NATIONAL ECOLOGICAL NETWORK HUNGARY

Alkaline lakes

NATIONAL ECOLOGICAL NETWORK 4.

Foreword

The Act on Nature Conservation, in force since 1 January 1997, has declared alkaline lakes ex lege protected (i.e. protected since the Act's entering into force, without a designation procedure), along with caves, sinkholes, bogs, springs, tumuli and earthen fortifications. With good reason, since this type of wetland once so typical of the Carpathian Basin has drastically declined, just like bogs and mires, according to a recent national survey led by the Authority for Nature Conservation, Ministry of Environment. When we say they are endangered we do not just refer to modifications in their water level, water quality or composition: it is the very existence of the remaining lakes that is threatened.

On-site studies have shown that the majority of alkaline lakes located mostly in the Danube-Tisza Interfluve and the Hajdúság area, and to a lesser degree in the Mezőföld, Jászság, Nagykunság and Nyírség areas as well as along the rivers Körös and Maros are threatened by ill-considered interventions (draining, amelioration, pond-creation, eutrophication caused by superficial contamination, ploughing or misuse of grasslands, mining, etc.).

Not all wetlands classified as alkaline lakes by conservationists and ecologists are permanently under water, moreover, not all of them qualify as lakes. The special attention and full-scope protection worldwide are necessitated by their sensitivity and endangered status as well as the high number of protected and rare species these wetlands hold. The Carpathian Basin, and within it, Hungary, is the well-marked, western border of the chain of typical Eurasian habitat types, including alkaline lakes. Salt lakes are well-represented in other continents, as well, but they are significantly different from Hungarian continental type alkaline lakes in species composition, habitat types and hydrochemical features.

The annex of the EU Habitats Directive contains under the heading 'Coastal and Halophytic habitats' a new point, 'Pannonic salt steppes and salt marshes', so the protection of Hungarian alkaline lakes will soon become an international obligation by EU legislation.

It may sound 'interesting' to the layman that the past existence of a number of already drained alkaline lakes is only indicated by sluices, water-lifting devices or dykes – the 'memento' of sometimes inconsiderate water management measures. It is an important task for nature conservation to re-create the conditions for at least temporary flooding, wherever it is still possible, in these biogeographically very valuable habitats.

This task is not just a matter of financing, since in certain regions of the Great Plain, especially in the Danube-Tisza Interfluve, the water table has sunk 6–10 m, strongly limiting the possibilities of water management.

The ‘ex lege’ status of bogs and alkaline lakes and the declaration of their national register expected in the near future will hopefully start a new chapter in the practical conservation of these outstanding natural assets.

Introduction

‘It was water that made the barren, flat alkaline plains of my childhood so beautiful.’

Domokos Varga

Salt and alkaline lakes can be found in every continent. Within salt lakes, alkaline wetlands, almost ubiquitous in Hungary’s lowlands, form a hydrochemically distinct group. They include numerous large lakes, but the majorities are shallow, often seasonal still wetlands. Hydrologically, the term wetlands means a shallow standing water body whose environmental conditions are significantly different from those of true lakes.

The two largest shallow alkaline lakes of the Carpathian Basin are Lake Neusiedl and Lake Velencei. Nevertheless, the most typical Hungarian alkaline wetlands – markedly seasonal and diverse ponds, marshes and small wetlands – are predominantly found in the Great Plain.

Alkaline wetlands are often called alkaline lakes or marshes in common parlance. Scientifically speaking, however, shallow lowland water bodies are not true lakes, since their depth and environmental conditions do not allow distinction between the littoral zone and the limnic zone. Despite this, the traditional term has been preserved, and we still call these wetlands alkaline lakes, where the term alkaline unambiguously describes the real character of the wetland.

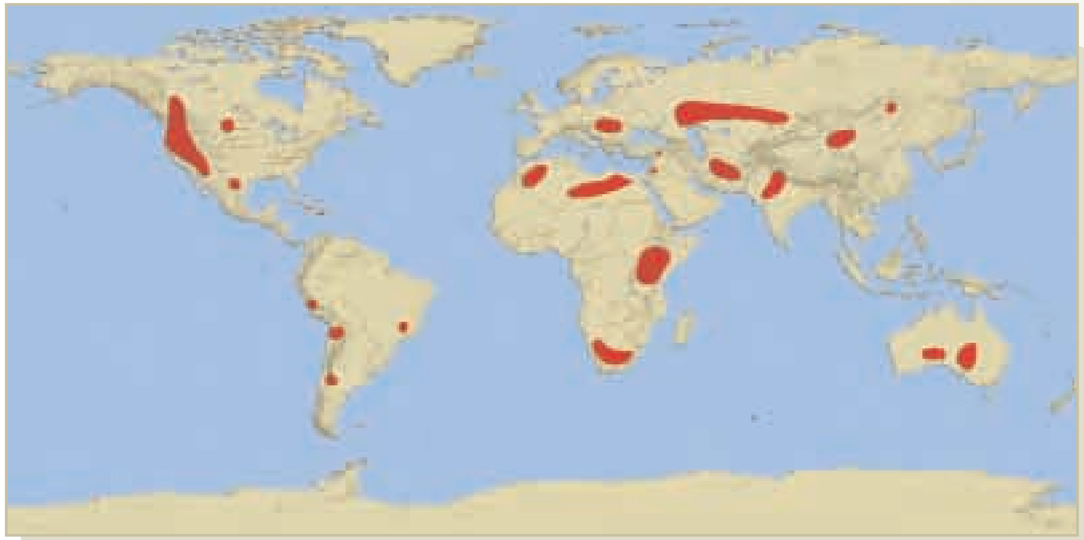

Figure 1: The distribution of alkaline areas on earth (based on Löffler)

Why are alkaline wetlands important?

'Lakes were for many years doomed to destruction. Their eyes mirroring the sky were to be closed forever. Their bottoms were to be converted into ploughlands, meadows and pastures.'

Domokos Varga

A sad result of Man's large-scale landscape forming activity is the drastic decline of terrestrial wetlands in the 20th century, particularly in Europe. The distribution of Eurasian alkaline wetlands reaches its westernmost border in the Carpathian Basin, which makes Hungarian alkaline wetlands particularly important. Furthermore, inland alkaline wetlands possess a specific salt-resistant and salt-loving flora and fauna: a number of plant and animal species typical to alkaline habitats have their nearest relatives in maritime and seaside salt wetlands and lagoons.

The Carpathian Basin is particularly rich in alkaline lakes within Europe. They are of international importance as staging and roosting sites of migrating waterfowl and shorebirds, most of which breed in he Arctic tundra. A number of species within the above groups migrate and overwinter in coastal habitats. These species, flying across Europe, find similarly barren areas and shallow alkaline wetlands in the Carpathian Basin. The traditional staging sites formed in geological times are, therefore, a key factor to their survival.

