sizes decrease). This process threatens the sand hill areas but to a lesser extent than for instance our lowland oakwoods, loess steppes. The age of fragmentation was the time of ploughing of pasture in the middle of the 19th century, then the vineyard establishing, tilling, afforestation in the 20th century. Even though this process still goes on, fortunately its speed has decreased significantly though the danger should not be underestimated.
Today we can also see examples of the opposite process. At the margins of sand hill areas, on former vineyards, orchards, arable fields the regeneration of grasslands, shrubs progresses well. At Fülöpháza it has lead already to the point that the two sand hill areas have become connected.

PRESENT STATE OF SAND DUNE AREAS

We know little about how similar the former sand dune areas used to be, or in what did they differ in. One thing is sure: today's sand dunes are very diverse. There are ones which appear semi-natural (e.g.: the Tázlár sand dunes and parts of the Buckás-wood near Csévharaszt), others bear the signs of felling and overgrazing (e.g.: the sand dunes of Fülöpháza and Pirtó), other are still grazed (e.g.: the sand dunes of Tatárszentgyörgy and Kisizsák), some woodland has more or less regenerated with the ceasing of grazing (e.g.: Kisasszony wood and Bugac juniper woodland). Table 8. shows the most important features and natural protection data of the present sand dune areas.

The "average" sand dune area

On the basis of the data above the "average" sand dune area can be described as a protected area of several dozen hectares with slightly disturbed vegetation, advancing black locust stands, and moderate habitat diversity. Dunes are either gentle with *Stipa* and *Festuca*, or steeper with poplar and juniper groves. Interdune depressions are dry, the soil is slightly humous, the flora and fauna are not or are only partially studied. It is an abandoned pasture or is still being grazed.

Clearly no such sand hill area actually exists, as is apparent from Table 8. The reasons for its diversity have been discussed in former chapters. Diversity is stressed because we believe that nature conservation management should be tailored to the present state, and the present and future dynamics of sand dunes.

> "I believe that the best solution to the question of nature conservation management of grasslands will come from a deeper understanding of nature's logic and multidisciplinary research." László Tálas

NATURE CONSERVATION STRATEGIES IN THE SAND DUNE AREAS

NATURE CONSERVATION – IN THEORY

In our quickly changing, "accelerating" world the practical tasks of nature conservation are clearly set: to prevent the tilling of grasslands, woodlands, shooting of the birds of prey, draining of fens. Should such things take place, the perpetrator should answer for his deeds. (Unfortunately the damage can not be repaired in most cases – an ancient grassland, a 300 year old oak, a sedge fen, a white tailed eagle (*Haliaetus albicilla*) can not be "created" in a matter of days, even in our "modern" civilisation.) In fact, the everyday tasks of nature conservation consist of preventing such damages.

Nature conservation has other purposes as well: to preserve as many habitats as possible, landscapes that contain diverse habitats, with many species and stable populations, and this all in the dynamic state that is nature's own. The question is whether the current state and dynamics of these areas were suitable for such aims (that is, what is necessary for a sand woodland-grassland mosaic, a fen, an oak grove, *Dianthus diutinus*, for an eagle or viper for its long-term survival). Even though these questions come up every day at every level of nature conservation, thorough planning is hindered by "everyday tasks". Thus despite even the deepest good-will irreversible damages can take place at habitat-, area-, population- and species-level, due to the lack of long-term plans.

The question is thus the following: what are those desirable dynamics and states and what actions should be taken to reach these? Certainly this book is not enough to discuss all aspects of this question. Our aim is only to reinforce the scientific discussion and common thinking that has already started in this respect.

Passive protection?
In this case the land is "completely" left on its own thus opening ground for nature to develop according to its own rules. The land will not necessarily return to its ancient state (perhaps never will) but the present environmental conditions and the current state of vegetation sets the path towards which the dynamics will start off.
Passive protection will only function if the land has enough regeneration capacity and acting internal and external factors (e.g.: aggressive alien species, pollution) do not obstruct this process.
Apparently this method is working in abiotically more stressed habitats (e.g.: in rock grasslands, alkali *Artemisia*-steppes) at least on the middle term. No significant degradation was observed. (Or the dynamics of these habitats is so slow that we can not notice it?)
According to our experiences, in grasslands (especially in hay-fields, fen and marsh-meadows mainly of clear fell origin, but in denser steppes as well) deliberate non-interference leads to "ageing", litter accumulation, woodland regeneration and often to a decrease in diversity. This is regarded as a negative process, even though the other side is that a self-established, though species poor pioneer woodland is of the same value, if not of more, than the mowed fen meadow that is kept species rich artificially, since the pioneer woodland's spontaneous dynamics is not restricted. This judgment is sometimes easier, sometimes difficult to make, but it depends always on the scale thus investigations on changes at a regional level can help to make the local decision.

Predefined end-state?
In Western European nature conservation practice (especially in England and the Netherlands) experts defined a desirable end state based on the current state of the area: the goal of the nature conservation action. After this a well-planned, detailed action plan was prepared and carried out. Generally speaking – even if it is not always put into words – this is pretty much what is going on in Hungary. We would like to achieve that the areas settled into a predetermined "desirable" state and their dynamics would depend on the environmental factors.

