Folia Forestalia Polonica, Series A – Forestry, 2025, Vol. 67 (2), 61–75

ORIGINAL ARTICLE

DOI: 10.2478/ffp-2025-0007

Phytosanitary condition of age-old trees of the V.V. Pashkevych arboretum of the National Dendrological Park "Sofiyivka" of the National Academy of Sciences of Ukraine

Tetiana Kopylova[1a], *Yurii Rumiankov*[1c], *Olha Porokhniava*[1b], *Hryhoriy Muzyka*[1d], *Volodymyr Vitenko*[2e], *Oleksandr Bayura*[2f], *Heorhiy Hrynyk*[3g] ✉, *Olena Hrynyk*[4h]

[1] National Dendrological Park "Sofiyivka" of the National Academy of Sciences of Ukraine, Department of Dendrology and Park Construction, Kyivska 12a, 20305, Uman, Ukraine

[2] Uman National University of Horticulture, Faculty of Forestry and Landscape Management, Department of Forestry, Instytutska 1, 20305, Uman, Ukraine

[3] University of Lodz Branch in Tomaszów Mazowiecki, Department of Forest Sciences, Konstytucji 3 Maja 65/67, 97-200 Tomaszów Mazowiecki, Poland, e-mail: herohiy.hrynyk@filia.uni.lodz.pl

[4] Forest Research Institute, Department of Ecology, Braci Leśnej 3, Sękocin Stary, 05-090 Raszyn, Poland

ORCID ID: a – 0009-0003-0328-5777; b – 0000-0002-9636-9990; c – https://orcid.org/0000-0002-6253-7618; d – https://orcid.org/0000-0002-3389-363X; e – https//orcid.org/0000-0001-5762-9238; f – https//orcid.org/0000-0003-1679-5840; g – https://orcid.org/0000-0001-7417-5047; h – https://orcid.org/0000-0002-2710-6118

Abstract

The results of research into the phytosanitary condition of age-old trees in the historical part of the V.V. Pashkevych arboretum are presented. The small triangular-shaped arboretum occupies an area of 1.87 ha, which was founded in 1889–1891 by professor V.V. Pashkevych. As a result of the inventory assessment of the territory (as of 2024), it was established that the taxonomic composition of the arboretum is represented by 90 species and forms of tree species, including 44 from the period of the creation of the arboretum itself. A total of 102 taxa aged 100–135 years were identified. It was determined that representatives of dendroflora belong to 12 families, including 14 taxa from the Pinophyta division and 90 taxa from the Magnoliophyta division. In terms of quantity, the largest number of age-old trees in the arboretum plantings are from the families Malvaceae Juss. (30.75%), Sapindaceae Juss. (13.46%), Fagaceae Dumort. (11.5%), and Pinaceae L. (10.57%), and the smallest number of age-old trees are from Simaroubaceae DC., Ulmaceae Mirb., and Cannabaceae Mart. (0.96%). Rapid climate change significantly reduces the resilience of plantations in the Right-Bank Forest-Steppe of Ukraine and contributes to outbreaks of epiphytoses of bacterioses, the reproduction of pests, and drying out of the surface root system. A set of diseases and pest infestations were found in tree species within the research area, which significantly affected their growth and development and their resistance to current climatic factors. The most common are local necrotic-cancer diseases, caused by the fungi *Nectria ditissima*; damage by xylotrophic fungi (*Poliporus squarnosus* and *Fomes fomentarius*); rot; frost cracks; leaf damage by powdery mildew, the course of which is chronic. A decrease in the esthetic condition of the stand was noted:

Received 13 March 2025 / Accepted 8 May 2025

a sparse and asymmetrical crown, leaves and needles damaged by pests, a trunk tilt from 10° to 40°, a dry tree top, hollowness, etc. According to the sanitary rules in the forests of Ukraine, it was determined that trees of category I of sanitary condition (without signs of weakening) accounted for 31%, trees of category II (weakened) accounted for 36.4%, category III (very weakened) accounted for 25.9%, and category IV (dying) accounted for 6.7%. It was noted that one of the reasons for deterioration in the condition of trees in the stands is colonization by the semi-parasite *Viscum album* L. As a result of the research, 22 trees with varying degrees of *Viscum album* damage were identified. Of these, 4.9% were slightly damaged, 6.9% were moderately damaged, 5.9% were severely damaged, and 3.9% were very severely damaged. It was determined that 32 trees required sanitary pruning, 25 trees required pest and disease treatment, and one 130-year-old *Robinia psevdoacacia* L. tree was recommended for removal.

Key words

historical part of arboretum, pests, diseases, semi-parasitic plant, category of sanitary condition

Introduction

1In the context of the current problems of rapid climate change and natural plant reproduction, dendrological parks, which are centers of biodiversity conservation, are gaining significant importance (Bìdolah et al. 2022; Kirk et al. 2021; Oke et al. 2021). One such introductory center is the National Dendrological Park "Sofiyivka" of the National Academy of Sciences (NAS) of Ukraine, which belongs to the objects of the nature reserve fund, on the basis of which a research institute operates as part of the department of general biology of the NAS of Ukraine. The dendrological park was founded in 1796 and is a monument of landscape architecture of world importance from the late 18th century to early 19th century, listed in the state register of national cultural heritage. The activities of the "Sofiyivka" dendrological park are aimed at conducting scientific research focused on obtaining and using new knowledge in environmental science, substantiating the concept of garden and park and landscape construction of "Sofiyivka," meeting the social, economic, and cultural needs of the population and innovative development of garden and park art. Given the above, there is a need to determine the phytosanitary condition of age-old trees of the V.V. Pashkevych arboretum of the National Dendrological Park "Sofiyivka" of the NAS of Ukraine for their further preservation.

The purpose of the study is to determine the phytosanitary condition of age-old plantings in the historical part of the V.V. Pashkevych arboretum and develop project proposals for their preservation and maintenance. The object of research is the age-old trees of the V.V. Pashkevych arboretum. The subject of the study is the composition and condition of age-old trees of the V.V. Pashkevych arboretum.

