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***Pseudotsuga Menziesii* (Mirb.) Franco on Protected Areas of Ukrainian Polissya**

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Abstract. In Europe, including Ukraine, a serious consideration is given to *Pseudotsuga menziesii* (Mirb.) Franco, as a prospective species for the creation of various types of plantations. The use of this tree species in plantations looks advantageous. The species composition of rare exotic arboreal plants, including *P. menziesii*, their representation and state of preservation were studied in the protected territories of the Steppe, Forest Steppe, and Ukrainian Polissya. Presently, it is relevant to study the age-class composition, quantitative and qualitative characteristics of *P. menziesii*, species condition and representation in various types of plantings in the protected areas of Ukrainian Polissya. The purpose of this study was to determine the distribution, status, biometric indicators, and age-class distribution of *P. menziesii* in the protected areas of the Ukrainian Polissya. Three research methods were utilized: field (route), analytical, and comparative analysis. In the Ukrainian Polissya, *P. menziesii* was first introduced in Vozdvizhenskyi Garden Art Park Monument (PMLA) in 1903. Mass introduction of the species into reserves in most locations took place in the 1960-70s. Among the areas that accepted introductions, 53.3% were concentrated in Volyn Polissya, 26.7% in Zhytomyr Polissya, and 20% in Novhorod-Siverskyi Polissya. The results of our research revealed that *P. menziesii* grew in 14 protected areas in groups, strip plantations, and as a single tree (a total of 107 specimens were found, of which 17% were *P. menziesii* var. *glauca* (Beissn) Franco). In the Radomska Dacha reserve district, *P. menziesii* plantation was created. In the age-class distribution, 53% of trees fell into 41-60-year-old category, with age categories of 1-40 and 61-80-year-old containing 33% and 7% of trees, respectively. *P. menziesii* produced viable seeds in 14 locations (seed production score varied between 2 and 5 at the maximum score of 5). In one other location trees did not produce seeds because reproductive age was not reached. Three locations were characterized by viable natural regeneration in the amount of 2 specimens per 1 m². Among seedlings, 83.2% were in good condition. The obtained results could be used to compare quantitative and qualitative indicators of *P. menziesii* in various types of plantations created in the Forest-Steppe and Steppe, representing the deciduous forests of Ukraine belt

Keywords: Douglas fir, parks-monuments, natural monuments, dendrological parks, tree stand

Introduction

In the coming decades, forestry in the world will be tasked with the goal of restoring ecosystems [1]. In terrestrial ecosystems, forested areas are the main absorber of atmospheric mercury (Hg) [2]. Sustainable forestry may help to increase biodiversity, improve ecosystem services, and restore areas after tree harvest [1]. *Pseudotsuga menziesii* (Mirb.) Franco [3], which has great economic and ecological importance and is one of the five tallest tree species, is suitable for the formation of sustainable multi-species and multipurpose forested areas [4]. *P. menziesii* was introduced to Europe from western North America in the 19th century [3], about 150 years ago [5]. Currently, in Central

Europe, preference is given to *P. menziesii*, which considerably surpasses all native forest tree species due to fast growth, effective suppression of competing vegetation, and high drought resistance [1; 3]. In Germany, *P. menziesii* is the most common introduced tree species, occupying about 2% of the forest area [5]. In Central Europe, *P. menziesii* is less affected by pests and pathogens than natural *Picea abies* (L.) Karst. and *Pinus sylvestris* L. *P. menziesii* litter decomposes better in comparison with native coniferous plants [1; 3]. Mixed *P. menziesii* and *Fagus sylvatica* L. as well as *P. menziesii* and *Picea abies* tree stands with sufficient light (after thinning or naturally less dense) are more resistant

