2. ЛІСОЗНАВСТВО, ЛІСІВНИЦТВО ТА МИСЛИВСЬКЕ ГОСПОДАРСТВО

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The age structure of *Ulmus* L. stands in the eastern regions of Ukraine

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The aim of the research was to determine the features of the age structure for natural and artificial elm stands depending on species, origin, and region. The proportion of the stand area of natural and artificial stands of each elm species by 10-year age classes was evaluated for the forest fund of the Donetsk, Kharkiv, and Sumy Regional Forest and Hunting Management Administrations (RFHMA). Four main forest-forming elm species are represented in the forest fund of the Donetsk and Kharkiv RFHMA (U. minor, U. laevis, U. glabra, and U. pumila). In the Sumy RFHMA, there are three forest-forming elm species: U. minor, U. laevis, and U. glabra. The maximum age of U. minor is 120, 117, and 91 years in the Donetsk, Kharkiv, and Sumy RFHMA, respectively. The mean and the maximum age of U. minor and U. glabra tends to decrease in the Donetsk–Kharkiv–Sumy RFHMA row. The proportion of U. laevis is larger in man-made plantations than in natural stands, however, in natural stands, it also increases in the Donetsk–Kharkiv–Sumy RFHMA row. U. glabra prevails in natural stands. U. pumila in the Donetsk RFHMA grows mainly in man-made plantations. A decrease in the area of newly formed U. minor stands in the Donetsk RFHMA occurred after the 1950s, and in the Kharkiv RFHMA after the 1960s in both artificial and natural stands. In the Sumy RFHMA, this also happened in the 1960s in man-made plantations. A decrease in the area of U. glabra natural and artificial stands occurred also after the 1960s. We suppose that an epiphytoty of the Dutch elm disease, well-known in Europe in the 1960s, could also be the cause of elm decline in the eastern part of Ukraine. The proportion of the stands' area preserved up to a certain age, depends on particular elm species, region, and stand origin. However, in order to clarify the survival rate, it is necessary to consider the type of forest site conditions, the proportion of elms in the stand composition, and some other features that are to be analyzed in future research.

***Key words**: Ulmus minor* Mill., *Ulmus laevis* Pall., *Ulmus pumila* L., *Ulmus glabra* Huds., *man-made plantations, natural stands, Dutch elm disease, survival.*

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Introduction. Elms (*Ulmus* spp.) as a part of the forest and protective stands promote litter decomposition, as well as nitrogen and phosphorus cycling due to a high concentration of alkaline, and a low concentration of acidic, buffering substances (Matuszkiewicz, 2015; Collin, Bozzano, 2015). These trees are widely used as urban greenery due to their high ornamental value and tolerance to soil compaction, root hypoxia, wind, poor soils, and pollution (Buiteveld, Werf, & Hiemstra, 2015). The wood of this species is highly valued because of its mechanical properties, resistance to water, as well as for its beautiful color and texture (Скольський, 2013; Venturas et al., 2015; Thomas, Stone, & La Porta, 2018; Christopher et al., 2022).

The rapid decline in interest in elm cultivation was associated with the onset of the epiphytoty of Dutch elm disease (DED) and the mass decline of elm trees in the 1960s and 70s (Brasier, 1991; Santini, & Faccoli, 2015; Linnakoski, Kasanen, Dounavi, & Forbes, 2019).

In the forest fund of the State Forest Resources Agency of Ukraine, elm forests occupy less than 0.1% (Захарчук, 2014; Загальна характеристика лісів України, 2022). Elm is not considered a very important tree species in Ukraine, and its damage by various natural and anthropogenic factors has been little studied (Шевченко, 1986, 1987; Скольський, 2009; Пузріна, Явний, 2020). In the eastern part of Ukraine, elm distribution by forest site conditions was studied in the forests of the Donetsk, Kharkiv, and Sumy Regional Forest and Hunting Management Administrations (RFHMA) (Meshkova, Kuznetsova, Khimenko, 2021). It was concluded that *U. minor* is the most common, and *U. glabra* is the least common in the region. At the same time, *U. pumila* dominates in the Donetsk RFHMA and is absent in the Sumy RFHMA. *U. laevis* is most common in the Kharkiv RFHMA.