Material and methods

The V.V. Pashkevych arboretum occupies a small triangular area of 1.87 ha, which was founded in 1889–1891 by professor V.V. Pashkevych. A fairly large number of exotic tree and shrub plants, valuable in decorative and park terms, grow in the arboretum areas. The landscape structure of the arboretum includes 22 separate plots, an operating water distribution well, a pool with a collection of aquatic plants, and a stone hill with a small grotto. The walking area is represented by wide shady alleys, narrow paths, and benches for resting. Based on the inventory of arboretum plantings, information was obtained about the species composition of tree plantings in a historical context. It has been established that as of the spring of 2024, the range of plants consists of 90 species and forms, including 44 species and forms planted in 1889–1891 (Kopilova et al. 2024). Age-old trees have great scientific, historical, ecological, and esthetic value. Since 2024, the department of dendrology and park construction of the dendrological park "Sofiyivka" has been conducting scientific work on the topic, "Theoretical aspects of the revaluation of landscapes of historical parks." The study of age-old trees is one of the directions of these studies. Therefore, special attention

was paid to studying the taxonomic composition and phytosanitary condition of trees aged 100–130 years.

The taxonomic composition was analyzed using Plants of the World Online (POWO) (Kew Science 2024). The inventory of plantings was carried out according to the methodological recommendations for inventory, assessment, and monitoring of perennial plantings in historical parks of Ukraine (Kosenko et al. 2014). Disease diagnostics were performed based on external macroscopic signs: the presence of xylotrophic fungi, cancer ulcers, hollows, dry apex, bacterial dropsy, bark detachment, etc. Inspection of tree plantations for the presence of stem pests was carried out in accordance with the methodological recommendations of the state service for protected areas of the Ministry of Ecology and Natural Resources of Ukraine (Deržavna služba zapovìdnoï 2003). The nature of the damage to trees by the hemiparasite was assessed using a 5-point scale proposed by Kuznecov et al. (2000): 5 points – unaffected; 4 points – slightly affected (the crown is affected by no more than 20%–25%–up to five bushes of the parasite); 3 points – moderately affected (by 30%–50% – from six to 15 bushes); 2 points – severely affected (by 60%–80% – from 16 to 24 bushes); and 1 point – very severely affected (by 90%–100% – 25 or more bushes). Assessment of *Viscum album* tree damage was conducted in early spring and fall. Tree condition categories were determined in accordance with the sanitary rules in the forests of Ukraine (Kabìnet Mìnìstrìv Ukraïni 1995).

Research results

Currently, the landscape structure of the arboretum contains 22 separate plots (Fig. 1). It was established from the inventory results that in the V.V. Pashkevych arboretum, the basis of the plantations was formed by the oldest trees numbering 64 pcs (1.16%), the age of which was 121–135 years (Fig. 2).

Slightly fewer trees were in the age group 101–120 years (50 pcs; 0.91%). The number of trees in the age structure are occupied by plants aged 21–40 years – 33 pcs (0.60%) and 81–100 years – 28 pcs (0.51%). The fewest trees were in the age groups 41–60 years, 12 pcs (0.22%), and 61–80 years, 11 pcs (0.20%). The age group of 1–20 years included young plants of seed and vegetative origin. Mostly, they were undergrowth of those species that grew on the territory of the arboretum, and their number reached 5298 pcs (96.40%).

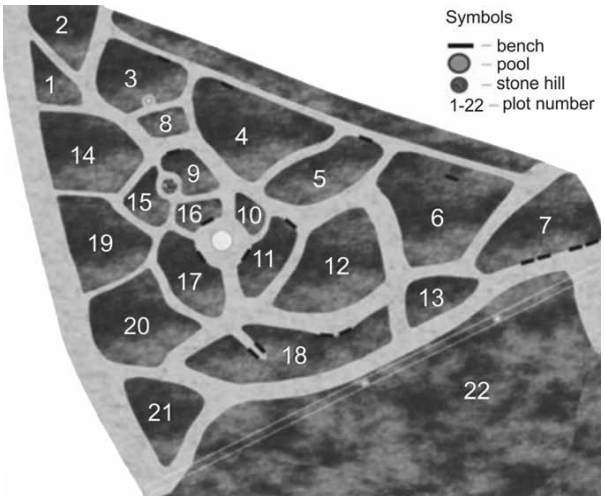

Figure 1. Plan-scheme of the V.V. Pashkevych arboretum

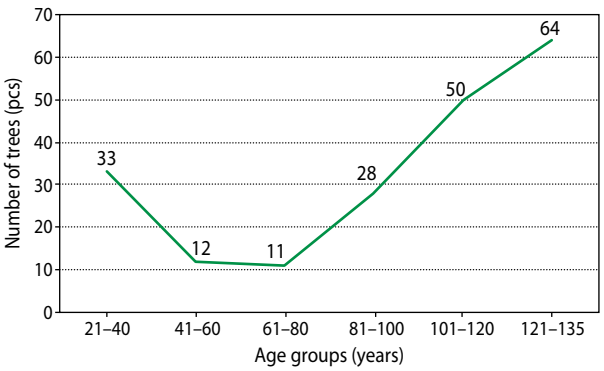

Figure 2. Quantitative characteristics of trees by the age structure

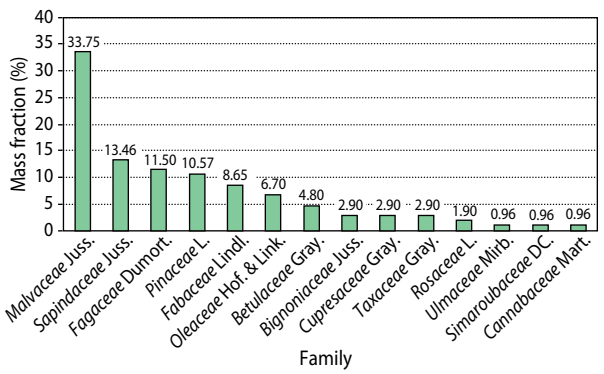

Figure 3. Structure of age-old trees by family affiliation (%)

Age-old trees were representatives of 12 families (Fig. 3). In terms of quantity, the largest number of age-old trees in the arboretum stands belonged to the Malvaceae Juss. family (30.75%), Sapindaceae Juss (13.46%), Fagaceae Dumort. (11.5%), Pinaceae L. (10.57%), and the least number of trees belonged to Simaroubaceae DC., Ulmaceae Mirb., and Cannabaceae Mart. (0.96%).

Climate change not only leads to a deterioration in the phytosanitary condition of plantations, but also significantly reduces their stability in the conditions of the Right-Bank Forest-Steppe of Ukraine. Natural factors such as warm winters, hot summers, minimal rainfall, and reduced soil moisture contributed to outbreaks of epiphytoses of bacterioses, the proliferation of pests, and drying out of the surface root system. Another reason for deterioration of the condition of trees in the stands is the colonization of *Viscum album* L., which leads to changes in their structure (Ìvancìv and Ìvancìv 2013; Klimenko et al. 2020).

In accordance with the sanitary rules in the forests of Ukraine, during the survey, age-old trees were divided into five categories of tree condition (Tab. 1).