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to pests than pure stands of *P. menziesii* [6]. At the same time, as noted by T. Fiala, Ja. Holuša, A. Vélé [7], in Central Europe (Western Bohemia), there is a threat of native bark beetles attacking exotic tree species of the genera *Abies*, *Picea*, *Pinus*, and *Pseudotsuga* in resort forests. In 12 localities in the western Czech Republic, 19 native bark beetle species were identified, which affected over 10% of exotic tree species in 1 year. A wide range of epigeal arthropods is preserved in the pure middle-aged *P. menziesii* stands in small areas (Germany, north-western Lower Saxony), so the amount of biodiversity is sufficient. However, afforestation by pure Douglas fir has led to marked changes in epigeal invertebrate communities compared to deciduous forests from autochthons *Quercus petraea* Liebl. of the same age in Western Europe [8]. In north-eastern Spain (Catalonia) in the Montseny Nature Park *P. menziesii* naturalized less than 30 years after the creation of plantations at an altitude of >1000 m and was able to naturally regenerate in adjacent areas within 100 m from the original plantation footprint [9]. In southwestern Germany, based on regional inventory data A. Bindewald, S. Miocic, A. Wedler, J. Bauhus [10] estimated the risk of *P. menziesii* and *Quercus rubra* L. being invasive in protected forests by quantifying natural regeneration and its height. Natural renewal of both plants was observed on 0.3% of the total area of protected biotopes. It was found that in stands with sufficient light in the understory and competitive tree species, there is a risk that *P. menziesii* and *Quercus rubra* L. may cause changes in species composition in the absence of management. Such risks can be minimized in protected areas by establishing buffer zones and regularly removing unwanted regeneration [10]. Researchers note that the invasive potential of *P. menziesii* in Central Europe is very limited and can be controlled at any time if *P. menziesii* plantations are created in combination with the shade-tolerant *F. sylvatica* [1; 10]. Based on the inventory of conifers in Orleans (France), J.-P. Rossi, V. Imbault, T. Lamant, J. Rousselet [11], found that in 5 districts of the city, *P. menziesii*, *P. sylvestris*, and various species of the *Cedrus* genus are less common than *Pinus nigra*. In Denmark, based on 50 years of research in 13 sites with 12 species (*F. sylvatica*, *P. menziesii*, *Abies grandis*, *Larix kaempferi*, *Chamaecyparis lawsoniana*, *Pinus contorta*, *Pinus mugo*, *Abies procera*, *Picea abies*, *Quercus robur*, *Abies alba*, and *Picea sitchensis*), it was noted that North American coniferous tree species have a considerably higher biomass production potential than other species [12]. Research conducted in Great Britain (North Wales) and a comparative analysis of spruce-fir forests of the Swiss Jura showed the possibility of creating sustainable mixed tree stands with a density of 27.4 m² ha⁻¹ using *P. menziesii*. Such stands could be created with lower *P. menziesii* tree density that is 85% of that in Norway spruce plantations. However, the volume increment in *P. menziesii* plantations is estimated to be greater than that of common spruce by 15.3 m³ha⁻¹year⁻¹ [13]. Thus, in Europe, considerable attention is paid to epy research of *P. menziesii*, as a prospective species for creating various plantations. Similar studies are being conducted in Ukraine. Yu. Debryniuk emphasizes the advantage of creating tree stands with *P. menziesii* in the western region of Ukraine, where wood reserves could be as high as 700 m³ ha⁻¹ or higher at the age of 50-60 years [14]. Considerable attention

is paid to research in the protected areas of Ukraine. For example, on the territory of the State Dendrological park (DP) "Trostanets" of the National Academy of Sciences of Ukraine (Sumy region), *P. menziesii* is resistant to abiotic and biotic factors and has high seed production [15]. On the territory of the National Nature Park (NNP) "Vyzhnytskyi" (Chernivtsi region), invasive plants occupy 3% of the area of the NNP. Among the invasive plants, *P. menziesii* ranks second in terms of area – 35.7 ha (Sukhyi reserve (24.3 ha), Slavets (2.8 ha), Vyzhenka (8.6 ha)), which is 10.9% [16]. In "Roztochchia" reserve (Ivano-Frankivsk region), researchers noted that the artificial restoration of forests involving invasive plants in the past has led to the transformation of forests in the reserved territories [17]. The researchers claim that under the canopy of artificial plantations involving *P. menziesii*, *Pinus strobus* L., *Larix leptolepis* (Sieb. et Zucc.) Gord., there is unsatisfactory or insufficient renewal of native species (*Fagus sylvatica* L., *Carpinus betulus* L., *Acer platanoides* L., and *Acer pseudoplatanus* L.), and introduced species are not regenerating either, except for *Quercus rubra* L. [17]. V.M. Prokopchuk, M.V. Matusiak, Yu.O. Pankratiev, Yu.A. Yelisavenko [18], having assessed the viability and perspective of the introduction of *P. menziesii* in the area of the "Ladyzhynskyi Hai" dendrological park, note that *P. menziesii* is rare (4 specimens present) and that species is one of the promising decorative species for creating compositions in parks. *P. menziesii* has a remarkably high decorative effect [19]. However, *Pseudotsuga menziesii* var. *glauca* can be attacked by bark beetles (*Ips typographus* and *Pityogenes chalcographus*) [20]. In Ukraine, rare tree species including *P. menziesii* were studied in various natural zones on protected territories: in the Steppe zone [21; 22], in the Forest-Steppe [23; 24], in the zone of deciduous forests [25], in Ukrainian Polissya [26-28]. The authors of the mentioned studies analysed the species composition of dendrosozoexotes, the categorical, regional representativeness of the conservation status of the protected dendrosozoflora, including age-class composition. However, the age-class composition is not covered, the quantitative and qualitative features of the plants are not described, and the state and species representation of *P. menziesii* in tree stands in the protected territories of Ukrainian Polissya were not investigated.

The purpose of this study is to investigate the representation, status, biometric indicators, and age-class distribution of *Pseudotsuga menziesii* (Mirb.) Franco in the protected areas of Ukrainian Polissya.

