

VEGETATION HISTORY OF THE KARDOSKÚT AREA (SE. HUNGARY) II.: THE LAKE FEHÉR-TÓ IN THE LAST 200 YEARS

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Abstract. Reconstruction of past vegetation changes provides useful information for the understanding of present vegetation. Based on historical data, old aerial photos and maps, a detailed vegetation survey, and the vegetation description by György Bodrogközy from the 1960's, the vegetation history of the lake Fehér-tó at Kardoskút for the last 200 years was drawn. Historical data indicates that the lake remained in a near-natural state till the late 1970's. Since 1980, climatic drought has induced fundamental vegetation changes which differ in the 3 parts of the lake, probably as a consequence of differences in geological history. Predictions about the future of the lake vegetation, based on historical data and comparisons with other drying alkali lakes, are also given.

Keywords: drought, nature conservation, repeated vegetation mapping, succession.

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Introduction

There is a wide choice of methods for studying vegetation dynamics. At the year-decade time scale changes can, for example, be followed by permanent quadrates or by remapping the vegetation pattern. Indirect approaches, which create artificial chro-nosequences and palaeobiological methods, help larger scale studies (Dierschke 1994).

Historical botanical data can provide important data for studies of vegetation dynamics. Floristic surveys, cenological studies or vegetation maps provide direct data about past vegetation, though this data is often scarce and incomplete. In Hungary, historical data are available since the late 18th century (Kitaibel in Gombocz 1945). From the middle of the 19th century onwards, floristic data are abundant. Since the 1910's more and more cenological descriptions and vegetation maps have been prepared.

Spatial changes of vegetation can be best analysed by vegetation maps. Generally, those situations were remapped where anthropogenic degradation caused profound changes or where regeneration after disturbance or perturbation resulted in a fast vegetation change (Dierschke 1994). The time scale of

these studies is generally several years or a couple of decades.

In the Great Hungarian Plain river control, drainage and recent climatic drought resulted in dryness induced successional changes (cf. Zólyomi 1931, Szabolcs 1961, Bagi 1995). Though the alkali lake studied was also temporal in the past, as a consequence of the drought period of the last 15 years, the water regime of the lake has changed considerably for the worse. A vegetation map from 1962-63 (Bodrogközy 1966) serves as a detailed reference to follow changes.

The goal of our study was to answer the following questions:

- Has the vegetation of the lake bed changed as a consequence of the drought?
- What vegetation types changed the most?
- What vegetation types changed the least?
- Do the real successional changes correspond with the theoretical trajectories established by Bodrogközy?

Based on the historical data prior to the 1960's, the brief history of the lake has been drawn. The goal of this reconstruction was to trace back the present twofold character of the lake vegetation to past features.

The area is a bird migratory site of European importance (Ramsar site; Nagy 1993) and is managed by the Nature Conservation Directorate of Körös-Maros. Since the lake and the neighbouring wetlands are drying out, which threatens the famous bird life, a research project was started in 1992. Based on the historical reconstruction, the management of the area was reevaluated (Molnár and Biró 1995).

Study area

Kardoskút lies in SE. Hungary, in the Tiszántúl region, on the alluvial fan of the river Maros. The lake is surrounded by continental alkali steppes and cultivated fields.

The lake (called Fehér-tó after its white appearance in late summer) originated in the Holocene from two Maros meanders. The western has clayey deposits, the eastern part has more sandy deposits. The two lakes merged later (Molnár and Mucsi 1966). The Copper, Bronze and Iron Age mollusk fauna indicates high habitat diversity, presence of woodlands, permanent and temporary water bodies, and densely vegetated marshes (Domokos 1984).

At present the lake is temporary with maximum water in April, and a dry bed in July and August. The water has a high NaHCO_3 , NaCl and Na_2SO_4 content and its pH is about 8.5-10 (Megyeri 1963). The bed is a highly salty solonchak originating from redeposited Pleistocene loess (Bodrogközy 1966). Till the late 1970's, as a unique feature, in the dried out lake bed circular, dark muddy patches appeared, where soil water reached the near-surface layers or even the surface. These wells played a crucial role in the water regime of the lake (Kiss 1963). Since 1980, the lake has been gradually drying out (Sterbetz 1992, Nagy 1993). From 1988, water from deep bored wells has been added in spring and autumn to provide habitat for migrating birds.

