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Evaluation of wetlands along the Ipoly using comparative application of different mapping methods

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Tartalom

1. Introduction and objective

The negative impact of human activity on the ecosystem has become limitless today, according to a study by UNEP (United Nations Environment Programs), we have lost 90 percent of wetlands worldwide in the last 300 years and 50 percent of forests worldwide in the last 50 years (UNEP 2016). All of these anthropogenic influences are dangerous to humanity itself, so reversing this process is one of the greatest challenges of our time (Szabó 2019). In order to prevent the impoverishment of the living world, it is necessary to know the processes and the responses of the living world to the constantly changing and new effects. By recording, mapping and monitoring the conditions, the change in the area can be scientifically documented (Fekete et al. 1997), so the protection intervention can be planned (Haraszthy 2014). The last few decades have seen major extremes in Europe's climate due to the consequences of global climate change (IPCC 2014). Due to the changing climatic conditions, irregular fluctuations of droughts and floods can be observed in the Carpathian Basin (Bartholy and Pongrácz 2007; 2014). A significant decrease in wetlands has been observed since the beginning of the 19th century (Čížková-Končalová 2013). The implementation of the Water Framework Directive (Directive 2000/60 / EC) in the European Union, which places great emphasis on nature conservation aspects, the maintenance and improvement of the condition of aquatic ecosystems, terrestrial ecosystems directly dependent on water and their condition, is closely related to nature conservation. tasks (European Commission 2002). Wetlands, such as rivers, also play an important role in regulating natural processes and conserving biodiversity, as they connect different habitats in the river basin, create links between habitats and help the natural distribution and survival of wild species. Due to the river regulations, ecologically unfavorable effects have occurred, the natural fauna of the floodplains has survived almost only in the floodplains, only here the free water flow of the rivers prevails (Tardy 2002). The present dissertation deals with the habitats between the administrative boundary of the Central Ipoly Valley sample area Dejtár and Ipolyvece. This area was considered suitable for investigation in several respects. The studied section of the Ipoly Valley is less affected by water management. Recent decades have seen a decline in rainfall in this area. As a consequence of these effects, changes in vegetation are also observed. These habitats are also exposed to the appearance and distribution of invasive species due to the linearity of Ipoly (Schmoczer 2014). The meadows of Dejtar and creek are home to a variety of habitats and the many different plant communities associated with them. Parts of the area were protected as local values in 1973 (Hegyi et al. 2007), and since 1997 the entire Ipoly Valley has been part of the Danube-Ipoly National Park. In addition, it is of great Community importance because it is a special nature reserve (HUDI20026) and a special protection area for birds (HUDI10008), as well as a Ramsar Convention for migratory waterbirds. According to previous surveys (Bíró et al. 2010, Penksza et al. 2012), Ipoly has been a good indicator of changes in environmental factors in vegetation.

In view of the above, it has become even more important nowadays to explore and possibly improve the current state of natural habitats, document the status and formulate a current management proposal for the most effective adaptation to the current climate, which is also included in the Global Biodiversity Outlook 5 (2020) report.

In the doctoral dissertation I am looking for the answers to the following questions, which are the main objectives of the study:

1. Mapping and documenting the study area based on different methodologies, observing possible differences and matches - using the general habitat classification methodology and category system to prepare the Á-NÉR map and the General Habitat Category (GHC) methodology based habitat map for the current land use EBONE using protocol-compliant categories (Bunce el al. 2005).

2. Comparison of the preliminary vegetation survey of the area in 2010 and the current 2020, presentation of its change, and observation of the habitats most affected by the process.

3. Comparison of field observations with the results of multi-aspect indices (NDVI, GNDVI, MNDWI, NDWI) generated from satellite data in the period between 2017 and 2021, and comparison with field observation.

4. Survey of the condition of the grassland in the study area, with coenological and co-systematic studies. Based on these, observe the effect of the present maintenance (grazing) treatment on vegetation. Evaluation of the obtained results according to social behavior types, relative ecological indicators, nature conservation value categories and life forms.

2. Material and method

The study area is located in the northern part of Hungary, on the left bank of the river Ipoly, between the villages of Dejtár and Patak, on a total section of about 3.35 km2. For the purpose of coenological data collection, four separate grassland associations were selected, which can be said to be valuable for the study delimitation. Grassland management is carried out in these grasslands under national park supervision, and I will describe the areas in detail below.

