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ORIGINAL RESEARCH ARTICLE

Occurrence of black cherry (*Prunus serotina* Ehrh.) in the State Forests in Poland

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Abstract. Among the invasive tree species identified in Polish forests, black cherry (*Prunus serotina* Ehrh.) appears to pose the greatest threat. The objective of this study was i), to determine the abundance of this species in the forests managed by the State Forests National Forest Holding (PGLLP) and ii), to characterise the ecological conditions that it is found in. The source data was obtained from the State Forests Information System (SILP) database. In Polish forests, black cherry mostly occurs as an understory plant and is present in a total area of 99,185 hectares, which is 1.4% of the forest area under the management of the PGLLP. Although *Prunus serotina* can be found within a wide range of habitats, it most commonly occurs on sites that can be considered average in terms of fertility (mixed coniferous and mixed deciduous types) developed primarily on rusty soils (podzols).

Key words: black cherry, ecological conditions

1. Introduction

Modern forest management worldwide – now directed towards the production of large amounts of timber on a short-term time scale – is nowadays mainly associated with the silviculture of tree species occurring beyond their natural ranges (Woziwoda 2012). Introduction of alien tree species into Europe's forests started in the middle of the 19th century, and it became more than ever intensive in the 20th century. Above all, the reason for this was the call for increasing timber production. The interest in growing new forest species was instigated by scarcity of species in native dendroflora (Bellon et al. 1977; Danielewicz, Wiatrowska 2012) and urgent needs for lumber as a result of rapidly developing economy. However, for quite some time already, attention has been drawn to negative effects of introduced tree species, especially due to their invasive nature (Szwagrzyk 2000; Danielewicz, Wiatrowska 2012; Woziwoda 2012). Some alien plant species have gotten out of control and are now spreading throughout local ecosystems causing considerable changes. These are called alien invasive species and have lately become a serious global problem, especially from the perspective of biodiversity conservation at a local level (Danielewicz, Wiatrowska 2012; Gazda 2012; Woziwoda 2012). Because of increasing interference of some alien species, there is a necessity to have complete knowledge on their distribution, frequency as well as conditions for growth and development within Poland.

Among invasive plant species identified in Poland's forests, the most threatening is black cherry *Prunus serotina* Ehrh. (Namura–Ochalska 2012). In the 1950s, this species was far and wide planted so as to improve phyto-amelioration within forest monocultures, and also – for soil protection reasons (Starfinger et al. 2003). The species, which now can be found extending throughout almost the entire country (Fig. 1), used to be promoted for its remarkable growth in young pine stands and assistance in pine self-pruning (Dominik 1947). Recommendations for planting black cherry as a supportive species in land improvement in poor habitats were

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included in subsequent editions of the manual 'Forest Silviculture Principles' (Zasady Hodowli Lasu) until the end of 1980s. Having appropriate conditions for development, black cherry has spread beyond control right through Poland's forests with negative influence on native phytocoenoses. The pressure of this tree species is now more and more visible (Halarewicz 2012; Otręba 2013), even though according to some authors, black cherry is yet to achieve the maximum of its population in Europe (Zerbe, Wirth 2006). Identification of factors affecting black cherry growth and development as well as a rate of new site colonisation seems most necessary and could become a base for building a strategy for effective control of this neophyte.

Figure 1. Distribution of black cherry *Prunus serotina* Ehrh. in Poland (Zając, Zając 2001).

Even if the importance of some invasive alien species has been constantly growing, studies on this issue with regard to forest ecosystems have been limited (Gazda 2012). Investigations on black cherry position in Poland's phytocoenoses have also been insufficient and in short supply. So far, the latter have focused on species dispersal and concern only in selected areas (Danielewicz 1994; Halarewicz, Rowieniec 2009; Halarewicz 2011b; Otręba 2013). Ecological factors affecting black cherry growth and development in different forest plant associations have been up to now sporadically addressed both in Poland (Stypiński 1977, 1979; Halarewicz 2011a, 2012; Halarewicz, Kawałko 2014) and Europe (Godefroid et al. 2005; Vanhellemont 2009)

The aim of the present study is to determine the scale of black cherry *P. serotina* Ehrh. incidence in Poland's forests managed by the State Forests National Forest Holding (PGLLP) and to depict the characteristics of site and soil conditions within the forests where this species occurs.