The objective of this study is to conduct an inventory of *P. menziesii* trees in reserved areas of Ukrainian Polissya, distribute them by age class, to determine the quantitative and qualitative indicators of *P. menziesii*, and to identify the types of *P. menziesii* plantations.

Materials and Methods

The study was conducted during 2014-2021 in park-monuments of landscape art, dendrological parks, a botanical garden, and natural monuments of the Hamarnia landscape reserve, and Shatskyi National Nature Park. During field research, the status of *P. menziesii* was assessed and ranked (good – trees are healthy, normally developed, needles are dense, evenly distributed on the branches, normal size and

colour, no signs of disease and pests, wounds, damage to the trunk and skeletal branches, as well as hollows; satisfactory – the trees are healthy, but with signs of slow growth, with an unevenly developed crown, few needles on branches, minor mechanical damages and small hollows; unsatisfactory – the trees are weakened, the trunks are twisted, the crowns are poorly developed, dry branches are present, the one-year shoot growth is insignificant, mechanically damaged trunks, hollows) [29]. The diameter at breast height (1.3 m) was measured with a tree calliper, and the height was measured with a Suunto PM-5/1250 altimeter. Seed production was assessed visually according to the unified scale of O.A. Kalinichenko [30], where 0 points meant the plant does not produce seeds; 1 point – the crown contains very few flowers covering 0-20% of crown area; 2 points – the crown contains few flowers covering 21-40% of crown area; 3 points – the crown contains an average amount of flowers covering 41-60% of crown area; 4 points – the crown contains a large amount of flowers covering 61-80% of crown area; 5 points – the crown contains very large amount of flowers covering 81-100% of crown area. The age-class distribution was assessed according to the inventory description with trees assigned to the following age classes: 1-20 years and 21-40 years (young), 41-60 years (middle-aged), 61-80 years (semi-mature), 81 to 100 years (mature), from 100 to 200 years (over-mature). *P. menziesii* was checked for a presence on The International Union for Conservation of Nature (IUCN) Red List of Threatened Species [31].

Results and Discussion

70 reserved areas of Ukrainian Polissya were studied. These areas included 54 park-monuments of landscape art (PMLA), three dendrological parks (DP), Shatskyi National Nature Park (arboretum), Hamarnia landscape reserve (LR) (arboretum), botanical garden (BG) of the Polissia National University, 10 natural monuments (NM), reserved area (RA) Radomska Dacha. *P. menziesii* was detected in 15 nature reserve areas, which contains 21% of the total number of experimental plots. *P. menziesii* is mesophyte, mesotroph, heliophyte, microtherm [26], belongs to the Least Concern category of the IUCN Red List [31]. In Ukraine, *P. menziesii* was first introduced to the Bantyshevskiy Park in the Donbas region in 1864 [32]. In Ukrainian Polissya, *P. menziesii* was first planted in the Vozdvizhenskyi PMLA in the early 1900s [33]. The largest representation of *P. menziesii* in reserved territories of the Forest Steppe is in 46 localities, including PMLAs – 32, BGs – 5, and DPs – 7 [23]. In the Steppe, *P. menziesii* grows in 16 localities (Fig. 1), mainly in man-made reserved areas, namely in five BGs and seven PMLAs, two DPs [21]. In Ukrainian Polissya, the number of localities and categories varied in 2017 (13 localities, seven categories) and in 2019 (11 localities, six categories) [26; 18]. Having conducted field research using the route method, the author of this study specified the number of reserved plots (15), belonging to nine categories. Among them are PMLAs (4), NMs (4), DPs (3), BG (1), LR (arboretum), NNP Shatskyi (arboretum), and Radomska dacha RA (Fig. 1), where *P. menziesii* is growing. *P. menziesii* var. *glauca* (Beissn) Franco was also found in our research plots.

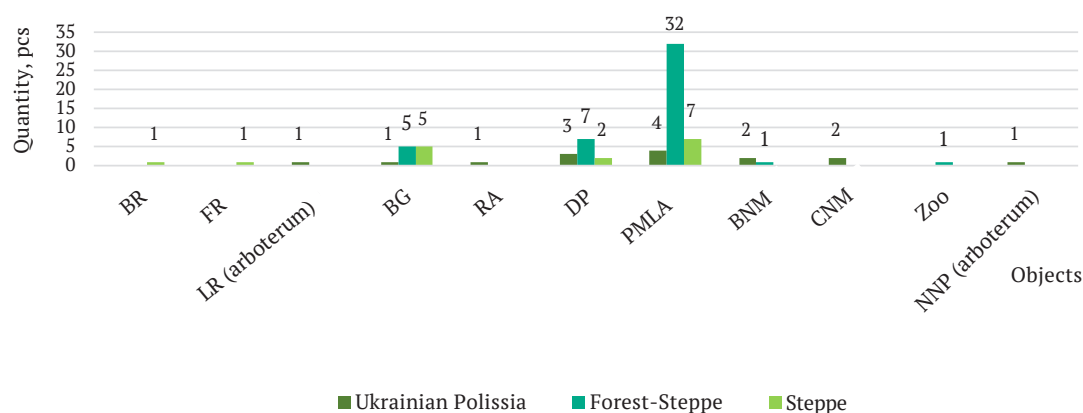


Figure 1. Representation of *P. menziesii* in the reserved areas of Ukrainian Polissya, Forest-Steppe, Steppe (BR – Biosphere Reserve; FR – forest reserve)

