УДК: 630.2

https://doi.org/10.33220/1026-3365.144.2024.13

ELMS (*ULMUS* L.) IN THE BRANCH "MYRHOROD FORESTRY" OF THE STATE SPECIALIZED FOREST ENTERPRISE "FORESTS OF UKRAINE"

V.L. Meshkova[1]*, O.A. Kuznetsova[2], T.S. Pyvovar[3]

The database of the Ukrainian State Forest Management Planning Association "Ukrderzhlisproekt" for 2010 and 2017 was analyzed for the former parts of the Branch "Myrhorod Forestry" (SE "Lubny Forestry Enterprise" and SE "Myrhorod Forestry Enterprise") to reveal the distribution of the forest-covered area, area with *Ulmus* sp. as a dominant species, and area of subcompartments with *Ulmus* sp. in the stand composition by forest site condition (FSC) types, and age classes. From 2010 to 2017, the area of natural stands with elms as the dominant species and the proportion of the dominant elm species *U. minor* has significantly increased. The average and maximum ages of the stands depend on the elm species and stand origin. The most dramatic decrease in the survival rate of all elm species in natural stands occurred in the VI age class and planted stands in the V age class. Respective natural and planted stands were formed in the 1960s and 1970s when Dutch elm disease peaked in many regions. Elm species are presented in a wide spectrum of fertility and humidity classes (trophotopes and hygrotopes). As a part of stand composition, the same elm species grow in a wider range of forest site conditions than the elms as the dominant species. *U. minor* prefers fresh fertile FSC. *U. laevis* grows mainly in fresh forest site conditions, and *U. pumila* occurs in dry to wet habitats. *U. glabra* is present only in natural stands and absent in planted stands.
K e y w o r d s : *Ulmus minor, U. laevis, U. pumila, U. glabra*, dominant species, survival rate, forest site conditions.

Introduction. Stands with elms (*Ulmus* sp.) as a dominant species occupy less than 0.1 % of the forest fund of the State Forest Resources Agency of Ukraine (State Forest Resources Agency of Ukraine, 2024). More often, elms are the accompanying tree species in the stands with oak, alder, birch, etc. as the main species (Puzrina and Yavny, 2020). Elms are widely used in landscaping settlements and establishing protective forest belts (Thomas *et al.*, 2018) due to their ecological benefits, positive effect on the cycle of substances in the soil (Matuszkiewicz, 2015), and contribution to biodiversity (Napierała-Filipiak *et al.*, 2016; Collin *et al.*, 2020). The spread of Dutch elm disease (DED) in the 20th century caused the mortality of elms in a large area (Brasier, 1991; Jürisoo *et al.*, 2021); however, individual species varied in susceptibility and tolerance to the disease, some trees recovered by sprouts and root suckering, while others formed new hybrids (Santini and Faccoli, 2015). Recently, reports on bacterial diseases of elms have been published (Khodaygan *et al.*, 2011; Alizadeh *et al.*, 2017; Ali *et al.*, 2020). Bark beetles are moving from infected trees to healthy ones for adult feeding and vector the fungal and bacterial pathogens (Kuzminski *et al.*, 2024). In Ukraine, the spread of *Ulmus* sp. and its damage by different causes are relatively poorly investigated (Maslovata *et al.*, 2016; Yavny and Puzrina, 2018; Puzrina and Yavny, 2020). The database of the Ukrainian State Forest Management Planning Association "Ukrderzhlisproekt" for 2017 shows the presence of four elm species in the forests of Donetsk and Kharkiv regions. They are *U. minor* Mill. (field elm) – in Ukrainian "berest"; *U. laevis* Pall. (white elm, spreading elm, or fluttering elm) – in Ukrainian "hladkyi"; *U. pumila* L. (Siberian elm) – introduced Asian elm species – in Ukrainian "dribnolysty", "nyzkyi"; *U. glabra* Huds. (wych elm, Scotch elm) – in Ukrainian "shorstkyi", or "holyi" (Meshkova *et al.*, 2022).

In the forest fund of Sumy region, three elm species (*U. minor*, *U. laevis*, and *U. glabra*) are mentioned in the database. Field research in 2019 in the State Enterprise "Trostyanets Forestry" (since

[1] Meshkova Valentyna, Dr. habil. (Agricultural Sciences), Professor, Ukrainian Research Institute of Forestry and Forest Melioration named after G.M. Vysotsky, 86 Hryhoriia Skovorody Street, Kharkiv, 61024, Ukraine. E-mail: valentynameshkova@gmail.com, ORCID: https://orcid.org/0000-0001-6483-2736
[2] Kuznetsova Olena, PhD Student, Ukrainian Research Institute of Forestry and Forest Melioration named after G.M. Vysotsky, 86 Hryhoriia Skovorody Street, Kharkiv, 61024, Ukraine. E-mail: urbanscapeke@gmail.com, ORCID: https://orcid.org/0009-0005-8079-9186
[3] Pyvovar Tetiana, PhD (Agricultural Sciences), Senior Researcher, Ukrainian Research Institute of Forestry and Forest Melioration named after G.M. Vysotsky, 86 Hryhoriia Skovorody Street, Kharkiv, 61024, Ukraine. E-mail: pyvovartatiana@gmail.com, ORCID: https://orcid.org/0000-0001-7250-8549
* Correspondence: valentynameshkova@gmail.com

2022 reorganized to the Branch "Trostyanets Forestry" of the State Specialized Forest Enterprise (SSFE) "Forests of Ukraine") revealed the symptoms of DED and bacteriosis in all elm species (URIFFM, 2019). In various fragments of shelterbelt along M 03 road, passing Kyiv, Poltava, and Kharkiv regions, the presence of these pathogens in *U. glabra*, *U. laevis*, and *U. pumila* was confirmed by laboratory analyses (Kuznetsova *et al.*, 2023; Meshkova *et al.*, 2024). The presence of bark beetles was confirmed by entomological analysis of sample trees. Tree health condition and damage severity from biotic agents depended on elm species and the location of inspected shelterbelt fragments. The inspected shelterbelt fragment in the Poltava region is located not far from the forest fund of the Branch "Myrhorod Forestry" of the SFE "Forests of Ukraine". When reforming the forestry branch, the forest fund of SE "Lubny Forest Enterprise (FE)" merged with the Branch "Myrhorod Forestry" of the SFE "Forests of Ukraine". Basic stand-wise forest inventory and management planning of these stands were carried out in 2010 and 2017.