1. This end-state is often the natural ancient state and the dynamics system that belong to it. The reservation-approach of nature conservation assumed that our best areas are in their natural state so the best action would be conserving it by fencing off. Since then it became evident that no area exists in Hungary that is in its natural state, furthermore the ancient state is hard to imagine and to study since the European landscape has been influenced by man for several millenia, so neither local nor regional natural processes can show themselves.
2. The choice can be a state that existed in the near past, e.g.: in the 18^{th}, 19^{th} or in the 20^{th} century. For these there is sufficient historical data for the reconstruction. In these case two problems have to be handled. On one side today's landscape is not the same due to the drainage, alien species, air pollution, more isolated habitats. Even if we succeed in reconstructing the once-were environmental surroundings, we can not be sure that it will have the same effect. In most cases, due to the social economical changes, the farmers are missing to carry on with the desirable land-use (pasturing, hand-mowing, woodland use). There are no traditional herdsmen, smallholders who sustain themselves and their families in the sand hill areas. The solution could be that we find other management methods, but care should be taken because the effects could be different than our expectations (like the side-effects of medicaments).

3. Some believe that the recent state is what to be conserved. By retaining the present land-use and environmental conditions this would be possible (e.g.: natural water management, traditional mowing). But if today's state is a result of a past dynamics (may it be spontaneous or artificial) for this aim this dynamics (and those that start today) should be stopped or set on a circulatory trajectory.
4. Our aim could be that the system possessed a more natural dynamics and depended less on human use or deliberate nature conservation actions.
5. The aim can also be reaching some – theoretical – natural state. For instance, lot of "good" species, only few "weeds", the landscape should be "nice" and good to look at.

Continuously modified end-state?

This means that the changes in the vegetation are monitored, meanwhile the end-state and the necessary actions (or no action at all) are constantly redefined. This method is basically a practical manifestation of the above mentioned, since it is almost impossible that an area should be protected according to the same principles for decades or centuries.

Choosing the management actions: how?

If we know what our aims are the task is to observe, monitor how the selected area changes. If it proceeds in the "good direction" then we can lean back and leave them go on undisturbed. When these do not turn out as we expected we have to intervene. (The question is, do we know what direction does our habitat head towards? I believe, sometimes it is easier, sometimes it is more difficult to judge.) If we intervene, what should the action be? To cut trees? Or plant them? To graze or to mow? What is beneficial in the long run? The big question is: do we have sufficient knowledge to bring decisions in this issue? According to some: yes, but a practical nature conservationist with his experiences says the knowledge is less than necessary.

According to ecologists, lots of well planned and implemented dynamical-treatment experiments have to be carried out, and based on the results it will be possible to judge what should be done and what is an "optimal" treatment action. The longer (perhaps decades) the series of observation or experiments the greater the chances for understanding the logic of sand vegetation and smaller the chances of viewing short term changes as general, determinative and characteristic processes.

The management experiments generally implemented on some dozens of square meters raise the question: will it be possible to judge what effects will a treatment have on the given vegetation on a larger scale if it has been tried out only on such a small scale, and whether this treatment is "optimal". The question of applicability is also raised: can the same method used for another sand hill area?

Since there is not time to wait decades for answering these questions, other information sources have to be found. Along the "objective" scientific results we need to rely more on our practical knowledge, our intuitions which can be improved by thorough long-term observations, studying the past and the present and by the evaluation of so-called experiments by chance. The suggestions and intuitions of an experienced field expert – if proposed humbly – can prove more useful in the long run than the treatment planned according to the newest (and continuously changing) ecological theories. We could rely more on the knowledge of our long-lived foresters, herdsmen, farmers, botanists and nature conservationists. We should not leave out that they have seen and experienced a lot of changes, and the former farmers have utilised centuries-old traditional management techniques. They have lived in the land for

many years, breathed with it in winter, summer, rainy and dry years. This knowledge can not be gathered from scientific experiments, for this you have to live there!
Of course, this so called practical knowledge has its own limits. Primarily it is a more subjective knowledge gathering, which is selective in another way, and rational thinking is of less importance. In the long run, however, these different approaches should comprise that knowledge basis on which the nature conservation plans and decisions will be based.

HISTORY OF NATURE CONSERVATION IN THE SAND AREAS OF THE KISKUNSÁG BEFORE THE FOUNDATION OF THE NATIONAL PARK

Róbert Vidéki and Dr. András Iványosi Szabó

The disappearing vegetation of the Kiskunság was noted already in the second half of the 19th century and thus conservation efforts have started very early, even thought results in conserving the natural values of the region were achieved only much later on. Anton Kerner wrote the following in 1863: "…today steam-trains roll in every corner of the Great Plains, the extensive moors are forced among boundaries, lush arable lands replace steppes. We are going to see the disappearance of not just one steppe species…"
Vince Borbás approached this question from the viewpoint of destruction of vegetation. Based on his experiences at Bugac and Koháryszentlõrinc (which used to be the backyards of Kecskemét at that time) he summarised the sand-fixing practices, stressing that new vineyards and plantations (1884, 1886, 1895) had already taken away nearly 100 000 cadaster acre from sand steppes. He mentioned *Dianthus diutinus* as a species threatened by extinction.