1. Coenological sample area: steppe (Agrostis tenuis mountain meadow): The first area is characterized by a sandy lawn with a silver sedge (Figure 2). Before 2010, the area will be used exclusively as a meadow, and from 2010 as a pasture and meadow. In the dissertation it is called a steppe (Agrostis tenuis mountain meadow).

2.Coenological sample area: Agropyron dominant open grassland: Most of the former meadow is a fresher area dominated by common ryegrass (Elymus repens, Agropyron repens), but as a result of intensive grazing, star grass (Cynodon dactylon) is also common. Beef cattle are grazed in the former meadow area. In this area, according to the national park guard, shrubbing is also carried out every 2-3 years, mainly the thinning of Craetegus monogina, which is no longer grazed by the animals. In the dissertation, I named this area Agropyron dominant open lawn. For the sake of simplicity, I have designated N2 for the processing of coenological data.

3.Coenological sample area: Open sandy grassland: In the higher area of the area approx. They have been grazing cattle for 20 years. There is a steppe in the less used area of the area. In the dissertation it is called the open sand lawn.

4.Coenological sample area: A heavily used part, similar to the previous area, also grazed for 20 years, which is used as a resting place for the animals, has also been isolated.

Coenological recording was performed using 2 × 2 meter squares, recording cover values according to the method of Braun-Blanquet (1964). The species names were recorded according to the nomenclature of Király (2009), the nature conservation value categories were provided by Simon (2000) and the social behavior types by Borhidi (1995). During the evaluation of the data, I considered the types of social behavior and relative ecological indicators (WB, NB) according to the work of Borhidi (1993), and the nature conservation value categories based on Simon (1988). I worked from the work of Soó (1973-1980) when examining life forms, and from the Flora database when examining flora element groups (Horváth et al. 1995). The species names follow the nomenclature of Király (2009). I also evaluated the data according to Raunkiaer's (1934) lifestyle system.

We used R programming language for our statistical analyzes. It is a freely available software environment for statistical calculations and representations. Of the indirect ordination methods, principal component analysis (PCA) and detendable correspondence analysis (DCA) are the most commonly used. The former attempts to describe the linear relationship of variables (species) along an assumed background gradient, while the other assumes a unimodal (i.e., maximal) response curve. With DCA, it is possible to represent objects and species in the same coordinate system using an interactive procedure, so this method was chosen when analyzing the data. The ordination space is determined by the number of ordination axes scaled to standard deviations for DCA. The first version was written by Ross Ihaka and Robert Gentleman (1996). I used Microsoft Excel to process the data and illustrate its evaluation.

During the habitat mapping, the area is surveyed on the basis of a classification system with a standardized field survey (Á-NÉR) (Takács and Molnár 2009). I was the first to prepare for the dissertation, the most important part of which is the acquisition of basic maps, the systematic review and comparison of orthophotos, Google Earth imagery and Sentinel satellite imagery with previous data. Accurate field delineation is possible with the help of GPS. In addition to the characteristic species of the given habitat type, the stocks of protected and invasive species are also recorded.

General National Habitat Classification System (Á-NÉR)

The Á-NÉR was developed in connection with the National Biodiversity Monitoring Program (Fekete et al. 1997). The most frequently used complex system for habitat mapping in Hungary, which is under continuous development. Compared to plant coenological classifications, it contains significantly simpler, fewer, and broader categories. It classifies plant communities into larger, easy-to-understand habitat types; it can be used reliably with less species knowledge, but it is also suitable for both phytosociological and nature conservation practical use (Bölöni et al. 2008b). The number of habitat categories is over 110. Its categories cover all habitat types occurring in Hungary, including semi-natural, degraded and artificial habitats; transitions and secondary habitats can be managed well. In his system, the main categories for natural, near-natural, degraded habitats are more detailed, and the classification of artificial surfaces (agricultural habitats, settlements, industrial areas, etc.) is more generous (cf. CORINE Land Cover, Heymann et al. 1994). The classification of habitats is not hierarchical, the categories are equal to each other and can be grouped in several ways. Basically, medium-scale habitat maps (1: 10000-1: 25000) can be made using it, but it can be used up to a scale of 1: 50000 (Fekete et al. 1997, Nagy 2004, Bölöni et al. 2008b). The application of ÁNÉR is a suitable solution to the shortcomings discovered during the use of plant coenological systems for habitat mapping purposes (Bagi 1991a, 1997, 1998, Bartha 2000). The manual for mapping based on ÁNÉR contains the methodology of mapping, the types of habitats are extremely detailed, clear, and several aspects (production site, physiognomy, species stock, etc.), which significantly facilitates the field identification and accurate documentation of habitats (Bölöni et al. 2008b).

