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PLANT COMMUNITIES IN DRAINAGE DITCHES – CONDITIONS, CHARACTERISTICS AND ENVIRONMENTAL FUNCTIONS

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Abstract:
Ditches and drainage canals are an important element in the post-bog meadows. Their basic function is to regulate air-water relations in ecosystems, mainly in agrocenoses. The environmental functions of ditches and canals consist of maintaining a large diversity of flora and fauna species due to high humidity of these ecosystems. The study of plant communities in the ditches in the post-bog meadows habitat of the Supraśl Dolna valley structure in 2010–2020 was carried out. There were 23–27 species of plants in the ditches. Species diversity did not change significantly during this period, while changes in individual species' coverage and viability were found. The species were classified into two rush communities: reed rush (*Phragmitetum australis*) and rush (*Phalaridetum arundinaceae*). As a result of the lack of maintenance of the ditches, an invasive species of flapped barbed (*Echinocystis lobata*) was found. The natural valorization carried out by the Oświt method showed that plant communities in the drainage ditches are in the lowest valorization classes.

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Key words: habitat, invasive species, valley ecosystems, diversity of flora, environmental valorization.

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INTRODUCTION

There are flowing natural surface waters referred to as surface water bodies (JCW/SWB) in river valleys and riparian habitats. The concept of the surface water bodies was introduced along with implementing the Frame Water Directive (Directive … 2000/60/EC) and Water Law (2017), to manage waters and their environmental monitoring efficiently. Apart from the natural JCV (SWB) in river valleys and highly humid areas, there are also drainage ditches, drainage and irrigation channels and drainage networks (Kaca and Interewicz, 1991; Kiryluk, 2007). The main function of melioration devices is the regulation of water conditions in used agrocenoses and protection of land against degradation and flooding (Water Law, 2017). For these devices to function efficiently, they should undergo periodic maintenance.

Valley ecosystems are important and highly diversified natural environment elements (Dajdok and Wuczyński, 2005). The basic environmental functions of ditches and canals are to maintain high species diversity. Various biotopes occur in the ditches, affecting the balance in the environment (Załuski and Kamieńska, 1999; Dąbkowski and Pachuta, 1996) and they are also a refuge for many species of avifauna (Dondina *et al.*, 2018; Fuller, *et al.*, 2004; Pawłat-Zawrzykraj and Podawca, 2017). The environmental functions of the ditches were confirmed in the RDP agri-environmental and climate programs (www.arimr.gov.pl). The occurrence of drainage ditches in protected areas may interfere with the performance of their irrigation and drainage functions (Grzywna and Szajda, 2008; Kiryluk, 2007). Conservation measures in ditches and canals, progressive eutrophication of waters contribute to the formation of anthropogenic succession in plant communities occurring there (Kryszak *et al.*, 2011). Proper selection of the type and timing of maintenance works on the bottom and the slopes of the watercourse may reduce changes in the composition of communities and the number of taxa (Bondar-Nowakowska *et al.*, 1997; Przybyła *et al.*, 2011). The groundwater table lowering significantly influences the floristic diversity in the summer (Kiryluk, 2007).

Drainage ditches occurring in areas devoid of forest complexes and shrubs may constitute a suitable habitat for insects, small mammals, amphibians, and reptiles or birds – places of their reproduction, feeding, or wintering (Boutin *et al.*, 2003; Corbacho *et al.*, 2003; Deschenes *et al.*, 2003; Fuller *et al.*, 2004; Karg, 2004; Orłowski, 2004; Sobczyk, 1998). Plant communities accompanying natural watercourses and artificial canals are often referred to as buffer zones or biogeochemical barriers (Szpakowska and Życzyńska-Baloniak, 1994; Haycock *et al.*, 1996; Ryszkowski *et al.*, 2002). The several-meter wide buffer zones near the ditches are very effective barriers that stop biogens from migrating from higher-lying areas (Dajdok

