Polish J. of Environ. Stud. Vol. 17, No. 4 (2008), 581-586

Original Research

Influence of Chosen Environmental Abiotic Factors on *Salix lapponum* L. Populations in Polesie Lubelskie Region

M. Pogorzelec*

Department of General Ecology, University of Life Sciences, Akademicka 13, 20-950 Lublin, Poland

Received: 28 September, 2007
Accepted: 26 February, 2008

Abstract

The decline of the *Salix lapponum* population and reduction of the number of its natural stands is mainly attributable to changes in water conditions in the habitat (dehydration and changes in water chemical composition) which are caused by various anthropogenic factors. Selected parameters of abiotic environment were determined in 15 chosen downy willow stations on the peat-bogs in Polesie Lubelskie Region in Poland, from May 2001 to August 2003. Based on a comparison of the abiotic conditions in the research stations, in terms of the population size of *S. lapponum*, the optimum values of the factors were determined (habitat hydration, acidity and electrolytic conductivity of the underground water, as well as ion content) for adequate functioning of a given species.

Keywords: *Salix lapponum*, abiotic factors, habitat conditions

Introduction

The downy willow (*Salix lapponum* L.) is an inconspicuous bush, one meter high and, when competing for light with other bushes, up to two meters high. Brown shoots and leaves with silvery grey napped underside are a typical feature of the species. *S. lapponum* is a dioecious plant, it blooms in May/June [1].

Salix lapponum is a species that is commonly found in peat bogs of the subarctic and boreal areas of Eurasia, mainly in northern and north-eastern Europe and western Siberia. In isolated stands it also grows in Scotland and in some of the mountain ranges in Central and Southern Europe. The southwestern confines of the species' distribution run through Poland [2-4].

In Poland, the downy willow is a glacial relic, legally protected and listed in The Polish Red Book of Plants as an endangered species, with a rapidly declining number of stands located in Poland [3, 5, 6]. At present, *S. lapponum* stands exist only in mid-eastern Poland, mainly in the Polesie Lubelskie Region and in the Karkonosze Mountains [7-16]. In the natural lowland stands of Polesie Lubelskie, *S. lapponum* grows on valley and blanket peat bogs. Shoots of the downy willow usually grow individually or in small clusters [12, 17, 18]. This species favours moderate light, moist and wet, mezo or oligotrophic biotope, and highly acidic (pH 4 – 6) soil, rich in organic matter [19].

The decline of the species' population and reduction of the number of its natural stands is mainly attributable to changes in habitat conditions. Even slight fluctuations in the level of underground water may result in an irreversible reduction of the size of the *Salix lapponum* population.

First of all, building the melioration system of the Wieprz-Krzna Channel had negative effects by changing the natural water balance. It disturbed the rate of water outflow, making no stagnation, and allochtonic water directed through channels and ditches, characterized by different

*e-mail: m.pogorzelec@op.pl

trophy and chemical composition, contributed to the change of habitat conditions in ecosystems of peat bogs [20, 21]. In consequence, the ecological succession processes occurred there by arborescent and shrubby plants appearing on peat bogs. They simultaneously have shaded other plants and intensely transpirated the local water. The vanishing of some boreal flora species like *Salix lapponum* is accelerated by the natural processes of succession, intraspecific competition related to it and the displacement of populations demonstrating poorer adaptation potential [22, 23].

Procedures

The 15 research stations (different in reference to habitat) in the Polesie Lubelskie Region were determined on the basis of a review of literature and a preliminary field survey (Fig. 1). These stations were situated on the peat bogs of Długie Lake (Nº 1, 2), Moszne Lake (3, 4), Karaśne Lake (5, 6, 7), Blizionki forest peat bog (8) in Polesie National Park and in the Park's buffer area – on the peat bog of Bikcze Lake (9, 10, 11, 12, 13, 14, 15).

In the first place, underground water level was described in all research stations (with a centimetre ruler being pressed down on the bog surface by human weight 70 kg).