The classification system has been amended several times since its inception. The first full update was the MÁ-NÉR published in 2000 (Molnár and Horváth 2000). Later, the META - covering natural and semi-natural habitat types - was repeatedly renewed (Á-NÉR2003, mmÁ-NÉR), introducing significant changes (eg naturalness-based habitat quality characterization, regeneration potential, new, consolidated categories) (Bölöni et al. 2003). As the secondary and cultural habitats were not included in the list of Á-NÉR2003, it became necessary to link them with Á-NÉR1997, which also included the missing categories, which was achieved with the introduction of Á-NÉR2007 (Bölöni et al. 2007). The experience gained in the meantime has also been incorporated into the revised system. The latest version of Á-NÉR is Á-NÉR2011, which contains minor refinements and clarifications compared to Á-NÉR2007 (Bölöni et al. 2011). The classification system is hereinafter referred to as the ÁNÉR.

General Habitat Categories (GHC)

The GHC classification (Bunce et al. 2005, Bunce et al. 2008) was basically developed to monitor biodiversity. The habitat category system has been tested several times (Bunce et al. 2005, Metzger et al., 2005) and covers the entire Pan-European region except Turkey. Its aim is to make it uniformly usable in the region, so that the various national and European classification systems can be harmonized and interconnected, making it possible to describe and assess the biodiversity of different landscapes and to compare the quality and quantity of different habitat maps. Its design is linked to the European Union's BioHab (Project for Biodiversity and Habitat Monitoring 2002-2005) project (Bunce et al. 2005). The basic unit of classification is the habitat, however, unlike the classifications, in the case of vegetated habitats it is based on the lifestyle types of the species, the physical characteristics and land use in areas without vegetation. The significance of the novel habitat classification is that, going beyond the difficulties of classifications based on associations and association complexes (eg habitat complexes, transitions, subjectivity, underrepresentation of vegetation-free areas and disturbed habitats), the Raunkiaer habitats. The classification is simpler, multi-purpose, and less time consuming to apply in the field than for systems with a phytosociological approach. Non-biogeographical and non-locally defined, determinants are based on statistical rules, GHC habitat types and quality characteristics are defined according to clear specifications (Bunce et al. 2005, Bloch-Petersen et al. 2006, Bunce et al. 2008). The system classifies the areas into five main categories: 1. Urban, built; 2. Agriculture; 3. Covered with sparse vegetation; 4. Areas covered with herbaceous water or land, 5. Areas covered with woody plants (trees and shrubs). Once the main categories have been defined, the basis for classification is further provided by the lifestyle types of the dominant species within the given habitat. It is exceptional in terms of the method of mapping that the GHC also categorizes habitats according to their spatial appearance - spatial, linear and point elements. In addition to the delimitation and classification of habitats, the environmental and management characteristics of the habitat patches, as well as the soil and water management conditions are also recorded (Bunce et al. 2005, Bloch-Petersen et al. 2006, Bunce et al. 2008). Due to the close relationship between plant life forms, life form compositions and environmental characteristics, the analysis of GHC habitat maps can be used to infer environmental factors specific to the area, as well as anthropogenic disturbance and the impact of farming (Pandey and Verman 1990, Prasad 1995). , McIntyre et al. 1995, Vind and Andreasen 1997), however, they provide an important basis for conducting biodiversity studies (Kovács-Hostyánszki et al. 2013). The habitat acquisition method can be used to record and evaluate minor changes in plant composition at other local, regional and global scales, which are difficult to monitor with other methods focusing on species composition due to the multiplicity of background effects. In addition to the positive traits, it should also be emphasized that GHC is not suitable for detecting changes at the species level (species disappearance, lack of species, changes in species composition) (Bloch-Petersen et al. 2006).

Sentinel-2A satellite imagery

The aim of the work was to compare habitats with satellite imagery. The Sentinel-2A satellite updates the data every three days. Several aspects had to be considered in the selection on the one hand, the cloud cover should always show a value below 0.1% and the sample area should not be covered by a cloud, because the values of the given pixels cannot be evaluated. The following dates have been selected:

• May 28, 2017

• May 3, 2018

• April 30, August 19, 2019.

