

Development of forest ecosystems on biota monitoring plots in the area of influence of Gabčíkovo Waterwork

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Abstract: The construction and operation of waterworks has a significant impact on natural ecosystems. The evaluation of their negative impact and the proposal to minimize their impact, as well as the revitalization, especially of large rivers, have been given great importance in recent decades. The main goal of the study is to present impact of Gabčíkovo Waterwork on forest ecosystems after 30 years of damming. Specially evaluated are monitoring sites where changes are observed in the Slovak part of the so-called inland delta, i.e., between old and new riverbed of the Danube. The assessment of changes in terrestrial vegetation on selected monitoring sites was compared with the assessment of parallel measured soil moisture data. At the same time, data from the National Forestry Centre were also used to monitor changes in the state of forest ecosystems in the whole area of interest.

When comparing the species composition from state to 2015 and from the period before GW was put into operation (in 1990) an increase was found in the area share of hardwood floodplain forest by 5.77% and the area shares of softwood floodplain forests decreased by 1.71%. Between 1990 and 2015, 68.43% of the territory remained unchanged at the level of forest type groups. A change in habitat conditions towards drier forest types was recorded on 23.61% of the territory.

Keywords: Long-term monitoring; Floodplain; Forest ecosystem; Soil moisture; Ecological changes.

INTRODUCTION

The issue of anthropogenic impact and ecosystems of large rivers has been in the attention of scientific research, both theoretical and applied, in recent decades. In addition to the French school of research on large rivers (Amoros and Bornette, 2002; Amoros and Roux, 1988), German, Austrian and North American authors (Findlay et al., 2002; Junk et al., 1989; Schiemer et al., 2001; Ward and Stanford, 1995; Ward et al., 2002) are prominent in this field. Importance is placed on the hydrological connectivity of its inundated area (Birkás et al., 2021; Brázdil et al., 2011; Bzour and Válanski, 2023; Chovanec et al., 2015; Grežo et al., 2020; Hart and Finelli, 1999; Kišš et al., 2022; Manina and Halaj, 2019; Thomaz et al., 2007). Damming a watercourse often has a significant negative impact on the hydrological connectivity between river and adjacent water bodies (Kubinský et al., 2015; Pringle et al., 2000; Ward et al., 1999), which can lead to a reduction in the heterogeneity of river habitats and a decrease in biodiversity (Tockner et al., 1998).

Hydro morphological degradation of rivers is one of the main threats to the ecological integrity of large rivers in Europe. This problem has been partly reflected in political and legislative measures at the national level, as well as at the level of EU legislation (Natura 2000; EU Commission, 2000).

Artificial flow regimes negatively affect biodiversity not only in the stream but also in the entire adjacent river landscape (Hart and Finelli, 1999; Poff and Zimmermann, 2009). Efforts to correct the negative consequences of waterworks, including proposals for the revitalization of watercourses, require the processing of high-quality studies. Long-term observation is

critical for documenting temporal changes in river ecosystems and for identifying natural and anthropogenically induced changes in flows (Naiman et al., 1995). Relatively few ecological studies are based on more than a few years of data collection, often from a single observation or from observations made over a short period of time (Armitage and Gunn, 1996; Elliott, 1993; Resh et al., 2013; Rhoads and Germano, 1986; Wright and Symes, 1999). Therefore, the database based on long-term monitoring are an important tool for better understanding and assessing ecological conditions and trends in large rivers (Langraf et al., 2021; Magnuson et al., 1990; Petrovičová et al., 2021).

In Slovakia, the impact of the construction and operation of the Gabčíkovo Waterwork (hereafter GW) on the natural environment has been monitored for longest time. In 1989, three years before the construction of the GW, a system for monitoring the impact of the GW on the natural environment was launched. The goal was to capture the changes caused by the construction and operation of the GW on the natural environment (Mucha and Lisický, 2006). It consisted of surface and underground water monitoring, agricultural land monitoring, forest ecosystems and biota monitoring (Matečný, 2008). The purpose of the monitoring was to verify the expected negative consequences of the construction and operation of the GW and subsequently propose measures for their elimination. A long-term monitoring of the parameters of the water regime in the monitored area for 30 years enabled the acquisition of data as a basis for correct assessment of the impact of changes on terrestrial ecosystems.

The aim of the paper is to evaluate the 30-year development of the state of terrestrial eco-systems in the area of the so-called of the inland Danube delta, using data from selected biota monitoring areas as well as forest ecosystem monitoring as part

of the assessment of the impact of Gabčíkovo Waterwork on the natural environment with suggestions for its possible improvement in localities with a negative development of the moisture regime.

MATERIAL AND METHODS

The area of interest is the so-called the inland Danube delta, it means periodically inundated area between the old riverbed of the Danube and the old dams (Fig. 1). In the mentioned area, the most significant change in the water regime was manifested as a result of the diversion of the main flow of the Danube into a new navigation channel (Lisický and Mucha, 2003). In the given area, there are monitoring plots (hereafter MP) for biota monitoring as well as forest ecosystem monitoring areas (hereafter TMP).

The development of ecosystems on monitoring areas of biota was monitored on relatively natural forest communities from 1990. When evaluating terrestrial vegetation, we are coming out from results of vegetation monitoring in 1990–2020 on selected MP sites (Lisický et al., 1991; Matečný, 2020; Rovný et al., 1992), from the phytocenological map of the left-side inundation area of the Danube in the Dobrohošť-Sap section at scale 1:10 000 (Šomšák et al., 2001) and from data from botanical research. For the overall assessment of the state of terrestrial vegetation, we used the evaluation of the development of forest ecosystems by National Forestry Centre Zvolen (hereafter NFC) (Matečný et al., 2018, 2019). The spatial distribution and representation of forest types was evaluated in 2005 and 2015 by NFC based on data that is updated every ten years for the renewal of forest management plans.