Selected parameters of abiotic environment were determined in all stations by analysis of the upper layer of water stagnating in peat-bogs at least 7 days after a rainfall. Determinations were carried out 3-8 times in each station (it depended on the possibility to reach to the station), from May 2001 to August 2003. Acidity was measured *in situ* (pH; using a field battery-operated pH-meter) as well as electrolytic conductivity (μS cm^{-1}; using a field battery-operated conductometer).

The water samples (from a level of 20 cm) for chemical laboratory analysis were collected 4 times to determine the concentration of anions (PO_4^{3-}, NO_3^-, NO_2^-, SO_4^{2-}, Cl^-) and cations (Ca^{2+}, K^+, Mg^{2+}, Zn^{2+}, Cu^{2+}, Na^+, Fe^{3+}, Mn^{2+}). Laboratory analyses were made in The Central Laboratory - University of Agriculture in Lublin and The Laboratory of Provincial Inspectorate of Environmental Protection in Lublin.

Because of the small number of environmental abiotic factor measurements, and in order to ascertain the important statistic differences between them, all stations were divided into two groups: stations of *S. lapponum* with uncommon occurrence (where we recovered less than 30 shoots of downy willow, stations Nº 1, 2, 3, 5, 7, 8, 10, 11) and station of *S. lapponum* with common occurrence (over 30 shoots of *S. lapponum* - stations Nº 4, 6, 9, 12, 13, 14, 15).

The results of research were analyzed by means of the standard statistical analyses, including the Mann-Whitney U test. Value at α=0,05 was accepted as level of significance in all tests.

Results

The highest and the lowest values of researched factors of water (acidity, electrolytic conductivity and underground water level) have been written down in stations of *S. lapponum* with rare occurrence (Table 1).

The significant statistical differences between contents of ions (NO_2^-, PO_4^{3-}, Cl^-, Mg^{2+}, Na^+ and the general phosphorus) in the water of stations of *S. lapponum* with uncommon and common occurrence have been recovered. The superior concentrating of these ions took a stand in the water collected from the station of *S. lapponum* with common occurrence. Statistical analyses have shown the lack of significant difference between others ions and the rest of the factors, which was researched in ground water from peatbogs (Table 2).

Discussion of Results

Research of habitat conditions allows us to establish the plant's requirements relative to particular factors of environments. This is particularly important in the case of rare plant species [24].

Salix lapponum prefers the moist and wet, mezo or oligotrophic biotope and a highly acidic (pH 4 – 6) soil [19].

The habitat conditions in the *S. lapponum* stations in Polesie Lubelskie Region were studied for the first time by Fijałkowski in 1958. He described the *S. lapponum* occurrence in the sites where the level of ground water has amounted to 0-45 cm, and the soil reaction was pH 3.5-6.5. Fijałkowski noticed that the *S. lapponum* condition decreases along with the dropping of the reaction of peat, but he did not mark such dependence referring to the quantity of examined populations [25].

From 1996 to 1998, Urban & Wawer carried out the study of *S. lapponum* occurrence in Sobibór area in Łęczna-Włodawa Lakeland. There was only one examination of the water level (that oscillated in boundary 0-20 cm) and the basement soil acidity (pH 3.2-4.5 in a peat-bog near Dubeczyńskie Lake, and pH 3.5-4.0 in the 'Three Lakes' nature reserve). Urban & Wawer noticed that the most important danger for *S. lapponum* were the change of natural water balance and shading by other plants in the stations [14].

In the original research from 2001-2003, statistical analyses indicated the lack of influence of ground water acidity on the number of *S. lapponum* specimens in its stations. However, it is possible that in the stations with extreme values of water reaction (average pH 6.17 – station Nº 5 and 4.16 – station Nº 8), the *S. lapponum* quantity was considerably smaller than in the research stations where ground water acidity was at the level of pH 4.9 – 5.9 (middle values – stations Nº 4, 9, 12, 13, 15; Table 1).

Likewise, the lowest and the highest levels of ground water were noticed for stations of *S. lapponum* with uncommon occurrence.