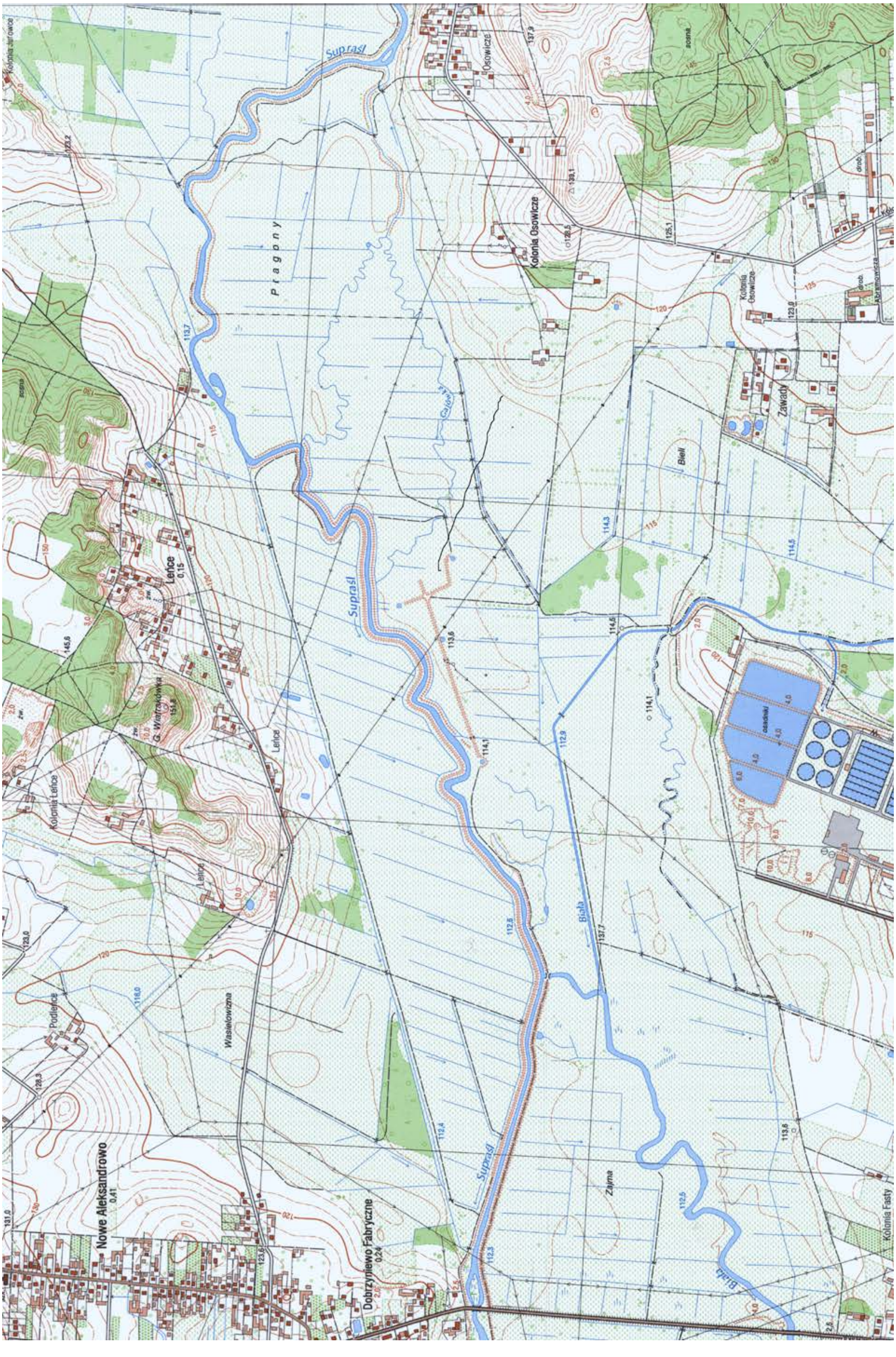

Fig. 1. Land reclamation system in the Supraśl Dolna valley (km: 7+500 to 15+300). Source: own elaboration based on GUGiK topographic map Nowe Aleksandrowo N-34-107-A-c-4.