Monitoring of the moisture conditions

Monitoring of the moisture conditions consists in periodic measurement of the groundwater level and soil moisture.

Groundwater level measurement is carried out by Slovak Hydrometeorological Institute automatic stations in sites MP-6, MP-9, MP-10, MP-14. Soil moisture at the MP biota was measured volumetrically by the neutron method in approximately 14-day intervals (Table 1). The measurement depth was every 10 cm up to the groundwater level (hereafter GWL) since 1990: MP-6 up to 600 cm, MP-9 up to 500 cm, MP-10 up to 200 cm, MP-14 up to 500 cm. Basic physical and chemical soil parameters were determined for each MP, as well as the borehole profile for soil moisture and GWL. They were monitored in 1989, in 1991–1995 and in 2006 in all four MPs (Matečný and Bedrna, 2014). We evaluated course of the moisture condition of each location from the compiled soil moisture data graphs, considering the physical properties of individual soil profiles. The reaction of the biota, in brief, is presented according to Matečný (2008 and 2020).

Assessment of plant communities on the biota monitoring plots

A detailed botanical analysis was carried out by Petrášová-Šibíková et al. (2017). To evaluate the dynamics of the species composition and the properties of the biotope, data were obtained from the long-term collection of phytosociological data, supplemented by measurements of soil moisture (indicator of changes in floodplain ecosystems – Ellenberg, 1988; Havlová et al., 2004; Matečný and Bedrna, 2014). MP 6, MP 10 and MP 14 were evaluated for the period 1990–2013 (Fig. 2). Five environmental factors that influence communities were calculated according to Ellenberg's indicator values, including soil moisture, nitrogen content, soil pH, temperature and light requirements (Ellenberg et al., 1992).

Due to their close connection with water level, trends in species abundance, characteristic of the *Salicion albae* (hereafter *Salicion*) alliance, were assessed individually for all species

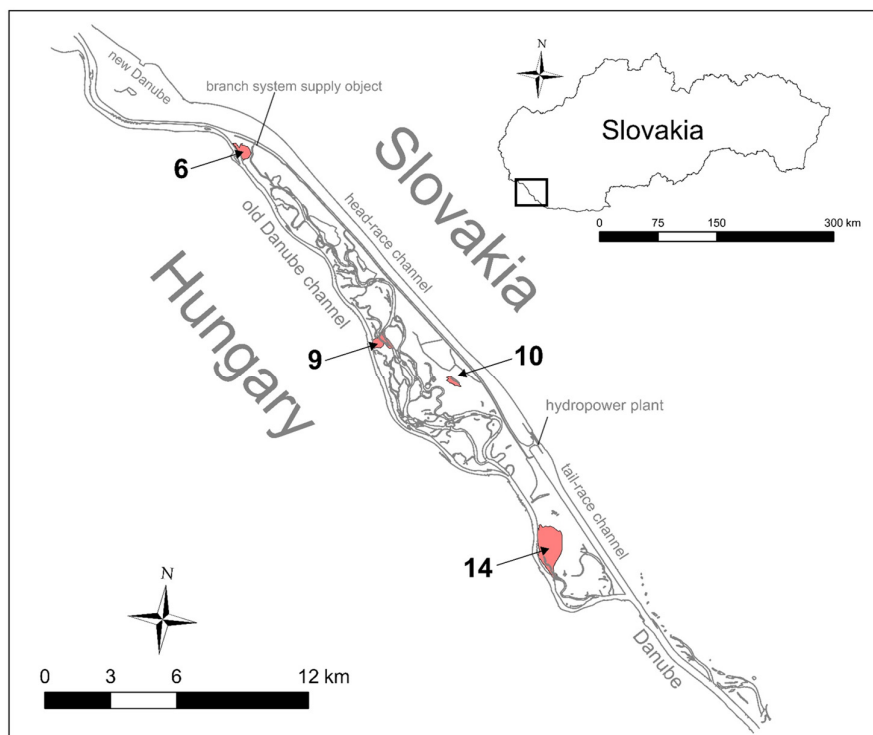
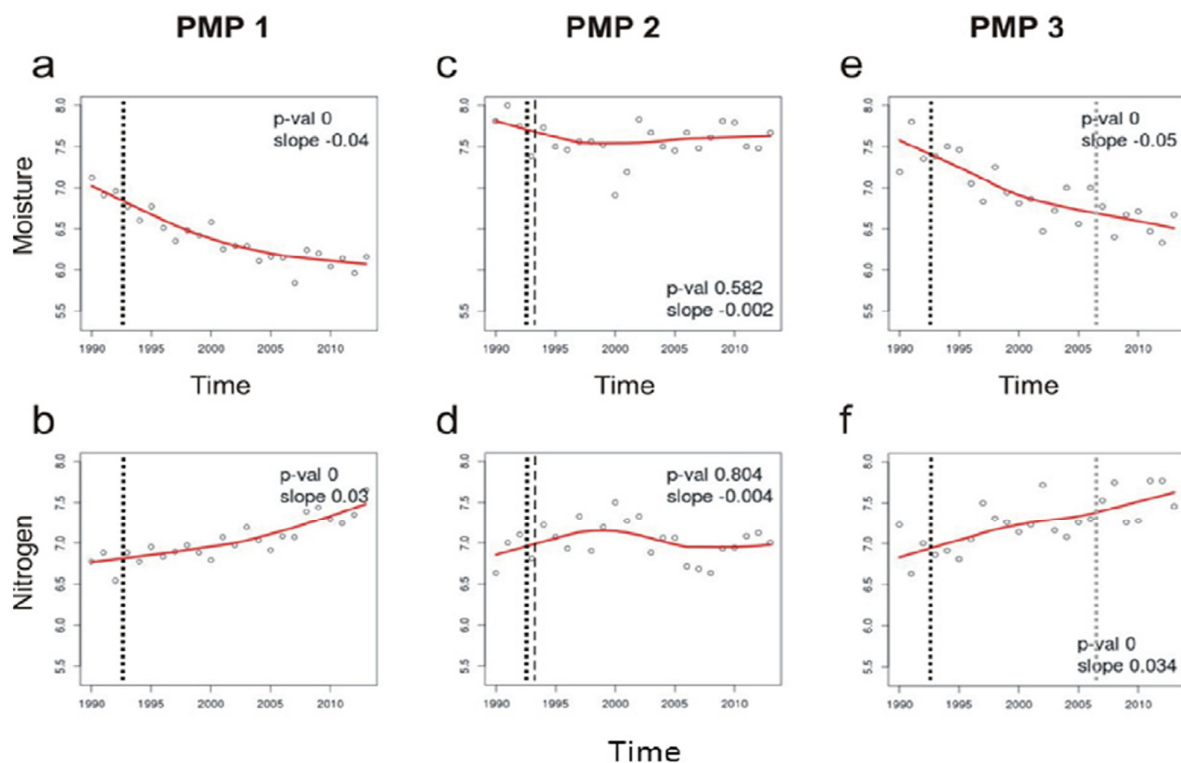