This research *aimed* to discover the features of *Ulmus* sp. distribution by stand origin, age, and forest site condition, in the forest fund of the Branch "Myrhorod Forestry".

Materials and Methods. The data as of 2010 and 2017 on the forest fund of enterprises included in the Branch "Myrhorod Forestry" of the SFE "Forests of Ukraine" were selected from the database of Ukrainian State Forest Management Planning Association "Ukrderzhlisproekt" using *SQL*-query and converted to the *.xls files. The area distribution by types of forest site conditions (FSC) was assessed following the Ukrainian forest typology as a combination of hygrotope (humidity) and trophotope (soil fertility) indices reflecting respective classes. According to it, the hygrotope classes are: 1 – dry; 2 – fresh; 3 – moist; 4 – dump; 5 – wet. Trophotope classes are: A – poor; B – relatively poor; C – relatively fertile; D – fertile. For example, C_2 means the fresh relatively fertile FSC (Bondar *et al.*, 2020). The distributions for the entire area covered with forest vegetation, areas with elms in the stand composition, and areas with elms as the dominant species were compared for various elm species and stand origins, using χ^2-test (Atramentova and Utevskaya, 2007). The percentages of stand areas of different origins and elm species in 2010 and 2017 were compared using *z*-test in the two proportions comparisons (StatisticsLectures.com, 2017). Inputs were the proportions of area, and outputs were *z* (observed value) and |*z*| (critical value at a significance level $P = 0.05$), two-tailed. As the computed *p*-value was greater than 0.05, one cannot reject the null hypothesis H_0 (the difference between the proportions is equal to 0). In another case, the difference between the proportions is different from 0 (hypothesis H_a). To assess the survival dynamics, the area for subcompartments with various elms as the dominant species and as a part of stands composition have been analyzed by 10-year age classes for natural and planted stands. The proportion of the stand area of each 10-year age class was assessed for each set of subcompartments. Then the proportion of the stands' area, which survived up to a certain age, was evaluated (Meshkova *et al.*, 2023).

Results. For 2010–2017, the area of stands with elm as the main species increased in the forest fund of both parts of the former SE "Myrhorod forestry" (Myrhorod FE). However, only an increase in the proportion of the natural stands ($z = 3.93$; $P < 0.05$) and all elm stands ($z = 2.48$; $P < 0.05$) in the forest-covered area is significant (Table 1).

Table 1

Area of stands with elms as the dominant species in the forest fund of the parts of the current Branch "Myrhorod Forestry" in 2010 and 2017 (%)

Former parts of the current Branch "Myrhorod Forestry"	Forest-covered area, ha	Area of elm stands, ha	Proportion of elm stands, %	Forest-covered area, ha	Area of elm stands, ha	Proportion of elm stands, %
	2010			2017		
Stands of natural origin						
Myrhorod FE	10 227.6	73.3	0.72a	11 860.1	147.6	1.24b
Lubny FE	6 029.8	54.5	0.90	7 640.6	54.8	0.72
Together	16 257.4	127.8	0.79a	19 500.7	202.4	1.04b

Table 1 (Continued)

Former parts of the current Branch "Myrhorod Forestry"	Forest-covered area, ha	Area of elm stands, ha	Proportion of elm stands, %	Forest-covered area, ha	Area of elm stands, ha	Proportion of elm stands, %
	2010			2017		
Planted stands						
Myrhorod FE	14 686.3	19.9	0.14	15 284.9	15.2	0.10
Lubny FE	6 656.0	37.4	0.56	8 230.7	43.4	0.53
Together	21 342.3	57.3	0.27	23 515.6	58.6	0.25
All stands						
Myrhorod FE	24 913.9	93.2	0.37a	27 145.0	162.8	0.60b
Lubny FE	12 685.8	91.9	0.72	15 871.3	98.2	0.62
Together	37 599.7	185.1	0.49a	43 016.3	261.0	0.61b

Note. The percentages with the same letters in one line have no significant difference at $P = 0.05$.

The part of natural stands with elms as dominant species in the total elm stand area also increased significantly in 2010–2017 only in the former Myrhorod FE, and less in the current Branch "Myrhorod Forestry" (Fig. 1).