Public interest in sand areas of the Duna-Tisza köze increased further during the millenial celebrations. Árpád Degen gave the warning in 1895 that "the characteristic and unique sand flora of Hungary is disappearing visibly" … "sand areas, where the plough-iron so far avoided the descendants of the original sand flora, are several hours away from each other". In his reports he was worried not only about the disappearance of the sand flora around the capital, but about the destruction caused by the expansion of factory areas, railway lines, arable land. He saw the sand flora and the endemic species threatened by the spread of the ruderal flora and by the wine grape and black locust plantations established after the phylloxera epidemic. He mentioned the following disappearing species: *Peucedanum arenarium*, *Tragopogon floccosus*, *Gypsophila* spp., *Astragalus varius*, a hairless form of *Linum hirsutum* (*Linum hirsutum* subsp. *glabrescens*), but first of all *Dianthus diutinus*, which had not been seen by Hungarian botanists for half a century.
Between 1894-96 the mayor of Kecskemét, Elek Kada and Ottó Herman published several articles about the ethnographical and natural values of Bugac, thus promoting its nationwide reputation. In 1896 a more than 200 pages long scientific work was published bearing the title "The past and present of Kecskemét" about the central parts of the Sand Ridge. The names of the authors (István Hanusz, Imre Hajagos, László Hollós, Rezső H. Franché, Lajos Bíró) are still well remembered among specialists. In May 1898 12 zoologists, led by Lajos Abafi-Aigner carried out investigations arranged by the Zoological Department of the Hungarian National Museum in the Bugac sand hill areas and steppes. The summary reports stressed the diversity of the fauna of the area.

The first step in the legislational protection of plants was the Order of the Minister of Agriculture No. 21.257/1900. which stated, that "trees and coppices distinguished by their rarity and value of their geographical distribution or location" have to be preserved.

Károly Sajó's enterprise (1905) was a pioneer attempt to preserve the sand flora of the Kiskunság, when he provided for an undisturbed habitat for sand plant formations on his private estate. He stood up for the protection of *Alkanna tinctoria*, on which the rare species *Oxynychus erythrocephalus* fed. Due to the dye-content of the rhizomes, the plant had almost become extinct near his estate, once even the rhizomes from his estate were stolen. In order to save *Oxynychus erythrocephalus,* he used the collected seeds from the remaining plants to regenerate the population of *Alkanna tinctoria.* He reported the decrease of the numbers of another sand species, *Echinops ruthenicus* as well.

In 1909 Árpád Degen was the first to make a proposal for the protection of some species in answer to the above mentioned order of the Minister of Agriculture. It included the symbol of the sand vegetation of the Kiskunság, *Echinops ruthenicus*, even though he did this due to the "uncontrolled" destruction on the shores of Lake Balaton. In 1912 László Madarassy dealt with the ethnographical values of Bugac, stressing that traditional animal husbandry could only have a chance if the diversity of the sand steppes remained.

Between 1914 and 1920 János Szurák, György Timkó, Ádám Boros and Rajmund Rapaics were taking repeated botanical surveys in the Bugac area. Sándor Jávorka botanist, Pál Magyar forester and Péter Treitz agro-geologist drew attention to the postglacial relicts of the marginal turján of Bugac in the joined effort what we would now call team-work. Randolf Rungaldier, a German geographer in 1929 named Bugac to be the most beautiful of Hungary's steppes and adding that "Bugac is worthy of becoming a national park of Hungary".

In 1926 Károly Kaán obtained the assignment from the Hungarian Academy of Sciences to write a book about the history of Hungarian nature protection and its natural values. The book published in 1931 described areas suggested to be protected, together with its geological, landscape, botanical and zoological aspects, its caves, monuments, sites of historical interests. Among the "Areas suggested for protection" it lists several locations from the Kiskunság for the protection of the sand flora. "In the Pótharaszti Puszta, the classical representative of the Duna-Tisza köze sand wastelands, where the sand flora is untouched by cultural influences. In Királyhalma, near Szeged, is an area suitable for a reserve area, as the southern example of the Duna-Tisza köze sand areas being the locality of several rare sand plants (*Dianthus diutinus, Bulbocodium vernum, Astragalus dasyanthus, Crocus reticulatus*). In the Bugac side of Kecskemét, zoologists have proposed the establishment of a closed juniper area where the sand fauna would find refuge."

In other publications he wrote that on the yet undrained Sand Ridge „István Font local landowner and ornithologist protects Lake Szappanos at Bócsa". This used to be an excellent habitat for avocet (*Recurvirostra avocetta*), black-winged stilt (*Himantopus himantopus*), snowy plover (*Charadrius alexandrinus*) however he warned that "respect and protection can not be provided forever even with utmost care".