Differences in the spread of elm species can be associated not only with the availability of favorable forest site conditions but also with the different resistance of individual species to diseases. The latter factor manifests itself in different survival rates of elm species during epiphytoty. Another reason is the decrease in the elm proportion in man-made forest plantations due to the preference for more economically valuable species.

The study of the age composition of elms in the region may also be important for the evaluation of the maturity age of this species. Studies of other forest tree species, in particular, Silver birch (*Betula pendula* Roth) (Meshkova, & Koshelyaeva, 2019) and European ash (*Fraxinus excelsior* L.) (Meshkova, & Borysova 2019) showed that the maturity age evaluated by growth dynamics is much higher than the actual age of tree mortality from disease in the face of the threat of epiphytoty, leading to a loss in the timber quality.

An object of research is the age structure of elm stands. *The subject of research* is the features of age structure for natural and planted elms of different species in the eastern part of Ukraine. *The aim of this article* was to determine the age structure of natural and artificial elm stands depending on species, origin, and region.

Objects and methods. Database of Ukrainian State Forest Management Planning Association «Ukrderzhlisproekt» (by 2017) was analyzed for the forest fund of Donetsk, Kharkiv, and Sumy RFHMA using SQL-query and converting it to the *.xls files. All these regions are located in eastern Ukraine and represent different natural zones: Donetsk region is entirely in the Steppe zone, Kharkiv region is partly in the Forest-Steppe and Steppe zones, and Sumy region is partly in Polissya and Forest-Steppe zones (Генсірук, 2002).

Four elm species were analyzed (Meshkova et al., 2021): *U. minor* Mill. (field elm) – in Ukrainian "berest"; *U. laevis* Pall. (white elm, spreading elm, or fluttering elm) – in Ukrainian "gladky"; *U. pumila* L. (Siberian elm) – introduced Asian elm species – in Ukrainian "dribnolysty", "nyzkiy"; *U. glabra* Huds. (wych elm, Scotch elm) – in Ukrainian "shorstky", or "goly".

In this study, subcompartments were selected from the database for each region, where the corresponding elm species was the main forest-forming species. For each region and species of elm, statistics of age distribution were evaluated (Атраментова, Утевская, 2008). The area of natural and artificial stands of each elm species in each of the 10-year age classes was calculated. The dynamics of the age composition of elm stands are presented starting from the year of their planting or natural regeneration, indicating the current age class.

The probability of elm stand survival up to a certain age class was modeled. According to this, the proportion of the stand area of each 10-year age class was estimated for each elm species and stand origin. Then the proportion of the stands' area, which survives up to a certain age, was estimated (Meshkova, & Borysova, 2019; Meshkova, & Koshelyaeva, 2019).

Microsoft Excel software and the statistical software package Paleontological Statistics (PAST) Software Package for Education and Data Analysis (Hammer et al. 2001) were used.

Results. In the forest fund of Donetsk region, there are four elm species that are the main forest-forming species. *U. minor* prevails in terms of area (Meshkova et al., 2021), and both *U. minor* and *U. pumila* dominate in terms of the number of subcompartments (Fig. 1). *U. laevis* occurs in the youngest stands, and the minimum age of *U. glabra* is 29 years. The oldest stands (120 years old) were found in *U. minor*, while the maximum age of other elm species does not exceed 80 years. The age of *U. laevis* is the most variable (V = 46.4 %), and that of *U. pumila* is the least variable (V = 15.9 %).

Differences in the mean age of different elm species in Donetsk region are significant according to the Kruskal-Wallis test for equal medians (H (chi^2) = 118.4; $P < 0.0001$). A pairwise comparison of the Tukey test shows the significance of differences in age between *U. minor* and *U. laevis* ($P < 0.0001$) as well as between *U. minor* and *U. pumila* ($P < 0.0001$).

In the forest fund of Kharkiv region, four elm species are also represented as the main forest-forming

species, however, *U. minor* prevails in a number of subcompartments (Fig. 2). *U. laevis* is almost three times less represented, and the remaining 2 species occur singly as the main forest-forming species.