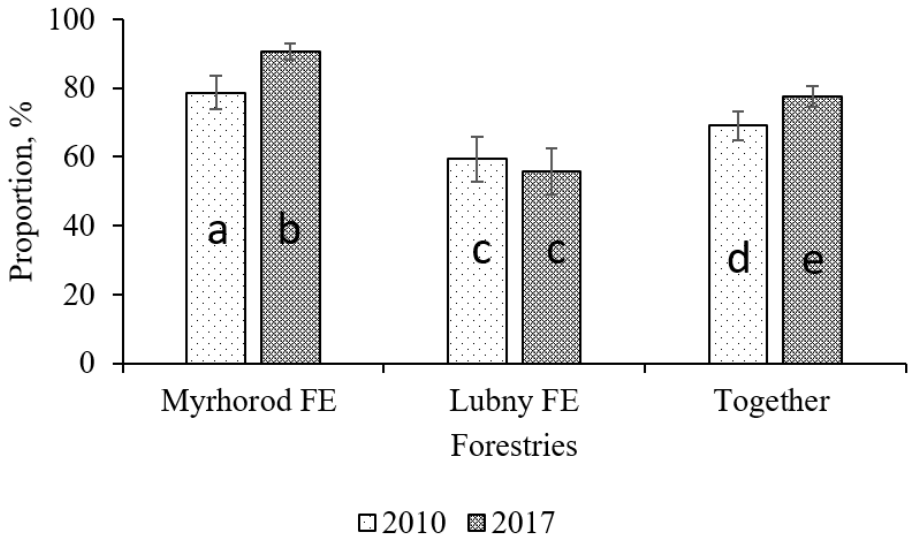
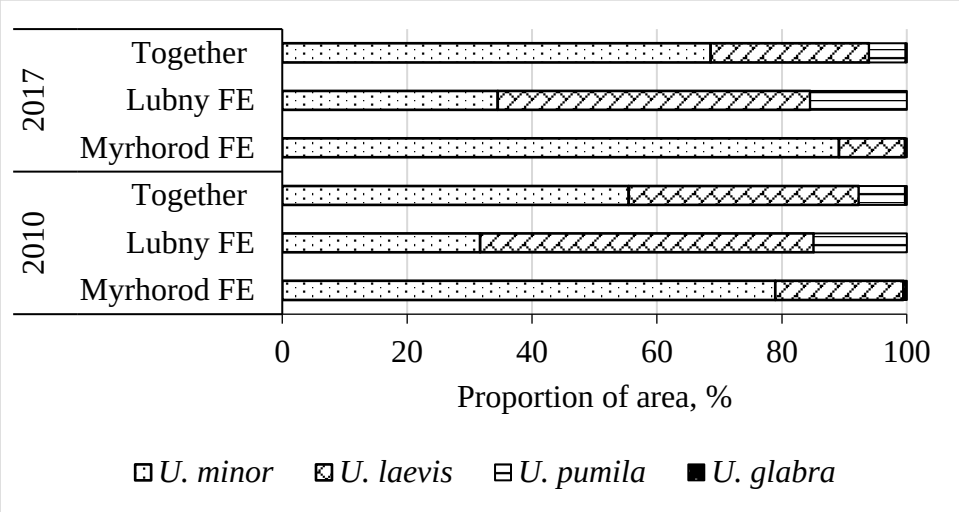


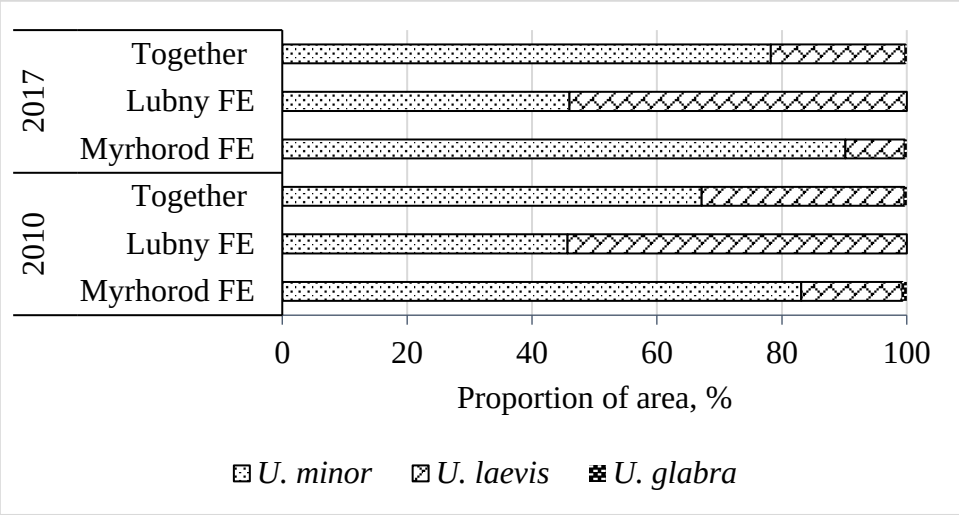
Fig. 1 – Proportion of the area of natural stands with elms as dominant species in the total area of elm stands in the forest fund of the former parts of the current Branch "Myrhorod Forestry" (Myrhorod FE and Lubny FE) in 2010 and 2017 (the columns with the same letters have no significant difference at $P < 0.05$)

Four *Ulmus* species were presented in the Branch "Myrhorod Forestry" (Fig. 2, *a*). In both assessments, *U. minor* dominated in the former Myrhorod FE, increasing in 2017 (79.0 and 89.1 % in the total area with elm as the dominant species in 2010 and 2017, respectively; $z = 2.2$; $P < 0.05$). In the former Lubny FE, *U. laevis* covered about 50 % of the area with elm as the dominant species in 2010 and 2017. *U. glabra* was present only in former Myrhorod FE (0.5 and 0.3 % from the elm stands area in 2010 and 2017, respectively), and *U. pumila* only in former Lubny FE (14.9 and 15.5 % from elm stands area in 2010 and 2017, respectively).

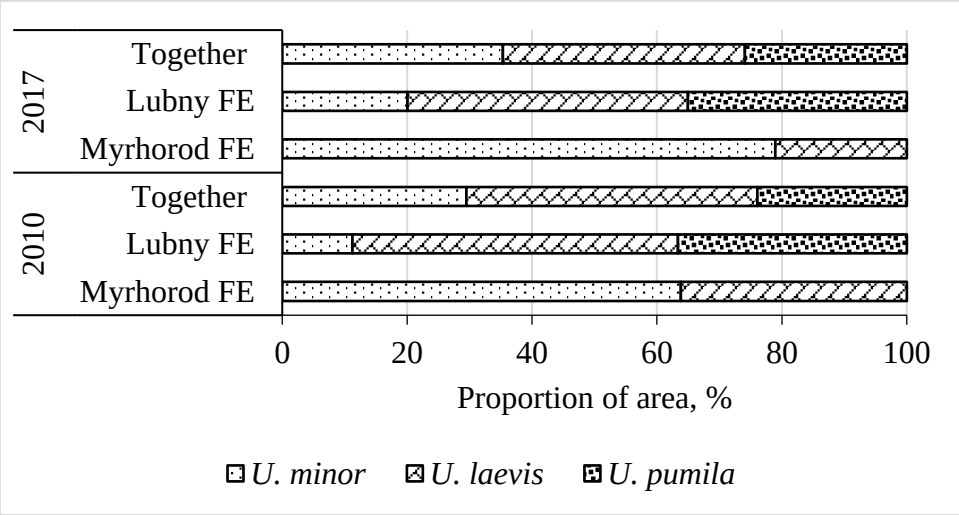
The presence and proportion of elm species in the total area of forest with *Ulmus* sp. as the dominant species depended on stand origin (Fig. 2, *b*, *c*). *U. pumila* was absent in the stands of natural origin. The proportion of *U. minor* trended to increase. At the same time, *U. laevis* and *U. glabra* decreased in the natural elm stands of former Myrhorod FE in 2017 compared to 2010 (see Fig. 3). However, these changes are not confirmed statistically ($z < 1.5$; $P > 0.05$).



