Pannonian grazed sandy grasslands in the Ipoly Valley

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The results of global climate change can be observed in climate of Hungary. In the last couple of decades significant have been observed extremes in the climate of Europe due to global climate change (IPCC, 2014), which the irregular alternation of droughts and floods could be traced in the Carpathian Basin (Bartholy et al., 2009, 2014). The river floodplains and adjacent wetlands were outstanding from a nature conservation point of view due to the increasingly exposed to this change (Capon et al., 2013). Because of climatic effects, floodplain areas are even more exposed to the spread of invasive species (Szollát and Schmotzer, 2004; Schmotzer, 2008; Füri, 2000; Füri and Kelemen, 1997; Čížková-Končalová et al., 2013), and changes in land use also aggravate this problem (Mosneret al., 2015; Penksza et al., 2012). The aim of this study is to present the impact of extreme climatic situations on vegetation in grazed grasslands. The question was, which *Festuca* species occurs in addition to this? Can *Festuca javorkae* or *Festuca pseudovina* be found. The *Festuca javorkae*, which was related to *Festuca rupicola*, could also be problematic, although this species was clarified (Penksza, 2000a, b, 2009; Penksza et al., 2020, 2021; Markgraf-Dannenberg, 1980) and its species differentiation was shown using molecular studies by Bauer et al. (2003) and Galli et al. (2006). According to the description of association *Salvio nemorosae-Festucetum rupicolae*, *Festuca rupicola* is one of the species of the association that appeared in the present study.

The present study analyzes an example of this change in sensitive grassland areas during a 5-years-period and it mainly compares the spring aspect of two extreme climatic years and analyzes of effects on the area of pastures that determine landscape use. In the research, which we can highlight the 2 extreme years of 2020 and 2021 and their spring conditions were analyzed in detail. The satellite data was supplemented and combined with field recordings using the classic square method. Based on the satellite images, we detected the impact of the extreme climate situation in the sandy grasslands along the Ipoly. There are differences between the NDVI and MNDWI data of the different vegetation units and sample points in the examined years, which shows a correlation with the changes in the vegetation (Szabó et al., 2010, 2011; Penksza et al., 1994, 1996) and biomass (Szentes et al., 2007, 2009; Penksza et al., 2007).

The sample area is located in Northern Hungary along the River Ipoly, on the border of the villages of Dejtár and Ipolyvece, with an area of 430.4 ha. The Ipoly is one of the last rivers in Hungary that is slightly affected by water management, in addition the entire area of the Ipoly valley is protected by law, it is also an area conforming to special bird protection (HUDI10008) and special habitat protection directives (HUDI20026), as well as a Ramsar site (Fodor and Gálosi-Kovács, 2019; Brow et al., 2018). Although the Ipoly has a linear location, the area of the Ipoly Valley is dotted with mosaic habitats, which is due to the natural, unregulated river (Penksza et al., 2012). The correlation between soil moisture content and vegetation heterogeneity has already been demonstrated along other watercourses in the Pannonian region (Mjazovszky et al., 2007). Changes in groundwater clearly influence the spatial arrangement of vegetation types (Verrasztó, 2010; Járdi et al., 2021).

Due to the sensitivity of the Ipoly floodplain sites, it responds quickly to various environmental changes, which meets the expectations for the selection of the sample area (Borhidi, 2003; Penksza et al., 2012; Mosner et al., 2015). The coenological survey was carried out with 2×2 meter squares, recording the cover value. The species names follow the nomenclature of Király (2009) and Engloner et al. (2001).

In the first area: calcareous sandy grassland is characteristic, with silver feather (*Corynephorus canescens*). Cenological classification of the silver sedge lawn: *Thymo serpylli-Festucetum pseudovinae* Borhidi 1958.

The second and third sample areas are their common characteristic is that they were used as a mowing board 10 years ago, and then grazed with beef cattle (Charolais) for 10 years. Their main difference is that the mesophilic type area is fresher, while this area is a drier habitat. Cenological classification: *Cynodonti-Poetum angustifolae* Rapaics ex Soó 1957. In the more mesophilic type, the meadow foxtail (*Alopecurus pratensis*), the orchard grass (*Dactylis glomerata*), the false oat-grass (*Arrhentanherum elatius*) and the creeping bentgrass (*Agrostis stolonifera*) become dominant, and they can also be found on the bentgrass (*Agristis tenuis*) typical of mountain meadows. In the drier stands, couch grass (*Elymus repens*) becomes the dominant grassland species, and as a result of intensive grazing, bermuda grass (*Cynodon dactylon*) is also common.

The fourth sample area: They have been grazing with Hungarian gray cattle for 20 years. In the less used area of the area, there is steppe heather, which can be classified in the association of sandy desert

heather (*Salvio-nemorosae-Festucetosum rupicolae* Zólyomi ex Soó 1964).
Sample area five: The area used as a resting place for Hungarian gray cattle is the most exposed to degradation among the examined sample areas. Cenological classification: *Cynodonti-Poetum angustifolae* Rapaics ex Soó 1957.

In general, it was characteristic that during the coenological survey, the species and their cover values followed the climatic differences. In the driest year of 2022, the proportion of drought-tolerant species increased in all sample areas of vegetation, these species were mainly *Agropyron repens, Koeleria cristata, Festuca pseudovina, Cynodon dactylon*. On the sandy steppe, the cover values of *Stypa borysthenica* also became more significant. At the same time, due to the smaller biomass, the grazing pressure was also higher, and thus the ratio of tillers and plants with creeping stems also increased. This is also related to the large-scale spread of stargrass (*Cynodon dactylon*), and the amount of white testis (*Trifolium repens*) has also increased. And among the rose-leaved species, the amount of plantain (*Plantago lanceolata*) doubled. The amount of prickly species has also increased: thorny holly (*Ononis spinosa*), field yarrow (*Eryngium campestre*).

On the deeper surface, connected complex patches, characteristic of most individual domestic habitats, appear (Malatinszky et al., 2013; Penksza et al., 2012; T.-Járdi et al., 2022; Pándi et al., 2014). Wet, marshy, fen or water-bound vegetation patches develop in the depressions that appear on the surface, which is typical in general (Körner, 1998; Courtwright and Findlay, 2011; Bátori et al., 2014, Penksza and Malatinszky, 2001), but especially in the central area of the Carpathian Basin. The water level is also important for this reason, which leads to the appearance of diverse and species-rich vegetation (Tölgyesi et al., 2014; Erdős et al., 2014; Bátori et al. 2014, Bajor et al., 2016). But the present investigation confirms that the changes can also be clearly detected in the vegetation of the sandy grasslands at higher altitudes. The methods used in the present case can be used not only in the fields of farmers (Veloso et al., 2017), but also in the evaluation of natural grasslands.

Based on our observations, it can be seen that within each habitat patch, which can be separated as a relatively unit patch during habitat mapping (Járdi et al., 2021; T.-Járdi et al., 2022), it is also suitable for more detailed analysis and more accurate monitoring of changes (Burai et al., 2016). In the recordings, in addition to *Festuca rupicola*, *Festuca pseudovina* also occurred in the more degraded areas, and we also found the species *Festuca ovina*.

Keywords: extreme climate conditions, Charolais, habitat changes, Festuca ssp.

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