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Marcin Churski, Władysław Danielewicz

Salix myrtilloides in north central Poland. Distribution, threats and conservation

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Abstract: Present status of a postglacial relict – *Salix myrtilloides* L. was investigated in north central Poland at 27 localities. Consequently 3 sites were confirmed, 4 were not confirmed, and the remaining 20 were considered to be extinct. In comparison to the historical distribution, ca. 74% of the sites existing 50 years ago do not exist today in the studied region. The confirmed populations were found near Oporówek (ca. 1600 stems), Rakowiec (ca. 100) and Bobrowo (15). At three sites confirmed in this study, the existence of vigorous hybrids between *S. myrtilloides* and *S. aurita* L. (*S.* ×*onusta* Besser) were observed. The most important threats to *Salix myrtilloides* L. populations in the studied region were assessed to be hybridization with other commonly occurring willow species, site isolation and habitat destruction. Natural habitat protection with adequate buffer zone and gene pool protection in a form of plantations was suggested as a conservation strategy. As an alternative strategy active protection '*in situ*' was proposed based on cutting competitive common species of willows.

Additional key words: glacial relict, willow, decline, habitat loss, extinction threshold

Adresses: M. Churski, Polish Academy of Sciences, Mammal Research Institute, Gen. Waszkiewicza 1 str., 17-230 Białowieża, Poland, e-mail: mchurski@zbs.bialowieza.pl
W. Danielewicz, Poznań University of Life Sciences, Department of Forestry Natural Foundation, Wojska Polskiego 71d str., 60-625 Poznań, Poland, e-mail: danw@au.poznan.pl

Introduction

Occurrence of subarctic and boreal species is one of the important geobotanical features of north central Poland (Czubiński 1937, Kępczyński and Rutkowski 1988, Gostyńska-Jakuszewska et al. 2001). Many of them are glacial or postglacial relicts. Ecological amplitude restricts occurrence of these species to the harsh habitats such as peat-lands (Gostyńska-Jakuszewska and Lekavičus 1989). Negative effects associated with such distribution include limited habitat availability, increased isolation from other suitable habitat, reduced patch size, and increased susceptibility to habitat change. Thus it is very likely that local populations of glacial and postglacial relict species are doomed to extinction. From a conservation point of view however, it is important to keep these populations viable and to prevent their total destruction. The decline of these species in north central Poland is in progress and has been confirmed in the field (Zając and Zając 2001, Gostyńska-Jakuszewska et al. 2001). It is not clear however, how fast the populations are decreasing or if there are any new sites being colonized. Most of the reports about glacial relicts in Poland have warned about their decline but also have informed about newly discovered sites (Rejewski 1972; Kępczyński et al. 1976; Kępczyński and Rutkowski 1985; 1988; Gostyńska-Jakuszewska and Lekavičus 1989; Gostyńska-Jakuszewska 1992). This is a reason for the uncertain status of many of the glacial

and postglacial relicts species in Poland, for which local conditions are known relatively well but not at the landscape scale. In order to study the dynamic processes of still existing populations, assess threats and develop a conservation strategy, an investigation of the species distribution at a landscape scale is necessary. In this study we developed an inventory of existing and historical *S. myrtilloides* sites in north central Poland and analyzed the present status of this species in the region.

Salix myrtilloides L. is a subarctic-boreal species of the boreal zone type of distribution that has decreased in numbers or disappeared from many sites in Poland during the last few decades (Skvortsov 1968, Hulten and Fries 1986, Jonsell et al. 2000, Gostyńska-Jakuszewska et al. 2001). Poland is at the western limit of the main population range (Gostyńska-Jakuszewska and Lekavičus 1989). The migration of *S. myrtilloides* and similar species followed the retreating glacier to the North. This process lasted until the Atlantic period (7700–5100 B.P.), after which the extinction processes started to dominate over the colonizations which might have occurred only on a local scale (Czubiński 1950, Polakowski 1963, Środoń 1977). Since the climatic optimum, the studied willow remained only in the harshest habitats where competition from other species was limited. In the same time the main *S. myrtilloides* distribution range became established in the subarctic-boreal zone leaving several island populations along the distribution fringe.