a



b



c

Fig. 2 – Proportion of elm species in the total area of forests with *Ulmus* sp. as the dominant species in the forest fund of the parts of the current Branch "Myrhorod Forestry" in 2010 and 2017: *a* – all origins, *b* – natural origin, *c* – planted stands

In 2010 and 2017, *U. glabra* was absent in planted stands of both former parts of the current Branch "Myrhorod Forestry", and *U. pumila* was absent in planted stands of the former Myrhorod

FE (see Fig. 2, *c*). In the planted elm stands, the proportion of *U. minor* trended to a slight increase, and *U. laevis* decreased in both former Myrhorod FE and Lubny FE in 2017 compared to 2010 (see Fig. 2, *c*). However, these changes are not also confirmed statistically ($z < 1.1$; $P > 0.05$).

Considering the absence of significant changes in the elm area in 2017 compared to 2010, we evaluated its distribution by age classes and types of forest site conditions according to the current Branch "Myrgorod Forestry" as of 2017.

Analysis shows the most dramatic decrease in the survival rate of all elm species in the 4th–6th age classes (Table 2). At the same time, the average and maximum ages of the stands depended on the elm species and its origin (natural or planted forest). For example, the average age of *U. minor* and *U. glabra* as the dominant species in the stands of natural origin was lower than the age of these elms in the stand composition (see Table 2).

Table 2

Survival rate of stands with various elm species in the forest fund of the current Branch "Myrhorod Forestry" depending on stand origin as of 2017, %

Elm species	Average age, years	Survival rate up to age class (Age class / Year of natural regeneration or planting)							
		3rd	4th	5th	6th	7th	8th	9th	10th
		1990	1980	1970	1960	1950	1940	1930	1920
Elm stands of the natural origin									
Elms as the dominant species									
U. minor	61	87.6	76.3	**73.5**	55.4	21.0	9.9	0.0	–
U. laevis	57	85.8	80.0	**56.7**	27.8	19.7	0.0	–	–
U. glabra	36	60.0	0.0	–	–	–	–	–	–
Elms in the stand composition									
U. minor	69	90.4	84.2	76.6	**66.5**	49.9	33.5	15.4	5.7
U. pumila	60	78.2	**68.3**	46.5	36.9	36.9	35.1	0.0	–
U. glabra	62	79.2	70.5	**67.1**	51.5	45.0	32.4	0.0	–
Planted elm stands									
Elms as the dominant species									
U. minor	62	87.9	**70.0**	34.8	21.3	4.3	0.0	–	–
U. laevis	65	98.2	**92.1**	42.3	16.7	0.0	–	–	–
U. pumila	54	77.6	**59.9**	0.0	–	–	–	–	–
Elms in the stand composition									
U. minor	62	89.4	85.2	**79.6**	49.3	24.8	10.0	4.5	3.3
U. pumila	56	98.9	82.9	**60.3**	16.3	3.4	3.4	0.5	0.0
U. glabra	34	40.8	14.4	14.4	12.4	3.5	3.5	0.0	–

Note. Bold indicates the years after which the survival rate is less than 50 %.

Only 55.4 % of *U. minor* trees as dominant species, and 66.5 % in the stand composition, survived up to the 6th age class. The survival rate of *U. glabra* was the lowest – it was not found as a dominant species in the natural stands of over 30 years old. However, *U. glabra* and *U. pumila* in the stand composition survived up to the 8th age class although they were inferior to *U. minor.*

In planted stands with *U. minor* as a dominant species, its average age was the same as in the stands with its participation in the stand composition. However, in the first case, only 34.8 % of trees survived to the 5th age class, and the oldest survived to the 7th class. In the second case, the decline in survival rate occurred gradually, and the oldest trees were in the 10th age class. In planted stands where elms are not the dominant species, *U. minor* also had the highest average age, and *U. glabra* had the lowest one.

The current Branch "Myrhorod Forestry" forested area contains A–D trophotopes and hygrotopes 1–5 (Table 3). Fresh fertile FSCs make up slightly more than half the area (51.5 %), and fresh relatively fertile FSC cover 10.8 % of the area. Elms are the dominant species in the B–D

trophotopes and hygrotopes 1–4. The largest area of such stands is represented in the D_2 (42.3 %), less – in C_2 and D_3. Elms within the stand composition are represented in the same FSC with a predominance of D_2 (57.4 % of the area). In addition, they are found in D_1, C_5, and D_5 (see Table 3).

Table 3

Distribution of the forested area and area with any *Ulmus* sp. of natural origin by forest site conditions in the forest fund of the current Branch "Myrhorod Forestry" as of 2017, %

Hygro-tope class	Forested area (19 501.0 ha)				Any *Ulmus* sp. as the dominant species (202.4 ha)			Any *Ulmus* sp. in the stand composition (3 145,1 ha)		
	Trophotope class				Trophotope class			Trophotope class		
	A	B	C	D	B	C	D	B	C	D
1– dry	0.4	0.1	0.2	1.5	–	10.9	–	–	0.6	2.7
2 – fresh	0.4	2.6	10.8	51.5	0.5	22.3	42.3	0.7	10.2	57.4
3 – moist	–	0.6	4.5	6.3	–	7.0	16.9	–	6.8	12.1
4 –dump	–	–	6.8	8.2	–	–	0.1	–	4.6	3.6
5 – wet	–	–	1.7	4.6	–	–	–	–	0.2	1.0

Planted stands were also represented in all trophotopes and hygrotopes 1–5 and were absent only in C_5 (Table 4). Planted stands with elms as the dominant species were almost equally represented in C_2 and D_2 (37.4 and 38.6 %) and planted stands with elms in the stand composition accounted for 71.1 % in D_2 and 18.1 % in C_2.