Fig. 1. Area of interest of the Danube inland delta (old Danube channel forms the state border).

Table 1. Number of soil moisture measurements.

MP	Location	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
6	Dunajské kriviny	28	29	30	32	25	28	27	30	14	16	21	23	21	21	21
9	Bodická brána	27	28	27	30	25	21	27	30	14	16	21	22	20	20	21
10	Kráľovská lúka	28	29	29	30	26	29	27	30	14	16	21	23	21	21	21
14	Istragov	28	29	29	30	26	27	25	30	14	16	21	23	19	21	21

MP	Location	2005	2006	2007	2008	2009	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020
6	Dunajské kriviny	22	21	21	21	17	20	21	20	21	22	20	16	21	21	20
9	Bodická brána	20	21	19	19	14	17	21	20	21	21	20	16	18	18	17
10	Kráľovská lúka	21	21	21	21	17	20	21	20	21	21	21	16	21	21	18
14	Istragov	21	21	21	21	17	20	21	20	21	21	21	16	21	21	20

**Fig. 2.** A moisture gradient is shown using Ellenberg's indicator values and as supporting data from soil moisture measurements (Dunajské kriviny = PM1, Kráľovská lúka = PMP2, Istragov = PMP3) (Petrášová-Šibíková et al., 2017).

found at each MP. The selection of *Salicion* species was based on the relevant phytocenological literature (Borhidi et al., 2012; Jarolínek and Šibík, 2008; Willner and Grabherr, 2007). From all types of *Salicion* at MP in 1990 to 2013 there were found 28 native taxa that were used in the trend analysis.

Assessment of the impact of changed conditions

The abundance of neophytes after the hydrological change was used to evaluate the changes. Neophytes are affected by the

dynamics of GWL changes in the number of species indicate changes taking place in ecosystems. The species were determined according to the inventory of non-native flora of Slovakia (Medvecká et al., 2012). In order to evaluate the impact of changed conditions on the long-term dynamics of the floodplain forest, soil moisture measurements were paired with five species ecological characteristics (Ellenberg, 1988) recorded in phytosociological relevés. There were analysed time series and identified trends for four selected ecological parameters/species groups: (1) soil moisture, (2) ecological

factors, (3) *Salicion* species, and (4) neophytes. Changes in soil moisture detected by measurements at depths of 20, 100 and 150 cm were evaluated. We supplemented the assessment based on biota monitoring areas with a full-area assessment of the development of forest stands based on joint analyses with the results of the NFC.

RESULTS

The analysis of changes in the species composition and ecological factors showed that the observed localities underwent negative changes in the monitored years. These were most visible in MP locations outside the influence of the subsidy object. The community change in these localities was caused by a decrease in soil moisture accompanied by changes in the floristic composition, a decrease in the number of so-called "*Salicion*" species and by increasing the number or coverage of neophytes.

MP6 Dunajské kriviny

MP6 Dunajské kriviny is located next to the beginning of the subsidy channel near Dobrohošť. After the launch of the GW it was outside the influence of the Danube subsidy system. Due to the impact of GW, a drop in the GWL by 300 cm to 400 cm was predicted. Before the construction of GW, GWL was staggered and spanned 50 cm to 250 cm below ground level. The soil is the Haplic Fluvisol on loamy sediments, with gravelly strata below 115 cm with conditions for the rise of capillary water only at high GWL. Its decrease after the construction of GW was also about 250 cm to 350 cm. Soil moisture before starting the GW was in the interval of 11 to 26% vol. at a depth of 50 cm, at a depth of 100 cm from 19% to 26% vol. After the start of waterwork it fluctuates significantly, at a depth of 50 cm from 3% to 33% vol., at a depth of 100 cm from 11% to 34% vol. (Fig. 3). According to the map of forest types, the site is sometimes registered in the most extreme category *Carbonaceous-soils elm stands* (Gábor in Matečný et al., 2018).