The area around the lake has been inhabited since the late Neolithic, mostly by nomadic tribes such as Körös culture, Baden culture, early and late Iron Age, Scythians, Jazyg-Sarmatians, Avars and Gepids (Szeremlei 1907, Banner 1943, Nagy and Szigeti 1984).

Methods

Earlier historical records about the lake are scarce (military survey maps, Bodnár 1928, Szenti 1983). In the 1960's, a multidisciplinary research project was set up by the Hungarian Academy of Sciences to study the lake's special features. The project covered the fields of botany and pedology

(Bodrogközy 1966, Kiss 1959), zoology (Sterbetz 1966, 1974, 1977, 1992, Marián 1966, Megyeri 1963) and geology and hydrology (Molnár and Mucsi 1966, Kiss 1963).

For the historical reconstruction, some documentary sources provided direct information, others could be interpreted by the preferences of plant species. The Hungarian plant sociological school has collected a great deal of data on the cenological, water, pH, nitrogen, etc. preferences of species and estimated their disturbance tolerance and specificity (for a detailed data base see Horváth *et al.* 1995). This data provided a good opportunity to recognize and follow changes in site conditions (e.g. decreasing salt content and drying).

Survey maps (1784, 1861-66, 1884, 1970 and 1983) and aerial photos (1950, 2 from 1953, 1964, 1976, 1981, 1987 and 1991) provided valuable information. In June 1995, colour aerial photos were made. Spatial movement and physiognomic transformation of vegetation patches in the lake bed were followed by documentary photos, made between 1966 and 1980, by István Sterbetz.

The map of present vegetation was prepared in July 1995. In each of the vegetation patches, cover values (%) of the most important species of the lake were recorded (*Crypsis aculeata*, *Suaeda maritima*, *Salsola soda*, *Puccinellia limosa*, *Camphorosma annua*, *Phragmites australis*, *Bolboschoenus maritimus*, *Aster tripolium* ssp. *pannonicum* and the cover of the meadow, dry grassland and weed species). Classification of patches was based on the dominant species combination.

Nomenclature of species follows Soó (1964-80).

Results

Vegetation of the lake

Plant communities of alkali habitats are usually species poor and can be easily characterized by several dominant species. The first detailed vegetation description of the area was prepared by Bodrogközy (1966). Since the 1960's, vegetation has undergone considerable changes (Figs 1, 2 and 3, Table 1).

Lake bed vegetation: the lake dries out in the summer. On the mud surfaces *Crypsis aculeata* is the first colonizer. Stands are often monodominated. On drier mud surfaces, *Suaeda maritima* is typical. The next zone is formed by the tussocky perennial grass, *Puccinellia limosa*. At the edge of the lake, on the driest and most alkali surfaces, *Camphorosma annua* is characteristic.

Alkali marshes: in the alkali marshes of the lake, *Bolboschoenus maritimus* and *Phragmites australis* or often only one of them, are the dominant species.

This habitat adjoins on the *Puccinellia* or often the *Crypsis* zones. In the upper zone of the alkali marshes, *Aster tripolium* ssp. *pannonicum* becomes dominant.

Table 1. Distribution of the mapped habitat types in the lake bed. “+++” indicates a common and typical habitat, while “+” a rare and non-typical one. Grouping corresponds to Fig. 1.

Habitats	Western basin	Transition	Eastern basin
1.a. Open water	++	-	-
1.b. <i>Crypsis</i> zone	+++	+++	++
1.c. <i>Suaeda</i> zone	+++	++	+
1.d. <i>Puccinellia</i> zone	+++	+++	++
1.e. Bare patches with <i>Camphorosma</i>	+++	++	+
1.f. <i>Phragmites</i> stands with <i>Puccinellia</i>	-	+++	++
2.a. <i>Phragmites</i> and <i>Bolboschoenus</i> stands	-	+	+++
2.b. <i>Phragmites</i> and <i>Bolboschoenus</i> stands with <i>Aster</i>	-	+	+++
3.a. Drying out <i>Phragmites</i> , <i>Bolboschoenus</i> and <i>Puccinellia</i> stands	-	+	+++
3.b. Dried out marshes and <i>Agrostis-Carex</i> meadows	-	-	+++

Drying and dried out marshes: if drying is fast and salt is lost, weed species appear. Stands dominated by the original species were considered as drying marshes and stands dominated by weeds as dried out marshes.