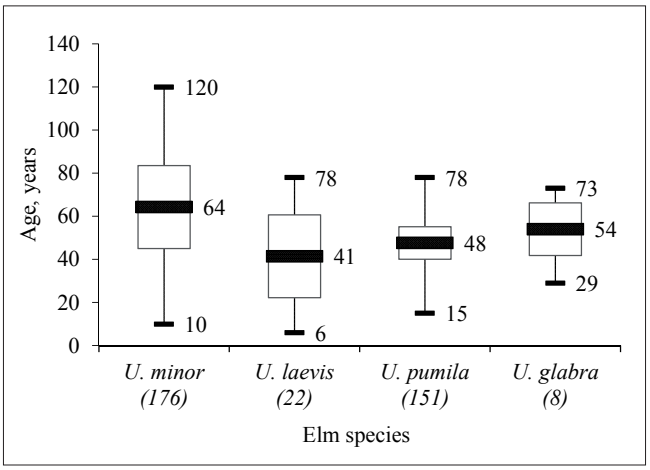

Fig. 1. Mean age of *Ulmus* species in the forests of Donetsk region (the numbers indicate the minimum, mean, and maximum age; numbers of subcompartments are in parentheses after species name; whisker type is standard deviation, box length is one sigma)

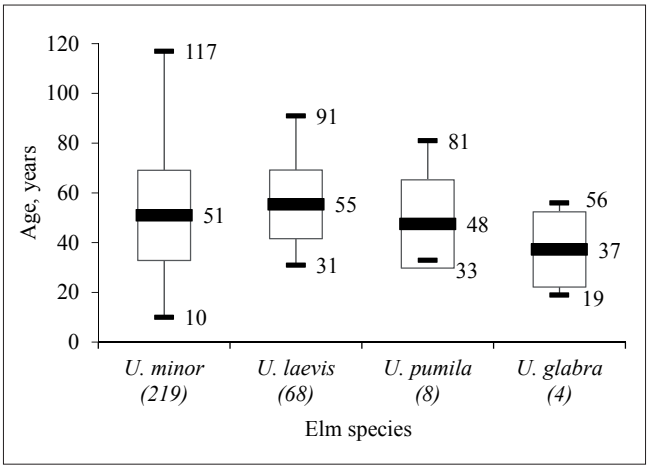

Fig. 2. Mean age of *Ulmus* species in the forests of Kharkiv region (the numbers indicate the minimum, mean, and maximum age; numbers of subcompartments are in parentheses after species name; whisker type is standard deviation, box length is one sigma)

U. minor occurs in the youngest and the oldest stands. The minimum age of *U. glabra* is 19 years and it has also the lowest maximum age.

Differences in the mean age of different elm species in Kharkiv region are significant according to the Kruskal-Wallis test for equal medians (H (chi^2) = 8.4; P=0.04). In a pairwise comparison, the Tukey test shows the significance of differences between *U. minor* and *U. laevis* (P=0.02), as well as between *U. glabra* and *U. laevis* (P=0.03).

In the forest fund of Sumy region, elms as the main forest-forming species are rare. *U. minor* is most frequent (but it is found only in 25 subcompartments) (Fig. 3).

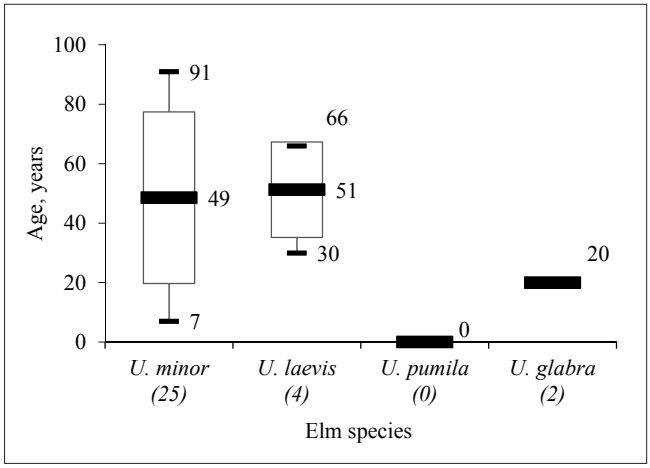

Fig. 3. Mean age of *Ulmus* species in the forests of Sumy region (the numbers indicate the minimum, mean, and maximum age; numbers of subcompartments are in parentheses after species name; whisker type is standard deviation, box length is one sigma)

U. laevis as the main forest-forming species occurs in 4 subcompartments, *U. glabra* – in two subcompartments, and *U. pumila* is absent at all. *U. minor* occurs in the youngest and the oldest stands. The age of *U. glabra* in both stands of its occurrence is 20 years, while *U. laevis* is represented in stands from 30 to 66 years old. Differences in the mean age of *U. minor* and *U. laevis* in Sumy region are not significant (P>0.1).