2. Material and methods

The source data was obtained from the State Forests Information System (SILP) and all concerned forest management units where black cherry incidence has been recorded. We gathered the records on black cherry locations, areas of its occurrence, forest site category as well as on soil type and sub-type. Based on these information, we determined the following features: the number and area of forest management units with black cherry specimens taking into account tree stand layers (first and second layer, brushwood, undergrowth, regeneration, remnants and afforestation) as well as stand age, the site category and soil types. The analyses considered the location of the stands with black cherry defined at the level of the Regional Directorates of the State Forests (RDLP).

SILP records from Gdansk, Lublin and Radom RDLPs do not include separate information on various *Prunus* species, thus forest areas under administration of these RDLPs were not considered in the present study as a consequence of the lack of chance to sort out native and alien *Prunus* trees. Characteristics of site and soil conditions in which black cherry occurs did not incorporate the areas of barrens, afforestation areas, fire lanes, as their record in SILP database lacked information on the forest site category and soil types. Given that black cherry is an admixture species, stock volume of forest stands with black cherry share was not analysed.

3. Results

In forests managed by PGLLP, black cherry occurs in 32,230 management units with the total area of 99,185 ha (Table 1). There prevail the units with black cherry in the undergrowth (the number – 96.7% and the area – 97.6%). The highest number of such units is documented in RDLP Poznań (11,840 units with the total area of 35,050 ha) and RDLP Wrocław (8338 units, 25,094 ha). Considerably large area with black cherry is also recorded in RDLP Katowice (11,524 ha) and RDLP Warszawa (7092 ha). On the whole, in the first and second forest layer, black cherry occurs only in 617 units with the total area of 1793

Table 1. Number and area of forest units with black cherry in various stand layers in Regional Directorates of State Forests.*

RDLP Regional Directorate of the State Forests	Stand		Understory		Bushes	
	number	area	number	area	number	area
	Qty.	ha	Qty.	ha	Qty.	ha
Białystok	3	5.52	1852	6401.05	67	336.27
Katowice	9	36.74	3279	11,523.2	27	21.82
Kraków	7	22.13	-	-	-	-
Krosno	1	0.54	-	-	-	-
Łódź	1	3.73	981	3020.63	6	3.22
Olsztyn	6	12.90	20	102.80		-
Piła	66	204.14	9	32.64	-	-
Poznań	61	162.29	11,840	35,049.74	106	72.54
Szczecin	18	33.86	1750	5969.42	23	13.23
Szczecinek	119	305.15	-	-	-	-
Toruń	21	47.29	1	18.41	-	-
Wrocław	159	455.05	8338	25,093.70	148	109.18
Zielona Góra	70	145.19	1034	2471.84	24	17.18
Warszawa	76	358.04	2062	7091.88	23	20.76
Total	617	1792.57	31,166	96,775.63	424	594.20

*excluding RDSF in Gdańsk, Lublin and Radom as they don't distinguish native and alien cherry

Tabela 2. Number and area of forest units with black cherry in 10-years age classes of this species

Age (years)	Number		Area	
	Qty.	%	Qty.	%
1–10	231	37.4%	589.93	32.9%
11–20	78	12.6%	171.82	9.6%
21–30	42	6.8%	84.31	4.7%
31–40	94	15.2%	308.81	17.2%
41–50	99	16.0%	321.22	17.9%
51–60	49	7.9%	231.35	12.9%
61–70	13	2.1%	50.12	2.8%
71–80	6	1.0%	25.75	1.4%
81–90	3	0.5%	4.05	0.2%
91–100	2	0.3%	5.21	0.3%
Total	617	100.0%	1792.57	100.0%

ha. The majority of such units is recorded in RDLP Wrocław (159 with the total area of 455 ha). Relatively large areas of black cherry in the first and second forest layer are also observed in RDLP Warszawa (358 ha), RDLP Szczecinek (305 ha), RDLP Piła (204 ha), RDLP Poznań (162 ha) and RDLP Zielona Góra (145 ha). In the rest of RDLPs studies, only individual management units as such were recorded. In general, forest stands with black cherry share are young (Table 2). Half of these are now classified in the first-age class, and only 12% of all stands with black cherry are older than 50 years. With regard to the area, there prevail units in the age classes Ia, IIb and IIIa (33%, 17% and 18%, respectively). Black cherry share in shrub layer was recorded on the total area of 594 ha, of which 57% – in RDLP Białystok and 18% – in RDLP Wrocław (Table 1). Remnants, tree groups and natural regeneration of black cherry occur in individual management units with the total area of only 23 ha.