The life-essential elements (nutrients) are uptaken by plants from solum. The macronutrients in the plants' organism are structural materials and the micronutrients hold catalytic and regulation function. In the case of a lack of life-essential elements, a plant cannot finish its life-cycle or produce generative organs. The quantity and

intensity of nutrient uptake is specific to the species, but it can also depend on habitat conditions (e.g. acidity) [26].

In the available literature, there is no detailed data on intensity of nutrient uptake and requirements by *Salix lapponum*. The results of research can suggest only the influence of nutrient contents in biotope on correct functioning of plant.

The quantity of examined populations was the only objective criterion which allows us to evaluate the population functioning. Comparing it with nutrient abundance in studied sites, it is not possible to exclude the role of the amount of this component for correct downy willow growth.

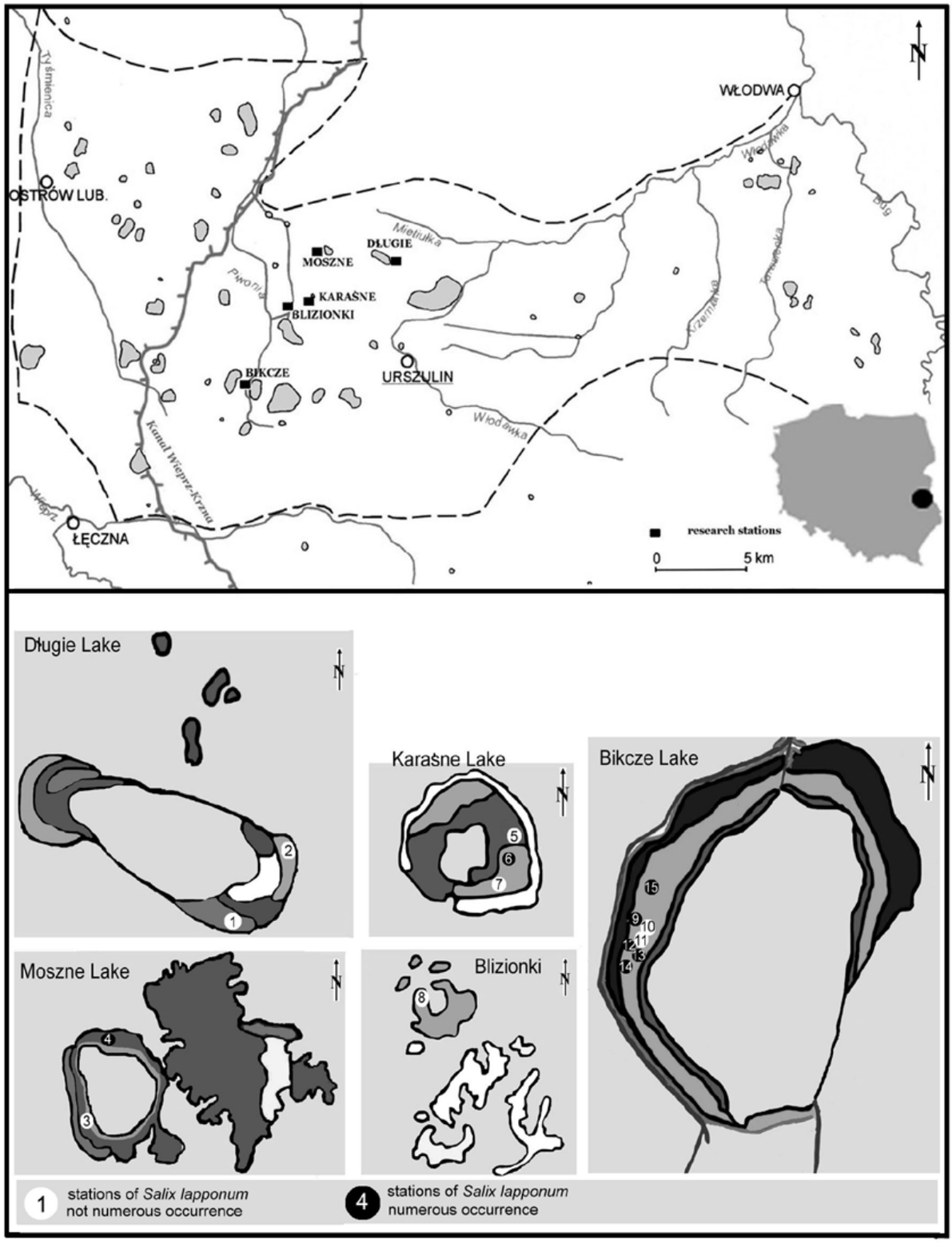

Fig. 1. Location of research stations in Łęczna-Włodawa Lakeland (Polesie Lubelskie Region).

Table 1. Descriptive statistics of chosen groundwater parameters in the research stations in Polesie Lubelskie Region (2001-2003).

station N°	Repetitions	Acidity (pH)					Electrolytic conductivity (μS · cm $^{-1}$)					Level of ground water (cm)				
		Mean	Standard deviation	Median	Min	Max	Mean	Standard deviation	Median	Min	Max	Mean	Standard deviation	Median	Min	Max
1	7	5.18	0.88	5.05	4.20	6.64	115.01	43.18	121.00	34.50	163.00	2.14	0.69	2.00	1.00	3.00