On this area in 1990 originally found a willow-poplar forest with white poplar (*Salici-Populetum typicum*, variant with *Cornus sanguinea*; Jurko, 1958). After the year 1992 GWL decreased, followed by a change in ecological composition of

species (Fig. 4). There was a decline of the white poplar (*Populus alba*) tree canopy. The tree layer became broken only having now a low coverage (around 15%). It was replaced by a close layer of shrubs. The moisture-tolerant plants gradually disappeared from the site. In 2013, a connection from the subsidy channel to the original perimeter channel was built, which slightly improved the situation. Despite this, GWL is permanently in the underlying gravel layer. An improvement of the current situation would be only achieved by raising the GW by at least 200 cm.

MP 9 Bodická brána

The area of MP 9 Bodická brána consists of a peninsula and an island. In the northern part there is a Šuľany side channel permanently carrying running water. After the construction of waterwork the GWL drop was estimated to be 300 cm to 400 cm. Since 1993, the side channels have been supplied only with water from the subsidy structure near Dobrohošť, which, in combination with the weirs, ensured stabilization of the water in the river arm system and the flow. The drop of water in the old riverbed of the Danube caused drainage and a decrease in GWL along its riverine zone. Topsoil of local Fluvisol consists of sandy and clay-sandy horizons with a thick gravel layer starting at 115 cm. Before the construction of the GW ground water level oscillated in the range of 50 cm to 450 cm. After the construction of GW, it is more stable at a depth of 300 cm to 400 cm, rarely even 100 cm. Soil moisture until 1993 had fluctuated less, it was in the range of 12 to 36% vol. at a depth of 50 cm and 26 to 40% vol. at a depth of 100 cm. After the waterwork was put into operation at the depth of 50 cm it fluctuated with an interval of 4 to 41% vol. and at a depth of 100 cm from 11 to 45% vol. (Fig. 5).

The monitored plot TMP-9A was originally a stand of hybrid poplar (*Populus x canadensis*). In 1993 it was clear-cut and replaced by a poplar monoculture. The growth is in a strip along the Danube with a negative drainage effect of the old riverbed. Within the forestry classification, this is the Oak-Ash woodland on semigleys (*Querceto-Fraxinetum*). Neither the simulated floods in 1995 nor 1998 did change the negative soil moisture conditions. The vegetation was only flooded during the extreme floods (June 2013).

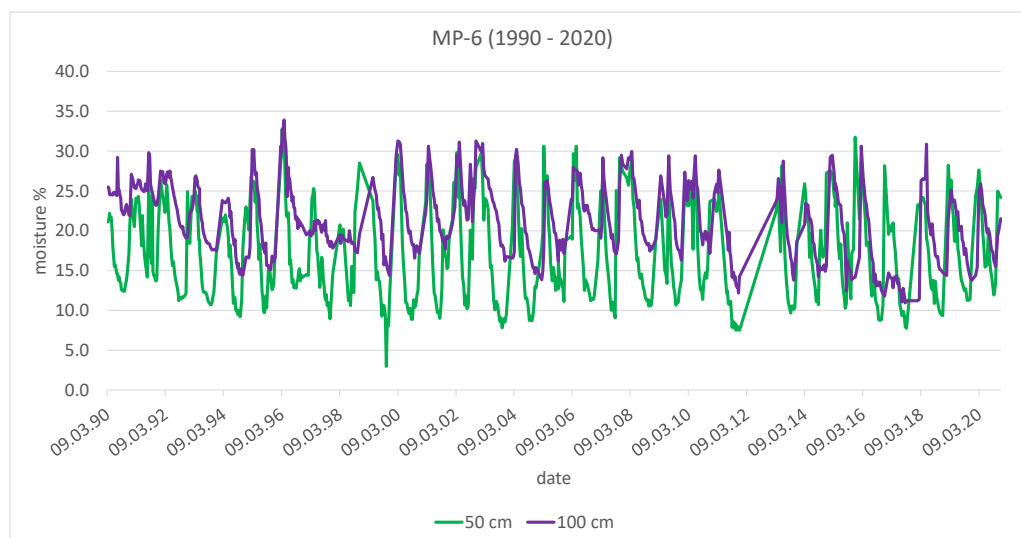


Fig. 3. Soil moisture for selected horizons on MP6 years 1990–2020.

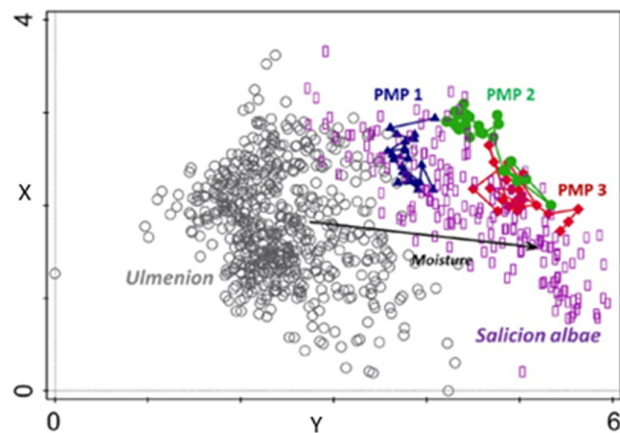


Fig. 4. Shift of the community of phytocenoses on MP 6 (PMP1) to a drier variant after building of Gabčíkovo Waterwork (Petrášová-Šibíková et al., 2017).

