

## RELICT BOREAL WILLOWS (*SALIX LAPPONUM* AND *SALIX MYRTILLOIDES*) AS AN ELEMENT OF PHYTOCOENOSES OVERGROWING THE WATER BODIES IN EASTERN POLAND

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**Abstract:** The aim of the present research, which was conducted in the years 2002 and 2012, was to determine whether and to what extent the biocenotic changes taking place in the aquatic peatland ecosystems affect the state of the populations of endangered boreal willows (*Salix lapponum* and *Salix myrtilloides*) in the Łęczna-Włodawa Lakeland (Eastern Poland). The results of this research show that the decline in population numbers of the studied species is associated with the changes that have taken place in their habitats since the 1950's. These changes manifest themselves in the species composition and structure of the phytocoenoses of which the species under investigation are components. In consequence, the intensive process of ecological succession can accelerate the rate of extinction of *S. lapponum* and *S. myrtilloides* within the area of the Łęczna-Włodawa Lakeland.

**Keywords:** *ecological succession, endangered species, habitat*

### Introduction

In natural ecosystems, any change in the abiotic environmental conditions are usually reflected in the functioning of biocoenoses. Neither large-scale anthropogenic transformations of the environment nor seemingly unnoticeable minor disturbances caused by natural factors leave the species composition and structure of phytocoenoses unaffected. Differences in ecological tolerance of individual species play a particularly important role here. With changing habitat conditions, one can observe both the encroachment and the withdrawal of particular species. The problem of disappearance of rare taxa, frequently strongly associated with their specific habitat, from their natural stands is now common.

In eastern Poland, the area of the Łęczna-Włodawa Lakeland has been subjected to strong anthropogenic pressure since the beginning of the 20th century. This region of exceptional environmental value was originally characterized by a significant proportion of inaccessible wetlands, peatlands, and lakes. In the 1950's hydraulic improvements were initiated in this area and these works continued until the 1980's; as a result of that, a significant part of the Lakeland area was drained, the wetland ecosystems became fragmented, and major eutrophication occurred which was caused by the waters that came from the outside via a system of canals and drainage ditches

(Bartoszewski and Michalczyk, 1996; Radwan et al., 1999). As one of the consequences of long-term anthropogenic impacts, ecological succession can be observed within this area and this process is particularly intensive in the aquatic peatland ecosystems. This process, which contributes to terrestrialization of the lakes in this Lakeland and to the changes in the nature of its peatland ecosystems, is often manifested in the encroachment and increase of population numbers of expansive species which crowd out rare species with a narrow range of habitat requirements (Radwan et al., 1999).

Since the 1950's, we have observed a decline in the number of stands and population numbers of relict boreal willow species (*Salix lapponum* and *S. myrtilloides*) which were once found in great numbers within the Łęczna-Włodawa Lakeland area (Fijałkowski, 1959). These are species associated with peatland ecosystems, with strictly defined habitat requirements and very sensitive to changes in them (Każmierczakowa and Zarzycki, 2001; Pogorzelec, 2008). Most of the old stands of boreal willow populations do not exist anymore due to the change in the nature of their habitats, whereas those that have survived are predominantly located in the peat bogs adjacent to different sized water bodies that are at different stages of the process of being overgrown (Pogorzelec, 2009; Pogorzelec and Banach, 2008). The succession changes in the stands of *S. lapponum* and *S. myrtilloides* are taking place with varying intensity and manifest themselves in characteristic changes in the species composition of these phytocoenoses (Pogorzelec, 2009).

The aim of the present research, which was conducted in the years 2002 and 2012, was to determine whether and to what extent the biocenotic changes taking place in the aquatic peatland ecosystems affect the state of the populations of endangered boreal willows. To test the thesis that the changes in biocenotic conditions have a significant impact on the functioning of these populations, an attempt was made to answer the following questions: How much has the quantitative and qualitative structure of the phytocoenoses in which the populations of the studied species function changed since the 1950's and over the last 10 years? Is anthropophytization of the flora taking place in the stands of downy and swamp willow? To what extent have the habitat conditions changed, which are determined based on, among others, the proportions of different ecological plant groups found in the phytocoenoses studied?