Table 1. Assessment of the sanitary condition of age-old trees of the V.V. Pashkevych arboretum

№	Species (taxon) name	Age (years)	Plant height (m)	Trunk diameter at a height of 1.3 m (cm)	Crown diameter (N–S × E–W) (m)	Sanitary condition category
1	2	3	4	5	6	7
Plot № 1						
1	*Aesculus hippocastanum* L.	132	21	84	14 × 14	I
2	*Ailanthus altissima* (Mill.) Swingle	132	21	21	18 × 17	I
Plot № 2						
3	*Larix decidua* Mill.	132	22	50	4 × 4	I
4	*Aesculus hippocastanum* L.	132	27	80	8 × 8	I
Plot № 3						
5	*Tilia cordata* L.	132	20	56	7 × 6.5	II
6	*Tilia cordata* L.	132	16	80 × 62	7 × 6	III
7	*Cladrastis kentukea* (Dum.-cours.) Rudd.	130	16	38	9 × 9	II
Plot № 4						
8, 9	*Tilia cordata* L.	130	12, 15	71, 51	5 × 5, 12 × 10	II, III
10, 11	*Tilia cordata* L.	130	8, 20	31, 32	1.5 × 2.5, 11 × 9	III, II
12	*Sophora japonica* L.	130	24	76 × 45	16 × 16	II
13	*Acer platanoides* L.	117	44	51	12 × 11	III
14	*Acer ginnala* Max.	117	9	10	7 × 7	II
15	*Acer platanoides* "Schwedleri" K. Koch.	130	18	44 × 38	8 × 8	III
16, 17	*Fraxinus excelsior* L.	130	22, 14	63, 33	9 × 8, 7 × 6	IV, II
Plot № 5						
18	*Tilia cordata* L.	132	16	115	12 × 10	III
19	*Tilia cordata* L.	110	16	45	8 × 8	II
20	*Tilia cordata* L.	130	16	56	12 × 11	II
21	*Sophora japonica* L.	105	17	42 × 32	10 × 10	I
Plot № 6						
22	*Tilia cordata* L.	130	21	52	8 × 8	I
23	*Tilia cordata* L.	130	21	58	8 × 8	I

1	2	3	4	5	6	7
24	*Larix decidua* Mill.	105	27	53	12 × 10	I
25	*Fagus silvatica* L. "Atropunicea"	105	26	69	16 × 16	I
26	*Fagus silvatica* L. "Atropunicea"	128	26	58	16 × 16	I
27	*Corylus colurna* L.	130	23	56	13 × 13	I
28	*Corylus colurna* L.	130	23	57	13 × 13	II
29	*Corylus colurna* L.	130	23	57	13 × 13	II
30	*Corylus colurna* L. "Nadia"	130	18	48	10 × 5	III
31	*Picea abies* (L.) H.Karst.	130	27	53	13 × 13	II
Plot № 7						
32	*Picea abies* (L.) H.Karst.	130	28	60	6 × 6	II
33	*Picea abies* (L.) H.Karst.	130	22	68	5 × 4.5	II
Plot № 8						
34	*Aesculus hippocastanum* L. "Pyramidalis"	130	18	13, 18, 18, 27, 19	6.5 × 5	II
35	*Tilia europaea* L.	130	18	62	8 × 8	I
Plot № 9						
36	*Quercus rubra* L.	130	20	71	12 × 4.8	II
37	*Quercus rubra* L.	120	18	46	6 × 9	I
38	*Tilia europaea* L.	120	17	43 × 48	3 × 6	II
Plot № 11						
39	*Tilia platyphyllos* Scop.	105	18	66	7 × 7	II
40	*Tilia cordata* L.	130	18	44	6 × 7	I
41	*Thuja occidentalis* L.	105	7	21	5 × 5	I
42	*Sophora japonica* L.	105	18	51	7 × 7	I
43	*Taxus cuspidata* Siebold & Zucc.	15–105	3		11 × 12	I
Plot № 12						
44	*Tilia cordata* L.	120	15	61	8 × 8	II
45	*Tilia cordata* L.	120	17	79	15 × 14	II
46	*Tilia cordata* L.	120	22	46	8 × 6	II
47	*Tilia cordata* L.	120	20	48	9 × 6	I
48	*Tilia cordata* L.	130	19	58	13 × 11	II
49	*Gymnocladus dioica* K. Koch.	130	26	60	16 × 10	I
50	*Fagus sylvatica* L. "Rotundifolia"	130	24	56	12 × 8	I
51	*Crataegus oxyacantha* L.	105	4	5	4 × 4	I
52	*Crataegus punctate* Jacq.	105	2		3 × 3	I
Plot № 13						
53	*Tilia cordata* L.	130	24	92	12 × 12	II
54	*Taxus baccata* L.	105	7	21	7 × 7	I
55	Taxus baccata L.	105	7	20	6 × 6	I
Plot № 14						
56	*Gymnocladus dioica* K. Koch.	130	26	110 × 83	17 × 15	II

1	2	3	4	5	6	7
57	*Pinus sylvestris* L.	130	26	58	3.5 × 4	I
58	*Pinus sylvestris* L.	130	26	43	3 × 5	III
59	*Pinus sylvestris* L.	130	23	45	3.5 × 2.5	III
60	*Aesculus octandra* Marsh.	110	14	26	5.5 × 7	I
61	*Aesculus carnea* Hayne.	105	14	36	6x8	III
62	*Aesculus hippocastanum* L. "Baumannii"	130	23	94 × 61	10 × 12	II
Plot № 15						
63	*Tilia europaea* L.	120	10	54	16 × 16	II
64	*Gymnocladus dioica* (L.) K. Koch.	105	20	42 × 47	13 × 8	II
65	*Tilia platyphyllos* Scop. "Vitifolia"	120	11	30	8 × 6	II
Plot № 16						
66	*Tilia europaea* L.	130	19	80	7 × 8	II
Plot № 17						
67	*Tilia americana* L.	105	19	56	7 × 6	III
68	*Carpinus betulus* "Globosa"	105	19	54	16 × 16	I
69	*Thuja occidentalis* L.	105	11	24	2 × 3	II
Plot № 18						
70	*Tilia cordata* L.	130	18	76	12 × 12	II
71	*Acer platanoides* L.	130	24	42	12 × 12	II
72	*Acer platanoides* L.	130	22	44	12 × 6	III
73	*Acer campestre* L.	130	22	44	9 × 9	III
74	*Acer platanoides* L.	105	20	44	12 × 8	II
75	*Ulmus laevis* Pall.	130	23	71	12 × 12	I
76	*Acer platanoides* L.	105	21	35	12 × 12	II
77	*Tilia cordata* L.	130	22	51 × 58	16 × 14	III
78	*Tilia cordata* L.	105	23	31	15 × 15	I
79	*Tilia cordata* L.	105	20	45	15 × 15	I
Plot № 19						
80	*Tilia cordata* L.	130	16	72	16 × 14	II
81	*Picea abies* (L.) H.Karst.	130	19	31	7 × 5.5	IV
82	*Picea abies* (L.) H.Karst.	130	16	29	6 × 5	III
83	*Pseudotsuga taxifolia* Britt.	130	26	56	10 × 9	III
Plot № 20						
84	*Tilia cordata* L.	130	19	58 × 102	15 × 14	III
85	*Celtis occidentalis* L.	130	12	45	11 × 10	I
86	*Catalpa bignonioides* Walt.	130	14.5	38 × 41	12 × 10	III
87	*Catalpa bignonioides* Walt.	130	17	41	12 × 10	III
88	*Robinia psevdoacacia* L.	130	16	68	8 × 5	IV
Plot № 22						
89	*Acer platanoides* L.	130	19	52	8 × 6	IV

