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CHANGES IN THE ECOLOGICAL STATE OF THE BÖDDI-SZÉK SODA PAN BETWEEN 2010 AND 2021

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Abstract: Monitoring the state of wetlands assists their conservation. In 2021, our research repeated a survey implemented a decade earlier, aimed at assessing the ecological condition of alkaline soda waters in the Carpathian Basin. Repeating the original examination of 20 characteristic factors offers the opportunity to monitor changes in the basic ecological state of soda pans. In the present paper data from 2010 and 2021 collected at the Böddi-szék soda pan in Dunatetétlen are compared. The indices used for the evaluation show that the condition of the soda pan and related wetlands has improved slightly. It is due to the reduction of arable land and the increase of grassland areas in the catchment area and the appropriate grazing of the shoreline. It has also increased the number of characteristic bird species nesting in the area. In addition, the previously detected water pollution from seepage and scattered waste has ceased to exist. Although the proportion of reed areas decreased slightly, the proportion of areas covered with *Bolboschoenus maritimus* increased in parallel. Significant change in the proportion of habitats in the soda pan bed has not been observed. The implementation of a LIFE project for the restoration of the area by the reallocation of a canal bypassing the pan may have additional significant positive effects on the ecological state of the alkaline soda ecosystem.

Keywords: soda wetland classification, evaluation for conservation, hydro-ecological factors, management and conservation factors

1. Introduction

The Carpathian Basin belongs to the biodiversity hotspot areas in Europe due to its geographical characteristics. Soda pans in this region are unique wetlands , because besides the limited distribution they provide habitats for special living communities (Boros & Kolpakova 2018). They are alkaline wetlands with shallow open waters, characterised by high salinity and stable alkalinity, their surface water level fluctuates during the year, and they periodically dry out (Boros & Vörös 2010, Boros et al. 2014, Boros et al. 2017). They provide habitat for many migratory bird species and plant communities (Boros & Ecsedi 2013).

In Hungary the conservation importance of the soda pans is well demonstrated with their ex lege protection, while on a European scale, soda wetlands are part of

the Natura 2000 network, and considered a habitat (1530) with high priority under the Habitats Directive (Molnár & Máté 2014).

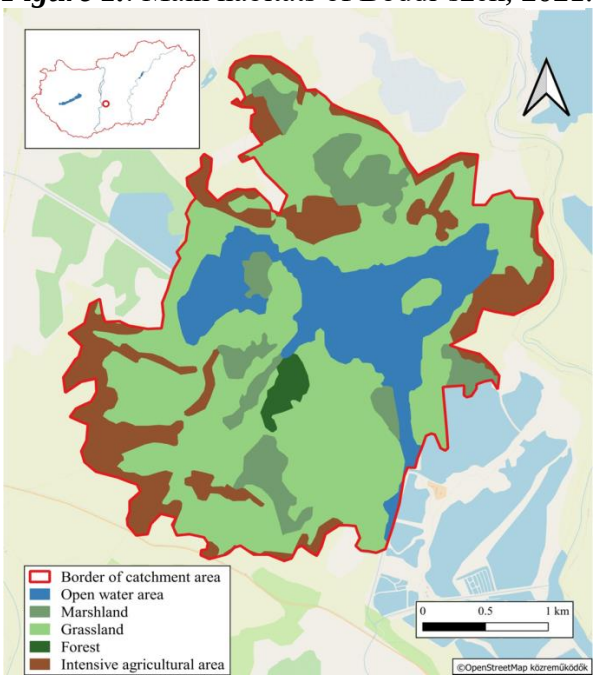
The monitoring of natural habitats is essential to maintain the favourable ecological condition of protected areas, as well as for the planning of nature conservation management and development (Szép et al. 2011).

In 2021, our research repeated a survey implemented a decade earlier, which aimed at assessing the ecological condition of alkaline soda waters in the Carpathian Basin.