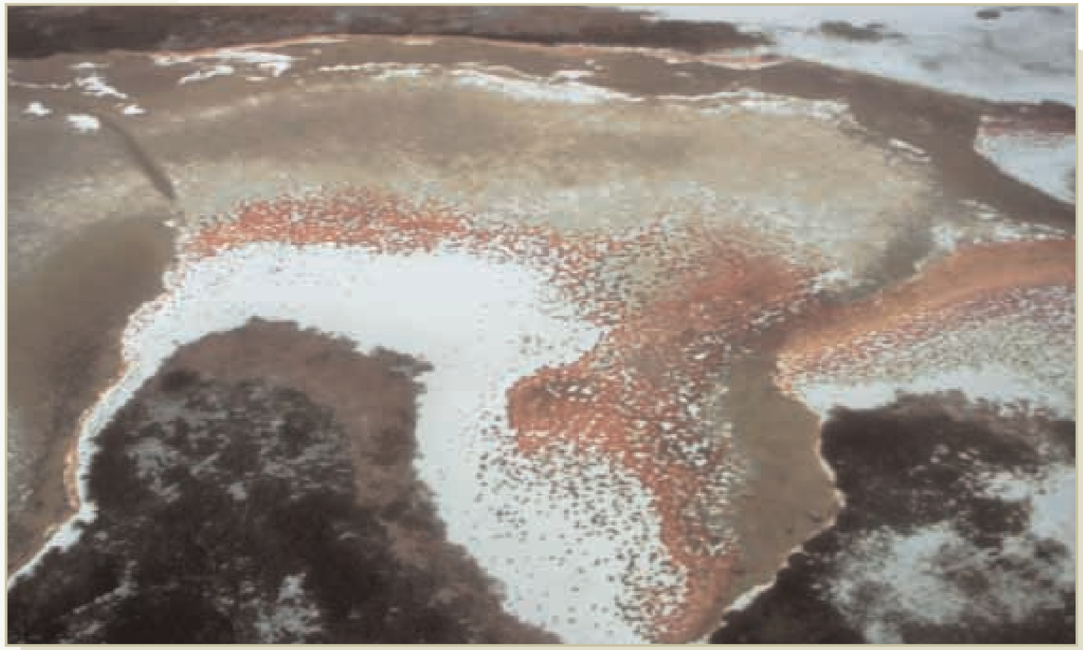

Photo 1: Alkaline shoreline in the Kiskunság in autumn

Where are they found within the Carpathian Basin?

The Hungarian Canaan has good black and fertile muddy soils, but also vast sands and infertile or poor alkaline plains wedged between them.'

Dr. Miklós Kállay

The largest alkaline wetlands of the Carpathian Basin are Lake Neusiedl and Lake Velencei, but these two differ from the classic Hungarian alkaline lakes by their mere size and character. Typical examples of smaller, shallow, open alkaline lakes can be found in a large number in the Danube-Tisza Interfluve, as well as in smaller numbers in the Hortobágy, the Hajdúhát, the Nyírség, and in the Lake Neusiedl – Seewinkel area in Austria. In addition, some scattered alkaline habitats can be found in the Mezoföld and the Csanádi-hát, too. The number of such wetlands in the Yugoslav part of the Danube-Tisza Interfluve is not yet precisely known. Moderately alkaline wetlands also occur in a number of other places within the Great *Plain:* because of their lower salinity, they are not the characteristic, barren and open lakes, but instead are slightly alkaline marshes, meadows and seasonal steppe wetlands. The largest continuous alkaline region of the Carpathian Basin is the Hortobágy.

Photo 2: Typical landscape in the Hortobágy

The reasons and conditions of alkalinisation

Alkaline areas have formed, to a degree varying from region to region, and among diverse geological conditions, in practically all lowlands of the Carpathian Basin in the recent geological epoch. The formation and evolution of lowland alkaline areas have been very variable in both space and time. This is well reflected in the present, diverse morphology of alkaline areas, as a result of the mutual effects of pedological, climatological and hydrogeological conditions. The reasons for alkalinisation in the lowlands of the Carpathian Basin are the following:

1. The necessary quantity and quality of salt is provided by the eroded debris of the surrounding volcanic and limestone hills, and by the sodium, calcium and magnesium content accumulated in loess and drifting sand areas.
2. The basin is almost completely closed.
3. Impermeable layers have evolved from the fine-grained, solid alluvial deposit accumulated over the millennia.

4. The climate has a continental character. Wet winters and springs are followed by warm, dry summers. Extreme changes between wet and dry seasons are typical, making floods and ensuing droughts regular.

Fluctuations in water level

The dissolved salt content of artesian and ground water accumulates from vast areas, and continuously moves towards lower lying alkaline lakebeds. In wet springs, the ground water pressure can be so high that the water may reach the brink of wells drilled near lakebeds, and ground water may even spout forth within such wells. In dry, droughty summers the water table may sink considerably, superficial lowland water bodies shrink, and water eventually collects in the deepest closed basins. The salts originating from a large underground catchment area reach high

Photo 3: Drying alkaline lakebed in the Kiskunság

concentrations in the reduced water volume. The intense evaporation draws up salty ground water from deeper strata, too. In the driest season, lakebeds completely dry out and the highly concentrated salt precipitates on the surface in the form of crystals. Due to the shallowness of alkaline wetlands, their temperature closely follows air temperature: in winter, for example, they often freeze to bottom.

Photo 4: Dry alkaline lakebed

It is clear that the physical and chemical features of superficial deposits are determinative in the process of alkalinisation; the great, region-specific differences in the morphology and salt content of accumulating waters can only be explained on the basis of these factors.

Hydrochemical Features

Compared with other salt lakes of the world, the alkaline lakes of the Carpathian Basin are characterised by lower salt content but higher alkalinity. This is the reason for distinguishing alkaline wetlands within salt lakes.

Typical lowland alkaline lakes are markedly different from Hungary's 'freshwater' lakes, due to their high dissolved salt content originating from ground water. Alkaline waters are rich primarily in sodium and hydrocarbonate ions, but the chemical components show great variations, both locally and seasonally, depending on environmental factors. Average salt concentration ranges from 0.5-7.5 g/l, but may reach up to 70 g/l in certain lakes during the summer evaporation.

The inorganic chemical composition of alkaline wetlands is characterised by the dominance of sodium, calcium, magnesium, hydrocarbonate and carbonate ions, and occasionally the chloride and sulphate ion content can also be significant (local and seasonal variations are generally great). Another type of alkaline wetlands comprises sodium lakes, with remarkably high quantities of sodium, carbonate and hydrocarbonate ions determining their chemical character. These waters show particularly high alkalinity, a result of the chemical features of sodium carbonate.