In the Rivne region, five protected areas were detected, where *P. menziesii* and *P. menziesii* var. *glauca* grow: botanical nature monument (BNM) Psevdotsuha tysolysta (Fig. 2a), a complex natural monument (CNM) Sarnenskyi dendrological park (Fig. 2b), CNM Rokytnivskiy dendrological park, PMLA Novostavskiy dendrological park, Bereznivskiy DP (Fig. 2c). BNM Psevdotsuha tysolysta covers an area of 0.1 ha. On the territory of the natural monument, *P. menziesii* var. *glauca* grows in a strip plantation of five plants along the road (planted 2 m apart) and five specimens – in a

mixed group with *Quercus robur* L., *Acer platanoides* L., and *Betula pendula* Roth. The average diameter is 40.8 ± 2.3 cm, the average height is 23.1 ± 1.1 m (Table 1), the largest specimen has a diameter of 49.0 cm and a height of 27.5 m. The condition of the plants is good (spreading crown 12 m wide) and satisfactory (crown raised high, unevenly developed, one-sided, inclined to the west). Regeneration was found along the road – a 3-year-old specimen 30 cm high and a 6-year-old specimen – 60 cm high (Fig. 3). Seed production was ranked as 3 and the plants were in good condition.

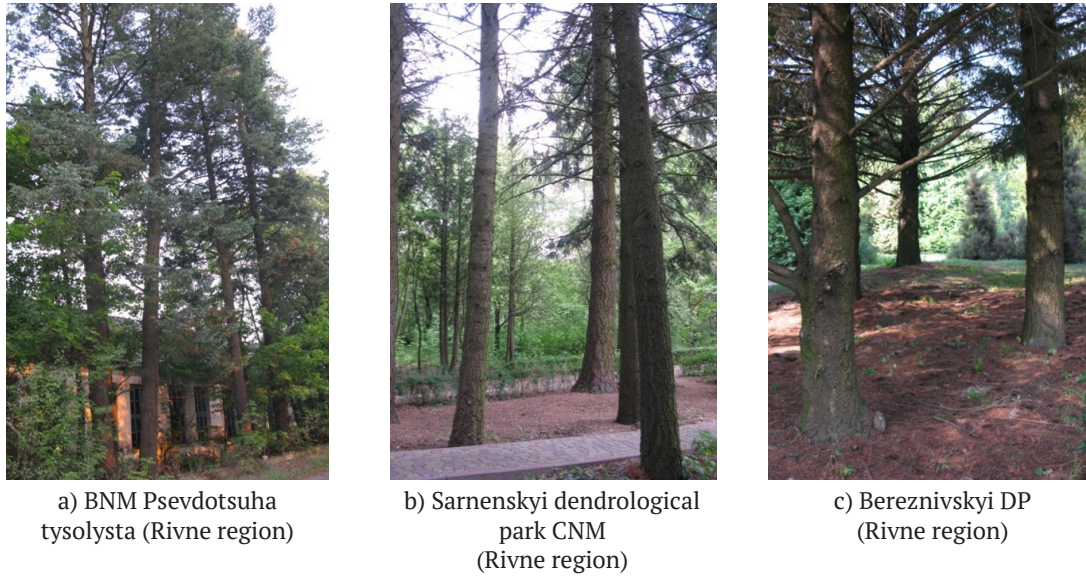


Figure 2. *P. menziesii* in the reserved areas of Ukrainian Polissya (author's photographs)

Table 1. Characteristics of *Pseudotsuga menziesii* (Mirb.) Franco and *P. menziesii* var. *glauca* (Beissn) Franco in the reserves of Ukrainian Polissya