In 1932 a conference was held in Paris on nature conservation and Hungary was one of the nine participating countries. The Hungarian nature conservation aims and efforts were summarised by Gerard De Pottere and Szilárd Schermann. According to Schermann, among other things "the protection of an ancient sand grassland in Királyhalom, near Szeged was planned".

The way for the legislational protection of natural values was finally cleared in 1935. Law No. 1939. IV. on Forests and Nature Conservation ordered the foundation of the National Nature Conservation Committee which was formed in 1939 as an advisory organ. It is interesting to note that Kázmér Dezsõ, the mayor of Nagykõrös proposed steps to be taken right after the publication of the Law (perhaps he was acquintant with the botanical works of Ádám BOROS, namely about the Nagykõrös area woodlands). Thus the body of representatives decided to declare the Pótharaszt area (today Csévharaszt) with its juniper and poplar covered sand hills and five other areas as protected. In the national registry for protected areas (kept from 1939 onwards) these areas were entered under the numbers 38-44 in 1940. (Today only the juniper-poplar area exists.)

Other initiations taking place meanwhile are also worth mentioning. János Annók F. Szabó, the „bird captain of Bugac" on assignment from the Ornithological Institute carried out regularly preliminary observations from 1935 onwards. In 1937 the Association for Natural Science recommended that around 500 hectares of the Bugac-wood should be placed under "perpetual protection". In 1942 the National Nature Conservation Committee organised even a field trip concerning this question.

Nevertheless hardly any area was declared protected before the Second World War on the Duna-Tisza köze. The list became longer only to include an oak at Kunferhértó and two sand poplar woodlands at Ásotthalom.

Declarations of protection seized between 1945-1950, and the political mentality of the following two decades did not bring advantages to nature protection either (it saw rather the destruction of existing natural values). Between 1950-1971 only 16500 hectares were declared protected in the whole country. Sand areas were left out almost completely. Altogether 1100 hectares were declared protected: a smaller patch of the woodland with *Botrychium virginianum* at Kunfehértó, Tõserdõ (which has sand woodland areas as well), the remnants of pedunculate oak woodlands and turjans of Kunadacs, Kunbaracs, Kunpeszér and Dabas, Büdös-szék at Pusztaszer (the eastern margin of the Ridge) and the juniper woodland at Bugac.

The clear dominance of woodlands is evident, due to some dedicated foresters. Other voluntary nature protectionists (György Mészáros, Sándor Urbán and followers) worked on ornithological observations in the surroundings of Fülöpháza. Meanwhile fundamental publications appeared about the vegetation geography of the Duna-Tisza köze (Ádám Boros), the habitats of the sand areas (Imre Babos), and about the spatial and temporal changes of saline areas (Sándor Somogyi).

THE RESULTS OF NATURE CONSERVATION IN THE PAST 30 YEARS IN THE KISKUNSÁG SAND RIDGES

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At last 1971 brought a turn in nature conservation. 10 years after the publication of the statutory rule No. 18. in 1961 the implementation plan was published as well. The obstacles in the way to establish national parks were removed and the concept of local and national level protection was severed. The National Nature Conservation Committee which had been brought into existence about a decade before and was restricted in its operation, was assigned real power to declare protected statuses.

In the Duna-Tisza köze these measures brought fruit in 1974-1976. This period of three years would be difficult to overtake in the aspects of increment in territories and of importance of decisions:

- on the western fringe of the Duna-Tisza köze Ridge, the northernmost part of the Turjánvidék - the Nature Reserve Area of Ócsa (3575 hectares) and two significant southern patches (the Tabdi and the Szücsi-wood, 181 hectares) became protected,
- the second national park in Hungary – the Kiskunság National Park – was established in this period on 30 628 hectares; at the start, to cover the mosaic and diverse landscape six separate areas were declared as part of the Park,
- the Nature Reserve Area of Pusztaszer was created on 21 497 hectares on the eastern margin of the Ridge,

- in the central areas of the Ridge the Nature Reserve Area of Orgovány (now part of the Kiskunság National Park) covered 2 953 hectares,
- the area of the woodland with *Botrychium virginianum* at Kunfehértó increased, and the sand hills of Kéleshalom and Lake Péteri, altogether 970 hectares were placed under protection.

With the establishment of the Kiskunság National Park new approaches and possibilities gained ground. This was the first time that nature conservation found itself in a situation where it disposed over own monetary resources within an independent organisation with the help of dedicated nature conservation personnel. Already in the first year the management of sand areas at Fülöpháza began to decrease the scars left behind by military actions. The geological and soil science investigations commenced. In 1979 the most valuable and non-military sand areas were declared as *biosphere reserves*.

To provide for the infrastructural needs of biological-ecological investigations in 1977 and 1982 the Field Research Stations of the Eötvös Loránd University and of the József Attila University were founded in Bugac, respectively. Later research camps and exhibition sites were set up in Fülöpháza, Bugac and at the Péteri Lake. These investigations have provided many useful data for the better understanding of the characteristic features, dynamics of the vegetation and wildlife of the Kiskunság.