Even if management units with black cherry can be found throughout a quite broad range of forest site categories, most often, this species occurs on the sites with medium quality in terms of soil fertility and those with relatively low moisture (Fig. 2). The units within coniferous and mixed coniferous sites constitute the largest areas (42% and 36%, respectively). Fresh forest sites constitute 88% of the area occupied by black cherry, whereas the extreme sites with regard to the moisture constitute only 1% and 0.02% (marsh and dry sites, respectively). Black cherry trees are most often observed on rusty soils (Fig. 3). Rusty soils occur on 27.3% of forest area with black cherry, rusty podzolic soils – on 22.5%, and brown rusty soils – on 12.4%. Podzolic soils in total comprise 15% of the areas where black cherry occurs. The share of other forest soil types is relatively low (Fig. 3).

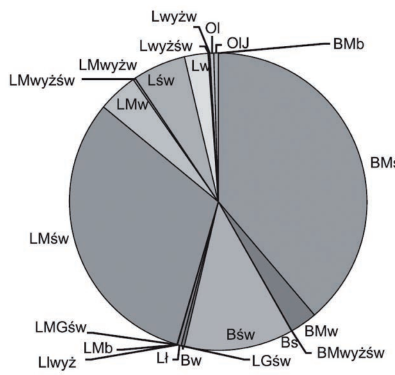

Figure 2. Share of forest site types in total area of forest units with black cherry:
BMb – marsh oligo-mesotrophic, BMśw – fresh oligo-mesotrophic, BMw – wet oligo-mesotrophic, BMwyżśw – upland fresh oligo-mesotrophic, Bs – dry oligotrophic, Bśw – fresh oligotrophic, Bw – wet oligotrophic, LGśw – montane fresh eutrophic, Lł – riparian, LŁwyż – upland riparian, LMb – marsh meso-eutrophic, LMGśw – montane fresh meso-eutrophic, LMśw – fresh meso-eutrophic, LMw – wet meso-eutrophic, LMwyżśw – upland fresh meso-eutrophic, LMwyżw – upland wet meso-eutrophic, Lśw – fresh eutrophic, Lw – wet eutrophic, Lwyżśw – upland fresh eutrophic, Lwyżw – upland wet eutrophic, Ol – alder, OlJ – alder-ash.

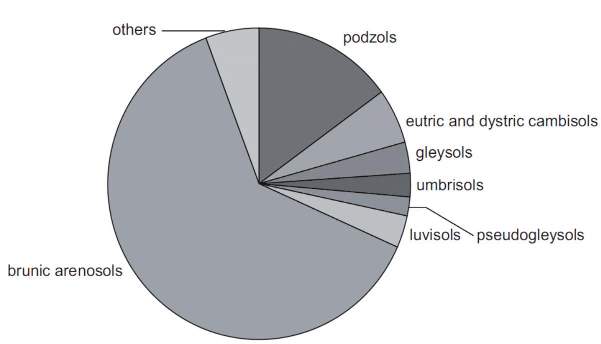

Figure 3. Share of soil types in total area of forest units with black cherry

4. Discussion

Black cherry occupies 1.4% of forest area managed by PGLLP and occurs all over Poland, except for the territories situated in north- and south-eastern parts of the country (Fig. 1). This is partially reflected in the records on the occurrence of this species in the State Forests (Table 1). Location of the *P. serotina* introduction, and hence the present occurrence of this tree species, was predominantly the result of the economic decisions related to the application of the silvicultural rules and recommendations valid at a given time. At the end of 1980s, black cherry was hitherto listed as a biocenotic and useful in phyto-amelioration species in the species composition of afforestations on post-agricultural lands with fresh, dry and mixed coniferous sites (Zasady Hodowli Lasu 1988). According to Gazda and Augustynowicz (2012), spatial distribution of alien species occurrence in Poland's forests can be differentiated depending on the forest layer. The share of black cherry in higher stand layers rarely exceeds 30%, whereas this species prevails in the undergrowth. Gazda (2013) found that *P. serotina* is rather rarely classified as an invasive species in SILP.

Black cherry is characteristic of large tolerance to different ecological conditions. The expansion of this species observed for quite a long time, has been possible owing to black cherry low demands with regard to the soil conditions, its resistance to the climatic factors and ability to grow and develop fast. Black cherry grows and produces fruit even on poor and dry soils, and it is resistant to drought and frost. It can also withstand both deep shade and full light conditions (Stypiński 1977; Starfinger 1991; Vanhellemont 2009; Vanhellemont et al. 2010; Namura-Ochalska 2012; Halarewicz 2012). The results of the present study partially confirm the statements by other authors. However, one has to bear in mind that the presented analysis of black cherry occurrence in Poland's State Forests principally concerns the sites where this species was deliberately and systematically planted. The results obtained can hardly be used for the description of black cherry optimal growth conditions, but can indicate a range of this species occurrence.