Protected area	Number of specimens, pcs	Age, years	Height, m	Diameter, cm	Condition
Dubechnenskyi PMLA	1	60	25.0	28.0	s
Bairak PMLA	1	45	25.0	31.0	s
Vozdvizhenskyi PMLA	9	120	24.1 ± 0.6	30.2 ± 2.3	g, s
Novostavsky dendrological park PMLA	10	58	25.9 ± 0.9	42.8 ± 4.8	g
NNP Shatskyi (arboretum)	3	50	19.0; 18.5; 21.5	45.0; 50.0; 63.0	g
Hamarnia LR (arboretum)	12	38	14.7 ± 1.4	26.7 ± 1.8	g, s
Rokytnivskyi dendrological park BNM	1(3)*	59	23.5; 23.5; 24.0; 24.5	35.0; 39.0; 49.0; 53.0	g, s
Sarnenskyi dendrological park CNM	8	57	26.6 ± 0.4	38.0 ± 3.6	g
Bereznivskyi DP	10(3)*	44	25.4 ± 0.4	48.4 ± 4.3	g, s
Hladkovetskyi DP	29(2)*	63	23.1 ± 1.1	30.8 ± 1.6	g
Elita DP	2	36	14.0; 14.0	28.0; 30.0	g
Psevdotsuha tysolysta BNM	(10)*	55	23.1 ± 1.1	40.8 ± 2.3	g, s
Forest arboretum BNM	2	12	1.5; 2.7	4.0; 5.0	g, s

Note: (*) *P. menziesii* var. *glauca*; g – good condition; s – satisfactory condition



Figure 3. Natural regeneration of *P. menziesii* var. *glauca* in Psevdotsuha tysolysta BNM (Rivne region)

Three 59-year-old specimens of *P. menziesii* var. *glauca* were measured, their diameter ranged between 35.0 cm and 49.0 cm (average diameter 41.0 ± 4.1 cm), height ranged between 23.5 and 24.0 m (Table 1) (average height 23.7 ± 0.2 m) and *P. menziesii*, which was 24.5 m tall and 53.0 cm in diameter. One specimen each of *P. menziesii* and *P. menziesii* var. *glauca* growing near the pond were in good condition, two specimens of *P. menziesii* var. *glauca* were in satisfactory condition ($\frac{1}{2}$ crown in the lower part has no needles). Plants produced t, with seed production rating of 3. A group of 8 *P. menziesii* specimens was growing at the CNM Sarnenskyi dendrological park CNM (Fig. 2b). The average diameter was 38.0 ± 3.6 cm, average height was 26.6 ± 0.4 m (Table 1), the maximum diameter was 56.0 cm, the maximum height was 27.5 m. Trees were in good condition, the crown was raised high, almost symmetrical, the diameter from west to east – 9 m, from north to south – 8 m. They produce seeds, the seed production rating of 3. Seeds are similar. At the age of 40-50 years, the trees produced natural regeneration, which was planted in the nearby stands. Currently, natural regeneration is absent.

In PMLA Novostavsky dendrological park, *P. menziesii* grew in a group along the path in the central part of the park in the quantity of 10 trees, aged 58 years. The average diameter was 42.8 ± 4.8 cm, the average height was 25.9 ± 0.9 m, the maximum diameter was 63.0 cm, the maximum height was 28.5 m, with seed production rating of 2s, in good condition. In the Berezniivskiy DP, 10 specimens of 44-year-old *P. menziesii* plants were detected. Seven plants grew in a group with a spacing from 3 to 9 m. The lighting was

sufficient, crowns were equilateral, lowered. The average diameter was 48.4 ± 4.3 cm, the average height was 25.4 ± 0.4 m, the maximum diameter was 67.0 cm, the maximum height was 26.0 m, in good condition. In the north-western part of the experimental plot, on an area of 70 m², there were 17 specimens of self-seeded trees aged 3-6 years old and 15-35 cm tall. The seed production rating was 3. Two specimens of *P. menziesii* grew in the “modular garden” area (height – 22.0 m; 20.0 m, diameter – 67.0 cm; 54.0 cm), another one – near the seed storage (height – 23.0 m, diameter – 63.0 cm) in good condition. *P. menziesii* var. *glauca* was represented by three specimens planted in 1979. The seedlings were imported from a nursery in Estonia. Two *P. menziesii* var. *glauca* grew in a group with *Thuja occidentalis* L. and *Fagus sylvatica* subsp. *Purpurea*, with the spacing of 3.5 m. *P. menziesii* var. *glauca*, which has sufficient lighting from the eastern and north-eastern parts, had a diameter of 49.0 cm, a height of 19.0 m, the crown was lowered, the condition was good. The second one, which grew in the middle of the group, had a high-raised crown, the lower branches were dead from suppression, the needles were not dense and unevenly spaced on the branches. Diameter was 39.0 cm, height was 18.0 m, in satisfactory condition, with seeding rating of 5. Three specimens of self-seeded 1-2-year-old trees were found. They were located at a distance of 13.0 m from the mother trees, the age of 5 years and 20 cm high. The third tree had sufficient lighting, diameter was 42.0 cm, height was 14.0 m, in satisfactory condition. Dead branches were present. Needles were unevenly distributed on the branches, in satisfactory condition, with seeding rating of 3.