Table 4

Distribution of planted forest area and planted stands with any *Ulmus* sp. by forest site conditions in the forest fund of the current Branch "Myrhorod Forestry" as of 2017, %

Hygro-tope class	Forested area (23 515.6 ha)				Any *Ulmus* sp. as the dominant species (58.6 ha)			Any *Ulmus* sp. in the stand composition (1 619.2 ha)		
	Trophotope class				Trophotope class			Trophotope class		
	A	B	C	D	B	C	D	B	C	D
1– dry	8.4	0.2	0.1	0.9	–	12.1	–	–	0,5	0,8
2 – fresh	12.1	33.2	13.1	26.2	5.1	37.4	38.6	4,9	18,1	71,1
3 – moist	–	0.3	1.0	1.2	0.0	0.9	4.1	0,5	0,5	1,8
4 –dump	–	–	1.5	1.6	–	–	–	–	0,9	0,7
5 – wet	–	–	–	0.1	–	–	1.9	–	–	0,1

In the stands of natural origin, the distribution of *U. minor* as the dominant species according to FSC was close to that of all elm species (see Tables 3, 5), since this species is dominant. Most *U. laevis* stands were located in C_2 and C_3 (51.6 % and 21.6 %, respectively). *U. glabra* was found only in B_2 and D_2.

Table 5

Distribution of various dominant *Ulmus* species in the stands of natural origin by forest site conditions in the forest fund of the current Branch "Myrhorod Forestry" as of 2017, %

Hygrotope class	*U. minor* (158.3 ha)		*U. laevis* (43.6 ha)			*U. glabra* (0.5 ha)	
	Trophotope class		Trophotope class			Trophotope class	
	C	D	B	C	D	B	D
1– dry	10.8	–	–	11.2	–	–	–
2 – fresh	14.3	51.9	1.8	51.6	7.1	40.0	60.0
3 – moist	3.0	20.0	–	21.6	6.0	–	–
4 –dump	–	–	–	–	0,7	–	–

In the natural stands with elms in the composition but not as the dominant species, *U. minor* is represented in all hygrotopes of C and D trophotopes and the fresh relatively poor FSC – B_2 (Table 6). *U. pumila* is represented in 4 FSCs and predominates in C_2 and D_2 (48.7 % and 29.9 % of the area, respectively). *U. glabra* is represented in 8 FSCs and predominates in C_2 and C_3 (34.3 % and 22.8 %, respectively).

Table 6

Distribution of various *Ulmus* species in the composition of natural stands in the forest fund the current Branch "Myrhorod Forestry" as of 2017 by forest site conditions, %

Hygrotope class	*U. minor* (2 970.3 ha)			*U. pumila* (27.1 ha)		*U. glabra* (147.7 ha)		
	Trophotope class			Trophotope class		Trophotope class		
	B	C	D	C	D	B	C	D
1– dry	–	0.7	2.8	–	–	–	–	1.8
2 – fresh	0.4	8.6	**60.1**	48.7	29.9	6.2	34.3	7.0
3 – moist	–	5.9	11.8	19.9	1.5	–	22.8	19.4
4 –dump	–	4.8	3.4	–	–	–	0.7	7.7
5 – wet	–	0.3	1.1	–	–	–	–	–

In planted stands, three elm species are the dominant ones in 2 FSCs each (Table 7). *U. minor* predominates in D_2 and C_2 (62.8 % and 30.4 % of the area), *U. laevis* predominates in C_2 and D_2 (48.9 % and 42.3 %, respectively), and *U. pumila* in C_1 and C_2 (46.7 % and 29.6 %, respectively).

Table 7

Distribution of various dominant *Ulmus* species by forest site conditions in planted stands of the current Branch "Myrhorod Forestry" as of 2017, %

Hygrotope class	*U. minor* (20.7 ha)		*U. laevis* (22.7 ha)		*U. pumila* (15.2 ha)		
	Trophotope class		Trophotope class		Trophotope class		
	C	D	C	D	B	C	D
1– dry	–	–	–	–	–	46.7	–
2 – fresh	30.4	62.8	48.9	42.3	19.7	29.6	–
3 – moist	–	1.4	2.2	6.6	–	–	3.9
5 – wet	–	5.3	–	–	–	–	–

The planted stands contain two elm species, with *U. minor* in 10 FSCs, and *U. pumila* in 8 FSCs (Table 8). *U. minor* predominates in D_2 (77.6 %), and *U. pumila* in C_2 (56 %), and a rather large part of the area with its presence falls on B_2 and D_2.

Table 8

Distribution of various *Ulmus* species in the composition of planted stands of the current Branch "Myrhorod Forestry" by forest site conditions as of 2017, %

Hygrotope class	*U. minor* (1444.7 ha)			*U. pumila* (174.5 ha)		
	Trophotope class			Trophotope class		
	B	C	D	B	C	D
1– dry	–	–	0.9	–	5.1	–
2 – fresh	3.4	13.5	77.6	17.5	56.0	17.4
3 – moist	0.4	0.5	2.0	1.9	0.5	0.6
4 –dump	–	0.9	0.8	–	1.1	–
5 – wet	–	–	0.1	–	–	–

The chi-square test showed significant differences ($P < 0.01$) in the distribution by FSC between all *Ulmus* species in the natural and planted forests, in the case of their representation as the dominant species or in the stand composition.

Discussion. Analysis of the database of the Ukrainian State Forest Management Planning Association "Ukrderzhlisproekt" for 2010–2017 shows a significant increase in natural stands area with *Ulmus* sp. as the dominant species by 2017 in the Branch "Myrhorod forestry" (Fig. 1). This is a positive moment considering the spread of DED and bacterial wetwood in different regions (Brown *et al.*, 2018; Collin *et al*., 2020).