Two main types of alkaline wetlands can be distinguished by colour. 'White' alkaline waters belong to sodium lakes, and are coloured by the greyish-white lime mud accumulating on the bottom.

When these lakes beds dry out, sodium 'blossoms', i.e. crystals appear on their surface. (This sodium used to be swept up and used as a household detergent.) When conditions are appropriate, bog lime may also form on the lakebed. Although bog lime occurs in a number of deeper, wind-eroded blowouts among the sand dunes of the Danube-Tisza Interfluve, this formation is a world-wide rarity. 'White' alkaline wetlands are normally sparsely vegetated.

Photo 5: White alkaline wetland in the Kiskunság

The other type is called 'black' alkaline wetlands. They form when white alkaline lakes sediment (fill) up and biological production results in organic debris accumulating on the alkaline lakebed. This type represents a transition form towards freshwater marshes. The buff coloration in the otherwise transparent water of 'black lakes' is the result of floating organic matter dissolved by alkalinity. Black alkaline wetlands are not open lakes, since they are normally rich in aquatic and emergent vegetation. White and black waters may occur simultaneously in the same lakebed during the course of vegetative invasion.

The classification of lakebeds

'Among the flats, lakes, salt pans, marshes, meres, fens, morasses, sedges, oxbows, swamps, wetlands, slimes, mudflats, mires, pools and puddles you can see here and there slightly elevated shorelines, shoals, islands, ridges, dunes and hillocks...'

István Tálasi

The above list shows well how diverse wetlands there are. Their evolution has been just as varied:

Ancient riverbeds. The remnants of former riverbeds that once cut through the loess-sand sediments but were later dissected from the river and became alkaline. Typical examples can be found along the rivers Danube, Tisza, Maros and Körös. Following the shape of former meanders and embayments, these wetlands are elongated, widely horseshoe-shaped or meandering. The original riverbed shapes have been significantly eroded by waves and in dry seasons by winds.

Blowouts are alkaline lakebeds formed in wind-eroded depressions of sand and loess sediments. This type includes the most typical alkaline lakes of the Danube-Tisza Interfluve and the Nyírség area. Their shape and longitudinal arrangement is a result of the constant eroding effect of wind. They appeared among the sand dunes after the Ice Age, but their shape, surface and extension have constantly changed ever since as the surrounding dunes have moved.

Photo 6: Alkalinised blowout at Bugac

Photo 7: Salt pan next to Konyár in the Hajdúság area

Salt pans. In our present knowledge, this type can only be found among the loess ridges in the Hajdúság area. Salt pans are characteristic, regular round formations along the flat, gently sloping crest lines of loess ridges. This type is generally well-known from the Russian steppe zone. The regular, rounded shape is a joint result of physical and chemical erosion by runoff water collecting and sinking in the depression and weathering the loess walls of the pan.

Alkaline soil types

'The meadows and marshes have become infertile alkaline flats that grow from year to year, gradually swallowing up the surrounding lands.'

István Györffy

While alkaline lake-beds are regularly flooded, the surrounding, slightly elevated lands rarely get under water. Nevertheless, salty ground water is near the surface even here, and alkalinises the soil around these lakes.

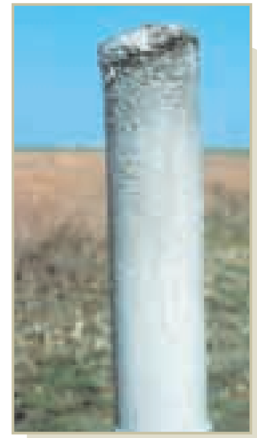

Photo 8: Solonchak soil section

In Hungary, the calcium-rich, Alpine sediments along the Danube Valley have evolved into typical lime-sodium solonchak soils,

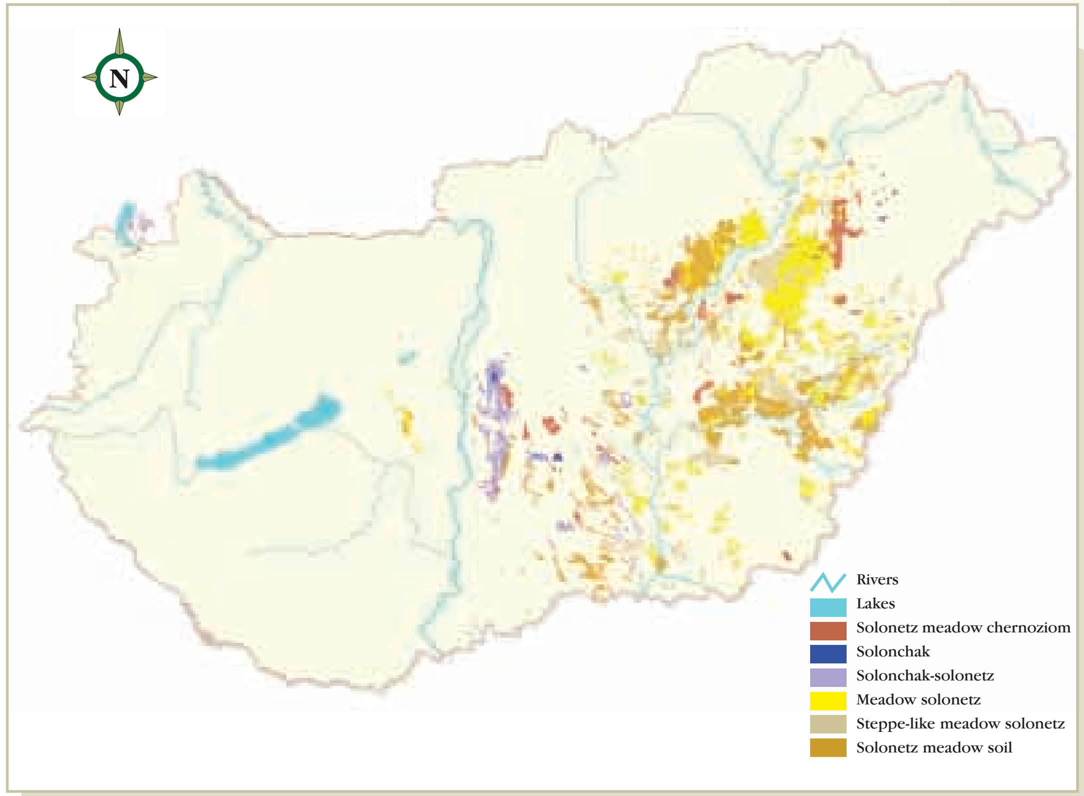

Figure 2: The distribution of alkaline soil types in Hungary (source: MTA, TAKI Agrotopo)

whereas volcanic sediments from the Carpathians are poorer in calcium and have evolved into solonetz and solod soils along the Tisza valley.