The fires which took place since the areas became protected have given a lot of work to the colleagues of the National Park. Extensive poplar-juniper woodlands (altogether almost 3000 hectares) burnt down in Bugac in 1979, in Bócsa in 1993 and in Orgovány in 2000. The assessment of the damage was followed by nature conservation oriented evaluation of the rehabilitation possibilities, and then by the implementation of rehabilitation (e.g.: felling of burnt pine forests and reclassification as clearings in the forestry plans).

Simultaneously, further areas were assessed and declared protected (e.g.: in 1978 the limestone exposure at Csólyospálos, in 1980 Bikatorok). To establish firmer foundations for a more effective conservation the buying out of land – as a pilot project – started in 1981.

To enhance tourism trekking paths were delineated in Bugac, Fülöpháza and Orgovány, and educational trails were marked out in Bugac and Fülöpháza. Simultaneously the closing of roads to and through the sand hill areas (e.g.: in Bugac and Fülöpháza) has decreased through traffic and tourism significantly.

From 1977 onwards detailed vegetation mapping was carried out on high value sand areas for taking a fuller inventory and for the preparation of management plans, primarily by the colleagues of the Botanical Departments of our greater universities. Between 1983 and 1994 stations (measuring background air pollution) operated on sand areas (Fülöpháza and Bugac). Management plans were first prepared in 1979 for selected regions. These plans are regularly rewritten and further developed with respect to national level (but not standardised) priorities.

For the retention of the waters of the Ridge, in 1979 a diverting channel was built around Lake Kondor and in 1981 nature conservation oriented water level regulation was started. In 1996 and in 1999 Parliament and Government regulations were published about the water management situation of the Duna-Tisza köze Ridge, so far only with negligible results.

Military use of sand areas until 1991 caused serious troubles. The reduction of the damage caused was almost impossible until the withdrawal of the Soviet Army, but from 1992 onwards land arrangement and partial explosives disposal was implemented. 5 years later in Orgovány and Bugac 45 military buildings were demolished and today military presence is excluded on the areas of the Kiskunság National Park.

The reduction of alien land management branches and overgrazing in the protected areas is an outstandingly important part of nature protection. The task is difficult, headway was only made when areas were nationalised from 2000 onwards. The results can become detectable in

a matter of 4-5 years. Another burning issue is the spreading of alien species. Attempts to push back *Asclepias syriaca*, black locust, *Acer negundo*, *Ailanthus altissima*, *Elaeagnus angustifolia* (depending on the species) have already shown some results or they are expected to do so.
An even more challenging task is to change or rather to revert the species composition of woodlands. This process – the replacement of alien species regulated in law from 1997 onwards (e.g. black locust, poplars, pine species) and the restoration of more natural forests – is going to consume several decades and at the moment only the first steps have been taken.

For the experimental estimation of the effects of the climate change on sand shrubs a complex experimental device was set up at Fülöpháza as part of an European research network (VULCAN). With the reduction of night radiation and rainfall reaching the soil surface the effects of the forecasted climate change are imitated.
The creation and sustaining of open, shifting sand dunes is a long debated question of sand hill area management. On certain areas regular experiments are carried out to create open sand surfaces (fencing off, grazing by racka sheep and goat, tilling and scraping off vegetation). Momentarily the two moving sand hills at Fülöpháza do not require considerable intervention.

As a summary, in the past years the number of nature conservation oriented management actions in sand hill areas have multiplied fortunately, and the possibilities, limitations, middle-term effects of such actions are better understood. Even though the majority of these actions are experimental, our knowledge is increasing which leaves hope that in the future we are going to be able to tackle problems concerning our sand dune areas and that we will be able to help along the self-healing regenerative processes of sand vegetation.
The most distinct structural change that took place in the past years is the dynamic ownership transition of the protected areas. Spending around 100 million HUF per year to acquire land, more than 70% of the 48 000 hectares are managed by the budget of the Kiskunság National Park. As a consequence the nature conservation oriented management actions are more predominant here. This fundamentally alters the direction and scope of future management actions.

CURRENT NATURE CONSERVATION TASKS

This chapter discusses the tasks and aims that are of prime importance to the survival, effective protection and general management of sand hill areas. The fact that despite the increasingly widespread nature protection activity our natural values are decreasing should not be forgotten. The loss is estimated at 1-3% every year. With this speed our natural vegetation heritage is halved in a matter of some decades: our land will become emptier and duller, less habitable! To stop the decline we need a wiser society and stronger nature protection.

Nature conservation oriented silviculture

In protected sand hill areas large regions are occupied by plantations of alien species that are neither economic, nor useful for sand fixation. The reason for this is that there is no appropriate legal regulation of conservation oriented silviculture in the case of sand woodlands. There is no way, for example, to eliminate alien plantations grown on grasslands. The forestry regulations forbid the reduction of any forested area, even if earlier plantations were economically or socially unjustified, or even harmful in terms of nature conservation. In this situation, nature conservation authorities have the following possibilities although neither of them presents a good solution:

1. to legalise the conversion of forest land (and the restoration of natural sand vegetation on it) by paying a substantial “forest protection” fine (double the potential cost of reforestation) – however, this would be beyond the resources of conservation authorities;
2. to implement “replacement afforestation” on an area equal in size to the forest land to be converted. Lack of financial resources and land make this solution impossible as well;
3. to leave the area as forest land and regenerate it with native species in accordance with nature conservation laws, even if, being only a “poor” grassland site, it is not really suitable.