and Wuczyński, 2005). The effectiveness of buffer zones' functioning depends on the species composition of communities and the width of the barrier (Gamrat *et al.*, 2008; Kryszak *et al.*, 2011). Buffer zones with a width of 2 to 5 m, located on agricultural land, along drainage ditches, streams, ponds, springs, small water reservoirs, may be the basis for receiving subsidies under agri-environmental and climate packages (www.arimr.gov.pl). The large diversity of flora in watercourses and drainage ditches also allows for assessing water purity in places using the Mean Trophic Rank method (Zbierska *et al.*, 2002). The anthropopression of large-scale conventional agriculture reduces biodiversity in cultivated areas and grasslands. Maintaining species diversity of flora in drainage ditches may compensate for this loss and affect many disappearing plant species (Dajdok and Wuczyński, 2005; Grzywna and Szajda, 2008; Podlaska, 2011).

Few studies in the literature on changes in plant communities in drainage ditches were observed over longer periods. The study aimed to assess conditions of plant communities in drainage ditches in post-bog habitats and the natural valorization of these habitats.

MATERIALS AND METHODS

The research was carried out in the lower section of the Supraśl River. The Supraśl river valley and the water system (Fig. 1) fulfill important environmental and economic functions due to their location between the Bialystok agglomeration and the Knyszyńska Forest complex). The economic functions comprise providing water for irrigation of post-bog meadows in the area of approximately 5000 ha, drainage of meadows in the early spring and heavy rainfall in summer. Environmental functions include mainly protection of large areas of post-bog against their degradation and protection of valuable natural plant communities. There are also water abstraction points for the Bialystok agglomeration by the Supraśl River.

In 2010, 2015 and 2020, floristic lists of plant communities in selected drainage ditches were prepared (Fig. 1). The research was carried out in three main drainage ditches named: Ditch A, Ditch B, Ditch C. Direct measurements of the parameters of water-drainage devices were performed according to the method of Kaca and Interewicz (1991). The results of the obtained floristic tests were calculated using the Microsoft Excel package. Due to the occurring processes of silting, shallowing and overgrowing of ditches, historical parameters (relating to the period before 2000) and current data are provided.

Nomenclature of species, scales of quantity, and viability were given following the Braun-Blanquet method (Pawłowski, 1972; Matuszkiewicz, 2008). Quantity of individual species was given according to the 7-point Braun-Blanquet scale: r – rare species, + – sparse species; 1 – <5% coverage of the recording area; 2 – 5–25% coverage of the area; 3 – 25–50% coverage of the area; 4 – 50–75% coverage of the area; 5 – 75–100% coverage of the recording area. Viability of the species is given according to the 4-point Braun-Blanquet scale: 1 – plants well-developed, undergoing a full, normal development cycle; 2 – plants developed luxuriantly, but not going through the full development cycle; 3 – poorly developed plants, reproducing, but not having a full life cycle; 4 – plants germinating randomly, not reproducing completely. The natural valorization of the studied plant communities was carried out using the method of Oświt (2000) and instructions (Zalewska *et al.*, 2013). Using Oświt (2000) method, a natural evaluation of the habitats of drainage ditches was performed. This method considers the quantity and evaluation points assigned to individual species. In the Oświt method, each species occurring in wet, boggy, and post-bog habitats is assigned a valorization number on a scale from 1 to 10, where 1 is the lowest, and 10 – the highest natural value of the species. The average indexation indexes adopted in this method were calculated considering the presence or absence of a given species in the habitat under study and its valorization number.