Stand TMP 9B with prevailing willows was originally established by a natural regeneration on clay-sandy alluvium. The area was not originally registered as a forestry land. It was a softwood floodplain forest of the *Salici-Populetum* type, a variant with *Urtica dioica* (sensu Jurko, 1958). After the launch of the GW, after the GWL drop, most of the willows dried up, the canopy was broken and more open, since the hydrological regime changed. Today, the area projection of the crowns of the tree layer here is only around 40%.

MP10 Kráľovská lúka

MP 10 Kráľovská lúka is for the most part a natural monument – an isolated oxbow leftover. GWL is close to the surface. Before the construction of the GW, it was 100 cm to 300 cm below the ground; after construction it is being stabilized at a depth of 100 cm to 200 cm and occasionally even near the surface. Capillary rise is made possible by the textural composition of carbonaceous Fluvisol with clay loam and clayey subsoil. The rising water affects the entire soil profile.

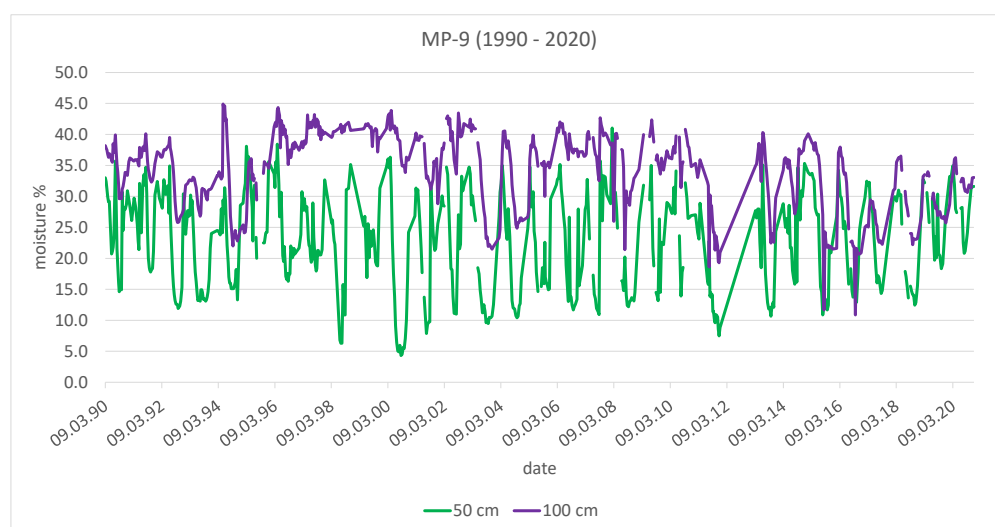


Fig. 5. Soil moisture for selected horizons on MP9 years 1990–2020.

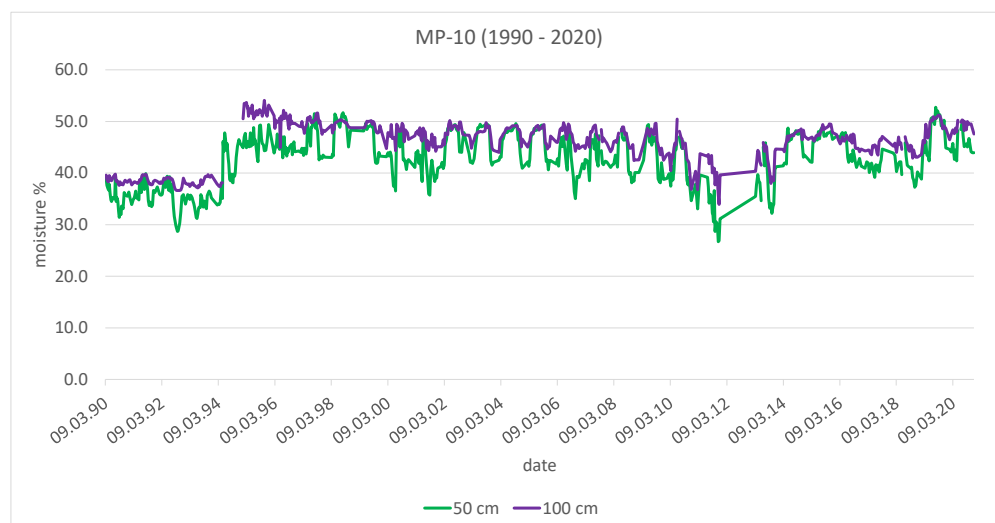


Fig. 6. Soil moisture for selected horizons on MP10 years 1990–2020.

Development of soil moisture before the construction of GW was in the interval of 29 to 40% vol. at a depth of 50 cm, at a depth of 100 cm from 37 to 40% vol. After the start of the GW is stabilized, at a depth of 50 cm in interval from 27 to 53% vol., at a depth of 100 cm from 34 to 54% vol. (Fig. 6). This is an area with the best and relatively balanced moisture conditions.

On MP 10, two stands of floodplain forest are monitored: TMP 10A - waterlogged type in terrain depression, with the occurrence of moisture-demanding species as well as the protected species *Leucojum aestivum*. TMP forms the margin in 2020 of a 60-year-old willow and white poplar stand with a natural wood composition in the main level. On a relatively elevated part, there is a homogeneous willow wood (TMP 10B). It is the remainder of a 52-year-old monoculture of tall willow with an undergrowth of nitrophilous, less moisture-demanding species. The mother stand was harvested in 2016, but the trees on the TMP were left behind. In the forestry classification, the habitat is already represented by the Oak-Ash on semigley soil (*Querceto-Fraxinetum*; Matečný et al., 2018). The habitat conditions after the construction of the GW can be considered permanently stabilized, balanced and relatively favourable at this plot.