In the past, *S. myrtilloides* has been reported in Poland from ca. 90 localities, several of which do not exist today. Most of the sites were concentrated in three regions: north central Poland (the Lower Vistula region), the Masurian and the Suwałki Lake districts and in the Lublin region. Isolated sites were also recorded from the Sudetes, the Sudetian Foothills, the Środkowomałopolska Highland and the Dobrzyń region (Ziemia Dobrzyńska) (e.g. Kulesza 1928, Czubiński 1950, Fijałkowski 1958, Rejewski 1972, Bróż and Przemyski 1983, Boratyński 1988, Sokołowski 1981). *S. myrtilloides* is known to be vulnerable to changes in the habitat – water conditions, pH and soil nutrition in particular. Many of the sites in Poland where this willow was previously reported do not exist today due to direct or indirect human activities. The most common examples of the habitat changes are: peat bog utilization by means of turf extracting, melioration, grazing, and vegetation cutting for winter fodder (Kępczyński et al. 1976, Olesiński and Olkowski 1976, Kornaś 1976, Herbichowa 1976, Gostyńska-Jakuszewska et al. 2001). This relict is also believed to be sensitive to shading so it often retreats while more competitive willows are entering (Urban and Wawer 2001).

Methods

The inventory was conducted during the summer and autumn 2003. The investigated sites were situated in north central Poland (Tuchola, Świecie, Bydgoszcz, Szubin, Chełmno, Kwidzyn, Brodnica, Włocławek), on the both sides of the Vistula including the Lower Vistula region, the Dobrzyń region (Ziemia Dobrzyńska) and the Brodnica Lake District (Fig. 1). In the studied region, *S. myrtilloides* occurrences comprise a substantial amount of all the Polish sites, allowing analysis of the decline process at the large landscape scale (Gostyńska-Jakuszewska and Lekavièius 1988). A postglacial landscape with many small lakes, peat-bogs, moraines, rivers and streams is characteristic for this region. Brown and sandy soils are the most common (Kondracki 2002). The studied sites are under the influence of Atlantic winds from the West and continental winds from the East. The yearly precipitation is very low ranging from 500–600 mm/year. The average temperature in January is –2.5°C and 18°C in July (Woś 1999).

All the localities (27) were selected primarily according to the Distribution Atlas of Vascular Plants in Poland (Atlas rozmieszczenia roślin naczyniowych w Polsce) (Zając A. and Zając M. 2001) and the "Distribution Atlas of Trees and Shrubs in Poland" (Browicz and Gostyńska-Jakuszewska 1970) and other literature sources. Each site was located using descriptions found in the literature. When sites where identified, the following procedure was applied:

1. Searching for *Salix myrtilloides*;
2. Site description.

If *Salix myrtilloides* was not found, plausible reasons for extinction were noted with special attention paid to the following features: an intensity of farming, urbanization, road network, and other constructions around the site; species composition of herbaceous plants, occurrence of the hybrid willows, shrub and tree cover, site moisture, turf extraction pits, drainage ditches, livestock, and other traces of anthropogenic influence – at the site.

In instances where a single willow was found, the following procedure was applied:

1. Counting the stems;
2. General health condition of a population was assessed.

A GPS unit was used to mark individual stems or patches of *S. myrtilloides*. The patch was defined as a circle with the radius, r = 1.5 m, which equalled the GPS receiver accuracy. All the stems were counted within the circle and recorded as a number confined to the geographical coordinates of the patch centre. Naturally occurring patches of the willow were identified at first and individual stems were counted. If the patches were not explicitly distinct, the patch centre was set up subjectively according to a rule that the