Soil classification groups alkaline soils among hydromorphic soils, which means they are strongly influenced by water, evaporate intensively and the salt dynamics of ground water is the most important factor in their formation. Thus, as it is popularly known, alkaline soils have evolved where dissolved salts, primarily sodium salts, play a leading role. Clay minerals that swell in humid conditions create a columnar structure in solonetz soils, whereas solonchak soils are typically unstructured. Solodisation is a form of degradation, meaning that lower strata come up on the surface as upper strata are eroded.

In a given locality, continuous transition among soil types and mosaic-like patterns can also be observed.

Alkaline soils are well-known to be prone to erosion, especially under grass cover, and this has led to the formation of diverse microreliefs. The most well-known of these are the berms of solonetz soils, typical to the Hortobágy puszta.

Characteristic erosion forms include seasonal streamlets, 'alkaline streams'. The smaller ones have leached, pale sand on their bottom, but larger ones may have silt accumulating there.

Tussocking is often typical in alkaline meadows. Tussocks form primarily because meadow soils regularly break up into columns during the summer droughts. The gaps widen as the humus is washed away in the wet season, and tussocks take form. Tussocking may also be a result of regular trampling by herds. In this case, it is the animals' feet that break up the soil by sinking in the mud.

The draining of alkaline wetlands and marshes can cause alkalinisation in even larger areas. This is called secondary alkalinisation, referred to by István Györffy as quoted above.

Photo 9: Marsh Sandpiper feeding

The cycle of materials and habitat characteristics of alkaline wetlands

The cycle of materials in alkaline lakes significantly differs from the ecological character of true lakes. Given the environmental conditions of the Carpathian Basin, we consider water bodies as wetland habitats if their average water depth does not exceed two meters. Within this limit, emergent marshy vegetation often appears, and the structure of the aquatic community cannot be divided into a littoral and a limnic zone, either. White alkaline lakes are normally very shallow (20–50 cm), but the high salinity prevents vegetation growth. Light can hardly penetrate the greyish-white alkaline water clouded by floating minerals, and this significantly prevents the growth of photosynthesising green algae.

Photo 10: The shallows teem with small crustaceans

The highly saline, seemingly sparsely vegetated alkaline plains are still invaded by masses of certain invertebrates, both in the water and on the shores. The same shallows host thousands of migrant waterbirds on migration. How is this possible, what is the basis of this feeding community?

The answer to this question lies in microscopic life forms. Although clouded waters are a 'desert' for algae, every drop contains millions of procaryote cyanobacteria. They are able to produce organic matter by photosynthesising in the upper 1-2 cm layer of water, and thereby provide life conditions for unicellular animals. The latter provide food for masses of floating crustaceans (already visible with the naked eye), such as water fleas. These crustaceans are consumed directly by water-filtering birds, as well as by predatory aquatic insects.

Aquatic insects are also important in consuming the organic debris sunk to the bottom. At the end of the food chain, birds are of special importance, since the distribution of fishes and amphibians, common competitors of birds in freshwaters, is very limited in alkaline waters due to the high salinity. The extreme ecological conditions of alkaline wetlands require special adaptations from their wildlife, which must have a wide range of tolerance to salinity and alkalinity.

Light can penetrate deeper down in black alkaline waters, thus their food chains are similar to those of freshwaters. However, the rich fauna building on the ample organic matter production still consists mainly of typical halophytic species.

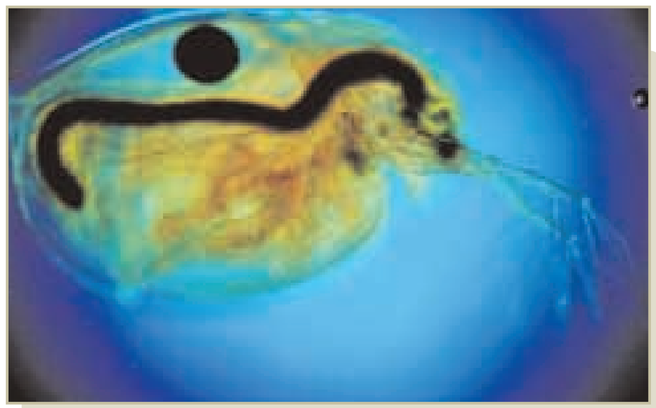

Photo 11: Water Fleas are common in alkaline wetlands

An overview of wildlife in alkaline wetlands

'The puddles that we called 'lakes' were teeming with life in the form of sluggish dots or tiny, dashing light-arrows'.

Lőrinc Szabó

Photo 12: Typical moss habitat on the side of a berm

Mosses

Several of the plant communities associated with alkaline habitats have a rich moss layer. Moss growth is predominantly influenced by the water balance of the soil, depending on the timing and amount of rainfall from year to year. Marginal and transitional zones, especially alkaline berms, banks and the swash zone of shorelines are rich in mosses, as they like to settle where the grass opens up. *Enthostodon hungaricus*, a Red Data Book species, is very typical in alkaline steppes and meadows. Other Red Data Book listed species found in the Kiskunság: *Phascum floerkeanum*, Flamingo Moss (*Desmatodon cernuus*), *Pterygoneurum subsessile*, and a rarity for Hungary, the *Pseudocrossidium revolutum*.

Photo 13: Phascum floerkeanum

Associated species usually include the sub-mediterranean *Pottia davalliana*, the halophytic *Desmatodon heimii*, the *Didymodon tophaceus* and the *Brachythecium albicans* that is common in sandy areas.

The less saline, solonetz steppes east of the River Tisza hold some species that do not occur west of this river, such as *Bryum alpinum*. Where the grasslands dominated by *Festuca pseudovina* open up, sub-mediterranean hepatic mosses appear, such as *Riccia ciliifera* and *Oximitra paleacea*, as well as a few representatives of montane slope steppes, for example *Riccia sorocarpa*, *R. papilosa* and *R. ciliata*.

The moss vegetation of the immediate environment of alkaline lakebeds is rather poor in the whole country. The aquatic *Drepanocladus aduncus* is abundant, but other species are not normally found in the water. Lakes and salt flats that regularly dry out by midsummer and autumn are almost completely devoid of mosses, apart from the temporary appearance of scattered patches.