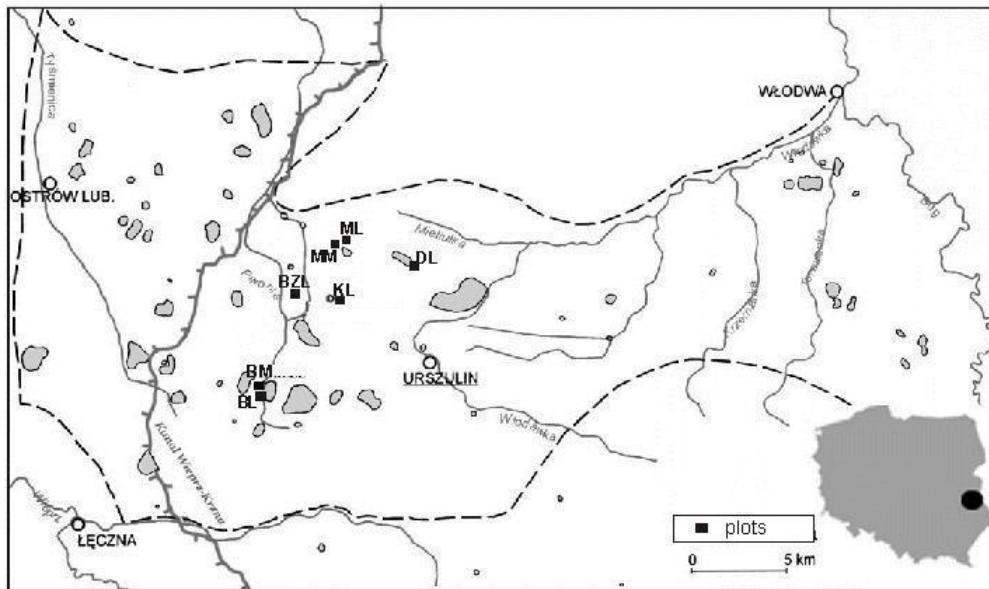
## Procedures

Field investigations were carried out at the peak of the growing season in 2002, from May to August, and they were repeated in 2012 within the Łęczna-Włodawa Plain (in the Łęczna-Włodawa Lakeland), which is one of the six of the Western Polesie mesoregions (Kondracki, 1981).

The first stage of the study involved the designation of seven study plots (100 m<sup>2</sup> in area) in the phytocoenoses in which the occurrence of *S. lapponum* and *S. myrtilloides* populations had been observed. The study plots were established at five study sites which were aquatic peatland systems at different stages of being overgrown. The criteria of selection of these study sites primarily included the stage of terrestrialization and differences in the size of the water bodies adjacent to the phytocoenoses studied. The following peat bogs within the Polesie National Park were included in the selected study sites: the Blizionki bog (the study plot designated BZL) – a completely overgrown mid-forest water body located in Torfowisko Orłowskie (Orłowskie Bog), a peat bog by Lake Karaśne (KL) which is at an advanced stage of being overgrown, the peatlands

surrounding Lake Długie (DL) and Lake Moszne (ML, MM) as well as a peat bog located outside the boundaries of the Park on the western shore of the largest of these water bodies - Lake Bikcze (BL, BM; Fig. 1-2).

The exact numbers of the *S. lapponum* and *S. myrtilloides* populations were determined within the study plots and in their immediate vicinity due to the fact that the study plots were located within the stands of the species under investigation, but they did not always cover the whole area occupied by these populations.

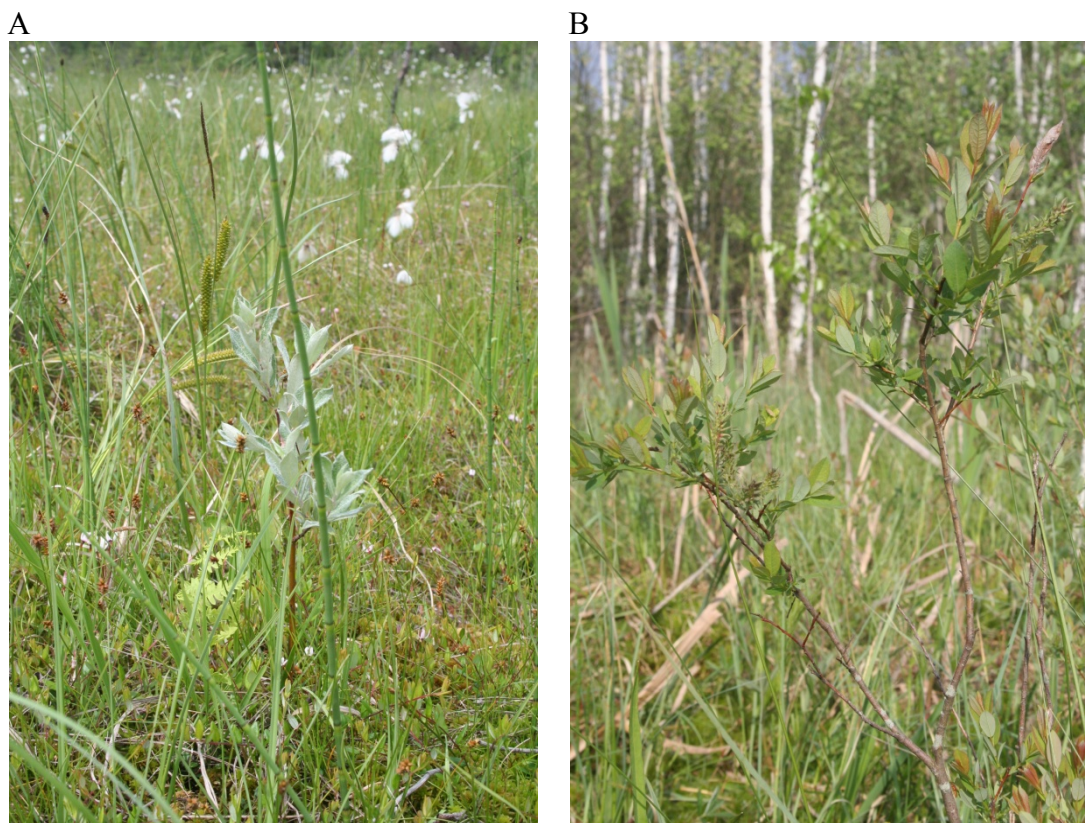


**Figure 1.** Location of the study plots in the Łęczna-Włodawa Lakeland

In each study plot, flora observations and phytosociological relevés were made using the Braun-Blanquet method. Species were identified following Rutkowski (2006), while species nomenclature followed Mirek et al. (2002). In addition, both in 2002 and 2012 one water sample was taken for physical and chemical analysis from each of soil piezometers installed in the central part of each of the study plots. At the Central Agro-Ecological Laboratory of the University of Life Sciences in Lublin, laboratory analyses were performed using standard methods to determine the following: electrolytic conductivity (specific conductance in  $\mu\text{S}\cdot\text{dm}^{-1}$ ), pH, nitrogen fractions (in  $\text{mg}\cdot\text{dm}^{-3}$ ): total nitrogen (N), ammonium nitrogen ( $\text{N-NH}_4$ ), nitrates ( $\text{N-NO}_2$ ), nitrates ( $\text{N-NO}_3$ ), phosphorus fractions: total phosphorus (P), phosphates ( $\text{P-PO}_4$ ), sulphates ( $\text{S-SO}_4$ ), basic cations: potassium (K), sodium (Na), calcium (Ca), magnesium (Mg).