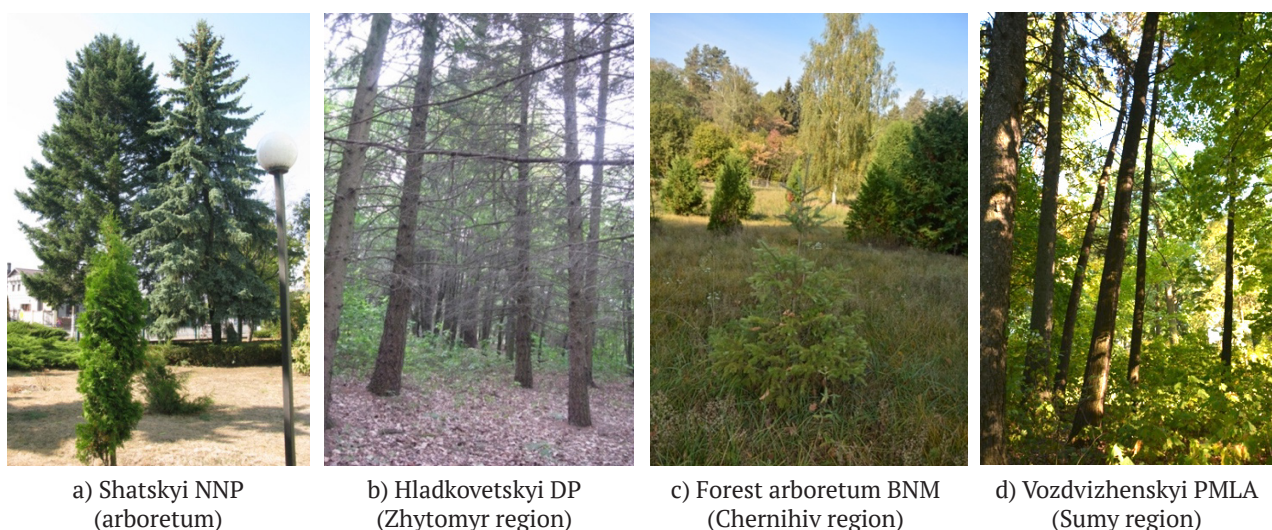


Figure 4. *P. menziesii* in the reserved areas of Ukrainian Polissya (author's photographs)

In the Volyn region, three 50-year-old specimens of *P. menziesii* grew in the Shatskyi (arboretum) NNP, their diameter was 45.0, 50.0, and 63.0 cm, height was 19.0, 18.5, and 21.5 m (Table 1). They were in good condition (Fig. 4a) and seeding rating of 3. They formed dissimilar seeds. One 50-year-old specimen of *P. menziesii* was found in the Dubechnenskyi PMLA. The tree had a diameter of 28.0 cm, and a height of 25.0 m. It grew in a group with *Picea pungens* Engelm. The crown was raised high, the trunk was poorly cleaned, the condition was satisfactory and seeding rating of 2. Natural regeneration was absent.

In the Zhytomyr region, *P. menziesii* was found in two dendrological parks, one arboretum Hamarnia LR, and a botanical garden. Their numbers ranged between 1 and 17 specimens. Two 36-year-old *P. menziesii* trees were growing in the Elita DP, their height was 14.0 m each, their diameter was 30.0 cm and 28.0 cm (Table 1). They were in good condition. The crowns were lowered, symmetrical. Seeding rating was 2. In the Hladkovetskyi DP, a 63-year-old *P. menziesii* grew in 20×25 m² area in a group of 29 specimens (the crown was raised high, the trunk was poorly cleaned of branches that started at a height of 2.5-3.0 m, the condition

was good) (Fig. 4b). Their average diameter was 30.8 ± 1.6 cm, the average height was 23.1 ± 1.1 m, the maximum diameter was 50.0 cm, and the maximum height was 24.5 m. The seeding rating was 2. Two specimens of *P. menziesii* var. *glauca* (diameter – 49.0; 36.0 cm, height – 24.0; 23.5 m) grew in the group with *Picea abies* Karst in good condition, with seeding rating of 2. Natural regeneration was absent. One 35-year-old specimen of *P. menziesii* grew at the entrance of the botanical garden of the Polissya National University. The height was 19.0 m, the diameter was 28 cm, in good condition. In Hamarnia (arboretum) LR, 12 specimens of *P. menziesii* were located, aged 38 years old. The average diameter was 26.7 ± 1.8 cm, height – 14.7 ± 1.4 m, the maximum diameter was 36.0 cm, the maximum height was 23.0 m. *P. menziesii* grew in a group with *Pinus sylvestris* L. and *Picea abies* Karst. Plants that were growing in sufficient light had better biometric indicators (good condition, seeding rating of 4) than those that were suppressed (diameter ranges within 16-24 cm, height – 8.5-15 m, satisfactory condition, seeding rating of 2).