[1]Species listed in the text are typed spaced-out if protected and in boldface if strictly protected

Photo 14: Limonium gmelini ssp. hungaricum

Flowering plants

The number of described plant associations is very high, so they can only be described here with a few character species. Alkaline wetlands and steppes are generally dominated by continental species, such as the otherwise Central Asian *Lythrum limifolium*, most of which are not found west of the Carpathian Basin. Western, maritime species are also represented in smaller numbers, for example Sea-milkwort (*Glaux maritima*), Sea Rush (*Juncus maritimus*), and next to Lake Neusiedl a flax species, *Linum maritimum*. Typically, alkaline areas are relatively rich in endemic and subendemic species. Plant associations found in the vicinity of alkaline lakes are characteristically zoned according to flooding conditions. They can be classified in the following categories with increasing exposure to floods (alkaline steppes, berms, salt flats, Puccinellia swards, salt marshes, lakebeds):

1. Seasonally flooded alkaline steppes

These are slightly elevated alkaline steppes around lakes, with a short sward rich in halophytic species. Steppe meadow species are uncommon, but instead there are *Festuca pseudovina* and *Artemisia maritima*, which are dominant in the communities forming on solonetz soils with berms. Character species include *Podospermum canum*, *Sedum*

Photo 15: Plantago schwarzenbergiana

caespitosum and *Limonium gmelini ssp. hungaricum*, widely used as a dry flower. *Ranunculus pedatus*, Slender Hare's-ear (*Bupleurum tenuissimum*), Narrow-leaved Bird's-foot-trefoil (*Lotus tenuis*) and Sea Plantain (*Plantago maritima*) are generally widespread. In Transdanubia, these habitats typically hold Sea-milkwort and *Kochia prostata*, as well as a clover, *Trifolium retusum* along the Danube. Solonetz soils with a thicker topsoil hold a more closed alkaline steppe community with *Achillea setacea* and Yarrow (*Achillea millefolium ssp. collina*) being dominant. These grasslands are home to numerous characteristic flowering species, for example *Inula britannica*, *Cerastium dubium*, *Podospermum canum* and *Gypsophyla muralis*, as well as tiny clover species, like Upright Clover (*Trifolium strictum*), the endemic *T. angulatum*, Subterranean Clover (*T. subterraneum*) and Slender Trefoil (*T. michrantum*). In addition, endemics such as *Plantago schwarzenbergiana*, also occur. In the spring, *Iris pumila* can be seen blooming here and there on the loess elevation surrounded by alkaline wetlands.

2. Seasonally wet alkaline meadows

Wet alkaline meadows, slightly flooded in spring, are found in the transition zone between elevated steppes and shoreline, periodically flooded salt flats. In most sites, it is Creeping Bent (*Agrostis stolonifera*), Grey Club-rush (*Schoenoplectus tabernaemontani*) or Saltmarsh Rush (*Juncus gerardii*) that associates with *Scorzonera parviflora*. Occasionally, Divided Sedge (*Carex divisa*) can also be dominant. *Blackstonia acuminata* lives in Creeping Bent and Distant Sedge (*Carex distans*) stands. In slightly more humid situations, where ground water remains near

Photo 16: Aster tripolium ssp. pannonicus

the surface throughout the year, salt marsh communities can be found. They can be classified according to the degree of alkalinity. Solonetz-like soils typically hold wet meadows dominated by Meadow Foxtail (*Alopecurus pratensis*) and Floating Sweet-grass (*Glyceria fluitans*). *Rorippa kerneri*, Blue iris (*Iris spuria*) and *Ranunculus lateriflorus* live on slightly alkaline meadows. Another character species of these habitats is *Achillea asplenifolia*, except east of the River Tisza. More alkaline soils of the solonchak type hold Common Spike-rush

Photo 17: Camphorosma annua

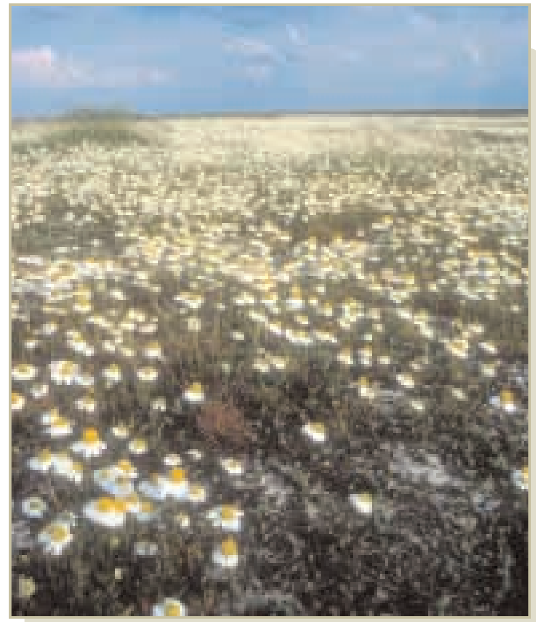

Photo 18: Blossoming Scented Mayweed field in the Hortobágy

(*Eleocharis palustris*), Marsh Foxtail (*Alopecurus geniculatus*), and the most alkaline soils have stands of *Beckmannia eruciformis*. A thistle, *Cirsium brachycephalum*, also occurs in alkaline meadows, as well as *Ranunculus polyphyllus* in the alkaline puddles, *Scorzonera parviflora*, *Taraxacum bessarabicum*, and the otherwise maritime *Triglochin maritimum*. In addition, endemics also occur here, such as *Aster tripolium ssp. pannonicum*, a common species of solonchak meadow soils. Alkaline meadows include tall herb salt meadows, that used to form part of the former alkaline steppe woodlands, once so typical of the Great Plain. Here grow Hog's Fennel (*Peucedanum officinale*), *Aster sedifolius* and *Linosyris vulgaris*.

3. The flora of salt flats and Puccinellia swards

The flora of seasonally flooded lowland

Photo 19: Puccinellia limosa

Photo 20: Lepidium crassifolium

meadows and sparsely vegetated salt flats typically contains many perennial grass species as well as dicotyledons. The alkaline shallows warm up quickly and, because they evaporate intensively, dry out by mid-summer. The unfavourable conditions, like high salinity and soda content, extreme temperatures and a bare surface, allow only halophytic desert and semi-desert species to survive here. Their great hygroscopic ability, prostrate shoot spreading on the surface and long, arm-like roots are adaptations to the arid conditions. Puccinellia swards are relatively sparsely vegetated. Character species include *Camphorosma annua*, *Bassia sedoides*, Sea Plantain (*Plantago maritima*), *Polygonum tenuiflora*, Mousetail (*Myosurus minimus*), *Pholiurus pannonicus*, *Acorellus pannonicus* and the well-known Scented Mayweed (*Matricaria chamomilla*). This habitat typically has

Photo 21: Shoreline marsh with Sea Club-rush and Common Reed

succulent plants, too, such as Annual Sea-blite (*Sueda maritima*) and another sea-blite, *S. pannonicus*.
In slightly deeper situations, where flooding remains longer, salt flat flora appears. On solonchak soils, its characteristics are *Puccinellia limosa* and *Lepidium crassifolium*. In addition, Common Spike-rush and Saltmarsh Rush, typical alkaline meadow species, may also occur.