RESULTS

Land reclamation devices, including irrigation and drainage ditches, were made on the tested facility in the last century seventies. iImportant parameters of these ditches are bottom width, bottom slope and depth, as they influence the efficient drainage and supply of water by gravity from the Supraśl River. Over time, the ditches became shallow and silted, and their gradient was reduced (Table 1). As a result of changes in parameters and unsystematic maintenance of ditches, their renaturization and overgrowing with multi-species plant communities occurred.

Plant communities on scarps of the ditches

In 2010–2020, there were 27–23 species of vascular plants on the slopes of the studied ditches (Table 2). These were communities with high water requirements with a significant share of *Carex* species. The quantity determined by the Braun-Blanquet method (2008) showed great di-

Table 1. Parameters of the studied drainage ditches.

Ditch name	Length [m]		Bottom width h [cm]		Width of the crown [m]		Mean water level in ditch [cm]
	Historical	Modern	Historical	Modern	Historical	Modern	
Ditch A	280	274	75	42	3.50	2.0	15–20
Ditch B	360	350	55	30	3.70	3.6	40–60
Ditch C	320	300	75	50	4.2	4.0	15–35

Source: own elaborated.

Fig. 2. The slopes of the ditch are overgrown with rushes. *Phragmitetum australis* (Phot. A. Kiryluk).

Table 2. Phytosociological characteristics of plant communities on the scarps of drainage ditches in the Supraśl Dolna object.

Species	Quantity of species			Viability of species		
	2010	2015	2020	2010	2015	2020
Alopecurus geniculatus L.	2	2	2	1	1	1
Carex riparia Curtis	2	2	2	1	1	1
Carex acutiformis Ehrh.	1	1	+	1	1	1
Carex acuta L.	2	2	2	1	1	1
Carex elata All.	1	1	1	1	1	1
Equisetum fluviatile L.	+	r	–	2	1	–
***Galium palustre* L.**	2	**1**	1	2	3	3
Glyceria fluitans (L.) R.Br.	1	**1**	1	1	1	1
Glyceria maxima (Hartm.) Holmb.	1	**2**	2	1	1	1
Hydrocharis morsus–ranae L.	+	**+**	+	2	1	1
Iris pseudacorus L.	1	**–**	–	2	–	–
Phalaris arundinaceae L.	2	**2**	2	1	1	1
Phragmites australis (Cav.) Trin. ex Steud.	2	**2**	2	1	1	1
***Polygonum bistorta* L.**	+	**r**	r	2	2	3
Ranunculus repens L.	1	**1**	1	1	1	1
***Ranunculus linqua* L.**	r	**–**	–	1	–	–
Rumex hydrolaphatum Huds.	+	**+**	+	1	1	1
Sagittaria sagittifolia L.	1	**1**	1	1	1	1
Scirpus sylvaticus L.	1	**1**	1	1	1	1
Sium latifolium L.	1	**1**	1	1	2	1
Sparganium erectum L. emend. Rchb. s.str.	1	**+**	+	2	1	2
Typha anqustifolia L.	1	**1**	1	1	1	1
Typha latifolia L.	2	**2**	1	1	1	1
Urtica dioica L.	2	**2**	2	1	1	1
***Valeriana officinalis* L.**	1	**1**	r	1	1	1
Invasive species						
Echinocystis lobata Michaux (Torrey and A. Gray)	1	**2**	2	1	1	1
Solidago canadensis L.	1	**4**	2	1	1	1
Mean plant–covered	1,11	1,28	1,17	–	–	–
Average viability of species	–	–	–	1.08	1.16	1.26
Number of species	27	25	23			

Explanations: (–) species is not present.