Comparison of the same elm species in different regions (*see* Figs. 1-3) shows that the mean and the maximum age of *U. minor*, which is most abundant in the forests of Kharkiv region, tends to decrease in the row Donetsk–Kharkiv–Sumy. Differences in the mean age of *U. minor* in the three regions are significant according to the Kruskal-Wallis test for equal medians (H (chi^2) =55.5; P<0.001). The Tukey test shows the significance of differences in *U. minor* age between Donetsk and Kharkiv (P<0.001) as well as between Donetsk and Sumy regions (P=0.03). Differences in age between Kharkiv and Sumy regions are not significant (P=0.7).

The mean age of *U. laevis* is the lowest in Donetsk region, its differences in Donetsk and Kharkiv regions are significant (H (chi^2) =11.3; P=0.03).

The mean age of *U. pumila* in Donetsk and Kharkiv regions differs insignificantly (H (chi^2) =0.94; P=0.3). At the same time, the minimum age of this elm species in Donetsk region is 15 years, and in Kharkiv region it is 33 years, and the modal value is higher in Donetsk region (50 and 37 years in Donetsk and Kharkiv regions, respectively).

The mean and the maximum age of *U. glabra* tends to decrease in the Donetsk–Kharkiv–Sumy row. The minimum age of this elm species is also the highest in Donetsk region. Due to the small sample size in Sumy region, the Kruskal-Wallis test for equal medians makes it possible to compare only Kharkiv and Donetsk regions (H (chi^2) =2.88; P=0.09). It indicates unreliable differences in the mean age of *U. glabra* in

these regions. The Mann-Whitney pairwise test shows that the difference in mean age is significant only between Donetsk and Sumy regions (P=0.05).

As of 2017, the area of stands with *U. minor,* as the main species, is only 309.3 ha in Sumy region, while in Donetsk and Kharkiv regions, it is 477.3 and 504.9 ha, respectively (Meshkova et al., 2021).

The forest fund of Donetsk region is dominated by 70-year-old stands of *U. minor*, created in the 1950s (about 40% of the area), and the proportion of younger stands is decreasing, and those created in the 2010s are only about 1% of the area (Fig. 4). In the forest fund of Kharkiv region, a considerable part of *U. minor* stands (31.8%) is 60 years old, that is, they were planted or naturally grown in the 1960s. The area of *U. minor* stands, created before the 1960s, tended to increase and then decreased.

In the forest fund of Sumy region, *U. minor* prevails in 80-year-old stands established in the 1940s and in 30-year-old stands established in the 1990s (*see* Fig. 4).

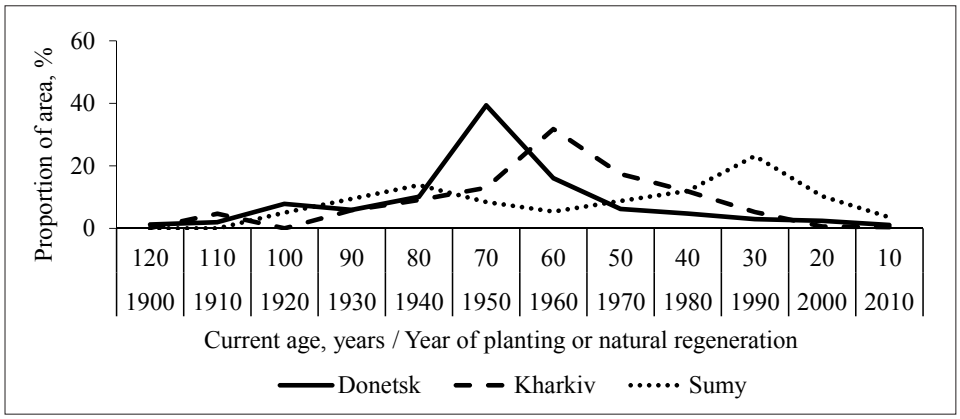

Fig. 4. Distribution of area of *U. minor* stands by current age and the years of planting or natural regeneration in three eastern regions of Ukraine