• May 22, 2020

• June 16, 2021

For the evaluation of satellite data, various multi-purpose indices (NDVI, GNDVI, MNDWI, NDWI) were used, with which quantitative data can be derived using optical bands. I also used QGIS to calculate the indexes.

4. Results and evaluations

Preserving and sustainably managing natural habitats is one of the greatest challenges of our time to adapt to. The Ipoly Valley is one of our last watercourses, little affected by water management, and it is in our common interest to preserve it. Monitoring and documenting sensitive areas is part of the Biodiversity Strategy to 2030 (European Parliament 2020) adopted by the European Commission. The last few decades have seen major extremes in Europe’s climate due to the consequences of global climate change (IPCC 2014). Due to the changing climatic conditions, irregular fluctuations of droughts and floods can be observed in the Carpathian Basin (Bartholy and Pongrácz 2007; 2014). Exploring, possibly improving the current state of natural habitats, documenting the status and formulating a current management proposal for the most effective adaptation to the current climatic environment, which is also included in the recommendations of the Global Biodiversity Outlook 5 (2020) report. The present dissertation deals with the habitats between the administrative boundary of the Central Ipoly Valley sample area Dejtár and Ipolyvece. This area was considered suitable for investigation in several respects. The studied section of the Ipoly Valley is less affected by water management. Recent decades have seen a decline in rainfall in this area. As a consequence of these effects, changes in vegetation are also observed. These habitats are also exposed to the appearance and distribution of invasive species due to the linearity of Ipoly (Schmoczer 2014). The meadows of Dejtar and creek are home to a variety of habitats and the many different plant communities associated with them. Parts of the area were protected as local values in 1973 (Hegyi et al. 2007), and since 1997 the entire Ipoly Valley has been part of the Danube-Ipoly National Park. In addition, it is of great Community importance because it is a special nature reserve (HUDI20026) and a special protection area for birds (HUDI10008), as well as a Ramsar Convention for migratory waterbirds. According to previous surveys (Bíró et al. 2010, Penksza et al. 2012), Ipoly has been a good indicator of changes in environmental factors in vegetation. The aim of the dissertation was to map the vegetation of the area between the administrative boundaries of Dejtár and Ipolyvece, which is supplemented by the coenological exploration of the valuable sandy grasslands studied. Coenological recordings were made in 4 different sample areas, two areas that have been used alternately for mowing and grazing for 10 years, one area that has been exclusively grazed for 20 years and another area that has been grazed for 20 years and used by the animals for rest. My goal was to compare the completed habitat maps with the Sentinel-2A satellite data using different vegetation indices, which allows the observation of vegetation change. Coenological recordings were made in May-July each year between 2017 and 2021, using 2 × 2 m squares, according to the method of Braun-Blanquet (1964), giving the percentage cover value of the species. I gave the species names according to the nomenclature of Simon (2000) and the nature conservation value categories also according to the system of Simon (1988). I also evaluated the data according to Raunkiær's (1934) lifestyle system, and I used social behavior types (SBT) according to Borhidi's (1995) system. The data, based on nature conservation value categories (TVK), show that the proportion of natural disturbance tolerance (TZ) increased by 2021 in each sample area, indicating overgrazing. The disadvantage of grazing is that in some parts there is too little grassland and a lot of dicotyledonous cover, which is consumed in negligible quantities by cattle. Due to overgrazing, this is accompanied by a decrease in the proportion of cover of popular species (Penksza 2008). This statement is confirmed by the results of Raunkiaer's classification of life forms, according to which the proportion of hemicryptophytic (H) herbivores increased by 2020 and 2021 in each area. In the disturbed, degraded resting (P) area, the largest number of protected Pulsatilla pratensis subs. nigricans, although open land or degraded vegetation develops around the resting or drinking area (Evans, 1977; Mackay and Tallis, 1996; Komarek, 2007a, b; Salata, 2017; Saláta et al., 2011, 2012, 2013; Catorci et al., 2017). This is mainly due to the toxic compounds found in the plant. Conservation has an important role to play in habitat conservation. Based on the DCA analysis of the coenological survey carried out between 2017 and 2021, it can be seen that the grasslands used for the first time as meadows (N1, N2) show a much more uniform picture with the area that has been grazed for 20 years (SZ). Coenological observation of grasslands is an aspect usa was for monitoring the selected habitat. I have compared different mapping methods, the application of which shows a complex picture of the current state of the Ipoly Valley sample area and the changes that have taken place over the last decade. In the area studied according to the General Habitats Classification System (ÁNÉR) methodology, the most significant habitat categories are the softwood pioneer and uncharacteristic forests (RB), which occupy the largest area with 77.66 hectares, followed by sand steppes (H5b) followed by 61.7 hectares and then peat. meadows and ponds (B1a) habitat category unit on 38.55 hectares. The marsh meadows (D34) also occupy a large area in the study area, with 54.68 hectares. Then the hawthorn-blackthorn-juniper (P2b) complexes provide the largest habitats in the area. Comparing the 2010 and 2020 habitat maps, there are changes in the size of habitats and the characteristics of habitat types in some habitat patches, and there has been a significant increase in the number of habitat patches. The number and extent of wetlands decreased significantly in 2020. The number of eu- and mesotrophic reed and Typha bed (B1a) habitat category patches decreased from 2 sites to 1 site, while their area decreased from 83.16 hectares to 38.55 hectares. Looking at the wetlands (habitats B and D and their complexes) as a whole, the results show that it was present on 166.9 hectares out of 17 patches in the dry period (2020) and on 216.7 hectares out of 14 patches in the wet period (2010). Two different complexes can be discovered between the maps. The 2010 map shows the H5b × P2b complex, which will be noticeably separated by 2020. Therefore, for the year 2020, H5b and P2b have been recorded separately. In the two years, only 7 categories (B1a × D34 × J3, J3, J3 × P2b × U9, J4 × B5, J4 × P2b × U9, J4 × U8 and U7) remained unchanged, so