In the Chernihiv region, two 12-year-old specimens of *P. menziesii* grew in the Forest arboretum BNM, the condition of one plant was satisfactory (height – 1.5 m, diameter – 4 cm, seeding rating of 1) (Fig. 4c), the second one was in good condition (height – 2.7 m, diameter – 4 cm, did not bear seeds) (Table 1). In 2014, in the Radomska Dacha reserved area (Radom Forestry Enterprise, quartal 88, stand 5), a 1.9-acre plantation was created using 2-year-old seedlings using the following mixing arrangement: 5 rows of *Pinus sylvestris* L., 5 rows of *P. menziesii*, and 1 row of

Quercus robur L. In this plantation, *P. menziesii* accounted for 45% of all trees. Thomas, Rzepecki, Werner [3] noted that mixed tree stands including *P. menziesii* and native tree species could be effective in sequestering carbon and nitrogen. Most environmental organizations recommend limiting the share of *P. menziesii* in plantations containing natural species at up to 30% ratio and to avoid *P. menziesii* monocultures.

In the Ukrainian Polissya, the oldest specimens of *P. menziesii*, aged 120 years, grew in the Vozdvyzhenskyi PMLA in the group near the pond (Fig. 4d), which was drained at the time of this study. Their average diameter was 30.2 ± 2.3 cm, height – 24.1 ± 0.6 m (Table 1), the maximum diameter was 43.0 cm, the maximum height was 29.0 m. The condition of the trees was good and satisfactory (crown was raised high, started at a height of 8 m, the trunks were poorly cleaned of branches, no needles in the lower part of the branches). Seeding rating was 3. There was one over-mature *P. menziesii* in one plot in Ukrainian Polissya. In other natural zones of Ukraine, over-mature trees grew in one or two localities, in the Forest-Steppe – in the Trostianets DP (120-year-old specimens of *P. menziesii*) [24; 34], a zone of deciduous forests in the Kremenetskyi BG (200-year-old *P. menziesii*), Mykhailivskyi PMLA (100-year-old *P. menziesii*) [25].

Having analysed the age-class distribution of *P. menziesii* and *P. menziesii* var. *glauca* in 15 areas of Ukrainian Polissya, the author found that trees aged 41-60 years (57%) predominated, with almost half of that (33%) in 1-40 years category, and 61-80 years and 7% in the age category of above 100 years (Fig. 5).

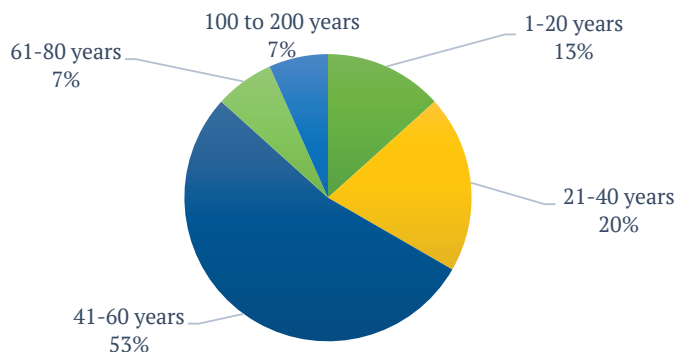


Figure 5. Age-class distribution of *P. menziesii* in reserved areas of Ukrainian Polissya

Tarabun [34] noted that one of the reasons for the insignificant distribution of *P. menziesii* is an insufficient amount of planting material due to the weak seed base. It was founded that in 93% of plots *P. menziesii* and *P. menziesii* var. *glauca* trees produce seeds; in one plot, *P. menziesii* did not produce seeds because the tree has not reached reproductive age. The seeding rating ranged from 2 (Hamarnia LR arboretum, *P. menziesii*) to 5 (Bereznivskyi DP, *P. menziesii* var. *glauca*). In three plots (Sarnenskyi dendrological park CNM, Pseudotsuha tysolyista BNM, Bereznivskyi DP) *P. menziesii* and *P. menziesii* var. *glauca* were able to regenerate naturally. In Shatskyi (arboretum) NNP, *P. menziesii* did not form similar seeds, which may be due to a negative correlation between population size and genetic diversity [5]. As J. Wojacki, P. Eusemann, D. Ahnert, B. Pakull, H. Liesebach [5] stated, an elevated level of self-pollination (1-13%) correlates with an increased inbreeding effect, resulting in a high percentage of

empty seeds. Therefore, at least 100 mature trees are needed to create elite wind-pollinated stands of *P. menziesii*.

We conclude that *P. menziesii* and *P. menziesii* var. *glauca* have a high potential for use in plantations in the geographic and climatic conditions of the Ukrainian Polissya, therefore it is advantageous to continue to create such types of stands as single trees, groups, strip stands, alleys, groves, and other forested areas. The same opinion was expressed by M.O. Tarabun, who investigated the conditions of the Left-Bank Forest-Steppe [34]. However, the recommendations of M. Méndez-López, A. Gómez-Armesto [2] should be considered as well. They noted that in forest stands, forest vegetation plays a key role in the transfer of atmospheric mercury to soil horizons, the accumulation of mercury in organic horizons is inherent in coniferous species and can increase the risk of mobilising mercury due to forest fires. For afforestation, it is desirable

to give preference to tree species that minimize the adverse environmental impacts caused by changes in the biogeochemical cycle of pollutants such as Hg. The research has showed that in the areas dominated by *P. menziesii*, soil concentration of Hg_{Res} is 2.5 times higher than in areas dominated by *Quercus pyrenaica*.