The areas with *U. laevis* as the main forest-forming species are much smaller than those with *U. minor.* In Kharkiv region, the stands with *U. laevis* as the main forest-forming species occupy an area of 111.6 ha, in Donetsk region – 61.7 ha, and in Sumy region – 12 ha (Meshkova et al., 2021). At the same time, the stands of *U. laevis*, planted or naturally grown in the 1970s, predominate in Donetsk region (35%). Smaller peaks are in the 1940s and 2000s (11 and 14.6%, respectively). In Kharkiv region, the proportion of *U. laevis* area increased in the 1950s and declined in the 1970s. In Sumy region, 69.1% of *U. laevis* area decreased in the 1950s (Fig. 5).

In Donetsk region, the stands with *U. glabra* as the main forest-forming species occupy an area of 14.1 ha, and in Kharkiv and Sumy regions – 3.1 and 3.4 ha, respectively (Meshkova et al., 2021). In Donetsk region, the main part of *U. glabra* stands (95.7%) was created in the 1960s, in Sumy region – in the 1990s (58.8%), and in Kharkiv region, three small peaks were registered (in the 1960s, 1980s, and 2000s). After each peak in all regions, except Sumy region, there was a period when plantations with *U. glabra* were not created (Fig. 6).

U. pumila is the main forest-forming species in Donetsk (379.4 ha) and Kharkiv regions (15.6 ha) (Meshkova et al., 2021). In Donetsk region, the proportion of this species increased until the 1970s, and in Kharkiv region – until the 1980s (Fig. 7).

We assumed that the age structure of individual elm species depends on the ratio of artificial and natural stands' area. So, *U. minor* stands of natural origin prevail in all three regions, but the proportion of man-made plantations increases from Donetsk towards Sumy region (Table 1).

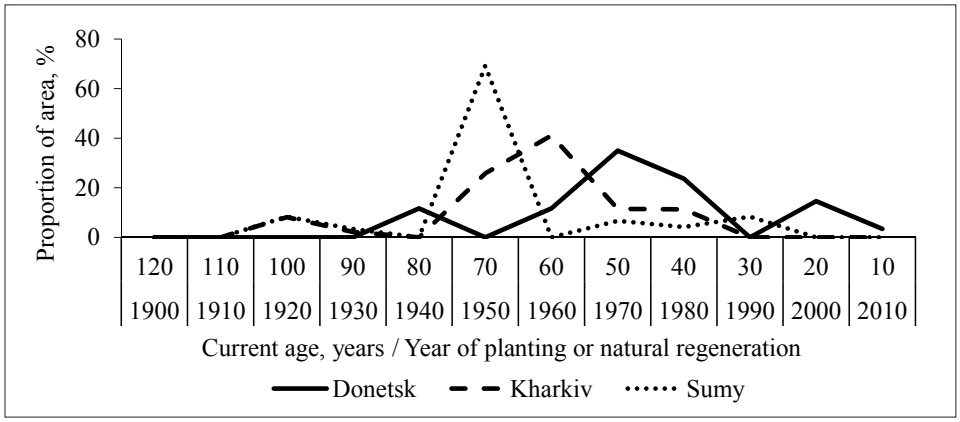

Fig. 5. Distribution of area of *U. laevis* stands by current age and the years of planting or natural regeneration in three eastern regions of Ukraine