most of the complexes were transformed. The map, made in a wetter year (2010), shows a declining trend in aquatic vegetation in low-lying, woodless habitats. There was also a significant change in the closed sand steppes (H5b) and their subtypes. They underwent a complete transformation, their presence in 2010 was lower than in 2020. Their area was 70.4 hectares in 2010, up from 145.5 hectares in 2020. Vegetation changed significantly in the years compared, under extremely dry conditions (2020) and extremely wet conditions (2010). The vegetation showed a difference in the two years studied, which was a good indicator of environmental changes. The extent of the lawn has increased significantly. The area of sand steppes (H5b) increased due to persistent rainfall, the number of patches increased from 6 (in 2010) to 14 (in 2020). Overall, the presence of dry habitats has increased and several dry patches have formed within 10 years, and the area of wet habitats has decreased. The General Habitat Category (GHC) Habitat Survey shows that a total of 75 habitat patches can be identified under this classification. The spatial segregation of habitat categories and the number of habitat patches are shown in. The largest area of habitat patches is 107.5 hectares of the complex of perennial monocotyledonous grasses and broadleaf, herbaceous habitats (CHE / LHE). The next largest area category is given by the category of tall shrubs, with a total of 85.5 hectares. The third largest complex is the complex of broadleaf herbs and monocotyledons (LHE / CHE). Comparing the ÁNÉR and GHC methodologies, it can be seen that the classification of the category as the ÁNÉR methodology is more detailed. In contrast to the GHC HEL category used for wet areas, the ÁNÉR distinguishes 3 categories (B1a, B5, B24). There is also a big difference in the case of woody vegetation, in the case of shrubs, where the MPH category of GHC corresponds to the P2a, P2b category of ÁNÉR. The FPH habitat covers a total of 4 categories based on the ÁNÉR methodology (S2, S4, RB, J4). It is clear that classification at the GHC level is simpler than mapping with the ÁNÉR category, so the former allows for international evaluation. I compared the recorded categories of the General Habitat Mapping System (ÁNÉR) with the data of Sentinel-2A available since 2016 to examine whether there is a correlation between the categories and the normalized vegetation indices (NDVI) of the satellite images. For the comparison of the satellite data and the ÁNÉR categories, I chose a late summer aspect from the satellite images, so that the vegetation was already well developed and the habitat could regenerate even after the summer grassland discharge. From the available recordings, I chose the year 2019, as it was considered to be moderately rainy among the years studied. According to the ÁNÉR classification, the category of stagnant waters (U9) is therefore visible in the NDVI range between 0.08 and 0.55. A higher value than negative in this case is possible because there is biological activity in the area, but the value of reflectance is extremely low due to chlorophyll-deficient areas (Didan K. 2015). This is also the case for intensive arable crops (T1). In the area of roads and wider paths (U11), where the mass of plant biomass is also low, similar to that in the previous category. NDVI values show a higher value where the plant activity is higher and the phenological phase of the plant is in a growth period. Low NDVI values were also found in the case of drier associations, including sand steppes (H5b). The vegetation of the marsh meadow (D34) is well separated from the vegetation complex types of willow-poplar floodplain forest (J4) and hawthorn-blackthorn (P2b) along the Ipoly. It did not show such a uniform picture in the case of woody vegetation, where the stock picture has a mixed species composition, other NDVI categories are included in a delimited habitat category depending on the phenological phase. In addition to the comparison of habitat categories and satellite images, I also examined the satellite images in the period under review, ie from 2017 to 2021, in order to see if there is a possible correlation and / or difference between the rainfall and the vegetation and water difference calculated from the satellite images. between indices. Based on the meteorological results, it is clear which year was the area most exposed to drought. In the years 2020 (Fig. 16), it also showed extremely low values for dry sandy grasslands (H5b) and the area dominated by Phragmites australis (B1a), which may give a confounding result in the identification of sandy grasslands and the detection of wetlands. This result is likely due to the high mass of dried-up biomass of Phragmites australis in the previous year. Compared to the NDVI results, the GNDVI index better presents the vegetation of 2021, which is richer in precipitation, showing values between 0.5 and 0.9. There is a correlation between the results of the meteorological data and the satellite images, as in the years when the measured precipitation was higher, much higher biological activity was observed, which is mainly seen in 2019 and 2021. In practice, the NDWI index is used to monitor the vegetation of drought-affected areas. The reedbed (B1a) and the grassland (H5b) are very nicely outlined, except for the 2018 survey. In the 2018 map, a high proportion of dry spots occur in all sample areas. In the 2021 survey, all habitats except the lake were filled with moisture. The index shows the water content in the mesophilic layer of the vegetation very well, but I used a different index to detect the water surface, which shows whether there is indeed a water surface or any empty spot in the given area. The 2020 NDWI survey also supports the GNDVI results, with the steppe and marsh vegetation being the most sensitive to declining rainfall in the area. The modified normalized water difference index (MNDWI) was used as a control for the clear presentation of water surfaces. The water surface in the middle of the sample area (B1a × U9) can be drawn very well in all years, except in 2017, when the lake was almost dry. Comparing the different years, 2021 had the highest water coverage in the area, while 2018 had the driest year. The section between the Ipoly Valley, Dejtár and Ipolyvece is of great value, and its preservation is extremely important. Based on the study spanning five years, it can be concluded that the sustainable use of the area, for which grazing with cattle is suitable, is important from a nature conservation point of view. By reducing the number of animals, the overuse of the area can be stopped, which will also increase the number of favorable monocotyledonous grasses. The use of satellite imagery has the potential to map and observe natural habitats (Bekkema 2018, Kaplan 2017, Majasalmi 2016) and areas that were previously difficult to access also become easily observable (Burai 2016).