MP14 Istragov

MP14 Istragov represented one of the wettest areas on the Danube inland delta before the construction of the GW (it is a relic of the Danube island). In the central part of the MP there was a flooded lagoon, connected to the perimeter channel by a narrow artificial channel. After the construction of the GW, the GWL water drop was estimated to be 300 cm to 400 cm. The soil is represented by carbonaceous sandy Haplic Fluvisol without coarse fragments. GWL is being fluctuating here as it had been earlier. However, it decreased of about 100 cm. The annual dynamics of the soil moisture is significant, before the construction of the GW it was at a depth of 50 cm in the interval of 20 to 30% vol., at a depth of 100 cm from 5 to 37% vol. After start of the GW at a depth of 50 cm is in intervals from 8 to 46% vol., at a depth of 100 cm from 1 to 40% vol. (Fig. 7). A decrease in soil moisture indicated a partial deterioration of conditions.

According to the results of measurements and modelling (Matečný, 2020), groundwater currently flows eastward to the tail-race channel from deeper horizons on the Hungarian side of

the Danube. In winter, it is located at a depth of 300–500 cm, in summer it is mostly 200–300 cm below the ground. In 2014 a new subsidy structure was built from a seepage channel, which allows parts of the perimeter channel to be occasionally filled with water up to a height of 100 cm. The site has been occasionally flooded with surface water, e.g. in 2010 to a height of approx. 80 cm above the ground, in June 2013 during the flood 200 cm. Waterlogged and flooded willow wood was a typical local community. In terms of the habitat type, it was originally a wet type with the *Salici-Populetum myosotidetosum* (Jurko, 1958). After the launch of the GW, the hydrological conditions changed significantly. The willows on the area dried up. The area turned into a growth of less moisture-demanding nitrophilous herbs, the original moisture-loving species disappeared. In 2008, the remnants of the original trees were harvested, and a new culture of Canadian poplar was planted on the TMP. In the first years to follow poplar growth was slow, several specimens died, lack of moisture manifested on the assimilation apparatus of trees. Currently, the increase in height and thickness of the poplars is satisfactory, since in the meantime the roots had become in contact with the capillary fringe.

The current state of the tree composition in the inundation area of the Dobrohošť - Sap section of the Danube

In the monitored area following tree species predominate (area share $\geq 0.5\%$): *Populus I 214* with an area share of 58.02%, *Populus alba* (and *Populus x canescens*) 11.69%, *Salix alba* 11.49%, *Fraxinus excelsior* (and *Fraxinus angustifolia*) 5.26%, *Populus Robusta* 3.59%, *Populus nigra* 1.43%, *Quercus robur* 1.23%, *Robinia pseudacacia* 1.18%, *Acer pseudoplatanus* 1.09%, *Negundo aceroides* 0.7%, *Alnus glutinosa* 0.5%, *Juglans nigra* 0.5%. Most of the territory has been dominated by stands of breaded poplars for decades.

The current woody composition of the forest stands is also evaluated at the level of stand mixtures of woody plants (Fig. 8). The basic unit is the stand type (PT), the higher hierarchical unit is the economic set of stand types (HSPT). In the given area, 66.44% of the total vegetation area is HSPT poplars (hybrids), HSPT Softwood floodplain forests make up 23.79%, and HSPT Hardwood floodplain forests 9.18%. Small areas are made up of HSPT 78 *Robinia* and HSPT 79 Alder.

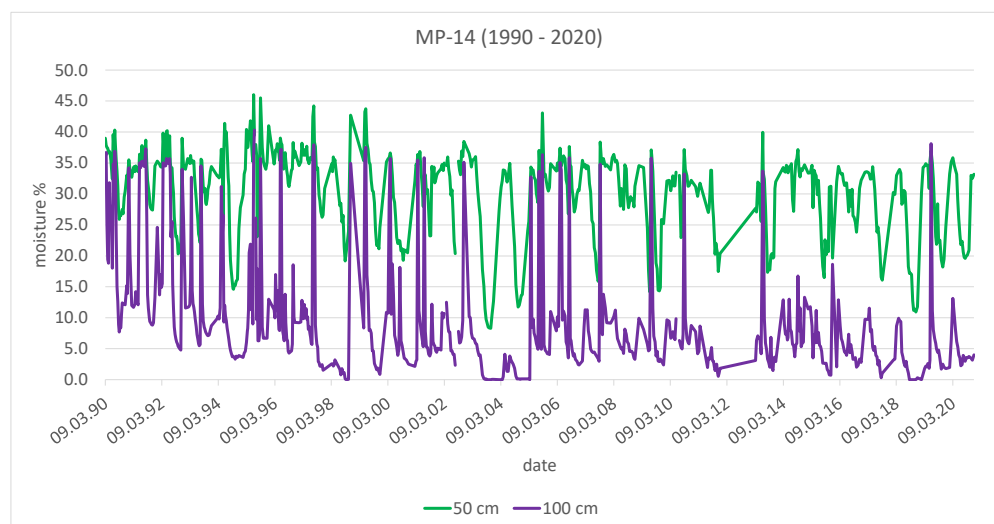


Fig. 7. Soil moisture for selected horizons on MP14 years 1990–2020.