2. Materials and methods

Our research area is the Böddi-szék - located near Dunatetétlen - one of the most significant, fragmented soda pan systems in the Kiskunság region (Boros, 1999). The area is *ex lege* protected and designated as a site under the Ramsar Convention. A previous partial rehabilitation of the hydrological regime in the Böddi-szék pan was applied by mitigating drainage at the end of the last century, which resulted in a significant increase of waterbird populations (Boros, 2003). This preliminary result served as the basis for Ramsar site designation and the complete rehabilitation plan for the ongoing LIFE project (LIFE12 NAT/HU/001188). The location of the soda pan and its habitats are shown in *Figure 1*. The digital topography model was created in the AutoCad program by digitising the study area from EOTR 35-212 map containing isolines. With the help of the resulting model, we determined the surface water catchment (study area) in ArcGIS ArcMap 10.8 Advanced program.

Figure 1.: Main habitats of Böddi-szék, 2021.



20 hydro-ecological, management and conservation indices were used to characterise the state of the soda pan: 8 hydrological, 4 biological, 4 management and 4 nature conservation measures indices (*Table 1*.). The new survey was conducted in 2021, and the result was compared with the baseline data from the former assessment (Boros & Ecsedi 2013).

Table 1.: Indices applied for the survey

Indices measured	Score range
Catchment structure of surface	Min.: -1 (Territorial proportion of arable land, woods or settlement (%)*-0.01); Max.: 1 (Territorial proportion of sward, meadow or marsh (%)*0.01)
Groundwater rise	Min.: 0 (None); Max.: 2 (Yes)
Turbidity	Min.: 1 (Coloured); Max.: 5 (Turbid)
Permanence of open water surface	Min.: 0 (Generally dry, very rare water cover); Max.: 2 (Seasonal, regularly of occasionally dries out)
Conditions of bed structure	Min.: -4 (Lakebed and shoreline significantly affected by anthropogenic disturbance); Max.: 2 (Pristine)
Drainage and channeling	Min.: -2 (Outflow drainage channel leading out of lakebed); Max.: 2 (None)
Feeding channel	Min.: -2 (Feeder channel transecting lakebed); Max.: 2 (None)
Indirect water pollution and contamination	Min.: -4 (Rubbish dump or organic material waste dump in the lakebed and in the shore); Max.: 4 (None)
SUM_HYDRO	
Territorial proportion of lakebed habitats	Min.: -10 (Territorial proportion of *Phragmites communis* , *Bolboschoenus maritimus, Typha sp. or Schonoplectus sp.* (%)*-0.1); Max.: 10 (Territorial proportion of open water, open water with pondweed, *vakszik, szikfok* or mudflat
Characteristic species	Min.: 0 (None); Max.: 5 (At least five different characteristic species)
Waterbird migration significance	Min.: 1 (Low); Max.: 3 (High)
Disparities	Min.: -4 (Degraded residual patches surrounded by a disconnected economic landscape); Max.: 1 (A natural system consisting of elements located close to each other, in a natural state, with natural connections)
SUM_BIO	
Grazing intensity	Min.: 0 (None); Max.: 4 (Very high, above 1.6 LU/ha)
Habitats affected by scything	Min.: -1 (Territorial proportion of *szikfok* (%)*-0.01); Max.: 1 (Territorial proportion of *Phragmites communis, Bolboschoenus maritimus, Typha sp. or Schonoplectus sp.* (%)*0.01)
Alien flora	Min.: -3 (Widespread); Max.: 0 (None)
Hunters hides	Min.: -1 (Hunting lookout towers, game feeding stations and aquatic hides); Max.: 0 (None)
SUM_MANAGEMENT	
Conservation status	Min.: 0 (Unprotected); Max.: 1 (Natura 2000 site, natural park, landscape protection area, nature conservation site of national or local significant)
Type of pressure on habitat	Min.: -1 (Agricultural activities based on grazing, tourism, angling motor sports or aviation); Max.: 0 (None)
Type and scale of tourism	Min.: -1 (Uncontrolled conventional tourism, angling or hunting tourism); Max.: 1 (None, or controlled conventional tourism, or ecotourism)
Infrastructure of tourism	Min.: 0 (None); Max.: 5 (Nature trail, information board, lookout tower, hides and accessible by asphalt road)
SUM_CONSERVATION	

Source: Based on Boros (2013).