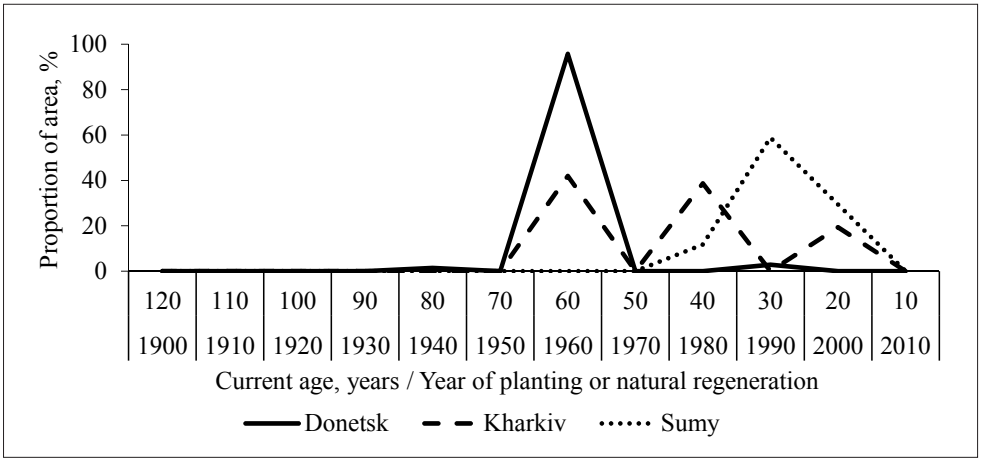

Fig. 6. Distribution of area of *U. glabra* stands by current age and the years of planting or natural regeneration in three eastern regions of Ukraine

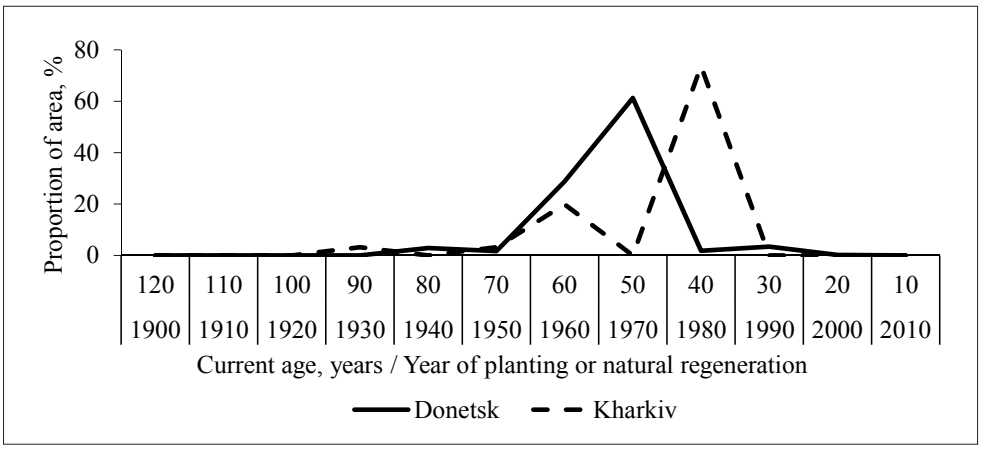

Fig. 7. Distribution of area of *U. pumila* stands by current age and the years of planting or natural regeneration in two eastern regions of Ukraine

Table 1. **Distribution of area of certain elm species by origin (%) in the forests of three eastern regions of Ukraine**

RFHMA	*U. minor*		*U. laevis*		*U. glabra*		*U. pumila*	
	man-made	natural	man-made	natural	man-made	natural	man-made	natural
Donetsk	8.3	91.7	66.0	34.0	21.3	78.7	95.2	4.8
Kharkiv	16.0	84.0	61.8	38.2	41.9	58.1	78.2	21.8
Sumy	23.9	76.1	55.0	45.0	14.7	85.3	absent	absent

The proportion of *U. laevis* is larger in man-made plantations than in natural stands, but the proportion of man-made plantations in the area decreases from Donetsk towards Sumy region. *U. glabra* prevails in natural stands, but its proportion is less than that of other elm species (Meshkova et al., 2021). *U. pumila* in Donetsk region grows mainly (95 % of the area) in man-made plantations, and in Kharkiv region, its proportion in natural stands increases.

Due to the different abundance of elm species, the years of their decrease were also different (Table 2, Figs 4-7).

Despite the rather high maximum age of individual stands, more than 50 % of them survived to age class VII only in natural stands of *U. pumila* in Donetsk RFHMA (Table 3).

Survival of *U. minor* exceeded 50 % in age classes V–VI, and only in natural stands of this species it sharply decreased after age class III. The survival of *U. laevis* in man-made plantations increased from Donetsk towards the Sumy RFHMA. Natural stands of this species in the Donetsk RFHMA already in age class II survived in less than half of the initial area, and in the Kharkiv and Sumy RFHMA, it happened

after age classes V-VI, respectively. *U. glabra* in the man-made plantations of the Donetsk and Kharkiv RFHMA and in natural stands of the Donetsk RFHMA survived up to age class V, and in other stands, its survival sharply decreased already in age classes I–III. Survival of *U. pumila* in both man-made plantations and natural stands of the Kharkiv RFHMA was less than 50 % already in age class IV, in man-made plantations in the Donetsk RFHMA in class V, and in natural stands only in class VIII (*see* Table 3).