2	7	5.31	0.64	5.00	4.41	6.20	103.07	28.56	105.50	63.10	155.00	3.57	3.26	3.00	0.00	10.00
3	7	5.70	1.04	5.74	4.38	6.76	117.08	67.42	104.00	49.00	199.00	**10.57**	2.69	10.00	7.00	15.00
4	7	5.55	0.92	5.93	4.20	6.41	122.93	29.51	125.00	79.20	175.40	5.85	3.38	5.00	1.00	10.00
5	7	**6.17**	0.82	6.33	4.99	6.92	**183.21**	97.64	180.00	79.00	352.00	5.57	4.39	5.00	1.00	13.00
6	7	6.15	0.63	6.53	5.33	6.75	133.20	57.36	127.00	74.00	247.00	4.85	2.91	5.00	1.00	10.00
7	6	5.91	1.01	6.51	4.25	6.60	131.33	46.20	119.50	90.00	220.00	1.66	0.75	2.00	0.50	2.50
8	3	4.16	0.05	4.19	4.11	4.20	92.93	6.98	89.00	88.80	101.00	2.00	1.00	2.00	1.00	3.00
9	8	5.52	0.45	5.63	4.72	6.12	144.25	75.93	120.65	78.40	318.00	3.87	2.53	3.00	1.00	8.00
10	8	5.27	0.76	5.22	4.21	6.34	137.84	56.22	130.20	60.00	256.00	2.12	1.22	2.00	0.50	4.00
11	8	5.48	0.34	5.52	5.02	5.89	135.50	56.62	116.30	85.30	254.00	1.87	0.91	2.00	0.50	3.50
12	8	4.94	0.56	5.00	3.98	5.52	154.45	87.33	133.55	64.90	354.00	3.37	1.92	3.00	1.00	7.00
13	8	5.45	0.55	5.51	4.43	6.30	143.10	80.14	121.00	62.10	332.00	3.62	1.77	3.00	1.00	7.00
14	8	5.96	0.35	6.00	5.20	6.41	157.29	65.85	138.00	99.50	306.00	8.00	4.72	8.00	2.00	15.00
15	8	5.79	0.41	5.91	4.99	6.29	123.89	46.59	112.00	65.00	201.00	5.94	4.69	5.00	1.00	15.00

The highest (black colour) and the lowest (grey colour) values of researched factors.

Table 2. Characteristics of researched groundwater parameters in *Salix lapponum* stations in Polesie Lubelskie Region.
Analysis of comparative results of abiotic factor measurements from the station of *S. lapponum* with common and uncommon occurrence (Mann-Whitney U test).