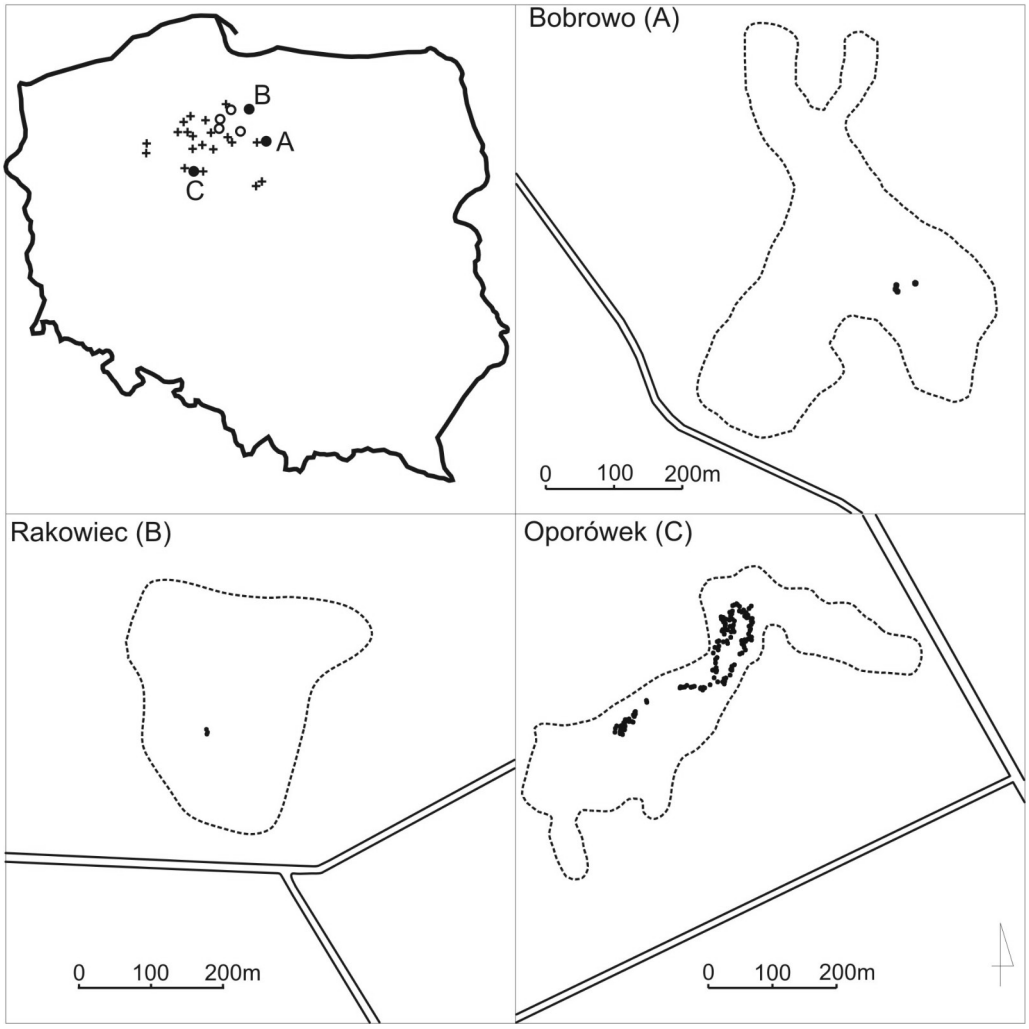

Fig. 1. Study area. The distribution of 27 revised localities and the schemes of three existing sites with marked patches of *S. myrtilloides* L.

distance between the patches should be greater than the distance between individuals in the patch. In the case of high densities of stems in the patch, the numbers were estimated and hence presented with a preposition 'circa' (ca.).

The sites where *S.myrtilloides* was found were classified as 'Confirmed'. Sites that were found according to the literature sources and *S.myrtilloides* was not found there, were classified as 'Extinct'. Sites that were not found, due to e.g. vague description in the literature sources or other objective and subjective reasons were classified as 'Not confirmed'. In the latter case the site might be either truly extinct or still existing.

Results

The inventory of 27 localities revealed a decline in population numbers. Out of 27 sites existing 50 years ago, 3 were confirmed, 4 were not confirmed, and remaining 20 were considered to be extinct (Table 1). In a comparison to the historical distribution ca. 74% of the sites existing 50 years ago do not exist today in the studied region. Out of seven localities that were confirmed in the 1980s yet another three are extinct (Gostyńska-Jakuszewska et al. 2001). The most abundant population was found at Oporówek, where ca. 1600 individuals were counted. Other two existing sites were much smaller, comprising 15 individuals in Bobrowo and ca. 100 in Rakowiec (Fig. 1). At three sites confirmed in this study the existence of vigorous hybrids between *S. myrtilloides* and *S. aurita* L. (*S.* ×*onusta* Besser) was observed. At 15 extinct sites changes in hydrology, increase of shrubs and trees, and decrease of the transitional peat-bogs species were observed. At the remaining 4 extinct sites no changes in the conditions were observed.