Using desk research, the changes in population numbers of the studied species were traced, also referring to the first data on their status from the 1950's (Fijałkowski, 1958; 1958a). A multifaceted analysis of the species composition of the flora in the study plots was made in terms of the assignment of species to historical-geographical (Mirek et al., 2002), syntaxonomical and ecological groups (Matuszkiewicz, 2001; Zarzycki et al., 2002). The habitat requirements of the investigated phytocoenoses were determined using ecological indicator values (Zarzycki et al., 2002; Diekmann, 2003). On the basis of species numbers, average weighted values of the following indices were determined: light (L), soil moisture (W), trophicity (Tr), acidity (R), and organic matter content (H).

The obtained results were compared with the available historical data (available only for *S.lapponum*) [12]. The habitat conditions and the changes that had taken place in the stands of the boreal willow species studied over a long (1958-2002) and short (2002-2012) time interval were characterized on this basis.



**Figure 2.** *Salix lapponum* (A) and *Salix myrtilloides* (B) in the stand located in the peat bog near Lake Moszne in the Polesie National Park (2012)

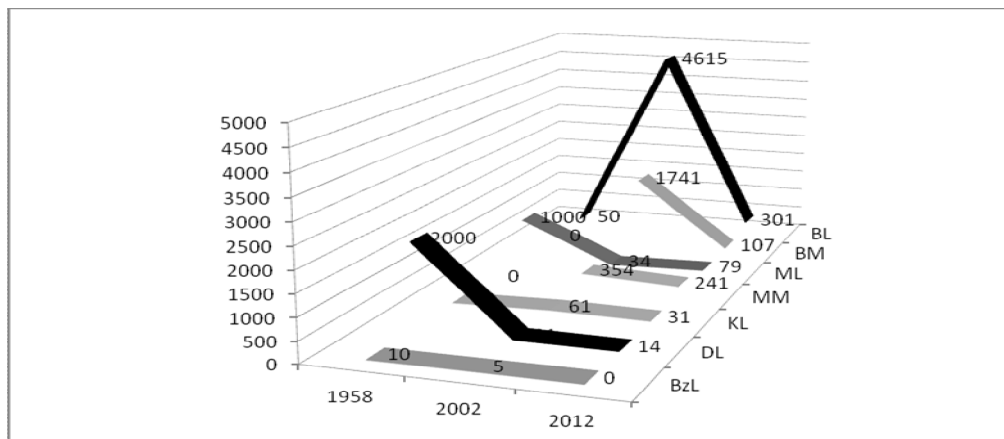
During the first stage of statistical analysis, a comparison was made of the Shannon-Wiener indices and the evenness index for the particular phytocoenoses in the study plots. Subsequently, a non-metric multidimensional scaling (NMDS), hierarchical cluster analysis (HCA) and redundancy analysis (RDA) were performed to analyse the data set. Statistical computations were carried out using the computing environment R, version 2.15.3 (2013-03-01), packages: Vegan, MASS and MVSP (Multivariate Statistical Package), version 3.22 (Oksanen et al., 2013; Chahouki, 2011; Ter Braak and Prentice, 1988).

## Results

The population numbers of the studied species changed in all the stands investigated. The most numerous population of *S. lapponum* existed in 2012 in the peat bog by Lake Bikcze, while that of *S. myrtilloides* near Lake Moszne, despite that a rapid decline in their numbers had been observed since 2002. In 2012 the population of *S. lapponum* in the Blizionki bog was found to have completely disappeared (Fig. 3).

The syntaxonomical analysis of the species composition (*Table 1*) of the studied phytocoenoses revealed that species characteristic of the classes *Alnetea glutinosae*, *Oxycocco-Sphagnetea* and *Scheuchzerio-Caricetea* were the most numerous group. An increase in the proportion of species of the alliance *Magnocaricion* and *Alno-Ulmion* could be observed, in particular in the stands located in the peat bog near Lake Bikcze.

Taking into account the species composition and proportion of the individual species throughout the study period (including the historical data), it was found that spontaneophytes had the highest number of representatives in the studied phytocoenoses (their percentage was 77% – 100%). Kenophytes, that is, alien species classified as anthropophytes, were found incidentally (the last time in 2012 in the bog near Lake Moszne).