Fig. 3. Fields of *Urtica dioica* on the slopes of ditches (Phot. A. Kiryluk).

versity and no clear dominance of species. The average viability was 1.08–1.26 on a four-point scale, proving the fairly good condition of flora species. In some of the more wet parts of the slopes, compact rush communities were found: *Phragmitetum australis* and *Phalaridetum arundinaceae* (Fig. 2). The share of *Valeriana officinalis*, which is important in the environment of ditches due to allelopathic properties, has decreased and its regression indicates overdrying of the habitat. In the middle of the research period, invasive species on the slopes: *Echinocystis lobata* and *Solidago canadensis*, were recorded.

Throughout the research period, the presence of field communities of *Urtica dioica* was found, indicating nitrogen release in rotting peats (Fig. 3).

Plant communities on the bottom of drainage ditches

The width and longitudinal slope of the bottoms of the ditches decreased over the period considered. Narrowing of the trench and reduced water flow contributed to increased water eutrophication (Fig. 4). Bottoms of the ditches have been significantly narrowed, mainly due to the lack of the so-called thorough conservation, removing silts (Bondar-Nowakowska *et al.*, 1997). The deterioration of the water conditions in ditches resulted in a reduced quantity of species *Caltha palustris*, *Ranunculus repens*, *Acorus calamus*, *Cardamine pratensis*, *Iris pseudacorus* and the expansion of *Lemnia minor* (Table 3; Figs 4–5). The viability of the species remained at a good level (1.24–1.36).

Due to abandonment in the following years, the maintenance of ditches and periodic or long-lasting water shortages, the development cycle was limited. It mainly affects *Caltha palustris* and *Ranunculus repens*.

Research on the species composition of plant communities showed a decrease in number of species on slopes of the ditches in 2015 and 2016 (Fig. 6B). One of the reasons for the reduction was a reduced rainfall in summer (Kiryluk, 2019). In the studied period, the mowing of vegetation on scraps was also limited, which prevented the growth and development of low-growing species.

Fig. 4. *Lemna minor* on the bottom, indicating a strong eutrophication of the water in the ditch (Phot. A. Kiryluk).

Table 3. Phytosociological characteristics of plant communities on the bottom of drainage ditches in the Supraśl Dolna object.

Species	Quantity of species			Viability of species		
	2010	2015	2020	2010	2015	2020
Acorus calamus L.	2	2	1	1	1	1
Alisma plantago-aquatica L.	1	1	1	1	1	1
Alopecurus geniculatus L.	+	+	+	2	3	3
Caltha palustris L.	+	+	-	1	1	-
Cardamine pratensis L.	1	1	+	2	3	3
Carex riparia Curtis	1	1	1	1	1	1
Carex acutiformis Ehrh.	2	2	2	1	1	1
Carex appropinquata Schumach.	2	2	2	1	1	1
Carex acuta L.	2	2	2	1	1	1
Ceratophylum demersum L.	1	1	1	1	1	1
Eleocharis palustris (L.) Roem. et Schult	1	1	1	1	1	1
Elodea canadensis Michx.	2	2	2	1	1	1
Glyceria fluitans (L.) R. Br.	1	1	1	1	1	1
Glyceria maxima (Hartm.) Holmb.	2	3	3	1	1	1
Iris pseudacorus **L.**	1	1	+	2	2	3
Lemna minor L.	2	3	3	1	1	1
Lysimachia thyrsiflora L.	1	1	1	1	1	1
Phalaris arundinaceae L.	2	2	2	1	1	1
Phragmites australis (Cav.) Trin. ex Steud.	2	3	3	1	1	1
Polygonum amphibium L.	1	1	1	1	1	1
Potaemogeton crispus L.	1	1	1	1	1	1
Ranunculus repens L.	+	+	+	1	1	1
Senecio aquaticus ssp. *aquaticus*	+	+	+	1	1	1
Solanum dulcamara L.	r	r	r	2	3	3
Sparganium erectum L. emend. Rchb. s.str.	+	+	+	2	2	3
Typha anqustifolia L.	1	1	1	1	1	2
Mean plant-covered	1.16	1.23	1.16	–	–	–
Average viability of species		–	–	1.24	1.31	1.56
Number of species	25	26	25	–	–	–

Fig. 5. Declining quantity of *Caltha plustris* and *Ranunculus repens* in the ditch (Phot. A. Kiryluk).