According to the results obtained, black cherry occurring in the State Forests mainly occupies medium sites in terms of fertility, that is, mixed coniferous forests and mixed deciduous forests. This observation was confirmed in previous studies on the occurrence of black cherry in different parts of Poland, even though some authors point out that also coniferous sites are optimal for *P. serotina* (Stypiński 1977, 1979; Danielewicz 1994; Danielewicz, Maliński 1997; Halarewicz, Rowieniec 2009; Halarewicz, Nowakowska 2005; Halarewicz 2012). According to many authors (Starfinger 1997; Halarewicz, Nowakowska 2005; Godefroid et al. 2005; Chabrerie et al. 2007; Verheyen et al. 2007; Closset–Kopp et al. 2007, 2011; Halarewicz, Rowieniec 2009), black cherry avoids wet sites, which is attributable, among others, to larger occurrence of the soil pathogens in wet environments. Excessive moisture in soil limits black cherry development since – as stressed by Tyszkiewicz (1949) – this species is sensitive to high ground water level. This was confirmed by Halarewicz and Kawałko (2014) who stated that the presence of black cherry trees and shrubs on wet mixed deciduous forest sites was, for the most part, reliant upon availability of water in deeper soil layers, while excessive dampness of the ground negatively affected all growth stages of black cherry. On the other hand, Suszka (1967) reported that black cherry seed germination was possible only under the conditions of water availability in soil. Also, Auclair and Cottam (1971, 1973) emphasised the importance of soil water in black cherry growth.

Black cherry shows low demands in terms of soil fertility; however, it grows the best on deep and fertile soils (van den Tweed, Eijsackers 1987; Starfinger 1991, 2010; Reinhardt et al. 2003; Halarewicz 2012). According to Stypiński (1977, 1979), this species finds optimal conditions for development on rusty soils as well as on brown leached soils, which was confirmed in the presented study. As reported by Halarewicz (2012) and Halarewicz and Kawałko (2014) strong acidity and low availability of nutrients in soil have no negative effects on young generation of black cherry. Also, Starfinger et al. (2003) found that in areas with widespread black cherry, soil pH was much lower compared to those with no specimens of this species. Furthermore, Chabrerie et al. (2007) reported that black cherry density was positively correlated at a significant level with phosphorus content in upper soil layers. The authors believe that this relationship is a result of low demands of black cherry, which was planted on poor sites so as to increase site productivity. According to Closset–Kopp et al. (2011), soil type significantly influences black cherry growth parameters (basal area and height increment) only when combined with light availability. Nevertheless, invasion rate and size are associated with the fact that black cherry populates faster and wider the areas with poor soils (podzols) compared to those with fertile soils (gleyed soils, luvisols or regosols).

In line with Godefroid et al. (2005) and Knight et al. (2008), light is a positive factor notably influencing black cherry growth; however, the importance of light conditions depends on tree growth stage. Halarawicz (2012) stresses that the importance of light changes during black cherry development. Strong shading results in seedling abundance. Nonetheless, even though population numbers in the brushwood layer do not depend on light conditions, the shift from the youth stage into subsequent growth stages requires light availability. That is why the majority of mature black cherry specimens have been found at forest edges and in gaps or clearances within forests (Closset–Kopp et al. 2011; Halarewicz 2012). This demonstrates the ability of black cherry to adapt to environmental conditions and to undertake survival strategies that allow for conquering new sites (Deckers et al. 2005; Closset–Kopp et al. 2007; Halarewicz 2011b).

5. Conclusion

Black cherry (*P. serotina* Ehrh.) is an alien tree species in Poland's dendroflora, which used to be intensively planted in the mid-20th century in forests, especially in pine monocultures, with the aim to improve phyto-amelioration and to protect soils. Low ecological demands and considerably dynamic growth resulted in uncontrolled spreading out of this species all over the country. For this reason, black cherry is now considered as an invasive alien species in Polish forests. Forest management units with black cherry can be regularly observed on medium sites in terms of fertility (mixed coniferous forest and mixed deciduous forest). In Poland, black cherry grows mainly on rusty soils, which is chiefly attributable to forest management practice and silviculture guidance operational at the time of black cherry planting throughout the country. The results obtained in this study confirmed up-to-date findings on black cherry site demands both under Poland's and Europe's conditions.

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