**Figure 3.** Changes in population numbers of boreal willows in the studied stands in the Łęczna-Włodawa Lakeland

**Table 1.** Species composition of the phytocoenoses of the study plots in the years 1958 (Fijałkowski, 1958a), 2002 and 2012, taking into account the characteristic cover-abundance of individual vascular plant species (Braun-Blanquet's scale with a 10-point modification acc. to van der Maarel 1979)

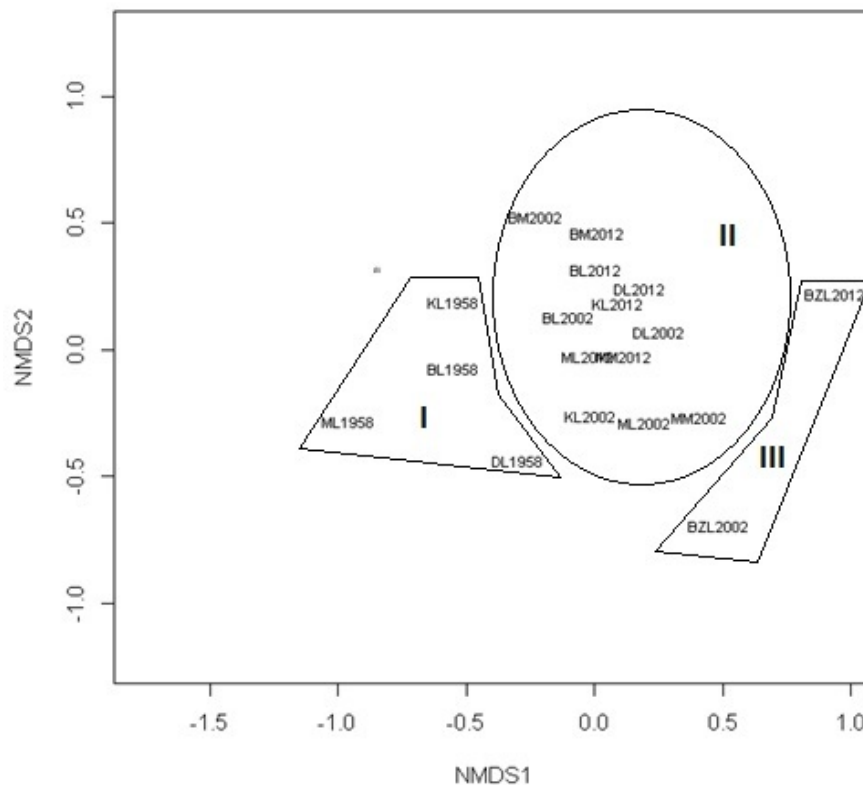
Plots	BL			BM		ML			MM		KL			DL			BZL	
	1958	2002	2012	2002	2012	1958	2002	2012	2002	2012	1958	2002	2012	1958	2002	2012	2002	2012
<b>Cl. Phragmitetea</b>																		
<i>Calla palustris</i>	+	1	+	+	1	+					+	+						
<i>Carex acutiformis</i>							3		1									+
<i>Carex appropinquata</i>	+					2			2									
<i>Carex elata</i>											+	+						
<i>Carex gracilis</i>											+							
<i>Carex rostrata</i>	+	1	1	1	1		1	1	1	1	2	1	1	+	1	1	5	
<i>Carex vesicaria</i>												+						
<i>Equisetum fluviatile</i>	3	2	2	2	1			1		1	+	1	1	+	+	1		+
<i>Galium palustre</i>		+	+	+	+		+	+			+	+	+					
<i>Glyceria maxima</i>													1					
<i>Lysimachia thyrsiflora</i>		+	1		1												+	
<i>Peucedanum palustre</i>	+	+	+			+	1	1	1	1	+			+	+	+		

<i>Phragmites australis</i>	+	+	1		1	+	1	2		+			6		7	8		3
<i>Ranunculus lingua</i>		+			1							+						
<i>Typha angustifolia</i>		1	+	+					1			+						
<i>Typha latifolia</i>					1													
<b>Cl. Scheuchzerio-Caricetea</b>																		
<b><i>nigrae</i></b>																		
<i>Agrostis canina</i>	+										+			+				
<i>Calamagrostis stricta</i>											+			+				
<i>Carex chorrodorhiza</i>	+													+				
<i>Carex davalliana</i>									3									
<i>Carex diandra</i>	+					1					+			+				
<i>Carex echinata</i>								1			+						1	
<i>Carex flava</i>	+						1											
<i>Carex lasiocarpa</i>	2	+	2		1	6		1		1	1		1	1		2		
<i>Carex limosa</i>	+					+	+	+		1	+	+	+			1		
<i>Carex nigra</i>	+	2	2	2	2	+		1		2	+	1	1	+	2	2		
<i>Comarum palustre</i>	+	3	2	+	3	1	+	1	2	+	+	1	1	+	+	1	+	+
<i>Drosera anglica</i>														+				
<i>Epipactis palustris</i>																		
<i>Eriophorum angustifolium</i>	+	+	1					1		1	+		+		+	1		
<i>Eriophorum gracile</i>	2													2				
<i>Juncus articulatus</i>		+																
<i>Menyanthes trifoliata</i>	+	1	3	1	1		2	1	1	1	+	+	1		2	3	+	
<i>Parnassia palustris</i>						+							+					
<i>Pedicularis palustris</i>	0					+												
<i>Rhynchospora alba</i>								+										
<i>Scheuchzeria palustris</i>	+							+										
<i>Stellaria palustris</i>			+		+													
<i>Triglochin palustre</i>							+											
<i>Viola palustris</i>							+					+						
<b>Cl. Oxycocco-Sphagnetea</b>																		
<i>Andromeda polifolia</i>		+	+				+	+										
<i>Drosera rotundifolia</i>	+	+				+	2	1		1		+	+	+	+	+		
<i>Eriophorum vaginatum</i>	+	+		+		1		+				+					2	
<i>Oxycoccus palustris</i>		3	1		1		6	3	6	6		3	1	2	4	2	4	2
<b>Cl. Molinio-Arrhenatheretea</b>																		
<i>Agrostis gigantea</i>						1					+							
<i>Carex panicea</i>			+			1	2	1			+				2			
<i>Cirsium palustre</i>										+								
<i>Dactylorhiza majalis</i>														+				
<i>Epilobium palustre</i>	+						+											
<i>Festuca rubra</i>												1						
<i>Galium uliginosum</i>	+	+				+				+				+				
<i>Juncus conglomeratus</i>		+																
<i>Lysimachia vulgaris</i>	+	1	1	+	1	+	+		+	+	+	1	1		1	+		+
<i>Lythium salicaria</i>	+	+		+			+	+			+	+		+	+			
<i>Molinia caerulea</i>	+	+				+	+	+						1				
<i>Poa pretensis</i>						1												