Natural valorization of plant communities in drainage ditches

The environmental valorization and the calculated indices (Table 4) indicate that species from the III valorization class on the ditches' slopes had lower natural values. At the bottom of the ditches, species of greater value belong to the IV valorization class. Better humidity conditions mean that species with high water requirements find a place for growth and development in the bottom of the ditch; however, their viability is sometimes more endangered than species found on slopes.

A lower valorization index was found on the slopes of ditches (Fig. 6B). The reduction in the index was caused by the disappearance of large species, e.g. *Galium palustre* L. The deteriorating humidity conditions contributed to the disappearance of species on sacred trees

Invasive species in drainage ditches

In studies of the communities at the watercourse and the drainage ditches, *Echinocystis lobata*, which is an invasive alien species, was found. Its occurrence outside the natural range may threaten some communities' species diversity (Chmielecki and Kucharski, 2018; Dajdok and Tokarska-Guzik B., 2009; Dajdok and Pawlaczyk, 2009; Dylewski and Maćkowiak, 2014; Lenda *et al.*, 2019; Commission

Table 4. Natural indexation of appearing species of plants according to the method Oświt (2000).

Species	Number of valorization points in the studied habitats			
	Scarps of the ditch		Bottom of the ditch	
	2010	2020	2010	2020
Acorus calamus L.	–	–	4	4
Alisma plantago–aquatica L..	–	–	4	4
Alopecurus geniculatus L.	3	3	3	3
Caltha palustris L.	–	–	4	4
Cardamine pratensis L.	–	–	3	3
Carex riparia Curtis	–	4	4	4
Carex acuta L.	4	4	–	–
Carex acutiformis Ehrh.	4	4	4	4
Carex appropinquata Schumach.	–	–	4	4
Carex elata All.	4	4	–	–
Ceratophylum demersum L.	–	–	4	4
Eleocharis palustris (L.)Roem.et Schult	–	–	4	4
Elodea canadensis Michx.	–	–	4	4
Equisetum fluviatile L.	4	–	–	–
***Galium palustre* L.**	4	4	–	–
Glyceria fluitans (L.) R.Br.	4	4	4	4
Glyceria maxima (Hartm.) Holmb.	4	4	4	4
Hydrocharis morsus–ranae L.	4	4	–	–
***Iris pseudacorus* L.**	4	–	4	–
Lemna minor L.	–	–	4	4
Lysimachia thyrsiflora L.	–	–	8	8
Phalaris arundinaceae L.	4	4	4	4
Phragmites australis (Cav.) Trin.ex Steud.	4	4	4	4
Polygonum amphibium L.	–	–	4	4
***Polygonum bistorta* L.**	3	3	–	–
Potaemogeton crispus L.	–	–	4	4
***Ranunculus linqua* L.**	4	–	–	–
Ranunculus repens L.	4	4	4	4
Rumex hydrolaphatum Huds.	4	4	–	–
Sagittaria sagittifolia L.	4	4	–	–
Scirpus sylvaticus L.	3	3	–	–
Senecio aquaticus ssp. *aquaticus*	–	–	8	8
Sium latifolium L.	4	4	–	–
Solanum dulcamara L.	–	–	4	4
Sparganium erectum L. emend. Rchb. s.str.	4	–	4	4
Typha anqustifolia L.	4	4	4	4
Typha latifolia L.	4	4	–	–
Urtica dioica L.	2	2	–	–
***Valeriana officinalis* L.**	3	1	–	–
Number of species	27	23	25	25
The sum of valorization points	90	76	106	102
Average valorization index	3.30	3.31	4.24	4.08
Valorization class	III A little natural values	III A little natural values	IV B medium moderate natural values	IV B medium moderate natural values

Explanations: (–) species with negligible numbers were not included in the valorization table.