Meadows: a unique habitat of the lake is the *Agrostis alba* and *Carex distans* dominated solonchak meadow (Bodrogközy 1966). Typical species, besides the *Agrostis* and *Carex*, are *Taraxacum besarabicum* and *Scorzonera parviflora*. Since this habitat needs less alkali soils, which are humid also in summer, it only occurs in the Eastern basin, at the edge of the lake where undersurface wells were common (Bodrogközy 1966). As a consequence of drought, this habitat is quickly disappearing.

History of the lake

Middle Ages

In the Middle Ages there were two villages near the northern shore (Szeremlei 1907, Banner 1943, Olasz 1959, Blazovich 1985). Apácaegyház was a straggling village, mentioned first in the beginning of the 11th century and destroyed by the Mongolians in the middle of the 13th century. The other village, Bagd, was ruined in the 16th or 17th century. Though we have no direct information about the medieval lake, these settlements show its importance in this steppe landscape.

1784 to 1960

From the 18th century onwards, there are more and more available data about the lake. The wells of the Eastern basin were mentioned first in 1794, when one of them was cased (Szenti 1983).

In the 1850's, water of the lake usually shrank in the summer, became highly salty and was therefore unsuitable for drinking (Szenti 1983). On the military survey maps from 1784, 1861–66 and 1884 the shape of the lake is different. In 1784, part of the Western basin is shown to be more temporary. In 1861–66, the joining basins seem to be part of the lake. Bodnár (1928) also mentions that in the 19th century, the shape of the lake was temporally different. Since 1847, the lake has probably been used more intensively, e.g. for grazing and reed harvesting after farm-houses were built on the shore (Szenti 1983).

Bodnár (1928) describes the lake in detail. The water level changed considerably. In normal years the lake was permanent throughout the year, but in dry years it dried out. In the Eastern basin, a small marsh usually remained. During extremely dry periods, even this part dried out and vegetation became sparse. Vegetation in the two basins was different as a consequence of the wells. In the Western basin, small amounts of vegetation were confined to the edges whilst in the Eastern basin, marsh vegetation with *Phragmites* and *Schoenoplectus* could be found.

The last water rich period (1960 to 1980)

In the springs of the 1960–70's, maximum water depths reached 40 to 50 cm and sometimes even 70 cm. The lake usually dried out by July or August. In November, the water was again 20 to 30 cm deep.

The Eastern basin, where frogs and leeches were common, was more permanent than the western (Marián 1966, A. Gyömörei personal communication). This difference was caused by the “Seven Wells” (I. Sterbetz, I. Farkas, F. Panyik personal communication). Owing to the work of Bodrogközy (1966), the vegetation of the lake in this period is well known (Fig. 3). There is also a high quality aerial photograph from 1964. This period was used for a reference to follow the changes caused by drought after 1980.

Though in the 1960's water conditions were more favourable, there was no aquatic and freshwater marsh vegetation in the lake bed. The Western basin was covered with *Crypsis* and *Suaeda* whilst near the edges *Puccinellia* and *Camphorosma* appeared in patches. In the Eastern basin, *Phragmites* and *Bolboschoenus* dominated alkali marshes with *Aster tripolium* and containing less than 5 % weed