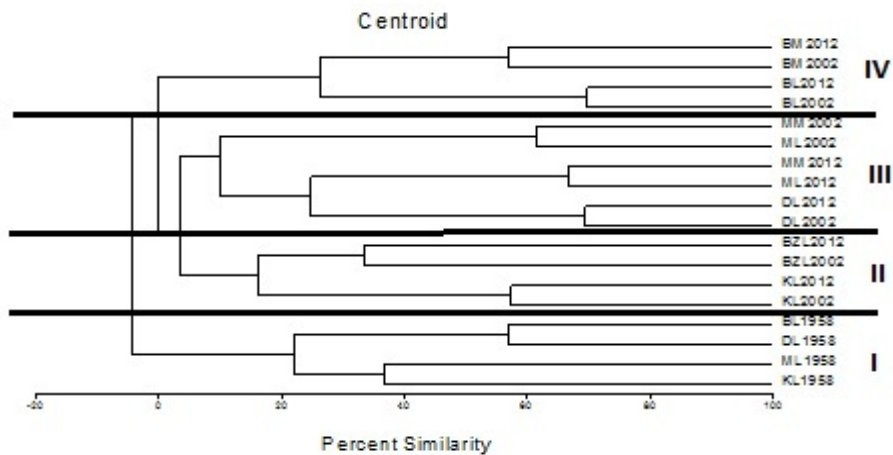
division of the stands into four groups. Group I included the phytocoenoses studied and described in 1958. The other clusters suggest similarity of the phytocoenoses related to their location within the study area; the stands located in close proximity are grouped close to each other. The results demonstrate distinct changes that have occurred both in the species composition and in the proportion of individual species in the phytocoenoses since the 1950's. Over the last 10 years, these changes were most evident in the Blizionki bog and on Lake Bikcze, which is evidenced by low similarity of the phytocoenoses in 2002 and 2012.

The habitat requirements of the plant patches determined based on the assignment of plant species to ecological groups indicate that over the period of the last 10 years (2002-2012) the most noticeable changes occurred in the stand in the Blizionki bog. One can observe there changes in the proportion of occurrence of species representing particular ecological groups of vascular plants for all the factors analysed. In the case of the other stands, in all time intervals minimal differences are seen in the proportions of different ecological plant groups, which does not exclude the possibility of tracing the changes in habitat conditions taking place there (Fig. 7).

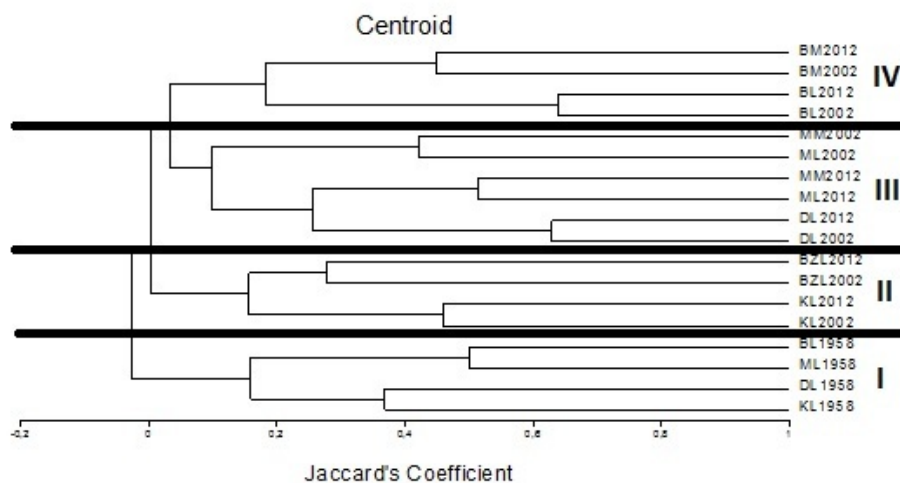


**Figure 4.** Two dimensional non-metric multidimensional scaling (NMDS) plot based on Bray-Curtis dissimilarities for phytocoenosis. The stress of the diagram non-metrically scaled in two dimensions is 0.157

The physico-chemical analysis of water samples collected from the soil piezometers installed in the study plots served as a habitat background for examination of the flora (Table 2) and was used for RDA ordination analysis.