Parameters	stations of *S. lapponum* uncommon occurrence						station of *S. lapponum* common occurrence						Value of test function Z	Level p
	Repetitions	Mean	Standard deviation	Median	Min	Max	Repetitions	Mean	Standard deviation	Median	Min	Max		
Acidity (pH)	45	5.64	0.94	5.69	4.11	6.92	63	5.50	0.61	5.57	3.98	6.41	0.798	0.425
Electrolytic conductivity (µS · cm $^{-1}$)	45	127.28	61.78	110.00	34.50	352.00	63	140.17	62.56	124.00	60.00	354.00	- 1.489	0.136
Level of ground water (cm)	45	4.64	3.90	3.00	0.00	15.00	63	4.31	3.44	3.00	0.50	15.00	- 0.050	0.960
General N (mg · dm^{-3})	28	5.86	3.54	4.92	1.52	13.33	35	6.85	3.97	5.72	1.88	18.08	- 0.996	0.319
NO_3 (mg · dm^{-3})	28	0.28	0.22	0.31	0.00	0.63	35	0.29	0.21	0.31	0.00	0.63	- 0.076	0.939
NO_2 (mg · dm^{-3})	28	0.02	0.05	0.00	0.00	0.20	35	0.08	0.15	0.01	0.00	0.58	- 2.143	0.032
General P (mg · dm^{-3})	28	0.51	0.49	0.30	0.07	2.10	35	0.96	0.79	0.91	0.07	3.33	- 2.649	0.008
PO_4 (mg · dm^{-3})	28	0.61	1.35	0.60	0.00	5.73	35	1.55	1.93	0.90	0.00	9.08	- 2.123	0.034
SO_4 (mg · dm^{-3})	28	2.44	2.04	1.18	0.40	9.59	35	4.77	16.10	1.70	0.02	96.83	0.380	0.704
Cl (mg · dm^{-3})	28	9.36	4.62	7.52	3.70	21.60	35	13.91	11.08	12.13	3.70	68.37	- 2.351	0.019
Mg (mg · dm^{-3})	31	1.59	0.97	1.40	0.47	4.06	38	2.28	1.32	2.06	0.19	5.71	- 2.255	0.024
Ca (mg · dm^{-3})	31	19.46	12.59	16.41	3.22	49.67	38	15.15	9.68	12.02	3.79	49.67	1.242	0.214
Na (mg · dm^{-3})	31	4.67	3.99	3.28	1.34	17.19	38	6.49	4.52	4.74	1.72	16.78	- 2.518	0.009
K (mg · dm^{-3})	31	7.59	5.55	5.62	0.87	25.22	38	8.53	8.19	5.29	0.87	34.46	0.012	0.990
Fe (mg · dm^{-3})	31	0.26	0.30	0.13	0.00	1.42	38	0.22	0.21	0.17	0.02	1.35	- 0.560	0.574
Cu (mg · dm^{-3})	31	0.02	0.01	0.02	0.00	0.05	38	0.01	0.01	0.01	0.00	0.04	0.241	0.809
Mn (mg · dm^{-3})	31	0.20	0.21	0.13	0.02	1.01	38	0.25	0.31	0.12	0.02	1.44	- 0.494	0.621
Zn (mg · dm^{-3})	31	0.06	0.06	0.04	0.00	0.26	38	0.06	0.05	0.04	0.00	0.26	- 0.168	0.865

Important differences statistically were differed by grey colour

Conclusions

The results of our research focusing on the habitat conditions of *S. lapponum* stations conducted in 2000-2003 in the Polesie Lubelskie Region, indicate a large diversity of abiotic conditions of its habitats. It may indicate that there is a relatively broad tolerance range of this species to various environmental factors.

Based on a comparison of the abiotic conditions in the research stations in terms of the number of *S. lapponum* specimens, the optimum values of the factors were determined (habitat hydration, acidity and electrolytic conductivity of the underground water, as well as its selected elements - cations and anions content) for adequate functioning of a given species.

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