Sand areas that have been restored to private ownership are vigorously being planted with alien species even today (black locust, Corsican pine, poplar hybrids).

Unfortunately, strong forestry lobbying in Hungary together with the simplistic interpretation of EU expectations regarding the area of forested land, encourage the further increase or maintenance of plantation, even at the cost of the destruction of natural resources.

Furthermore, the forestry regulations ordain a minimum canopy cover to be maintained in woodlands (70% including regeneration), which makes it practically impossible to manage open sand woodlands of native tree species. Besides the legal regulations, it is often up to the State Forest Service to decide whether to accept a regenerated area, or order the filling in of an open canopy stand. Therefore, it is essential to maintain good co-operation, based on reasonable compromise, between forestry and nature conservation authorities.

The shrub-grassland patches which are not classified as forests are threathened from another direction. If an area or part of it is not classified in the forestry branch of land use and is not used according to its current classification but its tree cover reaches 50% then it has to be transferred to the forestry branch. This is the case even if the area is at least 1 500 m^2 (less than 40x40 metres)! This legislation leads to the loss of the natural grassland – woodland mosaicity and to a state-determined land cultivation and to the formation of closed forests. Nature conversation offices have little influence on this process since – not surprisingly – the official control of land-use transfers on non-protected areas is not among the assigned tasks. Therefore on non-protected areas the homogenising of natural habitat mosaics to plantations can go on without official control.

The fact that common juniper (*Juniperus communis*) and Russian olive (*Elaeagnus angustifolia*) have been declared forest tree species in 2000, with the result that their stands must be planned, could further accelerate the senseless destruction of natural resources.

There are many other examples of how the thoughtless, over-generalised tendency to increase the wooded area may destroy great natural resources, even they conform to EU expectations.

Sensible water management

Although innumerable laws, regulations and decrees call for sensible water management (e.g. water retention in natural wetlands; the obligation to retain ecological water resources; the decree on the water supply of the Duna-Tisza köze sand ridge; the government regulation on the crucial water regime and water supply of the Duna-Tisza köze sand ridge), water conservancy authorities and farmers have so far failed to act accordingly. This fact further worsens the water deficient state of fresh sand habitats. What is more, a new inland water control program has been announced recently, the irresponsible implementation of which may cause further damage to nature (as has already occurred in several cases). Unfortunately, some technocrats still consider it worth draining inland water in spring and then artificially forcing water back to a given area in summer, instead of employing rational water management, considering local water retention, and directing laymen towards the sustainable use of water resources. Sensible land management, economical irrigation and controlled deep ground water extraction could greatly improve present water deficiency.

Hungarian Agro-Environmental Programme
This program, which has been accepted by the government, offers a wide variety of possibilities for the protection of semi-natural sand habitats (both protected and non-protected). Horizontal action plans will support environment-friendly methods of plant cultivation and animal husbandry and decrease the amount of agricultural pollutants, thus contributing to the preservation of semi-natural habitats. The system of Environmentally Sensitive Areas (ESA) enhances management, allowing for special nature conservation aspects. Considering that admission to the system is voluntary, it has to work well enough to bring farmers round to it. Information and propaganda about the possibilities and probable advantages of the system is vital.
The rural development plans aiming at EU financial support are being prepared. The National Park Directorates have to take on a professional role in the preparation. The SAPARD Plan has to be directed useful causes and to such rural development plans that do not damage the environment but lead to the spread of non-exploiting land uses. The SAPARD Plan provides possibility to propagate non-exploiting land use techniques, to develop sensible land-uses, and thus opens ground for the direct and indirect protection of nature. The distant (and not necessarily competent) EU-control is not always enough for not supporting nature-damaging practices on EU money. Thus a very strict home regulation and control is needed to prevent cases such as when applications were handed in for SAPARD funding for afforestation (poplar) and fishpond building on grassland, reed stands or high natural value areas.
With the implementation of suitable rural development plans grazing pressure can be reduced and near-natural forest management, afforestation with native species, transformation of arable land to grasslands, sensible water management, water-saving irrigation, ecotourism, establishing of display centres, etc. can be supported.

Compensation system
A nature conservation compensation system, already outlined by legal regulations, should be developed to provide financial support for those fighting for their existence because of nature conservation restrictions.