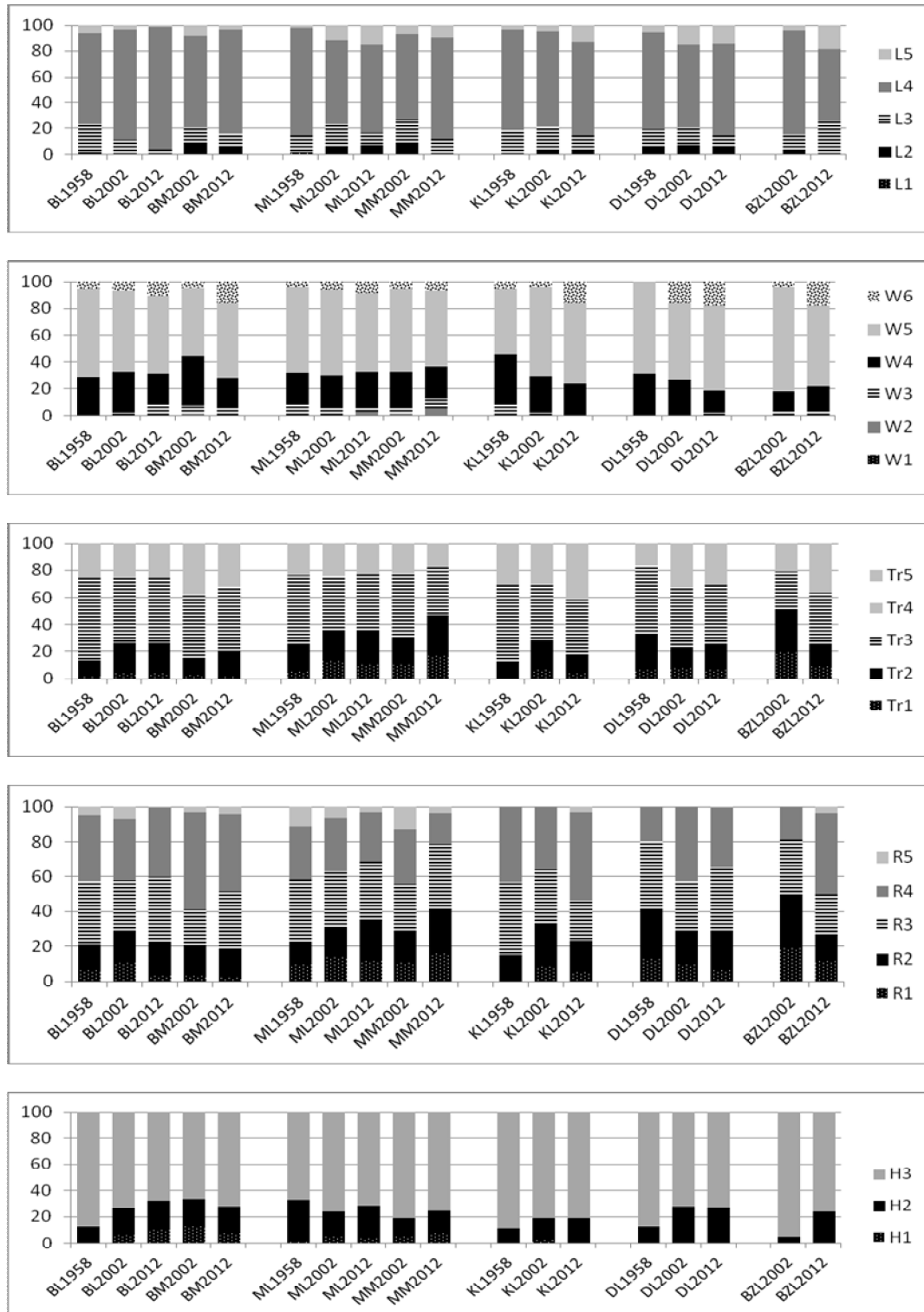
**Figure 5.** Dendrogram of hierarchical cluster analysis of 18 phytocoenoses based on percent similarity measure and centroid method.



**Figure 6.** Dendrogram of hierarchical cluster analysis of 18 phytocoenoses based on Jaccard's coefficient and centroid method.

RDA examines the relationship between environmental variables and species composition. The analysis was preceded by the determination of environmental gradient length. The obtained value of 2.49 recommends the use of redundancy analysis (RDA). Two data collections were considered: species composition and variable values of selected habitat factors. The phytocoenoses studied in 1958 were excluded from the analysis due to the lack of data.

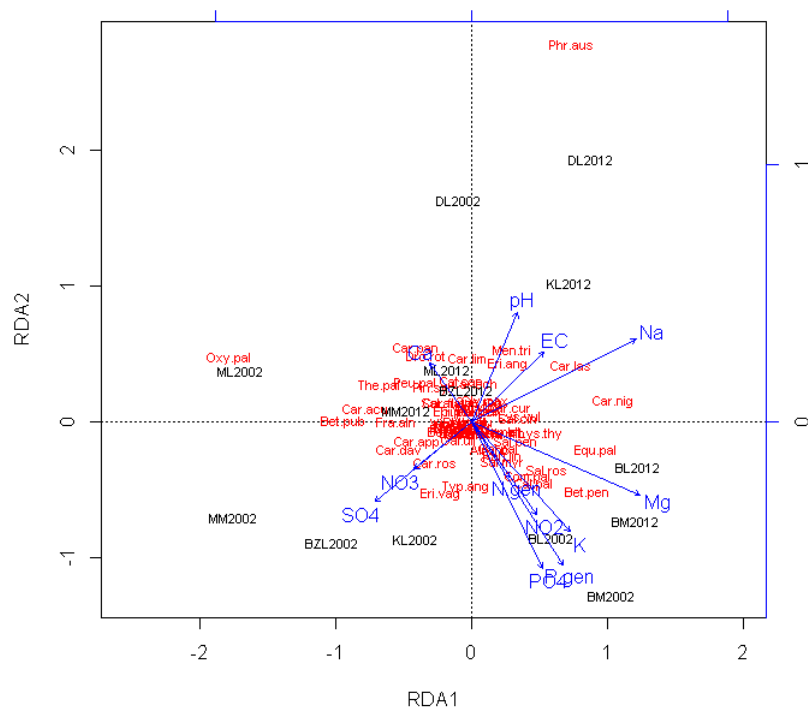
The analysis showed that there was a strong correlation of concentration of Na ions in the water sampled from the investigated habitats with electrolytic conductivity and water pH as well as a negative correlation of Na, with  $\text{NO}_3$  and  $\text{SO}_4$ . Likewise, there was a strong positive correlation between water concentration of  $\text{PO}_4$ , and Mg,  $\text{NO}_2$ , N, P as well as a negative correlation for  $\text{PO}_4$  and Ca (Fig. 8).