3. Results

Table 2. shows that theoverall ecological state of the Böddi-szék soda pan improved based on the 20 hydro-ecological, management and conservation indices.

Among the hydrological factors, the index related to water pollution showed a remarkable improvement. The previously detected water pollution from scattered waste and the former reed deposit in the area has ceased to exist. In addition, the proportion of arable land decreased and that of grassland areas increased in the catchment area, but the conditions of the bed structure regressed.

As far as biological parameters are concerned, the score of the territorial proportion of lakebed habitats increased slightly, due to the increasing openwater surface. The number of characteristic bird species nesting in the area also grew, resulting in a higher score of the characteristic species.

Table 2.: Change of ecological state of the Böddi-szék. (Changes are marked with bold.)

Indices measured (range)	2010	2021
Catchment structure of surface (range: -1–1)	**0,3**	**0,4**
Groundwater rise (range: 0–2)	2	2
Turbidity (range: 1–5)	5	5
Permanence of open water surface (range: 0–2)	2	2
Conditions of bed structure (range: -4–2)	**-2**	**-3**
Drainage and channeling (range: -2–2)	-2	-2
Feeding channel (range: -2–2)	-2	-2
Indirect water pollution and contamination (range: -4–4)	**-2,5**	**1**
SUM_HYDRO	**0,8**	**3,4**
Territorial proportion of lakebed habitats (range: -10–10)	**3,4**	**3,55**
Characteristic species (range: 0–5)	**3**	**4**
Waterbird migration significance (range: 1–3)	3	3
Disparities (range: -4–1)	1	1
SUM_BIO	**10,4**	**11,55**
Grazing intensity (range: 0–4)	2	2
Habitats affected by scything (range: -1–1)	**0,1**	**0,2**
Alien flora (range: -3–0)	-1	-1
Hunters hides (range: -1–0)	**0**	**-0,1**
SUM_MANAGEMENT	1,1	1,1
Conservation status (range: 0–1)	1	1
Type of pressure on habitat (range: -1–0)	**-0,4**	**-0,3**
Type and scale of tourism (range: -1–1)	**0**	**1**
Infrastructure of tourism (range: 0–5)	**1**	**5**
SUM_CONSERVATION	**1,6**	**6,7**
SUM_TOTAL	**13,9**	**22,75**

The indices related to management remained essentially unchanged during the studied decade. The ratio of scythed areas moderately increased, but the negative effect of the developed hunting infrastructure equalizes the score. Grazing pressure was between 0.6 and 1.0 livestock units per hectare in both study years.

On the other hand, regarding conservation measures, improvement can be observed in terms of tourism infrastructure development in the area.

4. Discussion

The indices used for evaluation show that the overall condition of the pan has slightly improved. The change can be partly due to the ongoing LIFE project, during which completed restoration activities included reduction of marsh vegetation, restoration of grasslands, as well as their maintenance by increased grazing in the area (Kovács et al. 2021). The canal crossing the soda pan will be relocated, which may also have significant positive effects on the ecological state and expand the ecosystem services offered by the soda pan in the future.

Within the conservation indices group the development of tourism infrastructure was the most significant. Tormáné Kovács et al. (2022) conducted a visitor survey in the area at the outset of the LIFE project. Their results showed a demand for tourism infrastructure development in the area and indicated that the recently constructed lookout towers are well integrated into the landscape and suitable for bird-watching activities.

The model does not make a distinction between different lakebed habitats in the scoring (e.g *Phragmites communis* and *Bolboschoenus maritimus)*. Besides grazing intensity the structure of grazing can also have an impact on the state of the soda pans which is not reflected in the scoring either. In the future, these could be the future directions for the development of the model.

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