Among four elm species, *U. minor* predominated, and its proportion increased in 2010–2017. The proportion of elm species in the total area of forests with *Ulmus* sp. as the dominant species depended on stand origin (see Figs. 2abc). On the one hand, forest management plans regulate species composition in planted forests and natural regeneration depending on suitable forest site conditions (Bondar *et al.*, 2020). On the other hand, the survival of different tree species depends on environmental conditions, particularly on the presence of pests and pathogens (Brown *et al.*, 2018).

The survival rate of stands is necessary for evaluating the maturity age of certain tree species and their resistance to various stressors (Tkach *et al.*, 2021). Our analysis shows the dependence of the average and maximum ages of the stands on the elm species and its origin (natural or planted). For all analyzed groups of stands, the most dramatic decrease in the survival rate of all elm species is observed at the 4^{th}–6^{th} age classes (Table 2). The natural stands of the 6th age class were formed in the 60s when the peak of Dutch elm disease (DED) was noted in many regions of Europe (Menkis *et al*., 2016; Jürisoo *et al*., 2021). At the same time, a sharp decrease in survival rate in planted stands with elms as the dominant species occurred in the 5th age class, and with elms as a part of stand composition after the 5th age class. An analysis of the forest fund also showed a sharp decrease in the survival rate of *U. pumila* after the 1960s in the Donetsk region, and after the 1980s, in the Kharkiv region (Meshkova *et al.*, 2022). The data on the survival rate of various *Ulmus* sp. may be used in the optimization of its maturity age (Tkach *et al.*, 2021). The consequences of DED are reflected in the age spectrum of elm stands (Napierała-Filipiak *et al.*, 2016). However, to evaluate elm survival capability, it is necessary to consider also forest site conditions, the proportion of various elm species in the stand composition, and some of their other features. Analysis of *Ulmus* sp. distribution by FSC shows a wide spectrum of trophotopes and hygrotopes in the Branch "Myrhorod Forestry". As a part of stand composition, elms grow in a wider range of forest site conditions than as the dominant species (Tables 3, 4).

The spread of elm species is mainly associated with the availability of favorable forest site conditions. For example, elm demands for humidity in Poland decreased in the row from *U. laevis* to *U. minor* and *U. glabra* (Napierała-Filipiak *et al.*, 2016). In the central (Puzrina and Yavny, 2020) and western (Skolskyi, 2013) regions of Ukraine, *U. glabra* dominates. *U. glabra* in the eastern regions covers only 0.4–1.5 % of elm stands area, prevailing in fresh relatively fertile FSC types, and in the Kharkiv region, it is also common in fresh fertile FSC type (Meshkova *et al*., 2022). In the Branch "Myrhorod Forestry" *U. glabra* is present only in natural stands (Tables 5, 6) and absent in planted stands (Tables 7, 8). *U. pumila* is more spread in the steppe part of Ukraine and in the forest-steppe in dry and fresh relatively fertile and fertile FSC (Meshkova *et al*., 2022). However, in the Branch "Myrhorod Forestry" this elm species occurs from dry to wet habitats (Table 8). *U. minor* is the most abundant elm species in the eastern regions of Ukraine, growing mainly in D_2. However, in the Donetsk region, *U. minor* occurs in the stand composition even in dry FSC (Meshkova et al. 2022). In the Branch "Myrhorod Forestry", it is present in various FSCs, preferring fresh fertile ones (Tables 5–8). *U. laevis* in the Kharkiv region takes second place after *U. minor* by area. It grows mainly in fresh FSC both in the Kharkiv region (Meshkova *et al*., 2022) and in the Branch "Myrhorod Forestry" (Tables 5, 7). However, it occurs also in dry FSC in the Kharkiv and Donetsk regions (Meshkova *et al*., 2022).

In future research, we plan to compare the forest fund assessment data with the data from field research and dendrochronological analysis. The data obtained can be used for the conservation of elm

genetic resources (Collin *et al.*, 2020), the selection of trees tolerant to DED (Chira *et al.*, 2022) and the assessment of their offspring (Martín *et al.*, 2021; 2023), breeding for resistance to DED (Domínguez *et al.*, 2022).

Conclusions. In the Branch "Myrhorod forestry", an area of natural stands with *Ulmus* sp. as the dominant species, and the proportion of the dominant elm species *U. minor* has significantly increased for 2010–2017. The most dramatic decrease in the survival rate of all elm species in natural stands occurred in the 6th age class and planted stands in the 5th age class. These natural and planted stands were formed in the 1960s and 1970s when the peak of Dutch elm disease was noted in many regions. In the Branch "Myrhorod Forestry", *U. minor* prefers fresh fertile forest site conditions. *U. laevis* grows mainly in fresh forest site conditions, *U. pumila* occurs in dry to wet habitats, *U. glabra* is present only in natural stands and absent in planted stands. As a part of stand composition, the same elm species grow in a wider range of forest site conditions than elms as the dominant species.

Funding. The paper was prepared in the framework of a research plan of URIFFM (grant 0120U101891), supported by the State Forest Resources Agency of Ukraine.

Acknowledgments. The authors thank the anonymous reviewers for their valuable advice, useful and constructive recommendations, and text revision.

REFERENCES

Ali, E., Hudson, O., Waliullah, S., Ji, P., Williams-Woodward, J. and Oliver, J. (2020) 'First report of bacterial leaf scorch disease of American elm caused by *Xylella fastidiosa* in Georgia, USA', *Plant Disease*. https://doi.org/10.1094/PDIS-11-19-2367-PDN

Alizadeh, M., Moharrami, M. and Rasuly Pirouzian, A. (2017) 'Geographic Information System (GIS) as a tool in the epidemiological assessment of wetwood disease on elm trees in Tabriz City, Iran', *Cercetari Agronomice in Moldova*, 50. https://doi.org/10.1515/cerce-2017-0018

Atramentova, L.A. and Utevskaya, O.M. (2007) *Biometrics. Chapter II. Group comparison and relations analysis.* Kharkiv: Ranok (in Ukrainian).