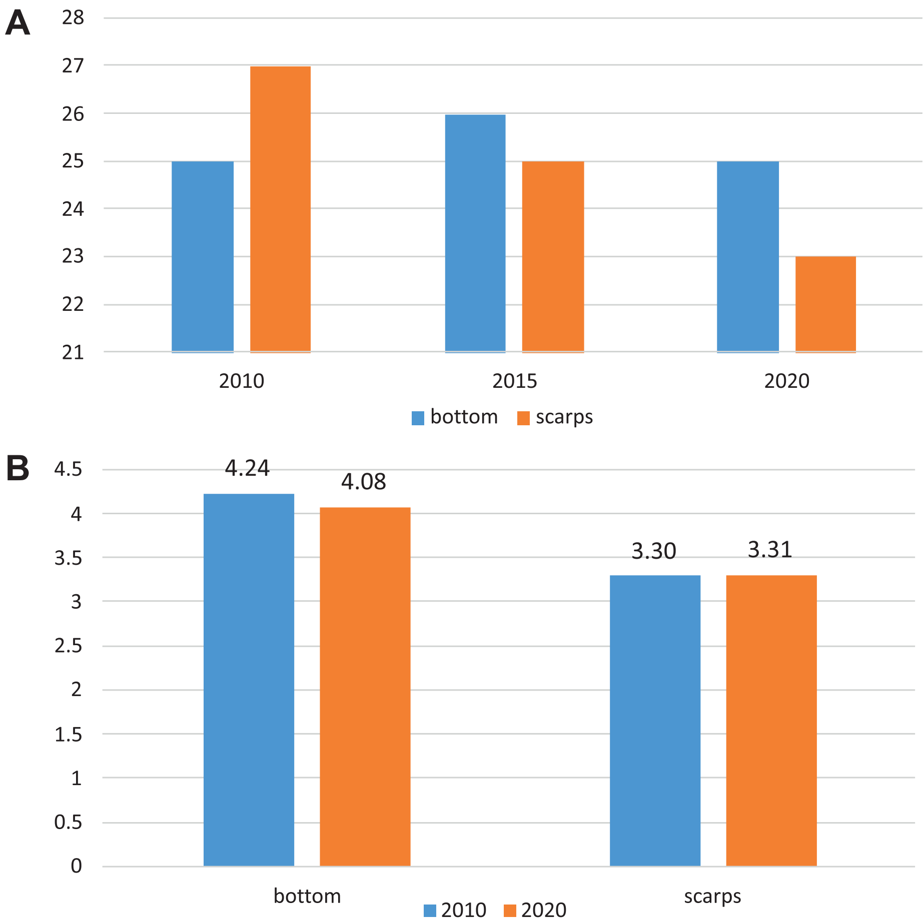

Fig. 6. A. Changes in the quantity of species occurring in the bottom and on the slopes of ditches in 2010–2020. B. Changes in the valorization indexes of plant communities in 2010–2020.

Implementing Regulation (EU) 2016/1141 of July 13, 2016). The species most often occurs in river valleys, along natural streams, canals, and drainage ditches. In full growth and flowering, it forms largely contained lobes. This species occurred in the research object in the rush communities of the *Phragmitetea* class. Due to its highly competitive abilities and allelopathic activity, *Echinocystis lobata* displaced from vegetation patches, among others common hops (*Humulus lupulus*). One reason for the spread of species on the studied object was the omission of periodic mowing of vegetation on slopes. Spreading of *Solidago canadensis* was also found on the ditch slopes (Dudek *et al.*, 2016) which, according to observations, was less invasive than *Echinocystis lobata*.