5. New scientific results

A map of ÁNÉR was prepared for the sample area in the Ipoly Valley, located on the border of Dejtár and Ipolyvece, using the methodology and category system of the general habitat classification. The classification according to the European Habitats Classification System (GHC) for the studied area has been completed. Comparing the ÁNÉR and GHC methodologies, it can be observed that the classification of the category as the ÁNÉR methodology is more detailed. GHC-level classification is simpler than mapping with the ÁNÉR category, so the former allows for international evaluation.
The analysis of the algorithms (NDVI, GNDVI, NDWI and MNDWI) based on the Sentinel-2A satellite images of the study area were compared with which precipitation data were compared between 2017 and 2021. The study has shown that anthropogenic disturbed pathways can also be detected using certain indices (Járdi et al. 2022). With the help of the indices, the change of the precipitation difference of the examined years can be well demonstrated.

Analysis of the temporal changes with the habitat mapping data in 2010 related to the Ipolyvece and Dejtár areas based on the new 2020 data. Habitat changes can be observed, especially in the case of grasslands the area of sand steppe (H5b) increased, while the number of vegetation in marsh meadow (D34) decreased. The presence of drought-indicating species can be observed in wet and fresh grasslands, such as Achillea collina, Plantago lanceolata, Agropyron repens, Dactylis glomerata (Járdi et al. 2022).

A new occurrence of steppe-forest-steppe vegetation (Potentillo arenariae-Festucetum pseudovinae and Thymo serpylli-Festucetum pseudovinae) in the studied area was confirmed during the coenology and co-costematical study of the grasslands. The patches of the vegetation type appear in the drier, acidic sandy areas of the sand ridges following the river (Járdi et al. 2021).

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