Conclusions

We determined that in nature conservation areas of Ukrainian Polissya, *P. menziesii* and *P. menziesii* var. *glauca* grew in 15 areas. In 14 localities, it grew in groups, strip plantations, and as a single tree (mainly in PMLAs, DPs, NMs) with a total of 107 specimens found. The plantation of *P. menziesii*, *Pinus sylvestris* L., and *Quercus robur* L. was created on one of the sites in the Radomska Dacha reserved area. The largest number of localities with *P. menziesii* and *P. menziesii* var. *glauca* as a component in plantations was concentrated in Volyn Polissya (8 localities), Zhytomyr Polissya (4 localities), and Novhorod-Siverskyi Polissya

(3 localities). The introduction of trees into reserved areas in 53.3% of localities took place in the 1960-70s. The oldest trees in Ukrainian Polissya were 120-year-old specimens of *P. menziesii* growing in the Vozdvyzhensky PMLA. The age distribution showed the dominance of 41-60-year-old trees (53%). The highest biometric indicators determined for *P. menziesii* and *P. menziesii* var. *glauca* in Bereznivskiy DP were height – 25.4 ± 0.4 m and diameter – 48.4 ± 4.3 cm. In 93.3% of localities, *P. menziesii* and *P. menziesii* var. *glauca* produced seeds, with the estimated seedling rating ranging between 2 (Hamarnia arboretum LR) and 5 (Bereznivskiy DP).

The results of this study enable the comparison of quantitative and qualitative indicators of *P. menziesii*, to assess the success of introduction and tree condition in diverse natural zones of Ukraine. Using the obtained qualitative indicators of *P. menziesii*, it will be possible to select the best specimens, considering the presence of native regeneration, to obtain high-quality planting material with subsequent introduction into various types of plantations.

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***Pseudotsuga Menziesii* (Mirb.) Franco на заповідних територіях Українського Полісся**

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Анотація. У Європі, у тому числі і в Україні, приділяється значна увага дослідженням *Pseudotsuga menziesii* (Mirb.) Franco, як перспективного виду для створення різних видів насаджень. Відзначено доцільність плантаційного вирощування. На заповідних територіях Степу, Лісостепу, Українського Полісся досліджено видовий склад рідкісних екзотичних деревних рослин, серед яких і *Pseudotsuga menziesii* (Mirb.) Franco, їхня представленість, стан збереження. Наразі є актуальним дослідити вікову структуру, кількісну та якісну характеристики *Pseudotsuga menziesii* (Mirb.) Franco, їхній стан та представленість у різних видах насаджень на охоронних територіях Українського Полісся. Метою дослідження було виявити поширення, стан, біометричні показники та вікову структуру *Pseudotsuga menziesii* (Mirb.) Franco на заповідних територіях Українського Полісся. Застосовано методи дослідження: польові (маршрутний), аналітичні, порівняльного аналізу. На Українському Поліссі *Pseudotsuga menziesii* (Mirb.) Franco була вперше інтродукована у ППСІМ Воздвиженський, у 1903 р. Масове впровадження рослин у заповідні насадження

у більшості об'єктів відбулось у 60–70-х роках ХХ ст. 53,3 % об'єктів зосереджені на Волинському Поліссі, 26,7 % – на Житомирському Поліссі, 20 % – на Новгород-Сіверському Поліссі. У ході проведених досліджень виявлено, що *Pseudotsuga menziesii* (Mirb.) Franco зростає на 14 заповідних об'єктах у групах, рядовій посадці, як солітер (всього виявлено 107 екземплярів із них 17 % *P. menziesii* var. *glauca* (Beissn) Franco). У заповідному урочищі Радомська дача створено масив з *P. menziesii*. У віковій структурі малопоширені 61-80-річні та вікові рослини (по 7 %), *P. menziesii* віком від 1 до 40 років та 41-60 років складають відповідно по 33 % та 53 %. *P. menziesii* плодоносять на 14 об'єктах (оцінка плодоношення становить від 2 до 5 балів), на одному об'єкті не плодоносять із-за не досягнення репродуктивного віку. У трьох об'єктах є самосів у кількості 2 екземпляри на 1м². 83,2 % рослин мають добрий стан. Отримані результати можуть бути застосовані для порівняння кількісних і якісних показників *Pseudotsuga menziesii* (Mirb.) Franco. у різних видах насаджень Лісостепу, Степу, зони широколистяних лісів України

Ключові слова: псевдотсуга, парки-пам'ятки, пам'ятки природи, дендропарки, стан