Legal regulation – Natura 2000
The need to bring Hungarian law into line with European Union regulations, and the acceptance of EU Habitat Directives and their Annexes, also enhance the protection of sand habitats and endangered species. Hungary will be obliged to designate Natura 2000 sites in sand areas (among others) on account of the gopher (*Citellus citellus*) (Annex II, chance of protecting closed sand steppes) and Orsini’s viper (*Vipera ursinii rakosiensis*) (Annex II). Within the framework of Hungary’s proposal there will be further opportunities to protect sand habitats and create Natura 2000 sites. Such proposed Annex II species are the mole-rat (*Spalax leucodon*), *Dianthus diutinus, Colchicum arenarium*, etc. Naturally, the designation of Natura 2000 sites must be carried out as thoroughly and professionally as possible.

Declaration of protection
There are still considerable sand areas worth protecting whose candidature for protection should be furthered, should they be extensive or small but precious regions surrounded by pine forests. The country’s accession to the EU and the adoption of EU nature conservation legal regulations will probably encourage more declarations of protection.

Nationalisation

The nationalisation of protected areas should be continued as state ownership can best guarantee the nature conservation oriented management of protected areas.

Natural areas

A list of natural areas (a new type of nature protection areas) has already been compiled by regional nature conservation authorities (i.e. national park headquarters). This list should be promulgated as soon as possible, and the relevant regulations from Hungarian nature conservation laws regarding these areas should enforced.

Ecological network

The designation of the ecological network system (created for the Hungarian Nature Conservation Plan, part of the Hungarian Environmental Protection Programme) might also be of help in the protection of natural sand habitats. It will have to be considered when preparing and making decisions at ministerial level as well. Thus, it is important to develop the best possible version of the database and to use it wherever possible to inform decision-making.

Management of protected natural areas

The suggestion that profit-oriented organisations should take over the organisation of the management of protected natural areas from national park headquarters should be rejected. In general, nature conservation should not be subject to the stress of profit making. Even today, there is a tendency for a considerable part of the budget of national park headquarters to come from the income that it generates.

Forcing national park headquarters into profit oriented land-use means jeopardising the very nature conservation interests that they are supposed to promote.

Management plans

According to the nature conservation law management plans have to be made for all protected natural areas. These plans guide nature conservation authorities in managing a given protected area. However, the decrees that specify the content and form of management plans have to emerge yet.

Unfortunately, the standard of content, elaboration and coverage of management plans is low owing to the lack of sufficient expertise. Although the directives (about e.g. grazing, mowing or non-intervention) refer to habitats, the system of habitat types is often schematic and poorly detailed. The directives should refer to specific sites, but the maps and databases on protected natural areas, their habitats, vegetation types and natural resources, are often incomplete or are missing. This will hinder the consideration of local conditions when preparing the management plan, a situation unfavourable for both nature conservation authorities and the owners and managers of protected natural areas.

We suggest that protected sand areas be left unmanaged (which usually means non-grazing) wherever possible. First we need to see how the system works without intervention, only then can we plan the sustainable use of the area. Obviously, in some cases it is in the interests of nature conservation to carry out active management. Such management could involve the eradication of adventive plants (e.g. black locust, Asclepias) and non-native animals (e.g. rabbit), the replacement of alien tree plantations, the abandonment of arable fields, or the restoration of grasslands. Individual species protection programmes are needed for the protection of endangered species.

Relationship with local communities

Naive as it may sound, people should be taught once again to be proud of the natural resources in their surroundings. This would help to achieve better compromises and solutions to conservation problems.

Areas rich in natural resources should be managed so that local communities receive material and cultural benefits, wherever possible. When planning the land-use and rent of protected natural areas the national park headquarters already discriminate in favour of local farmers. In co-operation with municipalities, nature conservation management (e.g. weed control, mowing) could also be carried out as public work. Ecotourism, with the marking and use of footpaths is also advantageous for local authorities. The names of the national parks could be better used for the marketing of goods (especially bio-products) produced in protected natural areas.

Non-governmental organisations and private conservationists

Professional support and increased contact with private conservationists, national and local non-governmental organisations (NGOs) is highly important. Voluntary conservationists should be aware of the location of strictly protected areas, the natural resources to be found there, the management plans and directives concerning protected natural areas, and the theoretical background to the protection of natural resources, so as to be able to efficiently help authorities. Experience from throughout Europe has shown how invaluable such voluntary conservationists can be in observing and reporting, collecting data, and in helping to develop and implement projects.

Research, surveys

The preparation of natural resources inventories and actual habitat maps should be accelerated, and the databases of natural areas specified by the Hungarian nature conservation legal system and the database of *ex lege* protected fens should be continuously updated. The stands of plant and animal species protected by EU nature conservation regulations, and those of species listed in the Habitat Directives Annexes should be thoroughly surveyed.

There are several scientific research topics relevant to the protection of natural resources related to sand. There is, for example, a serious lack of knowledge in the field of nature conservation oriented management in sand woodlands. Research into the control of weeds invading sand habitats, or surveys of the areas most affected by the invasion of adventives are urgent tasks. Spontaneous regeneration processes in sand areas should also be studied, for they are localities where biodiversity increases.

The study of habitat dynamics is essential. Long-term observations, fixed-location photo-series and repeated vegetation surveys are needed for the creation of scientifically sound databases.