DISCUSSION

Changing the technical parameters of drainage ditches, consisting of reducing the bottom's width, leveling longitudinal slopes, significantly reduces their economic functions. Such a change was found in the studied ditches in the Supraśl facility, and it is also common in other places (Dąbkowski and Pachuta, 1996). As a result of these changes, the moisture regulation deteriorates (Directive … 2000/60/EC; Kaca and Interewicz, 1991; Kiryluk, 2007; Kłos, 2013; Pabijan and Stachowiak, 2019). In terms of nature, the reduction of water movement in the ditches may contribute to stabilizing living conditions for some flora and fauna species. Some authors believe that reducing interference with ditche biocenosis (abandonment or rarely mowing vegetation in ditches) may have a positive natural effect (Banach *et al.*, 2006; Bondar-Nowakowska *et al.*, 1997; Boutin *et al.*, 2003; Corbacho *et al.*, 2003).

In Poland, it is not a common practice in the agricultural use of drainage areas to leave strips along the ditches (buffer zones), despite the possibility of compensating the loss of production area employing agri-environmental-climate programs (Dajdok and Wuczyński, 2005). Many authors' research indicates the great importance of the ecotonic zones near the ditches (Orłowski, 2004). Changes in the species composition of plant communities (quantity, viability), which to some extent occurred in the three studied ditches in 2010–2020, were caused by the influence of economic factors, as well as the deterioration of water conditions. In the analyzed decade, low precipitation and reduced flows in the Supraśl River were found on the site, limiting the irrigation of adjacent meadows (Kiryluk, 2019). Research by Kryszak *et al.* (2011) also showed that the factor determining the floristic diversity of plant communities in drainage canals and ditches are water relations, depending e.g. on a current state of land reclamation devices and their maintenance. In the years preceding the research period, the author's research on the flora of post-bog meadows (Kiryluk, 2004, 2010) showed the presence of species classified as endangered: snotch yarrow (*Achillea ptarmica* L.), broad-leaved cuckoo (*Dactylorhiza majalis* Rchb. PF Hunt & Summerh), mud helleborine (*Epipactis palustris* (L.) Crantz), marsh pea (*Lathyrus palustris* L.) and old swamp (*Senecio paludosus* L.). An important problem in the flora of drainage ditches is the successive appearance of invasive species. In studies on the object, patches with the participation of *Echinocystis lobata* were recorded. In wet habitats with a feature similar to drainage ditches, the authors indicate the appearance of many alien species, e.g., *Impatiens glandulifera*, *Ambrosia artemisiifolia,* and Sosnowski's borscht (*Heracleum sosnowskyi*) (Chmielecki and Kucharski, 2018; Dajdok and Pawlaczyk, 2009; Jackowiak, 1999; Lenda *et al.*, 2019).

CONCLUSIONS

The studies of the condition and changes of plant communities in the drainage ditches on the post-bog site indicate a large diversity of species in these habitats (23–27 species). It should be noted that in the ditches, there are semi-natural conditions for many species of flora. Besides, species are under the influence of anthropopressure involving, among others mowing vegetation as part of maintenance works, periodic changes in moisture content in irrigation cycles. These factors affect the number of species and their viability. Research has shown that the ditches bottom has more favorable conditions for plants than on the slopes. So far, the practice was aimed at subordinating ditches as drainage devices, improving production conditions on grasslands and arable lands. The natural functions of these specific ecosystems were marginalized or not considered. Due to the deteriorating water balance in the soil environment, resulting from the decreasing rainfall trend, important functions of ditches as refuges for maintaining the diversity of fauna and flora should be noted. The natural valorization of plant communities on the slopes and in the bottom showed relatively good valorization indicators. An efficient way to protect these habitats is to their inclusion in agri-environmental and climate programs under in current the RDP for 2014–2020 (Pawluśkiewicz, 2016) and in EFA of the direct payments greening (Piekut, 2016). Keeping of such places is also included in EU Biodiversity Strategy for 2030 (COM(2020) 380 final).

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