Bondar, O., Rumiantsev, M., Tkach, L. and Obolonyk, I. (2020) 'Prevailing forest types in the river catchments within the Left-Bank Forest-Steppe zone, Ukraine', *Folia Forestalia Polonica, Series A – Forestry*, 62(2), pp. 100–113. https://doi.org/10.2478/ffp-2020-0011

Brasier, C.M. (1991) '*Ophiostoma novo-ulmi* sp. nov., causative agent of the current Dutch elm disease pandemics', *Mycopathologia*, 115, pp.151–161. https://doi.org/10.1007/BF00462219

Brown, N., Vanguelova, E., Parnell, S., Broadmeadow, S. and Denman, S. (2018) 'Predisposition of forests to biotic disturbance: Predicting the distribution of Acute Oak Decline using environmental factors', *Forest Ecology and Management*, 407, pp. 145–154. https://doi.org/10.1016/j.foreco.2017.10.054

Chira, D., Borlea, F.G., Chira, F., Mantale, C.Ș., Ciocîrlan, M.I., Turcu, D.O., Cadar, N., Trotta, V., Camele, I., Marcone, C. and Mang, Ș.M. (2022) 'Selection of elms tolerant to Dutch elm disease in south-west Romania', *Diversity*, 14(11), 980. https:// doi.org/10.3390/d14110980

Collin, E., Rondouin, M., Joyeau, C., Matz, S., Raimbault, P., Harvengt, L., Bilger I. and Guibert, M. (2020) 'Conservation and use of elm genetic resources in France: results and perspectives', *iForest-Biogeosciences and Forestry*, 13(1), pp. 41–47. https://doi.org/10.3832/ifor3065-013

Domínguez, J., Macaya-Sanz, D., Gil, L. and Martín, J.A. (2022) 'Excelling the progenitors: Breeding for resistance to Dutch elm disease from moderately resistant and susceptible native stock', *Forest Ecology and Management*, 511, 120113. https://doi.org/10.1016/j.foreco.2022.120113

Jürisoo, L., Süda, I., Agan, A. and Drenkhan, R. (2021) 'Vectors of Dutch elm disease in northern Europe', *Insects*, 12(5), 393. https://doi.org/10.3390/insects12050393

Khodaygan, P., Sedaghati, E. and Sherafati., F. (2011) 'Isolation of *Enterobacter nimipressuralis* associated with bacterial wet wood from elm (*Ulmus* spp.) in Rafsanjan', *Iranian Journal of Plant Pathology*, 4(188), pp. 481–482.

Kuzminski, R., Mazur, A., Lakomy, P., Jelonek, T., Filipiak, M., Napierala-Filipiak, A. and Nowakowska, K. (2024) '*Scolytus* spp. associated with elms with symptoms of Dutch elm disease in Poland and the reproductive potential of *Scolytus multistriatus* (Marsham, 1802) (Coleoptera, Curculionidae, Scolytinae)', *Sylwan*, 168(1), pp. 33−47. https://doi.org/10.26202/sylwan.2023054

Kuznetsova, O.A., Turenko, V.P., Tovstukha, O.V. and Davydenko, K.V. (2023) 'Pest and disease incidence of *Ulmus* sp. in forest shelter belts along the Kyiv-Kharkiv highway', Forestry and Forest Melioration, 143, pp. 102–111 (in Ukrainian). https://doi.org/10.33220/1026-3365.143.2023.102

Martín, J.A., Domínguez, J., Solla, A., Brasier, C.M., Webber, J.F., Santini, A., Martínez-Arias, C., Bernier, L. and Gil, L. (2023) 'Complexities underlying the breeding and deployment of Dutch elm disease-resistant elms', *New Forests*, 54, pp. 661–696. https://doi.org/10.1007/s11056-021-09865-y

Martín, J.A., Solla, A., Oszako, T. and Gil, L. (2021) 'Characterizing offspring of Dutch elm disease-resistant trees (*Ulmus minor* Mill.)', *Forestry: An International Journal of Forest Research*, 94(3), pp. 374–385. https://doi.org/10.1093/forestry/cpaa040

Maslovata, S.A., Mamchur, T.V. and Parubok, M.I. (2016) 'A collection of herbarium specimens of the genus *Ulmus* L. in the scientific herbarium of the Uman National University of Horticulture', *Proceedings of conference Prospects of forestry and horticulture: Third Annenkiv readings,* UNUS, Uman, 12 May 2016. Uman, pp. 152–157 (in Ukrainian).

Matuszkiewicz, J.M. (2015) 'Rola wiązów w zespołach roślinnych Polski', in Bugała, W., Boratyński, A. and Iszkuło, G. (eds.) *Wiązy*. Bogucki Wydawnictwo Naukowe, Poznań, Poland, pp. 181–223.

Menkis, A., Östbrant, I.L., Wågström, K. and Vasaitis, R. (2016) 'Dutch elm disease on the island of Gotland: monitoring disease vector and combat measures', *Scandinavian Journal of Forest Research*, 31, pp. 237–241. https://doi.org/10.1080/02827581.2015.1076888

Meshkova, V.L., Kuznetsova, O.A. and Khimenko, N.L. (2022) 'Occurrence of *Ulmus* L. in the different forest site conditions of eastern Ukraine', *Forestry and Forest Melioration*, 140, pp. 3–11. https://doi.org/10.33220/1026-3365.140.2022.3

Meshkova, V.L., Moroz, S.M. and Kuznetsova, O.A. (2024) 'Bacterial wetwood of Siberian elm (*Ulmus pumila* L.) on the south of Ukraine', *Current state, problems and prospects of forest education, science and management*, *Proceedings of the IV International Scientific and Practical Internet Conference,* Bila Tserkva, Ukraine, 19 April 2024. Bila Tserkva: BNAU, p. 215 (in Ukrainian).