1	2	3	4	5	6	7
90	*Quercus robur* Sol.	110	24	48	10 × 10	I
91	*Tilia cordata* L.	110	14	45	8 × 7	III
92	*Fraxinus excelsior* L.	132	26	108	18 × 18	II
93	*Thuja occidentalis* L.	110	4–6	14, 14, 16	4, 4, 5	II
94	*Acer platanoides* L.	110	18, 14	30, 42	10, 13	III
95	*Catalpa bignonioides* Walt.	130	17	71	12	II
96	*Acer platanoides* "Schwedleri"	130	24	76	12	IV
97	*Acer campestre* L.	110	17, 19	33, 29	16, 18	IV
98	*Fraxinus excelsior* L.	130	22	84	15 × 18	III
99	*Fraxinus excelsior* L.	130	25	87	20 × 19	III
100	*Acer platanoides* L.	130	20, 17	41, 20	12, 10	III
101	*Gleditsia triacanthos* L.	130	22, 19	43, 33	8, 6	III
102	*Fraxinus excelsior* L.	110	21, 23	38, 53	8, 12	IV
103	*Acer platanoides* L.	110	18	32	14	III
104	*Fraxinus excelsior* L.	130	25	72	17	III

Trees of category I of sanitary condition without signs of weakening accounted for 31%, trees of category II (weakened) 36.4%, category III (very weakened) 25.9%, and category IV (dying) 6.7%.

The most common diseases for *Tilia cordata*, *Tilia americana, Tilia europaea,* and *Tilia platyphyllos* "Vitifolia" were growths, rots and hollows, cancerous growths, leaf damage by powdery mildew, sap leakage on branches and trunks, frost cracks, dry skeletal branches in different parts of the crown, trunk inclination from 10° to 40° from the vertical axis, crown thinning, reduction in leaf size and color intensity, and numerous water shoots and bushes of *Viscum album* L. (Fig. 4).

Cladrastis kentukea, Sophora japonica (Fig. 5A)*, Gleditsia triacanthos,* and *Gymnocladus dioica* (Fig. 5B) had dry tops from 10% to 30% hollows. *Robinia psevdoacacia* L. had a crown that had dried up by 80%; there were many shoots of crown renewal, necrotic-cancerous diseases, hollows, and growths.

Figure 4. Growths on the trunk of *Tilia europaea* (A) and *Tilia cordata* (B) with *Viscum album* infection

Figure 5. Pathological damage on *Sophora japonica* (A) and *Gymnocladus dioica* K. Koch. (B)

Figure 6. Pathological damage on *Aesculus hippocastanum* "Pyramidalis" (A) and *Pinus sylvestris* L. (B)

Trees of the genus *Aesculus hippocastanum* were affected by *Cameraria ohridella*, show hollows, mechanical damage to the trunks, and a thinned crown (Fig. 6A). Caring for diseased plants includes the need to remove fallen leaves and use appropriate herbicides.

Resin funnels were found on the trees of *Pinus sylvestris* and under the bark passages of *Ips acuminatus* and its companion *Ips sexdentatus*, leading to damage to the bast and sapwood, which is caused by a group of ophiostome fungi (Dragan et al. 2018; Rogovs′kij et al. 2023) (Fig. 6B). Over the past decade, drying out of age-old trees of the Pinaceae family in the "Sofiyivka" dendrological park has become an acute problem. In the V.V. Pashkevich arboretum, we observed drying out of

20–70% of the surveyed *Picea abies* trees due to arid climatic conditions and settlement of the pest *Sacchiphantes abietis*. *Pinus sylvestris* trees showed many hollows and drying out from 5% to 50%. Symptoms of the disease develop rapidly and lead to drying out of the tree. From 2006 to 2023, two oldest *Pinus sylvestris* trees fell in the arboretum. Trees that grew under coenotic pressure had asymmetrical crowns (Fig. 6B).

Figure 7. Pathological damage on *Carpinus betulus* "Globosa" (A). Infestation of *Fraxinus excelsior* and *Acer platanoides* trees by the hemiparasite *Viscum album* (B)

In *Carpinus betulus* "Globosa," crown thinning and dry top were found (Fig. 7A). In *Acer circinatum, Acer campestre, Acer platanoides,* and *Acer platanoides* "Schwedleri" trees growing under coenotic pressure, we observed crown thinning, asymmetry, trunk tilt from 10° to 40°, dry top, and secondary crown renewal. Local necrotic-cancer diseases caused by the fungi *Nectria ditissima* Tul., rot, frost cracks, leaf damage by powdery mildew, the presence of *Viscum album* L. bushes on tree trunks from 3 to 20 pcs were also detected (Fig. 7B).

The oldest trees, that is, *Fraxinus excelsior* trees, in the arboretum were almost all affected by *Viscum album*, from 3 to 25 bushes on one tree (Fig. 7B), were dry-topped trees, and were affected by tinder fungus – *Poliporus squarnosus* and *Foraes fomentarius*.

Corylus colurna has a sparse crown and hollows, while its species form "Nadia" has an asymmetrical crown, abundant root growth on all trees, and powdery mildew on the leaves. *Catalpa bignonioides* has a sparse crown and a dry top. *Thuja occidentalis* has dry branches, a broken upper part of the crown, a trunk tilting from the vertical axis, and an asymmetrical crown due to its close proximity to the crowns of other trees.