4. Salt marshes with more permanent water cover

The deeper, more permanently flooded shoreline zone of alkaline lakes holds marshy vegetation that creates black water conditions. The habitat is dominated by tall emergent species, such as Common Reed (*Phragmites communis*), Sea Club-rush (*Bolboschoenus maritimus*), and other club-rushes (*Schoenoplectus tabernaemontani* and *S. litoralis*). With the progress of sedimentation, a reedbed community may become dominant and, depending on environmental conditions, the whole lakebed may be overgrown with marshy vegetation.

Photo 22: Saltwort

Photo 23: Glasswort

5. Alkaline open wetlands, floating vegetation

In typical lakes, where water is practically not transparent due to floating colloids, only sparse floating vegetation exists, normally including Fennel Pondweed (*Potamogeton pectinatus*), Horned Pondweed (*Zannichellia palustris*), Holly-leaved Naiad (*Najas marina*) and *Ranunculus petiveri*. As the organic matter content of the water increases, communities typical to Hungary's freshwater lakes will also appear.

6. The salt pioneer sward of dry alkaline lakebeds and barren berm bases

Bare, dry lakebeds are characterised by scattered, annual halophytic and xerophytic plants. These include species typical to salt flats, as well as pioneer species such as the endangered *Heliotropium supinum* and *Verbena supina*. *Cerastium subtetrandum* and Saltwort (*Salsola soda*) occur in lakebeds of the Kiskunság region. Goosefoot (*Chenopodium spp*.), Orache (*Atriplex spp*.) and Glasswort species (*Salicornia prostata* and *S. europaea*), as well as *Heleochloa alopecuroides* and *H. schoenoides* typical to this habitat.

Invertebrates

Very few animal species are able to survive in strongly alkaline, hard benthos. Among nematodes, *Dorylaimus stagnatilis* lives on the bottom surface. Few-bristled worms (*Oligochaetes*), typical in freshwaters rich in organic matter, are only represented by *Limnodrilus hoffmeisteri* in black waters. Smaller numbers of some rotifer species also occur in alkaline wetlands. As for free-living Turbellarian flatworms, *Dendrocoelum lacteum*, a species widespread in Hungary's still waters, is also common in alkaline lakes. Less cloudy, black waters are inhabited by leeches, like Horse Leech (*Haemopis sanguisuga*) and Medicinal Leech (*Hirudo medicinalis*). Among molluscs, only small populations of Anisus spirorbis can tolerate the most saline wetlands. Other snail species with a wide range of salt tolerance are Ram's Horn Snail (*Planorbarius corneus*), Flat Valve Snail (*Valvata cristata*), White Ram's Horn Snail (*Gyraulus albus*) and Shining Ram's Horn Snail (*Segmentina nitida*). The number of snail species and individuals greatly increases in the shoreline vegetation and in black waters.

Photo 24: Cyclopoid copepods are important indicator species in alkaline lakes

In cloudy alkaline waters, the most numerous group of the invertebrate fauna is the meso-zooplankton, that primarily comprises copepods and cladocerans, The most typical indicator species of alkaline wetlands are *Moina brachiata* and *Arctodiaptomus spinosus*. In the spring, when waters are diluted and less saline, a number of other species may also appear, like the common *Daphnia magna*. As salinity increases during the summer, the number of species also drops significantly, but halophytic crustaceans may reach densities of 8-10 thousand/litre.

The fact that *Moina salina* and *Metacyclops planus* have been found in the Hortobágy and Kiskunság national parks indicates faunistic relations between Hungarian alkaline lakes and Mediterranean and Asian salt lakes.

Photo 25: Brachinecta ferox

The larger species of macro-zooplankton (1–20 mm) appear in alkaline wetlands in early spring. Its typical representatives are *Brachinecta orientalis*, capable of active locomotion, and *B. ferox*.

Black alkaline wetlands already hold some mayfly (Ephemeroptera) species, as well, for example *Caenis robusta* and *C. horaria*, and the

Photo 26: Lestes macrostigma

viviparous *Cloeon dipterum*.

The predatory dragonfly larvae grow in shallow waters covered with shoreline vegetation. *Lestes macrostigma* and *L. barbarus* are highly adapted to alkaline habitats, but Green (*L. sponsa*) and Scarce Green Lestes (*L. dryas*) may also occur here. Other character species of lowland seasonal wetlands include *Sympetrum fonscolombei*, *S. meridionale*, Ruddy sympetrum (*S. sanguineum*) and *S. depressiusculum*. Both the widespread Common Ischnura (*Ischnura elegans pontica*) and Scarce Ischnura (*I. pumilio*) can also be found.

Among insects, it is primarily the smaller biting midges (Ceratopogonidae) larvae, and secondarily the non-biting midges (Chironomidae) larvae that inhabit the benthos. Some typical biting midges are *Culicoides salinarius*, *C. nubeculosus*, and *Dashelea halophila*.

Among shore flies (Ephydridae), whose larvae live on lake bottoms, and soldier flies (Stratiomyidae), Brine Fly (*Ephydra riparia*) and *Stratiomys furcata*, respectively, are to be mentioned here.

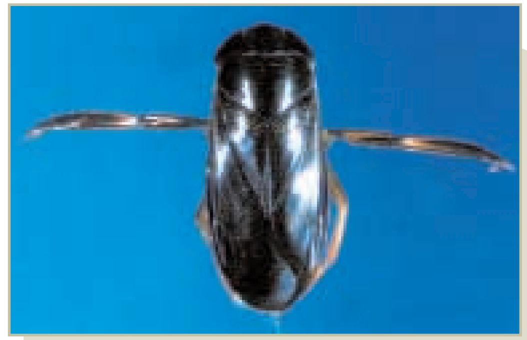

Photo 27: Some water boatmen species are characteristic of alkaline wetlands

In the most saline wetlands, the most numerous creatures are water bugs (Nepomorpha). The most typical species of seasonal open wetlands are *Sigara assimilis* and *S. lateralis*. *Mesovelia furcata, Microvelia reticulata* and *Gerris thoracicus* of the suborder of water striders (Gerromorpha) are not confined to alkaline wetlands, but occur in vegetated alkaline marshes, too. In temporary, smaller waters Toothed Pondskater (*G. odontogaster*) and Little Pondskater (*G. argentatus*) are also regular. Like in other invertebrate taxa, vegetated wetlands are normally more species-rich than homogenous, open water bodies.

The larvae of water scavenger beetles (Hydrophylidae) live on the benthos surface, while imagines lead a typical aquatic life. Some characteristic species include *Berosus spinosus*, *Helophorus guttulus* and *Ochtebius auriculatus*. Water beetles (Dytiscidae) are represented by *Bidessus nasutus* in alkaline wetlands that warm up quickly.