**Figure 7.** Proportion of species of different ecological groups of vascular plants in the flora of the study plots in the years 1958, 2002 and 2012 (L – light value; W – soil moisture value; Tr – trophity value, R – water acidity value, H – organic matter content value; the numerical designations denote the assignment to specific ecological groups following Zarzycki et al., 2002).

**Table 2.** Values of some abiotic factors as measured in the water samples in the years 2002 and 2012.

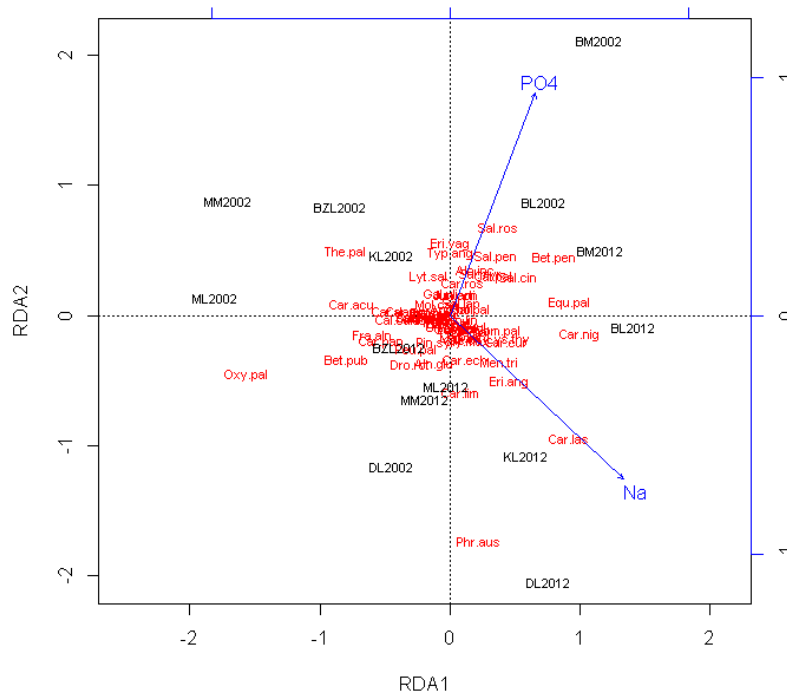
Plots	Year	Acidity	EC	N	NO <sub>3</sub>	NO <sub>2</sub>	P	PO <sub>4</sub>	SO <sub>4</sub>	Mg	Ca	Na	K
		pH	( $\mu S * dm^{-1}$ )	(mg * dm <sup>-3</sup> )									
BL	2002	5,49	147,0	8,36	0,10	0,29	3,66	7,00	1,20	4,91	13,11	6,91	15,58
	2012	5,30	74,0	6,75	0,07	0,00	1,55	2,20	0,12	3,45	15,10	34,70	6,30
ML	2002	6,41	175,0	1,88	0,13	0,00	0,32	0,15	3,42	0,97	33,38	1,72	2,79
	2012	5,90	102,1	1,47	0,00	0,00	0,28	0,00	0,19	2,79	26,40	22,60	4,58
KL	2002	6,53	154,5	4,93	0,20	0,00	0,12	0,12	9,59	0,62	16,41	9,59	11,49
	2012	6,50	293,7	5,08	0,06	0,00	0,39	0,00	0,00	3,81	75,10	35,60	5,30
DL	2002	6,64	163,0	6,52	0,26	0,00	0,72	1,51	0,87	0,55	6,20	3,30	10,33
	2012	5,70	107,2	2,21	0,05	0,00	0,26	0,00	0,13	3,37	25,30	35,80	5,93
BZL	2002	4,20	88,8	7,26	0,00	0,00	1,75	4,34	0,74	3,24	19,74	5,93	6,82
	2012	6,20	169,1	27,63	0,00	0,00	0,55	1,39	0,17	3,40	28,10	6,71	3,51
MM	2002	5,22	59,4	5,58	0,32	0,00	0,52	0,90	2,09	2,20	49,67	3,13	3,56
	2012	5,60	77,2	3,36	0,00	0,00	0,33	0,00	0,14	1,46	10,90	32,20	5,50
BM	2002	5,88	96,4	16,22	0,26	0,08	3,33	9,08	1,11	3,47	10,32	9,09	34,57
	2012	6,20	235,1	2,81	0,06	0,00	0,64	0,37	0,00	6,39	25,30	32,30	4,74



**Figure 8.** Redundancy analysis (RDA) ordination diagram (showing the first and second ordination axes) displaying the relation of phytocoenoses and the correlation pattern of all environmental characteristics (arrows). Scaling method 2. Eigenvalues for constrained axes: RDA1- 11.8773, RDA2- 10.9274, sum of eigenvalues for constrained axes - 51.197, sum of all eigenvalues – 55.588

At the next stage of the analysis, stepwise selection of environmental variables was performed (using Akaike's information criterion as the selection criterion) and a statistical analysis was made of their effect on variations in the phytocoenoses. The stepwise selection of the variables shows that only Na and PO<sub>4</sub> are significant ( $p < 0.05$ ) variables in the model (Fig. 9). The other environmental variables are not statistically significant ( $p > 0.05$ ).