Discussion

The rapid rate of decline proves the critical status of *Salix myrtilloides* in north central Poland. Our findings show that the extinction process of *S. myrtilloides* was possibly connected to habitat loss in the majority

Table 1. Present S. myrtilloides L. population status in a comparison to the previous studies

No	Previous studies				Present study		
	Site	Year	Authors	No of individuals	No of individuals	Status	Changes observed at the sites
1	Oporówek	1967	Kępczyński K. and Boiński M.	Many	ca.1600	Confirmed	No changes observed
2	Rakowiec	1985	Kępczyński K. and Rutkowski L.	Not many	ca.100	Confirmed	No changes observed
3	Bobrowo	1937	Czubiński Z.	?	15	Confirmed	No changes observed
4	Laskowice	1928	Kulesza W.	Many	–	Not confirmed	–
5	Nowe	1928	Kulesza W.	?	–	Not confirmed	–
6	Świecie	1928	Kulesza W.	?	–	Not confirmed	–
7	Trzebiełuch–Stanisławki	1928	Kulesza W.	?	–	Not confirmed	–
8	Dziedno	1972	Rejewski M.	Many	0	Extinct	– Change in hydrology – Increase bushes, trees – Decrease peat-bog species
9	Mąkowarsko	1972	Rejewski M.	Not many	0	Extinct	– Change in hydrology – Increase bushes, trees – Decrease peat-bog species
10	Szubin	1938	Wodziczko A. et al.	?	0	Extinct	– Change in hydrology – Increase bushes, trees – Decrease peat-bog species
11	Linowiec	1928	Kulesza W.	?	0	Extinct	– Change in hydrology – Increase bushes, trees – Decrease peat-bog species
12	Augustowo	1928	Kulesza W.	?	0	Extinct	– Change in hydrology – Increase bushes, trees – Decrease peat-bog species
13	Borówki	1906	Preuss H.	?	0	Extinct	– Change in hydrology – Increase bushes, trees – Decrease peat-bog species
14	Krusin	1928	Kulesza W.	?	0	Extinct	– Increase bushes – Decrease peat-bog species
15	Jezioro Ostrowite	1960	Kępczyński K.	?	0	Extinct	– Increase bushes, trees – Decrease peat-bog species
16	Barcin	1938	Wodziczko A. et al	Very little	0	Extinct	– Increase bushes, trees – Decrease peat-bog species
17	Osowiec	1938	Wodziczko A. et al.	?	0	Extinct	– Increase bushes, trees – Decrease peat-bog species
18	Lniano–Sierosław	1928	Kulesza W.	Many	0	Extinct	– Increase bushes, trees – Decrease peat-bog species
19	Skarpa	1928	Koppe F.	?	0	Extinct	– Change in hydrology – Wet, cultivated meadows
20	Tuchola	1906	Preuss H.	?	0	Extinct	– No peat-bogs found – Urban area
21	Twarda Góra–Milewski Las	1928	Kulesza W.	?	0	Extinct	– Changes in hydrology – Increase bushes, trees – Decrease peat-bog species
22	Gruczno–Dworzysko	1928	Kulesza W.	?	0	Extinct	– No peat-bogs found – Arable land
23	Łobżenica	1908	Bock W.	?	0	Extinct	– No peat-bogs found
24	Falmierowo	1988	Kępczyński K. and Rutkowski L.	50	0	Extinct	– No changes observed
25	Skępe	1960	Kępczyński K.	?	0	Extinct	– No changes observed
26	Chojno–Grzywinek	1937	Czubiński Z.	?	0	Extinct	– No changes observed
27	Linie	1928	Stecki K. and Kulesza W.	Very little	0	Extinct	– No changes observed

of sites, which conforms to a common observation that habitat change today is a major threat to plant biodiversity (e.g. Wilcove et al. 1998, Lindborg and Eriksson 2004). The only suitable habitats where *S. myrtilloides* or similar species (e.g. *S. lapponum, Betula nana*) can occur are acidic and moist transitional or high bogs. The abundance of such habitats has been declining over time since the glacier retreated. Despite that fact, there were still about 100 existing populations of *S. myrtilloides* at the end of the 19th century (Browicz and Gostyńska-Jakuszewska 1970).