Meshkova, V.L., Pyvovar, T.S. and Kuznetsova, O.A. (2023) 'The age structure of *Ulmus* L. stands in the eastern regions of Ukraine', *Proceedings of the Forestry Academy of Sciences of Ukraine*, 25, pp. 29–38. https://doi.org/10.15421/412302

Napierała-Filipiak, A., Filipiak, M., Łakomy, P., Kuźmiński, R. and Gubański, J. (2016) 'Changes in elm (*Ulmus*) populations of mid-western Poland during the past 35 years', *Dendrobiology*, 76, pp. 145–156. doi: 10.12657/denbio.076.014

Puzrina, N.V. and Yavny, M.I. (2020) *Elm stands of the Kyiv Polissia of Ukraine: silvicultural and health condition*. Kyiv: NULES of Ukraine (in Ukrainian).

Santini, A. and Faccoli, M. (2015) 'Dutch elm disease and elm bark beetles: a century of association', *iForest – Biogeosciences and Forestry*, 8, pp. 126–134. https://doi.org/10.3832/ifor1231-008

Skolskyi, I.M. (2013) 'Physical properties of *Ulmus glabra* wood in the conditions of the Western Forest Steppe of Ukraine', *Scientific Bulletin of the National Technical University of Ukraine*, 23.15, pp. 33–40 (in Ukrainian).

State Forest Resources Agency of Ukraine (2024) *General characteristic of Ukrainian forests*. Available at: https://forest.gov.ua/en/areas-activity/forests-ukraine/general-characteristic-ukrainian-forests (Accessed: 5 March 2024) (in Ukrainian).

StatisticsLectures.com (2017) *Z-Test for Proportions, Two Samples*. Available at: http://www.statisticslectures.com/topics/ztestproportions/ (Accessed: 2 March 2024).

Thomas, P.A., Stone, D. and La Porta, N. (2018) 'Biological flora of the British Isles: *Ulmus glabra*', *Journal of Ecology*, 106(4) pp. 1724–1766. https://doi.org/10.1111/1365-2745.12994

Tkach, V., Buksha, I., Slych, O. and Pasternak, V. (2021) 'Optimization of maturity age for coppice oak forests within Left-Bank Forest-Steppe in Ukraine', *Central European Forestry Journal*, 67(3), pp. 181–186. https://doi.org/10.2478/forj-2020-0026

URIFFM (2019) *Improvement of the methods of diagnosing damage to deciduous species by harmful organisms in the forest fund of the State Enterprise "Trostyanetske Forestry" and clarifying the criteria for tree removal by sanitary felling. Report on the research work No. 62*. [Meshkova, V., Ed.]. Kharkiv: URIFFM (in Ukrainian).

Yavny, M.I. and Puzrina, N.V. (2018) 'Bacterial disease of *Ulmus glabra* Huds. in the stands of the Kyiv Polissia of Ukraine', *Microbiological Journal*, 80 (1), pp. 67–76 (in Ukrainian). https://doi.org/10.15407/microbiolj80.01.067

В’ЯЗИ (*ULMUS* L.) У ФІЛІЇ «МИРГОРОДСЬКЕ ЛІСОВЕ ГОСПОДАРСТВО» ДЕРЖАВНОГО СПЕЦІАЛІЗОВАНОГО ГОСПОДАРСЬКОГО ПІДПРИЄМСТВА «ЛІСИ УКРАЇНИ»

Мєшкова В. Л.[1]*, Кузнецова О. А.[2], Пивовар Т. С.[3]

Проаналізовано базу даних ВО «Укрдержліспроект» станом на 2010 і 2017 рр. стосовно складових нинішньої філії «Миргородське лісове господарство» («Лубенське лісове господарство» та «Миргородське лісове господарство») для оцінювання розподілу вкритих лісовою рослинністю земель, площі з *Ulmus* sp. як панівного виду та площі ділянок із видами *Ulmus* sp. у складі насаджень за типами лісорослинних умов та класами віку. За період 2010–2017 рр. площа природних лісів із в’язами як панівними видами та частка домінантного виду *U. minor* значуще збільшилися. Середній і максимальний віки насаджень залежать від їхнього походження та виду в’язів. Найбільш різке зменшення збереження всіх видів в’язів у природних деревостанах відбувалося у VI класі віку, а в культурах – у V класі віку. Відповідні насадження сформувалися в 1960-ті та 1970-ті рр., коли в багатьох регіонах реєстрували пік поширення голландської хвороби в’язів. Деревостани з участю в’язів презентовані в широкому спектрі трофотопів і гігротопів. За присутності у складі насаджень ті самі види в’язів розповсюджені в ширшому діапазоні типів лісорослинних умов, ніж коли ці види є панівними. *U. minor* надає перевагу свіжим грудам. *U. laevis* росте переважно у свіжих грудах і сугрудах, а *U. pumila* – у гігротопах від сухих до сирих. *U. glabra* наявний лише в деревостанах природного походження та відсутній у лісових культурах.

Ключові слова: *Ulmus minor, U. laevis, U. pumila, U. glabra*, головні лісоутворювальні види, збереженість, лісорослинні умови.

Одержано редколегією 12.03.2024

[1] Мєшкова Валентина Львівна, доктор сільськогосподарських наук, професор, Український науково-дослідний інститут лісового господарства та агролісомеліорації ім. Г. М. Висоцького, вул. Григорія Сковороди, 86, Харків, 61024, Україна. E-mail: valentynameshkova@gmail.com, ORCID: https://orcid.org/0000-0001-6483-2736

[2] Кузнецова Олена Анатоліївна, аспірантка, Український науково-дослідний інститут лісового господарства та агролісомеліорації ім. Г. М. Висоцького, вул. Григорія Сковороди, 86, Харків, 61024, Україна. E-mail: urbanscapeke@gmail.com, ORCID: https://orcid.org/0009-0005-8079-9186

[3] Пивовар Тетяна Сергіївна, кандидат сільськогосподарських наук, старший науковий співробітник, Український науково-дослідний інститут лісового господарства та агролісомеліорації ім. Г. М. Висоцького, вул. Григорія Сковороди, 86, Харків, 61024, Україна. E-mail: pyvovartatiana@gmail.com, ORCID: https://orcid.org/0000-0001-7250-8549

* Адреса для кореспонденції: valentynameshkova@gmail.com