The results of the significance test of the first ordination axis show that there is a statistically significant ( $p \leq 0.01$ ) gradient causing variations in the habitats. The first axis explains 17% of the total variation, while the other one 9%. Moreover, the analysis also shows a statistically significant ( $p < 0.05$ ) relationship of the occurrence of phytocoenoses with the gradient of the RDA canonical axes.



**Figure 9.** Redundancy analysis (RDA) ordination diagram (showing first and second ordination axes) displaying the relation of phytocoenoses and the correlation pattern of selected 2 environmental characteristics (arrows). Scaling method 2. Eigenvalues for constrained axes: RDA1- 9.462 , RDA2 - 5.150, sum of eigenvalues for unconstrained axes - 40.976, sum of all eigenvalues - 55.5879

## Discussion of results

In phytosociology, among different categories of indicators we find the so-called species scales in the case of which changes in the composition and proportion of species or their groups depend on the intensity of environmental factors (Solon, 2005). It is also known that individual species, due to their specific habitat requirements, can be good indicators of the state of the environment (Godefroid and Koedam, 2003; Cousins and Lindborg, 2004; Furlan et al., 2006; Pietrzykowski and Krzaklewski, 2006). Species that are particularly sensitive to environmental disturbances are often rare species or

species threatened with extinction in the case of which the number of stands and population numbers are continually decreasing. In Poland such species in peatland ecosystems are, among others, *S. lapponum* and *S. myrtilloides* – relict willows whose few stands are outside the continuous species range (Każmierczakowa and Zarzycki, 2001).

The research conducted in Poland shows the progressive impoverishment of the populations of both species in question (Urban and Wawer, 2001; Churski and Danielewicz, 2008; Pogorzelec, 2008a; Pogorzelec, 2010). If we refer to the historical publications (Fijałkowski, 1958; Fijałkowski, 1958a; Fijałkowski, 1959) which provided the first data on *S. lapponum* and *S. myrtilloides* within the study area, it can be determined how much the extent and nature of the habitats in which populations of the studied species existed in great numbers have changed. Most of the populations that had survived in their stands until 2002 significantly decreased their numbers within the next 10 years. In one of its stands, the population of *S. lapponum* completely disappeared (the Blizionki bog), while in the other stands it has reached a state in which it may become impossible to restore the population if the habitat changes continue (near the lakes Długie, Moszne, and Karaśne). The population of this species is quite numerous only in the peat bog by Lake Bikcze, though the history of the rapid decline in its numbers does not bode well for the future, similarly as in the case of both studied populations of *S. myrtilloides* (quite numerous at the moment).

Habitat conditions are not the only factor determining the proper functioning and survival of populations of endangered species. Nevertheless, the analysis of the structure and ecological characteristics of the phytocoenoses in the stands of the studied willow species in 2002 and 2012 allows us to presume that in this specific case it is the habitat disturbances that will play a key role in weakening the condition of these populations. The statistical analysis shows differences in the habitats, depending on the year of the study, but the group of data collected in 1958 clearly stands out. These phytocoenoses exhibit low similarity, both in qualitative and quantitative terms, to the communities of the same area described in 2002 and 2012.

The gradual slow transformations taking place in the environment give time and possibility for species to adapt, which is quite different to quick and abrupt changes that can be destructive (Sprugel, 1991). The research carried out in 2002 and 2012 revealed that the greatest decline in numbers of the willow populations related to the stands in which the greatest changes in the species composition and structure of the phytocoenoses had occurred over the period of 10 years – the stands in the Blizionki bog and near Lake Bikcze. The habitat investigations carried out using indicator value analysis also confirmed this result.

In spite of the fact that *S. lapponum* and *S. myrtilloides* have a wide range of tolerance for the values of different abiotic environmental factors (Pogorzelec, 2008a), their populations are probably not able to resist the changes taking place in the aquatic peatland ecosystems undergoing succession. The encroachment of expansive species that win the competition for environmental resources, including related species (of the family Salicaceae) which additionally create a risk of hybridization (Pogorzelec and Nowosielski, 2006), has an adverse effect on intrapopulation processes that determine the numbers and condition of *S. lapponum* and *S. myrtilloides*.

Most of the studied stands of the boreal willow populations are within the Polesie National Park area that has been covered by area-based conservation since the 1990's and in which active conservation of the peatlands is carried out; it involves, among

others, the removal of expansive species (Różycki and Sołtys, 1999). In spite of these efforts, the populations of the studied species are on the verge of extinction. In analysing the historical data (Fijałkowski, 1958; Fijałkowski, 1958a), an observation can be made that the problem appeared in the second half of the 20th century. It is probable that the fragmentation and disappearance of the habitats of the species in question initiated a series of intrapopulation processes and changes in the habitats which have led to the present state through their impact on the biology of the studied species.

## Conclusions

The decline in numbers of the populations of relict boreal willows (*S. lapponum* and *S. myrtilloides*) existing in the Łęczna-Włodawa Lakeland is associated with the changes that have taken place in their habitats since the 1950's. These changes are manifested in the species composition and phytocoenosis structure in the stands of the studied species. Over the last ten years, these changes were most evident in the stands in the Blizionki bog and near Lake Bikcze where the greatest decrease in population numbers of the studied willow species is also observed.

If the changes in biocenotic and abiotic conditions of the habitats continue with the present intensity, these species will probably become extinct without the intervention of active protection ex situ.

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