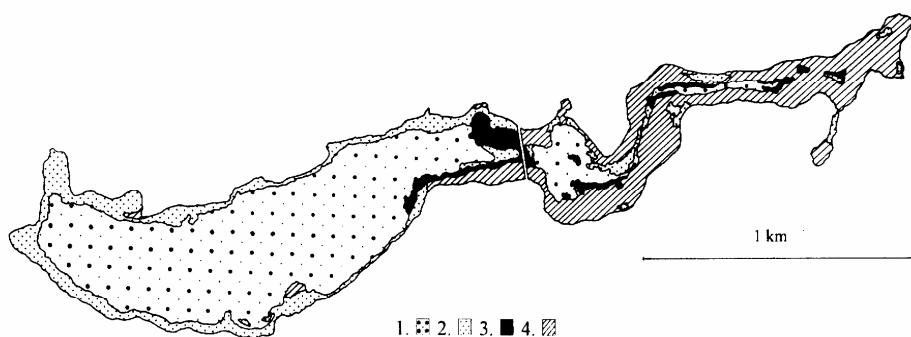
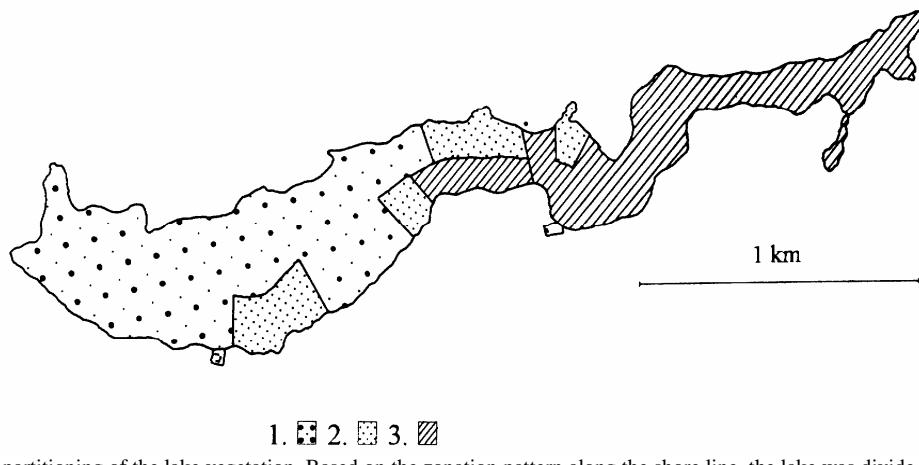


Fig. 1. Vegetation map of the lake Fehér-tó at Kardoskút. The map was made in July 1995, based on a recent colour aerial photograph and field survey. 10 vegetation types (see Table 1) were distinguished on the basis of dominant species that were later grouped as follows: Zone A: 1. *Crypsis* and *Suaeda* mud vegetation, 2. *Puccinellia* and *Camphorosma* swards, Zone B: 3. *Phragmites-Bolboschoenus* alkali marshes with *Aster* and *Puccinellia*, Zone C.: 4. Drying and dried out marshes and *Agrostis-Carex* meadows.



1. 2. 3. 4.

Fig. 2. Spatial partitioning of the lake vegetation. Based on the zonation pattern along the shore line, the lake was divide into three parts: 1. Western basin (only zone A), 2. Transition zone (zone A and B), and 3. Eastern basin (all 3 zones; for an explanation of the zones see Fig. 1). This partitioning coincides with the known distribution of wells (occurring only in the Eastern basin and the Transition zone - Bodrogközy 1966), the widths of the lake and may be a result of the geological history of the lake.

cover, were widespread. The distribution of these marshes and the wells coincide, because in these areas soil is more leached, less salty and more humid (Bodrogközy 1966). In the Eastern basin, *Crypsis* and *Suaeda* were less common and *Puccinellia* appeared in patches. Some of these stands were secondary, developed in the place of marshes as a consequence of cattle grazing (I. Farkas personal communication.). The most dense marshes were in the easternmost part of the basin, where the abundance of water was the highest. The height of the reeds reached 3 meters. In the 1940-50's, the reeds were smaller (I. Farkas and A. Gyömréi personal communication) which could be explained by either the drier climate or the more intensive grazing prior to nature conservation (1966, Nagy 1993). Solonchak

Agrostis-Carex meadows appeared only in the Eastern basin. Their species composition shows that in the 1960's they were still in a near-natural state.