Penalties

People violating nature conservation laws should be punished more effectively. This also means that at the same time local communities should be better informed about the legal regulations they have to observe. This would make it possible to avoid damage caused by good faith.

The National Parks Authority should exercise its right to ban all illegal damaging activities in sand habitats. Unauthorised trekking, pleasure driving and riding should be avoided in sand dune areas because of the serious damage that can be caused by constant visits to the same spot or constant use of the same path.

APPENDIX

PREPARATIONOF THE MAP OF ACTUAL VEGETATION IN THE DUNA-TISZA KÖZE: THE METHODS

The methods of preparing the actual habitat map

First a 1:12 500 scale, well documented field habitat mapping was carried out for 3.5% of the Duna-Tisza köze. Later local information were collected for another 20% of the area from botanists and nature conservationists. Finally, high resolution satellite image analysis was performed with a botanical approach on 46 930 points in nearly 17 000 semi-natural habitat patches (the grassland, moor, open water and open woodland patches of the Gauss-Krüger topographical map) utilising field and background information. Thus 24% of the spots are based on field data, 76% are based exclusively on satellite image analysis. This corresponds to 31% and 69% of the area, respectively.

The satellite image was prepared in 1998, habitat mapping data originate from 1997-1999, background information were also collected in the past couple of years, thus the habitat map reflects the end-90's state of the Duna-Tisza köze.

The following maps, databases were used in compiling the database: field habitat-data, EOV geocoded SPOT4 satellite image (FÖMI-TVH), grassland, moorland patches and open woodland of the Gauss-Krüger 1:25 000 topographical map (MH TÉHI), Kreybig 1:25 000-soil map (MTA TAKI), AGROTOPO 1:100 000 database (MTA TAKI), 1:100 000 surface geological map (MÁFI), the inland water cover map of the Duna-Tisza köze in March 1999. (FÖMI), database of natural areas (KNP).

During the analysis not the patches were characterised but selected points of the satellite image were interpreted and typed for the vegetation. To a maximum 6 hectares vegetation patch 1 point, to a 6-10 hectares patch 2, to a 10-20 hectares patch 3, to a 20-40 hectares patch 4 points were assigned. In patches larger than 40 hectares roundabout every 10 hectares were represented by 1 point. These points were spread out evenly to ease later estimations. After interpretation for every point the represented area was calculated and in spatial statistics this value was used. The reason why the point-method was favoured is that the delimitation of homogenous vegetation patches would have been very demanding (1000-1500 working days, estimated). At the same time with the point-method the characterisation of heterogeneous patches became easier and less arbitrary.

During identification first the colour of the patch (spectral characteristics) were noted. This information was supplemented with the pattern of the patch, the properties of the surrounding landscape and with the data from background maps. According to our experiences in most cases it was not possible to judge the habitat solely from patch colour.

The system of categories

Since we would like to prepare a habitat-map by botanical interpretation of satellite images it is necessary to set up a special key. The satellite image does not show what a botanist on the field would see. The species-list, weediness is not apparent, however biomass, the pattern of open water and soil surfaces is detectable (at 10x10 meters pixel size), and the landscape pattern is still well visible.

In the current landscape the difficulty of identifying the habitat-type is further increased by the transformation of the natural habitat pattern, the fragmentation of the vegetation mosaics (the lack of the natural landscape) and the different land uses of the patches. Even though the satellite images were prepared roughly at the same time (a great help!), heterogeneity in mowing and grazing prevented the distinction between mowed semi-natural meadow and ploughed grassland to be made. Nevertheless it was often difficult to distinguish between dry and fresh, saline and fen areas.
Whereas in the cases of open sand grasslands, juniper-poplar woodlands, Puccinellia swards and Bolboschoenus marshes each community was almost fully corresponded to a class in the category system, communities were united in the cases of fens and fresh meadows, floodplain and saline areas. According to our experiences the naturalness of bare alkali areas, saline lakes, sand hills, and water rich fens, are quite noticeable, whereas it is not possible judge with fens and steppes.

Sanctuaries

It is a common wish that the identification and delineation of our most valuable areas – the natural "sanctuaries" – would be possible on satellite images. Unfortunately there is only limited possibility for a number of reasons: principally due to the fact that the sanctuaries are what they are for their naturalness, species-richness, rare species and rare habitats. These features are invisible from the satellite, even better techniques in the future are not likely to change this situation.
Habitat-mapping based on satellite images serves other purposes. This method is used to map that part of the landscape that surrounds the sanctuaries. This "less interesting", semi-natural, more or less degraded habitat network defends the small (maximum 1-2%) sanctuary areas and the often extensive stands of species and habitats of medium rareness.

The method of preparing an overview habitat-map

The featured map contains each point of the habitat-point database. The colours and signs in the key are given so that the rough pattern of the landscape should be evident, however the finer scale habitat-distinction would still be possible. The more natural habitats are represented by darker, the more disturbed habitats are indicated by lighter tones. The 1-5 hectares points have smaller signs as larger areas. This way the points on the overview map cover those areas where the habitats are found almost perfectly (slightly enlarged).

TABLES (see int he hungarian text)