Now, *Viscum album* is already considered a real ecological disaster for large and medium-sized cities, as evidenced by numerous publications by Rumânkov, Ribalka, Vergeles, Vasilenko, Fìlìpova, Fučilo, Zelìns′kij, and other researchers (Kuznecov et al. 2000; Rumânkov 2010; Ribalka and Vergeles 2012; Vasilenko et al. 2013; Zelìns′kij 2024). Scientists consider mistletoe to be a very dangerous semi-parasite. This is because the number of plant species and forms that it is capable of infecting is constantly increasing (Ìvancìv and Ìvancìv 2013; Klimenko et al. 2020; Taran et al. 2007).

In our research, we identified 22 trees with varying degrees of damage caused by *Viscum album*. Of these, 78.4% were undamaged, 4.9% were slightly damaged, 6.9% were moderately damaged, 5.9% were

severely damaged, and 3.9% were very severely damaged (Fig. 8).

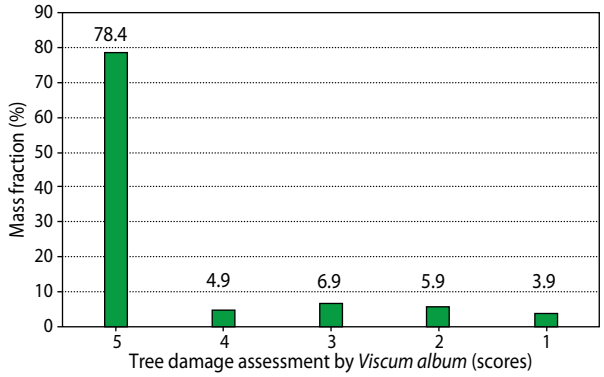

Figure 8. Assessment of damage to age-old trees by *Viscum album* in the V.V. Pashkevych arboretum (scores)

Our research allowed us to determine the species spectrum of trees affected by *Viscum album*. According to field observations in the study area, *Viscum album* infestation was detected on five tree species, including *Ulmus laevis* (4.5%), *Acer campestre* (9%), *Tilia cordata* (13.6%), *Fraxinus excelsior* (31.8%), and *Acer platanoides* (40.9%) (Fig. 9).

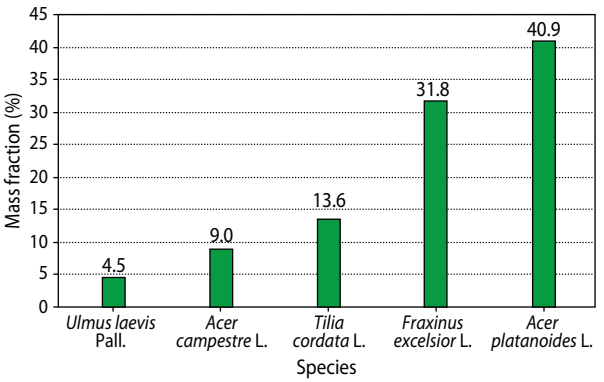

Figure 9. Species composition of trees affected by *Viscum album*

Apparently, *Viscum album* infects tree species that have soft bark and a weak cork layer. Therefore, it is necessary to annually inspect the park's tree plantations for *Viscum album* infestation and remove the affected branches and parts of trunks before the seeds of this semi-parasite begin to ripen (early autumn) (Ìvancìv and Ìvancìv 2013; Klimenko et al. 2020; Taran et al. 2007).

The viability of trees is also affected by the degree of closure of their crowns and the competition among them for light, moisture, and mineral nutrients. In addition, weakened trees are easily affected by pests and diseases. Therefore, there is a problem with renewing the park's plant assortment. Most diseases occur in a chronic form, which leads to a gradual decrease in the vitality of trees and a loss of their decorativeness. Closed frost cracks and minor wounds from necrotic-cancerous diseases with minor damage and minor external manifestations do not cause sharp negative consequences. The characteristic drying of pine and spruce when attacked by pests such as *Ips acuminatus* and *Ips sexdentatus* has a significant impact.

Inspection of age-old trees of the V.V. Pashkevych arboretum revealed that 32 trees required sanitary pruning, 25 trees required regular treatment against pests and diseases, and one *Robinia psevdoacacia* tree was subject to removal. The tree had completely lost its decorative effect, was 90% dead, and was dangerous for park visitors.

Discussion

According to archival materials, mass plantings of the arboretum's dendroflora were carried out in 1889–1891 and included from 200 to 270 taxa. From the literary sources we have studied, we know that a particularly large number of tree and shrub species in the arboretum fell during the harsh winters of 1929/1930 and 1939/1940 (Reva 1963).

According to the inventory conducted by M.L. Reva in 1963, 135 species and forms of dendroflora were included in the list. The following valuable collection species of trees and shrubs have not survived: *Pinus strobus* L,. *Juniperus communis* L., *Maclura pomifera* (Rafin.) Schneid, *Quercus robur f. maculata* Schn., *Eucommia ulmoides* Oliv., *Cercis canadensis* L., *Platanus acerifolia* Willd., *Platanus occidentalis* L., *Padus serotina* Borkh., *Fraxinus exelsior f. pendula* Ait., *Fraxinus pubescesns* Lam., *Tilia platyphillos f. vitifolia* Sim., *Phellodendron amurense* Rupr., *Ulmus scabra "Fastigiata"* Rehd., *Ulmus scabra "macrophylla"* Hort., *Cotinus coggygria* Scop., *Armeniaca sibirica* lam., *Staphylea pinnata* L.,