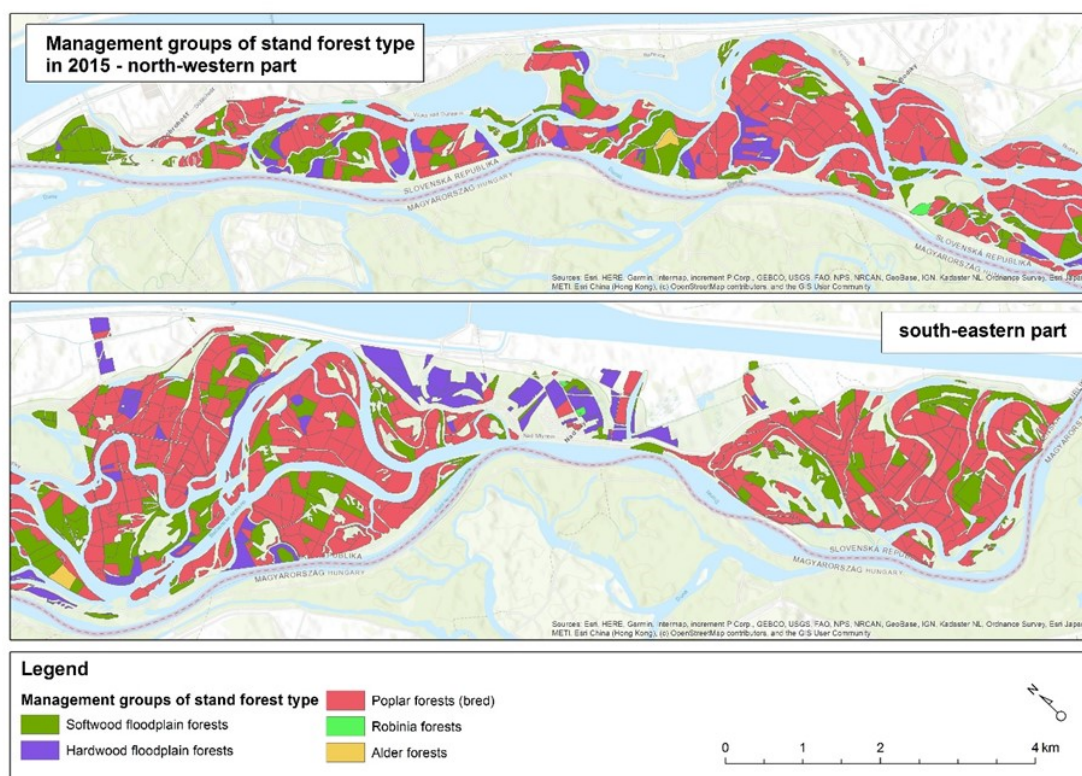


Fig. 8. The current state of forest stands expressed by the distribution of economic sets of stand types (HSPT) (NFC, Zvolen 2015).

Table 2. Share of area changes of forest type groups in the period between 1990 and 2015 (NFC, Zvolen).

Forest type groups	Share in %	Change
<i>Saliceto-Alnetum</i> > <i>Querceto-Fraxinetum</i>	4.66	to drier
<i>Querceto-Fraxinetum</i> > <i>Ulmeto-Fraxinetum populeum</i>	9.91	to drier
<i>Ulmeto-Fraxinetum populeum</i> > <i>Ulmeto-Fraxinetum carpineum</i>	5.65	to drier
<i>Saliceto-Alnetum</i> > <i>Ulmeto-Fraxinetum populeum</i>	2.43	to drier
<i>Saliceto-Alnetum</i>	8.93	no change
<i>Querceto-Fraxinetum</i>	22.46	no change
<i>Ulmeto-Fraxinetum populeum</i>	32.22	no change
<i>Ulmeto-Fraxinetum carpineum</i>	4.8	no change
<i>Querceto-Fraxinetum</i> > <i>Saliceto-Alnetum</i>	2.04	to wetter
<i>Ulmeto-Fraxinetum populeum</i> > <i>Querceto-Fraxinetum</i>	1.75	to wetter
<i>Ulmeto-Fraxinetum populeum</i> > <i>Saliceto-Alnetum</i>	3.26	to wetter

Changes in typological forest units in 1990-2015

When comparing earlier typological mapping from the year 2015 and from the period before GW was put into operation (year 1990) on the overlap of an identical territory with an area of 2000 ha, it is possible to note an increase in the area share of hardwood floodplain forest by 5.77%, in the group of forest types (SLT) *Ulmeto-Fraxinetum carpineum* by 5.63%; in SLT *Ulmeto-Fraxinetum populeum* by 0.13%. At the same time, the area shares of softwood floodplain forest in SLT *Saliceto-Alnetum* decreased by 1.71%. The relative share of the area of transitional floodplain forest decreased by 4.05%, in SLT *Querceto-Fraxinetum* there was a decrease of 6.01%, and the area share of the area of SLT

Ulmeto-Fraxinetum populeum increased slightly by 1.96%, respectively (Table 2).

A shift towards drier communities was noted especially in the upper part of the assessed territory, roughly in the section from Dobrohošť, around Vojka side channel to the Vojka Lake. It was mainly a shift of communities of transitional floodplain forest (especially SLT *Ulmeto-Fraxinetum populeum*) towards the habitats of the hardwood floodplain forest (especially SLT *Ulmeto-Fraxinetum carpineum*). Compared to the situation in 1990, the conditions for the occurrence of softwood floodplain forest communities (formerly SLT *Saliceto-Alnetum*) have almost completely disappeared in this part of the territory.