Drought period of the last 15 years (1980 to 1995)

Since the 1960's, precipitation in the Hungarian Great Plain has decreased considerably (Ráth 1994) which has caused fundamental changes in the water regime of the lake. The quantity of water falling directly into the lake and flowing into it from the surrounding alkali surfaces decreased considerably (Sterbetz 1992). The discharge from wells also decreased (I. Farkas and F. Panyik personal communication). Later reduction in water level was caused by the lowered soil water table in the sur-

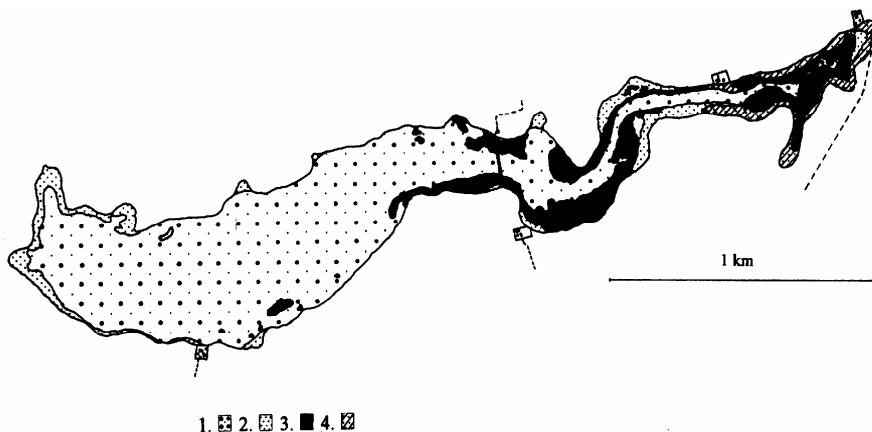


Fig. 3. Vegetation map of the Kardoskút alkali lake from 1962-63 (Bodrogközy 1966). This map was used as a reference to evaluate successional changes induced by the drought period. To help comparisons, the original map was adjusted to a 1: 10 000 map and corrected by the aerial photo from 1964. Note the similar twofold general vegetation pattern and the profound but spatially uneven changes in vegetation types between 1962-63 and 1995. 1. *Crypsis* and *Suaeda* mud vegetation, 2. *Puccinellia* and *Camphorosma* swards, 3. *Phragmites*-*Bolboschoenus* alkali marshes with *Aster* and *Puccinellia*, 4. *Agrostis*-*Carex* solontchak meadows.

rounding loess areas. Between 1970 and 1994, soil water table decreased by 0.8 meter (Kardoskút, Well No. 467, ATIVIZIG).

Since 1981, István Farkas has recorded the date of complete drying out, which fell between mid-May (1993, 1994) and early September (1981). Between 1982 and 1987 it was in July and August. Since 1988 it has been earlier, in May and June (except in 1991). The shortage of water had more serious affects in the spring than in the summer. Maximum water level in April decreased from 40-70 cm to 15-30 cm. This meant that in the last 15 years only the *Crypsis* and *Suaeda* (sometimes also the *Puccinellia*) zones have been flooded. Alkali marshes and meadows which were usually flooded till early summer, have remained dry throughout the year (I. Farkas, jr. personal communication, photos of I. Sterbetz).

Drought has brought about successional changes in the lake bed. Vegetation transformations include changes in the dominance and number of species of natural habitats, disappearance, movement, expansion and physiognomic changes of certain vegetation types.

The Western basin has changed the least. *Crypsis* and *Suaeda* are still the dominant species. *Puccinellia* zone has become contiguous and wider by 25 to 35 m, *Camphorosma* patches have not changed noticeably. The transition zone, where the mosaic of *Phragmites* and *Puccinellia* patches was characteristic, has changed to a greater extent. Reed stands have dried out, become shorter and have opened. The *Puccinellia* zone has expanded and encroached upon the reed patches.

Considerable transformations occurred in the Eastern basin. The *Phragmites*-*Bolboschoenus*-*Aster*

stands, the solontchak meadows and the *Puccinellia* patches near the edges have dried out and weeds like *Poa angustifolia*, *Festuca pseudovina*, *Agropyron repens*, *Carex vulpina*, *Sonchus arvensis*, *Cichorium intybus*, *Achillea collina* and *Cirsium arvense* often became the dominant species (60 to 80 %). Some of the specialists, like *Acorellus pannonicus* and *Triglochin palustre* have died out. The *Crypsis* zone has shrunk. In the *Suaeda* and the wetter *Puccinellia* stands there has been little change.