Photo 28: Water scavenger beetles are common in alkaline waters

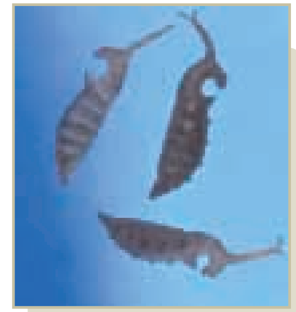

Photo 29: Pupae of Brine Fly

Photo 30: Fisher's Estuarine Moth

Caddisfly species (Trichoptera), of which *Phryganea grandis* and *Agripnia varia* are to be noted here, prefer black wetlands.

With regard to their life style, grass flies (Tethinidae), such as *Pelomyiella hungarica*, represent a transitional group; their metamorphosis has not yet been studied in detail. The Red data Book species ***Dorcadion fulvum cervae*** is endemic to salt lakesides and flats of alkaline plains in the Danube Valley. It shares its habitat with the closely related *Dorcadion pedestre kaszabi*.

The insect fauna of alkaline grasslands is very rich and even a brief overview would be beyond the scope of this brochure. The following is just an arbitrarily selected list of endemic food plant specialists: *Saragossa porosa kenderiensis*, ***Catopta thrips***, the character species *Calosoma auropunctatum* and *Stenodes coenosana*. A special highlight of tall herb salt meadows is **Fisher's Estuarine Moth** (Gortyna borelii), a species strongly tied to Hog's Fennel.

Fishes, amphibians and reptiles

The occurrence of fishes, amphibians and reptiles is very limited in the most saline wetlands. As salinity decreases, common lowland freshwater fish and amphibian species will soon appear in black waters. As regards salt tolerance, perhaps Fire-bellied Toad (*Bombina bombina*) is to be mentioned, since this toad is abundant in black waters in the spring. We have no mammal species specially adapted to alkaline wetlands, the mammalian fauna is the same as in the Great Plain in general.

Photo 31: Garganey

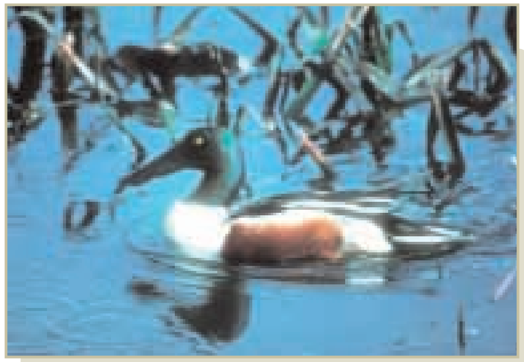

Photo 32: Shoveler

Birds

Perhaps the most spectacular sights around alkaline wetlands are the flocks of waterbirds that also play a major role in the nutrient cycle of the shallow, relatively small water bodies. In spring and autumn, alkaline lakes and wet steppes are dotted with extensive water surfaces, creating a habitat similar to the Arctic tundra in summer. This is why the alkaline wetlands of the Carpathian Basin are a traditional feeding and staging site for masses of long distance migrants, especially waterbirds from the tundra.

Practically all Hungarian waterbird species with a preference for shallow waters occur in alkaline wetlands. The most notable groups are waterfowl (Anseriformes), waders (Charadriiformes) and Common Crane (*Grus grus*).

For most wildfowl species as well as for cranes, alkaline lakes are important resting and roosting sites. Among geese, the Red Data Book listed **Red-breasted Goose** (*Branta ruficollis*) and the **Lesser White-fronted Goose** (*Anser erythropus*) have a particular preference for alkaline habitats. As for the duch species that

Photo 33: Migrating wild geese

migrate through Hungary in masses, the Teal (*Anas crecca*), the Garganey (*Anas querquedula*), the Wigeon (*Anas penelope*) and the Pin-tailed Duck (*Anas acuta*) are also strongly tied to shallow, open, alkaline waters and eat both plant and animal food there. Another characteristic duck species is Shoveler (*Anas clypeata*). It has been named after its shovel-formed bill, a perfect tool for filtering the plankton-rich alkaline waters. A similar method is used by the **Avocet** (*Recurvirostra avosetta*) and the **Spoonbill** (*Platalea leucorodia*), a representative of the ibises (Threskiornithidae).

Some lakes hold islands with large colonies

Photo 34: Courtship of Avocets

Photo 35: Ruff

Photo 36: Dunlins

of Black-headed Gulls (*Larus ridibundus*) and a few Common Terns (*Sterna hirundo*) among them. The **Whiskered Tern** (*Chlidonias hybridus*) and the **White-winged Black Tern** (*Chlidonias leucopterus*) breed on the floating vegetation of alkaline marshes and temporary steppe wetlands. The aquatic insect fauna and plankton communities of shallow alkaline lakes with bare shoreline zones provide an inexhaustible food supply to waders. The following species migrate through our alkaline wetlands in large flocks: Ruff (*Philomachus pugnax*), **Eurasian Curlew** (*Numenius arquata*), Whimbrel (*Numenius phaeopus*), Golden Plover (*Pluvialis apricaria*), Wood Sandpiper (*Tringa glareola*), Dunlin (*Calidris alpina*) and Little Stint (*Calidris minuta*). Another species tied to alkaline wetlands is the **Marsh Sandpiper** (*Tringa stagnatilis*), an East European bird that formerly bred in Hungary, too, but has declined throughout Europe. The alkaline lakes of the southern and eastern Great Plain used to be important stopover sites of the globally endangered **Slender-billed Curlew** (*Numenius tenuirostris*). The Dotterel (*Eudromias morinellus*) breeds in high mountains, but is a traditional autumn migrant on the sheep-grazed pastures of the Hortobágy.

Photo 37: Whiskered Tern

Another remarkable aspect of our alkaline lakes is that they hold an isolated Central European population of certain, otherwise in Europe typically coastal species, such as the **Avocet**, the **Kentish Plover** (*Charadrius alexandrinus*) and the **Black-winged Stilt** (*Himantopus himantopus*). Other characteristic alkaline lake breeders include the Northern Lapwing (*Vanellus vanellus*) and the **Common Redshank** (*Tringa totanus*), as well as the **Black-tailed Godwit** (*Limosa limosa*) on alkaline meadows. Unfortunately, the **Collared Pratincole** (*Glareola pratincola*) has become much scarcer in the vicinity of our lakes and steppes, while the **Black-winged Pratincole** (*Glareola nordmanni*) is just an occasional breeder. The **Stone-Curlew** (*Burhinus oedicnemus*) and the **Short-toed Lark** (*Calandrella brachydactyla*) nest in the wider environment of alkaline lakes with salt berms and Puccinellia swards. In Hungary, the breeding of the Eastern European **Aquatic Warbler** (*Acrocephalus paludicola*) is confined to the alkaline marshes and wet meadows of the Hortobágy.