Rhus typhina L., *Ptelea trifoliata* L., *Syringa josikaea* Jacg., *Rhodotypus kerrioides* S. et Z., *Viburnum lentago* L., *Berberis vulgaris f. atropurpurca* Rgl., *Securinega ramiflora* Muel., *Spiraea chamaedrifolia* L., *Spiraea opulifolia* L., *Padus avium* Gilib., *Biota orientalis* Endl., *Cercis salagnastrum* L., and *Crataegus crus-galli* L. (Reva 1963). Until 2006, there was a rapid growth of the second and third generations of woody vegetation of vegetative and seed origin (*Acer platanoides, Fraxinus excelsior,* etc.), which led to the disintegration of landscape compositions. After the restoration in 2006, their number amounted to 73 species and forms, including 45 species and forms planted in 1889–1891, which amounted to 33.3% of the plantings. It was found that 44 species and forms remained from the original plantings of 1889–1991. It is noted that many exotic trees and shrubs grow in the areas of the arboretum of the "Sofiyivka" dendrological park, which are of theoretical and practical interest to scientists, amateur gardeners, students, schoolchildren, and tourists (Kopilova et al. 2024). As of 2023, it has been established that the dendroflora of the arboretum is formed by 458 specimens of trees and shrubs belonging to 90 species and forms, of which 24 are aboriginal plant species and 66 are introduced species. In total, these plants belong to 24 families, which in quantitative terms is as follows: Rosaceae Juss. (24.3%), Hydrangeaceae Dumort. (14.4%), Malvaceae Juss. (9.5%), Sapindaceae Juss. (9.1%), Oleaceae Hof., & Link. (7.5%), Caprifoliaceae Juss. (6.9%), and the least – Rutacea Juss. (0.2%), Viburnaceae Raf. (0.2%), Staphyleaceae (DC.) Lindl. (0.2%), Cornaceae Bercht. & J. Presl. (0.2%). Plants from North America dominate in terms of the number of species (30.3%) and specimens (27.9%). It was found that the largest proportion of taxa belonged to the age group 121–135 years (25%) and a somewhat smaller proportion to the age group 101–120 years (19.23%). The youngest age group from 1 to 20 years also accounted for a fairly high figure (22.3% of taxa). The age groups from 21 to 40 years and from 81 to 100 years make up 12.69 and 10.77%, respectively. The number of taxa in the age groups from 41 to 60 and from 61 to 80 years is several times smaller (4.62 and 4.2%, respectively). But the smallest number of taxa is in the age group of about 208 years (1.15%) (Kopilova et al. 2024).

In general, comprehensive studies of the phytosanitary condition of the stands of the "Sofiyivka" dendrological park were not conducted. The phytosanitary condition of plantations created by planting trees of only one species, the so-called mono-plantations of *Quercus robur* L. (Rum'ânkov 2017, 2020) and species and forms of beech (*Fagus* L.) (Rum'ânkov 2018), was mainly studied.

During the survey and study of the "Dubynka" stand of the National Dendrological Park "Sofiyivka" of the NAS of Ukraine, its territorial boundaries were established and its artificial origin was confirmed (Rum'ânkov 2017). Within the plantation, a separate area of pure *Quercus robur* plantation has been allocated, the territory of which has clear boundaries and is outlined by a road and alley system, which defines it as a mono-plantation. Based on the inventory studies conducted, a tree catalog was compiled, which contained indicators such as tree serial number, tree diameter and height, and the number of dry and broken skeletal branches. The phytosanitary condition of *Quercus robur* trees in the "Dubynka" mono-plantation was assessed as moderately weakened (group II), and young trees were assessed as slightly weakened (group I). The degree of crown closure of *Quercus robur* was determined, which ranged from 0.25 to 0.40. According to the results of the inventory, it was determined that the quality of the plantations corresponds to class II (Rum'ânkov 2017).

The history of the introduction of beech species and forms in the National Dendrological Park "Sofiyivka" of the NAS of Ukraine was studied by Rumânkov (2018). It was determined that the park plantings of the *Fagus sylvatica* mono-plantation are localized in 16 quarters throughout the park. The dendrological structure was analyzed, and a quantitative characteristic of beech species and forms on the territory of the arboretum was presented on a quarterly basis. The least common forms of *Fagus* were identified in the arboretum, which were included in the list of planned plantings. Based on inventory studies, a map of the location of the mono-plantation of *Fagus* species and forms was compiled. It was determined that the age structure of beech species and forms is represented to a greater extent by young plants of pregenerative age, but not by old trees. The phytosanitary condition of trees of the mono-plantation was assessed; their condition was determined as slightly weakened (group I). The possibility of spring infestation of young beech

plants by aphids from the family Aleyrodidae Westwood has been identified. The quality of the beech trees in the park's stands is assessed as good. In the plantations of certain quarters, overthickening of the tree stand was detected, which reduces its quality to a satisfactory state (Taran et al. 2007). Based on the conducted research, a consolidated catalog of beech species and forms in mono-plantations of the "Sofiyivka" dendrological park of the NAS of Ukraine was created (Rum'ânkov 2018).

Studies of the phytosanitary condition of other arboretums and parks in the region of "Sofiyivka" of the National Academy of Sciences of Ukraine were carried out by the following researchers: Dragan, Dojko, Mordatenko, Rogovs′kij, Ìšuk, Strutins′ka, Ârmola, Krucìlov, Vìtenko, Gončaruk, Podzerej, Kilìvnik, Koval′, and Zelìns′kij (Dragan et al. 2018; Rogovs′kij et al. 2023; Vìtenko et al. 2022; Zelìns′kij 2024).

Vìtenko et al. (2022) investigated the plantings and vital state of the dendroflora of the Nemyriv park of Vinnytsia region. It was determined that 12 species of tree plantations in the park belong to the category of age-old trees (100 years or more), namely: *Quercus robur* (~120 pcs), *Fraxinus excelsior* (~80 pcs), *Aesculus hippocastanum* (~140 pcs), *Pinus sylvestris* (~30 pcs), *Acer platanoides* (~40 pcs), *Carpinus betulus* (~20 pcs), *Prunus avium* (1 pc.), *Ginkgo biloba* (1 pc.), *Paulownia tomentosa* (1 pc.), *Fagus orientalis* (1 pc.), *Platanus orientalis* (1 pc.), and *Populus alba* (1 pc.). According to the results of the research, the vast majority of age-old trees are in good and satisfactory condition (3–4 points on the 5-point scale of Kuznecov). *Acer platanoides* and *Fraxinus excelsior* are damaged by *Viscum album*, and *Aesculus hippocastanum* by the chestnut moth.

Studies of age-old trees were conducted by Dragan et al. (2018); they determined the phytosanitary condition of woody plants of the historical site of the eastern beam of the Dendrological Park "Olexandria" of the National Academy of Sciences of Ukraine. Disease and pest damage were detected on 331 specimens (36.8% of the total number) of trees belonging to 19 species. Most tree diseases do not lead to a loss of decorativeness of the tree or a weakening of its vitality. As in our case, the rapid death of *Pinus sylvestris* was caused by desiccation, which was caused by the colonization of trees by the pests *Ips acuminatus* and *Ips sexdentatus* and infection by ophiostome fungi. On *Fraxinus excelsior* suffers symptoms, characteristic of *Chalara fraxinea* disease (Kowalski 2007). These lesions lead to rapid drying of trees. It has been determined that this problem is global in nature and there are no effective measures to combat these phytopathogens. On *Ulmus scabra, Aesculus hippocastanum, Carpinus betulus,* and *Betula pendula* Roth, necrotic-cancerous wounds, crown thinning, and dry top were found; on old *Aesculus hippocastanum* trees, rot, hollows, and xylotrophic fungi were found; on *Betula pendula* trees, signs characteristic of bacterial dropsy were found (Švec′ 2015). We also observed such lesions on age-old trees of the V.V. Pashkevich arboretum.