The general "theoretical" successional sequence of the lake bed was described by Bodrogközy (1966, 1977): open water — *Crypsis* — *Suaeda* — *Puccinellia* — *Bolboschoenus* and *Phragmites* — *Bolboschoenus* and *Phragmites* with *Aster* — *Agrostis*-*Carex* — *Camphorosma*. Drought induced successional trajectories, however, do not always follow this sequence and differ in the three parts of the lake (Fig. 4). In the Western basin, *Puccinellia* is often followed by *Camphorosma* and not by an alkali marsh. Direct open water — *Suaeda* and *Crypsis* — *Puccinellia* transitions are also common. In the Eastern basin, drying *Crypsis* stands are often invaded by the *Bolboschoenus* — *Phragmites* marshes. Alkali marshes have not turned into meadows, but became weedy, changing into dry *Festuca* grasslands.

The two main types of changes were the movement of zones towards the lake bottom and the changes in species composition of non-moving stands. *Crypsis*, *Suaeda*, *Puccinellia*, *Aster* and *Festuca* were moving relatively fast, while *Bolboschoenus*, *Phragmites* and *Carex distans* are relatively slow.

The differences in speed resulted in zone inversions. For example, in the transition zone the spatial pattern and extension of the *Phragmites* stands has changed very little in the last 15 years (photos of I. Sterbetz from 1980). At the same time, the *Puccinellia* zone has moved towards the lake by 20-25 m. *Puccinellia* invaded the opened *Phragmites* stands and even formed a zone below the *Phragmites* zone. The upper and lower *Puccinellia* zones are, however, different, the lower zone being in terms of species composition (Bodrogközy 1966) and physiognomy (photos of I. Sterbetz from 1980) very similar to the stands of the 1960-70's, while the upper zone shows the signs of drying (*Aster tripolium*, *Lepidium perfoliatum*, *Agrostis stolonifera*, *Poa angustifolia*).

Discussions

The twofold character of the lake and its effect on drought induced succession

The twofold character of the lake has been only mentioned by Molnár and Mucsi (1966) and Nagy (1993), though it is easy to recognize by the distribution of wells (Kiss 1963, Bodrogközy 1966 — at normal water conditions) and by the vegetation pattern or the shape of the lake. The lake behaves as it were two independent lakes. Also the dynamics of vegetation differs considerably in the two basins. Differences may be ascribed to geological history.

The presence of marsh vegetation in the Eastern

basin was explained by fertilizer pollution, since arable fields border this basin, while grasslands border the other (Nagy 1993). The humus content of the deposits (Molnár and Mucsi 1966), and the presence of marsh specialist mollusc species from the Copper-Iron Ages (Domokos 1984) indicate, however, that the marshes of the Eastern basin might have existed for thousands of years. In the 1920's (before the increased use of fertilizers), the vegetation of the lake was already similar to the present situation. *Agrostis-Carex* meadows also produce evidence for the long functioning of the wells, since these meadows can only develop and survive where wells provide damp soil throughout the year (Bodrogközy 1966). Specialist species of these meadows (*Carex distans*, *Taraxacum bessarabicum*, *Triglochin palustre* and *Scorzonera parviflora*) do not or rarely occur in the Tiszántúl region (Soó and Máthé 1938) and thus also show the ancient character of this habitat.