Photo 38: Common Redshank, Northern Lapwing, Kentish Plover, Dotterel

Photo 39: Stone-Curlew

Photo 40: Short-toed Lark

Conservation aspects

'Some waters cannot be regulated'; and not because the present European generation were unable to overcome nearly any technical difficulties, but because the regulation of some waters would require more expenditure than the income to be expected from such projects; therefore, these waters cannot be economically regulated. – Such projects should be abandoned.'

István Széchenyi

In order to protect our geologically, hydrologically, botanically and zoologically unique, but endangered continental alkaline wetlands, section (2) of Article 23 in Act No. LIII. of 1996 on Nature Conservation, in force since 1 January 1997, has designated all Hungarian alkaline lakes that are still in a near-natural state. To implement this Act, the Authority for nature Conservation, Ministry of Environment has in the last few years made a national register of all such alkaline wetlands in Hungary. Nearly 350 natural alkaline lakebeds have been registered. Barely one-third of them had already been under protection, as parts of the Hortobágy, Kiskunság and Körös-Maros National Parks, as well as of some landscape protected areas and conservation areas. The experts of national park

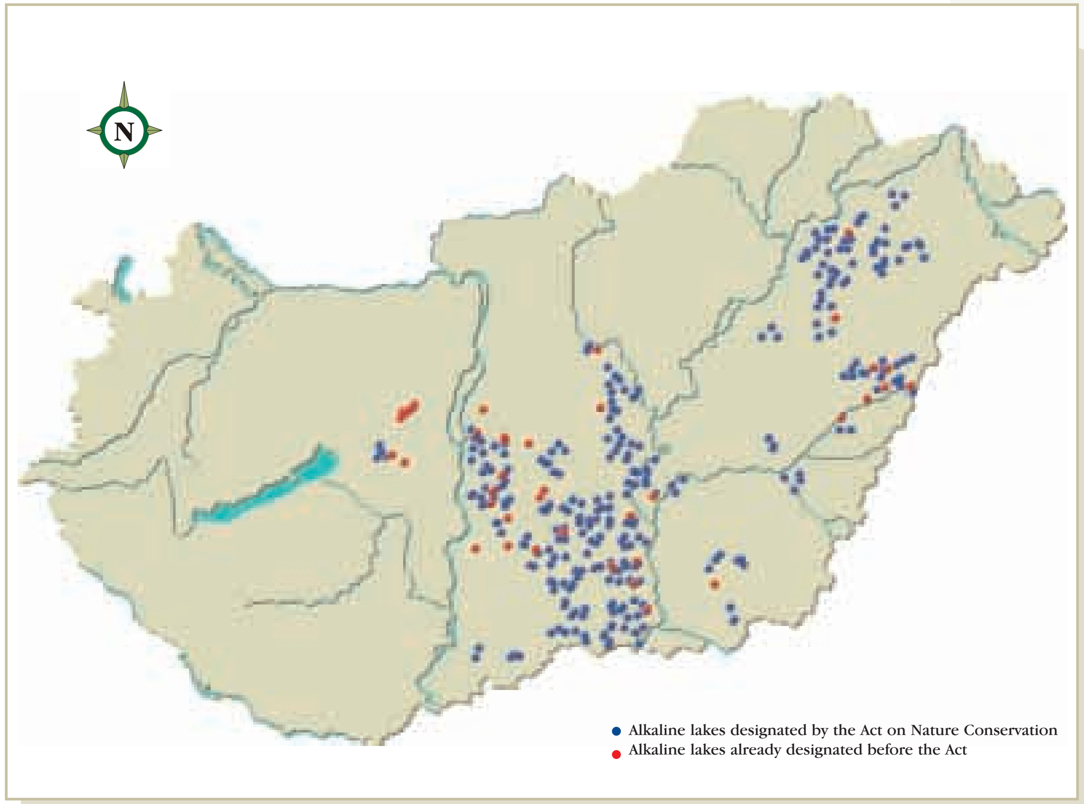

Figure 3: Indicative map of alkaline lakes in Hungary (Source: ANC, MoE)

authorities have always put a special emphasis on the conservation of alkaline lakes. In order to restore the damage caused by the serious drought that started in the 80s and lasted nearly a decade, a water-retaining and supplying project was elaborated and implemented in the most important habitats. The protection of small, scattered lowland alkaline lakes designate by the above Act will be a great challenge for the national park authorities and for land managers.

In addition, some of Hungary's alkaline lakes are protected by international conventions. Hungary has 21 sites under the 'Ramsar' Convention on Wetlands of International Importance Especially as Waterfowl Habitats, 6 of which consist largely of alkaline lakes and plains.

Practically all alkaline wetlands have also been included in the National Ecological Network.

Threats

The life of alkaline lakes is determined by the fact that they are seasonally flooded. In recent and modern times, people living in the Carpathian Basin have radically changed the hydrogeography of the Great Plain, in order to gain lands for agriculture. This process began with the large-scale river regulations of the 19th century and continued with draining projects in the 20th century. By today, the majority of lowland wetlands including a large number of alkaline lakes and temporary wetlands, has been irretrievably destroyed. All in all, it can be said that the greatest threat to alkaline lakes, as well as to other types of lowland wetlands, is water loss due to draining projects. In addition to deliberate drainage, climatic water deficiency due to global warming is another serious factor, and is probably also human-induced. Although drying out in summer is a part of the normal cycle in alkaline lakes, but so is re-filling with water from autumn to spring, and this has in recent years been much behind normal levels due to the decreasing amount of precipitation.

Photo 41: A major threat is lowland water regulation

The tendency to droughts incurs secondary damages, too. On one hand, it encourages

Photo 42: Canal draining an alkaline lake in the Kiskunság

people to 'conquer' these seasonally flooded lands from nature, e.g. by ploughing, even though it is a well-known fact that the fertility of alkaline lakes is poor. On the other hand, arid conditions favour non-native weed species that degrade the natural vegetation.

Photo 43: Aquatic Warbler

The remaining wetlands are often surrounded by ploughlands and other agricultural areas right to the shoreline. The fertilisers seeping into the lake cause intensive eutrophication, turn the alkaline wetland into a marsh or otherwise modify it. Pesticides may do further damage on aquatic wildlife.

If formerly they were not protected, people often want to turn the deepest parts of remaining alkaline wetlands into 'something useful', such as a fish pond or angling pond. Such major interventions can nearly completely destroy and transform the natural aquatic community.

It is unfortunate that the above motto by 'the Greatest Hungarian', István Széchenyi, is still not yet widely understood, and the destruction of the remaining natural heritage of lowlands in the Great Plain still continues. Let us finally cite another thought from Széchenyi, something more general than the issue of water regulation:

'We shall not delude ourselves, but should be convinced that our haughty speeches will not change the laws of nature.'

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