The assessment of the condition of the plantings of the park-monument of landscape art "Tomylivsky", with an area of 2.4 ha, was carried out in 2023 by Rogovs′kij et al. (2023). The research showed that the taxonomic composition of the park-monument is represented by 76 species. The Magnoliophyta division includes 64 species, two hybrids, and two cultivars, and the Pinophyta division includes eight species, of which 596 are trees, 1843 are shrubs, and seven are plants with a tree–shrub life form. The average age of plantations is 60–70 years. Eighty-seven trees require sanitary pruning, which is 14.5% of the total number of trees. The main reasons for the deterioration of the sanitary condition of trees in the stands are the colonization of *Viscum album* and changing climatic conditions. In particular, the decrease in precipitation and decrease in soil moisture reserves led to the loss of *Betula pendula* and *Juglans cinerea* L. from plantations. Excessive tree density and competition between them for light, moisture, and mineral nutrients weakens them and causes them to become susceptible to pests, such as *Picea abies* and *Buxus sempervirens* L.

In 2024, Zelìns′kij monitored the qualitative state and taxonomic composition of tree species in the Parks-Reservats "Tomylivsky" and "Fastivsky" (Zelìns′kij 2024). The "Fastivskyi" monument park with an area of 33.0 ha is part of the forest fund of the Fastivskyi forestry department. During the research, 195 species of higher vascular plants belonging to 142 genera and families were identified. Magnoliophyta taxa made up 97.4% of the stands, and the remainder consisted of Pinophyta taxa (2.6%). The leading families of the park-monument's dendroflora were: Asteraceae

(14.6%), Poaceae (8.7%), Fabaceae (7.4%), Lamiaceae (6.0%), Rosaceae (14.6%), Capryophyllaceae (5.4%), Brassicaceae (4.5%), Scrophullariaceae (3.7%), Liliaceae (3.1%), and Cyperaceae (2.9%). These families accounted for more than half (62.2%) of all flora species. As a result of research into the sanitary condition of the plantations, a significant number of dead trees were discovered. The condition of pine stands was defined as chronically weakened, and in some areas, very weakened. A significant amount of dead trees was formed as a result of skeletal branches breaking during the winter glaciation of past years. Other causes of tree drying are the influence of abiotic and biotic factors, namely: atmospheric droughts, lowering of groundwater levels, extreme weather events, and the development of phytopathogenic diseases. As in the conditions of the park "Sofiyivka," the drying of *Pinus sylvestris* is associated with the negative impact of a general moisture deficit. Against this background, there is a weakening and intensive population of the bark beetle and other secondary pest species. In addition, during the survey, a significant number of *Quercus robur* trees were found with signs of chronic weakening and dying. *Acer platanoides* was affected by the fungus of the genus *Verticillium*, and was found with local necrotic-cancer diseases caused by the fungus *Neonectria ditissima* (Tul. & C. Tul.) Samuels & Rossman, rot, frost cracks, and *Viscum album* bushes were found on plants of the Sapindaceae family. Research into the condition of the tree plantations of the "Fastivskyi" park-monument showed that that their condition was unsatisfactory, and the intended purpose of this object of the nature reserve fund may be lost.

Conclusions

The species composition and phytosanitary condition of the age-old dendroflora of the historical section of the V.V. Pashkevych arboretum were studied and the following were established:

1. The age-old dendroflora of the arboretum is represented by 102 trees and two shrubs, belonging to 44 species and forms from 12 families. The most numerous families in terms of number of specimens are Malvaceae Juss. (30.75%), Sapindaceae Juss. (13.46%), Fagaceae Dumort. (11.5%), Pinaceae L. (10.57%), and the least numerous are Simaroubaceae DC., Ulmaceae Mirb., and Cannabaceae Mart. (0.96%).

2. Trees of category I of sanitary condition (without signs of weakening) constitute 31%; trees of category II (weakened) – 36.4%; category III (very weakened) – 25.9%; category IV (dying) – 6.7%.

3. A set of diseases and pest infestations that harm plants and are a consequence of prolonged droughts have been detected on the trees of the arboretum. Most diseases are chronic. In turn, this causes bark beetle infestation and then desiccation in *Pinus sylvestris* (5%–50%) and *Picea abies* (20%–70%).

4. Twenty-two trees with varying degrees of *Viscum album* damage were identified. Of these, 4.9% were slightly affected, 6.9% were moderately affected, 5.9% were severely affected, and 3.9% were very severely affected. Thirty-two trees required sanitary pruning, 25 trees required regular treatment against pests and diseases, and one tree had be removed.

5. An important stage in developing a system of measures for plant protection and rehabilitation is annual ecological and pathological monitoring, sanitary pruning of damaged shoots and dry branches, and the use of biological preparations. Timely removal of self-seeding invasive and expansive species that suppress the growth of valuable plants is important. If possible, provide irrigation. For proper maintenance of historical plantings, it is necessary to predict the possible loss of trees, in the place of which clearings are formed. The possibility of conservation of the most valuable old trees of the arboretum is to be considered. Carry out timely replacement of tree species of the appropriate taxonomic group.

Conflicts of interest

The authors declare no conflict of interest regarding the design of the study and publication of this paper.

References

Bìdolah, D.Ì., Kuz′ovič, V.S., Grinûk, Û.G., Pìdhovna, S.M., Timans′ka, O.B. 2022. Analysis of the state and development prospects of greenery in the Forest Song arboretum (Kozova, Ternopil Region)

(in Ukrainian with English summary). *Scientific Bulletin of UNFU,* 32 (3), 12–19. DOI: https://doi.org/10.36930/40320302.

Deržavna služba zapovìdnoï spravi Mìnekoresursìv Ukraïni. 2003. Metodičnì rekomendacìï ŝodo viznačennâ maksimal′nogo rekreacìjnogo navantaženнâ prirodnih kompleksìv ì ob'êktìv u mežah prirodno-zapovìdnogo fondu Ukraïni za zonal′no-regìonal′nim rozpodìlom. Naukovij centr zapovìdnoï spravi Mìnekoresursìv Ukraïni, Kiïv.

Dragan, N.V., Dojko, N.M., Mordatenko, Ì.L. 2018. The evaluation of a phytosanitary state of landscape tree plantations of the „Eastern Ravine" of the „Alexandria" State Arboretum of the NAS of Ukraine (in Ukrainian with English summary). *Scientific Bulletin of UNFU,* 28 (2), 45–49. DOI: https://doi.org/10.15421/40280207.