The climatic drought of the last 15 years induced substantial successional changes in the lake. These changes provide fine examples of how past events control present vegetation dynamics (cf. Foster 1992, Peterken and Game 1984, Jackson *et al.* 1988). In the Western basin, changes are slow and vegetation zones follow the changes in site conditions. This can be ascribed to the finer sediments which prevent greater water and salt loss. In the Eastern basin, changes are more striking. Here the sediments are sandy and the wells provided access water and

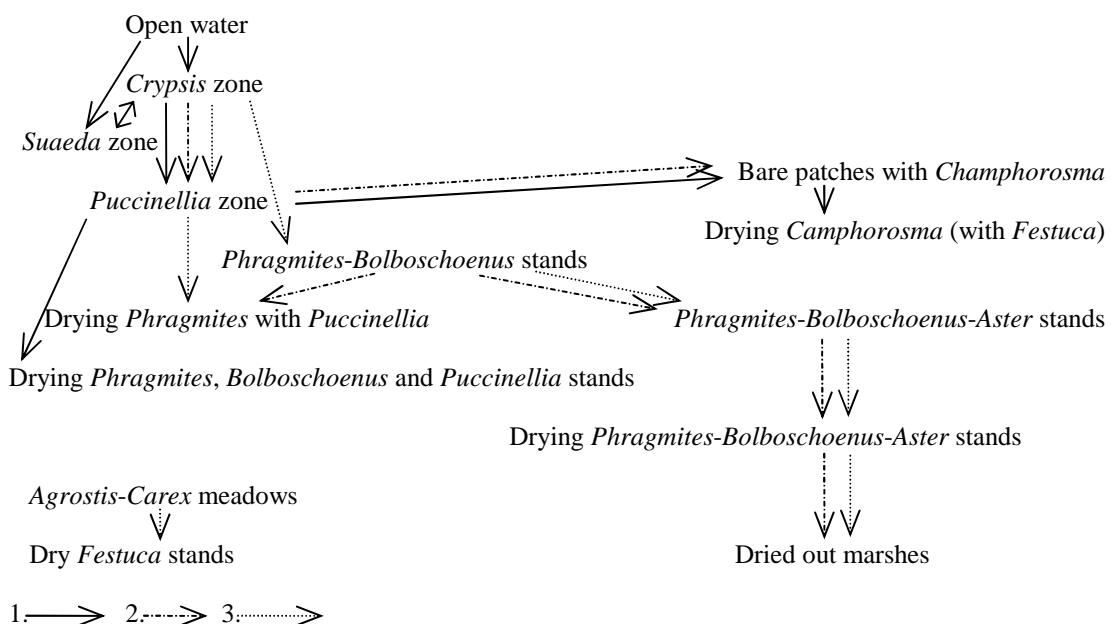


Fig. 4. Successional pathways in the 3 parts of the lake bed differ as a consequence of different history and physical characteristics.
1: Western basin, 2: Transition zone, 3: Eastern basin.

caused leaching (Bodrogközy 1966, Molnár and Mucsi 1966). Site conditions were more favourable in the past if compared with the Western basin. The effects of drought are thus greater, vegetation zones were not able to follow these fast changes and consequently stands became invaded with weeds.

Future of the lake

Historical data (Szenti 1983, Bodnár 1928, Military survey maps) showed that the temporal character and the vegetation of the lake changed little from the middle of the 19th century till the late 1970's. The lack of weed dominant patches in the 60's (Bodrogközy 1966) also indicate near-natural conditions. Thus the state of the lake in the 60's can be regarded as near-natural, and hence can be used as a reference to evaluate changes caused by the drought. Predictions on the future of the lake were based partly on the local history and dynamics and partly on transformations of other drying alkali lakes (Bagi 1995, Molnár unpubl.). It was presumed that the present drought period is more serious than those in the past 300 years (Pálfai 1991), and that drainage influenced well discharge adversely.

If water conditions can not be improved, in the Western basin, *Puccinellia* will spread slowly further towards the lake bottom and in the Eastern basin *Crypsis* and *Puccinellia* stands will be shortly invaded by *Bolboschoenus* and *Phragmites*. Drying will cause further salt loss, weed species will become even more dominant and solonchak meadows will disappear totally. Regeneration of the lake is only possible if natural water supply from the wells can be restored or if artificial water supply can imitate natural water level changes. Based on historical data (Bodrogközy 1966, Kiss 1959, 1963, Sterbetz 1992, I. Farkas and I. Sterbetz personal communication), this means a maximum of 40 to 70 cm in April, a dry lake bed in July and August and a second water maximum (20 to 30 cm) in November.

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