Another part of the territory, with more significant changes in the water regime compared to the state before GW was put into operation, is located in the lower part of the territory, to the south of the old port of Gabčíkovo until the confluence of the old and new Danube riverbed next the village of Sap. Changes were recorded in the area of sites suitable for the expansion of the so-called communities of softwood and transitional floodplain forest. These are the changes in the occurrence of SLT *Saliceto-Alnetum*, SLT *Querceto-Fraxinetum* and SLT *Ulmeto-Fraxinetum populeum*. The shift to wetter habitats was identified only rarely, especially in locations far from the old Danube bed, but currently affected by the right-side seepage channel.

Between 1990 and 2015, 68.43% of the territory remained unchanged at the level of forest type groups (SLT). A change in habitat conditions towards drier SLT was recorded on 23.61% of the territory.

DISCUSSION

The impact of water management objects and measures is reflected in changes in the hydrological regime of surface and underground waters. These changes can subsequently be manifested by changes in the aeration zone, with consequences in the change of vegetation (Čenohouz et al., 2012; Gallay et al., 2021; Havlíček et al., 2018, 2022; Lichner et al., 2023; Petlušová et al., 2017, 2021; Pipíšková et al., 2022; Tárník and Igaz, 2015).

The monitored natural system in the area of the Slovak part of Danube inland delta branch system is characterised by its complexity resulting from a combination of natural and anthropogenic processes. For a comprehensive evaluation of changes after the implementation of the GW to operation it is essential to have a database from long-term monitoring available. Subsequently, it is necessary to find a solution to ensure such a surface and underground water regime, that will best meet the ecological needs of the given territory.

Our results demonstrate that the GW had direct influence on forest ecosystems in observed area, particularly in the softwood floodplain forests. Transition of the Danube Waterflow from the old Danube riverbed to the new channel led to a significant decrease of the water level in the old riverbed. The average discharge of 2025 m³ s⁻¹ in the Danube old riverbed before damming was reduced to only 250 m³ s⁻¹ in winter and to 600 m³ s⁻¹ in summer (Lisický and Mucha (Eds.), 2003). Data from soil moisture measurement shows different development on observed plots.

As required by the Water Framework Directive (RSV, 2000), the renaturation of watercourses should generally lead to an improvement in the ecological status of all habitats in the inundation area of large rivers. For this reason, it was necessary to find ways to comprehensively evaluate these changes. From the surface waters perspective, the problems are represented by low water levels in the old riverbed of the Danube and their unnatural fluctuations, insufficient water supply to some locations (Istragov, Dunajské kriviny, the riverfront zone of Bodická brána). Furthermore, there is a very low frequency of flooding of the inundation area. After the damming of the Danube, extensive flooding of the inundation area does not occur often enough. The artificial flood system cannot ensure surface flooding of the entire territory. The main problem in terms of groundwater is the low water level combined with changes in the flow direction and speed of the groundwater in the inundation area along the old riverbed of the Danube, a lower range of water level fluctuations (Matečný, 2020).

In accordance with the study by Lisický and Mucha (2003), the goal of the proposals is to restore the integrity of the

ecosystem between Dobrohošť and Sap (between the original old embankments). Following measures were proposed to improve the current state:

- preventing the reduction of the area of water bodies in the area of interest,
- interconnecting the branch systems on the Slovak (and Hungarian) side with the old riverbed of the Danube,
- raising the water level in the old riverbed of the Danube with a system of bottom weirs,
- creation of new arms, or filling of channels which are currently empty to ensure selected areas of inundation,
- provision of underground and surface water subsidization of areas with significant deficits,
- ensuring an increased degree of protection for other valuable areas in the inundation, including stabilization and protection of original stands.

Considering these requirements within the framework of the SEA studies (Strategic assessment of the impacts of the Gabčíkovo – Nagymaros Water Works System on the environment – SEA (Matečný et al., 2011; 2018; 2019) a solution with four weirs in the old riverbed of the Danube was projected, with a parallel assessment of the impact on the regime of surface and underground waters and the subsequent impact on the fauna and flora on the Slovak part of old Danube between Dobrohošť and Sap.

CONCLUSION

The construction and operation of waterworks has a significant impact on natural ecosystems. In recent years, great importance has been attached to the assessment of their negative impact and the proposals to minimize their impact, as well as the revitalization, especially of large rivers. Based on this premise, the aim of this research paper was created. The analysis of changes in the species composition and ecological factors showed that the monitored MPs underwent negative changes in the monitored years. They were most visible in MPs outside the influence of the subsidized object. The species composition change in these localities was caused by a decrease in soil moisture accompanied by changes in the floristic composition, a decrease in the number of “*Salicion*” species and by increasing the number or coverage of neophytes.

When comparing the species composition from the typological mapping of the state to 2015 and from the period before GW was put into operation (status in 1990) on the overlap of an identical territory with an area of 2000 ha, it is possible to find an increase in the area share of hardwood floodplain forest habitats by 5.77%, in the group of forest types *Ulmeto-Fraxinetum carpineum* by 5.63%; in *Ulmelum* by 0.13%. At the same time, the area shares of softwood floodplain forests *Saliceto-Alnetum* decreased by 1.71%. The change to wetter habitats was identified only occasionally, especially in locations far from the old Danube riverbed, but currently affected by the right-hand seepage channel. Between 1990 and 2015, 68.43% of the territory remained unchanged at the level of forest type groups. A change in habitat conditions towards drier forest types was recorded on 23.61% of the territory.

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