Ìvancìv, V.V., Ìvancìv, O.Â. 2013. Ekologìčnì osoblivostì poširennâ omeli zvičajnoï v bìotopah m. Luc′ka. *Priroda zahìdnogo Polìssâ ta prileglih teritorìj*, 10, 94–99.

Kabìnet Mìnìstrìv Ukraïni. 1995. Postanova pro zatverdžennâ Sanìtarnih pravil v lìsah Ukraïni Nr 555 (27.07.1995). Kyïv. Available at https://zakon.rada.gov.ua/laws/show/555-95-%D0%BF/print (access on 01.02.2025).

Kew Science. 2024. Plants of the World Online. Available at https://powo.science.kew.org/ (access on 01.02.2025).

Kirk, H. et al. 2021. Building biodiversity into the urban fabric: A case study in applying Biodiversity Sensitive Urban Design (BSUD). *Urban Forestry and Urban Greening*, 62, 1–14. DOI: 10.1016/j.ufug.2021.127176.

Klimenko, M.O., Borŝevs′ka, Ì.M., Klimenko, L.V., Turčina, K.P., Mihal′čuk, M.A. 2020. Ecological features of the distribution of European mistletoe in the territory of Rivne. *Bulletin National University of Water and Environmental Engineering. Agricultural Sciences Series*, 2 (90), 38–49. DOI: 10.31713/vs220204.

Kopilova, T.V., Rum'ânkov, Û.O., Porohnâva, O.L., Muzika, G.Ì., Zaâčuk, V.Â., Vegera, L.V. 2024. Dendroflora and landscape organization of the arboretum named after V.V. Pashkevych of Sofiyivka National Dendrological Park (in Ukrainian with English summary). *Scientific Bulletin of UNFU,* 34 (3), 30–37. DOI: 10.36930/40340304.

Kosenko, Ì.S., Grabovij, V.M., Muzika, G.Ì. 2014. Metodičnì rekomendacìï z ìnventarizacìï, taksacìï ta monìtoringu bagatoričnih nasadžen′ v ìstoričnih parkah Ukraïni. Uman′: VPC «Vìzavì» (Vidavec′ «Sočìns′kij»).

Kowalski, T. 2007. *Chalara fraxinea* – nowo opisany gatunek grzyba na zamierających jesionach w Polsce. *Sylwan*, 4, 44–48.

Kuznecov, S.Ì., Levon, F.M., Klimenko, Û.A., Pilipčuk, V.F., Šumyk, M.Ì. 2000. Sučasnij stan ta šlâhi optimìzacìï zelenih nasadžen′ v Kiêvì. In: Ìntrodukcìâ ì zelene budìvnictvo. Mustang, Bìla Cerkva, 90–104.

Oke, C. et al. 2021. Cities should respond to the biodiversity extinction crisis. *Urban Sustainability*, 1, 11. DOI: 10.1038/s42949-020-00010-w.

Reva, M.L. 1963. 70 rokìv arboretumu V.V. Paškeviča u dendroparku «Sofìïvka». In: Pitannâ bìologìï aklìmatizovanih roslin. Kyïv, 9–16.

Ribalka, Ì.O., Vergeles, Û.Ì. 2012. Vpliv faktorìv dovkìllâ na poširennâ omeli bìloï (*Viscum album* L.) v urbanìzovanih landšaftah na teritorìï m. Harkìv. *Vìsnik HNAU*, 11, 153–161.

Rogovs′kij, S.V., Ìŝuk, L.P., Strutins′ka, Û.V., Ârmola, M.A., Krucìlov, A.Ì. 2023. Results of the dendroflora inventory and assessment of the plantations of the Tomylivskyi Park, a monument of landscape art. (in Ukrainian with English summary). *Agrobìologìâ*, 1, 215–229. DOI: 10.33245/2310-9270-2023-179-1-215-229.

Rumânkov, Û.O. 2010. Stupìn′ poškodžennâ omeloû (*Viscum album* L.) vidìv rodu *Celtis* L. u nasadžennâh nacìonal′nogo dendrologìčnogo parku «Sofìïvka» NAN Ukraïni. *Avtohtonnì ta ìntrodukovanì roslini*, 6, 42–45.

Rum'ânkov, Û.O. 2017. The park planting „Dubinka" of National Dendrological Park „Sofievka" of the National Academy of Sciences of Ukraine (in Ukrainian with English summary). *Scientific Bulletin of UNFU*, 27 (5), 43–47. DOI: 10.15421/40270508.

Rum'ânkov, Û.O. 2018. Monogardens of species and forms of beech (Fagus L.) in the National Dendrological Park „Sofiyivka" of the National Academy of Sciences of Ukraine (in Ukrainian with English

summary). *Scientific Bulletin of UNFU*, 28 (5), 44–48. DOI: 10.15421/40280509.

Rum'ânkov, Û.O. 2020. *Quercus robur* L. in the structure of phytocenoses of the Sofiyivka National Dendrological Park of the NAS of Ukraine and the Rohivsk forest district of Mankivka forestry (in Ukrainian with English summary). *Scientific Bulletin of UNFU*, 30 (3), 13–17. DOI: 10.36930/40300302.

Švec′, M. 2015. Bacterial dropsy of birch in plantations of Zhytomyr Polissya of Ukraine (in Ukrainian with English summary). *Scientific Bulletin of UNFU*, 25 (9), 89–96. DOI: 10.15421/40250914.

Taran, N.Û., Bacmanova, L.M., Meleško, A.O., Ulinec′, V.Z., Lukaš, O.V. 2007. Fìzìologìčne obrruntuvannâ metodìv profìlaktiki rozpovsûdžennâ ta borot′bi z omeloû bìloû u lìsoparkovih landšaftah. Lenvìt, Kyïv.

Vasilenko, Ì.D., Fìlìpova, L.M., Fučilo, Â.D. 2013. Fight against mistletoe on poplar trees in the green zone of Bila Tserkva (in Ukrainian with English summary). *Scientific Bulletin of UNFU*, 23 (12), 31–38.

Vìtenko, V.A., Gončaruk, V.V., Podzerej, R.V., Kilìvnik, V.S., Koval′, S.A. 2022. Dendroflora of Nemyriv Park in the Vinnytsia Region (in Ukrainian with English summary). *Scientific Bulletin of UNFU*, 32 (6), 18–24. DOI: 10.36930/40320603.

Zelìns′kij, B.V. 2024. Monitoring the state of wooden plantations of the protected parks «Tomylivskyi» and «Fastivskyi» (in Ukrainian with English summary). *Agrobìologìâ*, 1, 311–321. DOI: 10.33245/2310-9270-2024-187-1-311-321.