Spatial arrangement of the studied willow subpopulations suggests 'source and sink' metapopulation model where constant extinction and re-colonization processes occur within patches of suitable habitat (Levins 1969, Hanski 1997). Both habitat availability and dispersal abilities of species are crucial for maintaining these two processes in equilibrium. Since seeds of *S. myrtilloides* are wind adapted (they are small, light and bear hairs) it is highly possible that they can travel long distances (e.g. Gage and Cooper 2005). Mean distance between suitable habitats (transitional peat bog) in north central Poland is ca. 1400–2000 m. In this respect the studied species together with other willows, probably is not dispersal limited – it should be noted however, that only a small fraction of seeds might reach that far (Gage and Cooper 2005). Nevertheless the present condition of the *S. myrtilloides* population is rather unbalanced, where extinction dominates over the re-colonization process (Lande 1987).

Assuming that the studied willow is not dispersal limited it is the habitat availability that may be a limiting factor. It has been discussed in the literature (e.g. With and King 1999, Carlson 2000, Hanski and Ovaskainen 2002) that there exists a certain level of a suitable habitat below which a meta-population is not able to survive. Analyzing the historical sites however, in 4 cases the conditions have not changed and the sites remained transitional bogs. Despite the stable conditions sub-populations of *S. myrtilloides* are extinct on these sites. This could be explained by natural stochasticity in the environment that may pose a threat to species persistence in addition to habitat destruction (Boyce 1977, Nakaoka 1996, Garcia 2003). On the other hand the *S. myrtilloides* population from Polesie Lubelskie, Poland declined drastically as a consequence of melioration operations prior to a coal mine establishment in the adjacent area which indicates high susceptibility of that species to habitat change (Urban and Wawer 2001). Thus it is possible, that even a minor change in one of the habitat elements that we were not able to detect in this study, might have influenced the survival of a *S. myrtilloides* population.

Besides the habitat availability there is another factor influencing population dynamics of plants – interspecific competition and hybridization, known to be common in *Salicaceae* (Chmelař 1985). Hybridization and chemical environment pollution are believed to be responsible for species extinction in 38% of cases (Kornaś 1976). The inventory of the three confirmed sites in this study revealed the existence of *S. ×onusta* Besser hybrid and a number of intermediate forms that could be called a hybrid throng (Stace 1993). The real threat takes place when a parental species dissolves in the hybrid throng and disappears. In the cases of *S. myrtilloides* and *S. aurita* direct introgression toward *S. aurita* is probably prevailing, which may result in the slow disappearance of pure *S. myrtilloides*. Since *S. aurita* is more competitive and also more common outside the peat bogs, there is a constant inflow of seeds and pollen. Rare and isolated *S. myrtilloides* populations yield in total a much smaller number of seeds and pollen. Subsequently there is a constantly lower pool of pure *S. myrtilloides* and a higher pool of *S. ×onusta*.

Postglacial relicts are important elements of the studied landscape. It is desirable therefore to undertake conservation measures to maintain their viable populations. In light of our results and other studies reporting the decline in many relict plant species in north central Poland, it is very likely that we are already facing the so called "extinction dept" – time lagged response of a metapopulation to habitat destruction in the past – that could be rectified only through enhancing the landscape quality (Tilman et al. 1994, Hanski 1998, Hanski and Ovaskainen 2002). Therefore, natural habitat protection with an adequate buffer zone and gene pool protection in the form of plantations is suggested as a conservation strategy. As an alternative strategy active protection '*in situ*' is proposed based on cutting competitive common species of willows. Furthermore, detailed research is needed on the habitat change process, population dynamics, dispersal abilities, habitat availability, and the genetic diversity of relict species occurring in north central Poland, in order to establish effective management guidelines and conservation strategies.

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