Table 2. **Years of decreasing the area of establishment of man-made plantations and natural regeneration of *Ulmus* spp.**

RFHMA	*U. minor*		*U. laevis*		*U. glabra*		*U. pumila*	
	man-made	natural	man-made	natural	man-made	natural	man-made	natural
Donetsk	1950	1950	1980	1940	1960	1960	1960	low area
Kharkiv	1960	1960	1960	1950	1960	low area	1980	1980
Sumy	1960	1990	1950	1950	low area	low area	absent	absent

Table 3. **Survival stands up to certain age classes depending on elm species, origin, and RFHMA**

Elm species	RFHMA	Man-made or natural stands	Age classes							
			I	II	III	IV	V	VI	VII	VIII
			Year of planting or natural regeneration							
			2010	2000	1990	1980	1970	1960	1950	1940
U. minor	Donetsk	Man-made	100.0	100.0	100.0	100.0	83.4	**52.1**	11.1	0.8
	Kharkiv		100.0	100.0	100.0	87.1	**62.8**	24.4	18.9	7.9
	Sumy		100.0	99.6	99.6	93.2	85.4	**64.8**	48.0	20.3
	Donetsk	Natural	98.8	96.2	93.0	87.8	82.5	**67.8**	28.6	18.5
	Kharkiv		99.5	98.8	92.6	81.0	**64.9**	34.3	19.9	11.2
	Sumy		95.3	81.9	**51.5**	37.7	28.6	28.0	22.2	12.7
U. laevis	Donetsk	Man-made	100	100.0	100.0	**64.1**	17.7	0.0	0.0	0.0
	Kharkiv		100.0	100.0	100.0	83.6	**78.3**	24.5	1.3	1.3
	Sumy		100.0	100.0	89.4	89.4	89.4	**89.4**	6.1	0.0
	Donetsk	Natural	**90.0**	47.1	47.1	47.1	34.3	34.3	34.3	0.0
	Kharkiv		100.0	100.0	100.0	96.9	75.6	**54.9**	24.9	24.9
	Sumy		100.0	100.0	94.4	85.2	70.4	**70.4**	18.5	18.5
U. glabra	Donetsk	Man-made	100.0	100.0	86.7	86.7	**86.7**	0.0	0.0	0.0
	Kharkiv		100.0	100.0	100.0	100.0	**100.0**	0.0	0.0	0.0
	Sumy		**100.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Donetsk	Natural	100.0	100.0	100.0	100.0	**100.0**	1.8	1.8	0.0
	Kharkiv		100.0	66.7	**66.7**	0.0	0.0	0.0	0.0	0.0
	Sumy		100.0	**82.8**	13.8	0.0	0.0	0.0	0.0	0.0
U. pumila	Donetsk	Man-made	100.0	100.0	97.5	**95.7**	32.0	1.8	0.0	0.0
	Kharkiv		100.0	100.0	**100.0**	29.5	29.5	4.1	0.0	0.0
	Donetsk	Natural	100.0	96.1	74.6	72.9	60.8	60.8	**60.8**	0.0
	Kharkiv		100.0	100.0	**100.0**	14.7	14.7	14.7	14.7	14.7

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

Discussion. In the forest fund of the eastern part of Ukraine, four forest-forming elm species are presented, particularly, *U. minor*, *U. laevis*, *U. glabra*, and *U. pumila*. However, *U. pumila* is absent in the Sumy RFHMA. *U. minor* is the main forest-forming species in the largest number of subcompartments in all RFHMA. *U. laevis* as the main forest-forming species is most represented in the Kharkiv RFHMA. *U. glabra* in all regions analyzed is represented as the main forest-forming species in a small number of subcompartments (*see* Figs. 1-3).

Differences in the spread of elm species are mainly associated with the availability of favorable forest site conditions. For example, in Poland, *U. laevis* prefers riparian habitats, *U. minor* occurs at less humid sites, while *U. glabra* prefers moist slopes (Napierała-Filipiak et al., 2016).

In the eastern part of Ukraine, *U. minor* prefers fresh and dry fertile forest site conditions (FSC). *U. laevis* in the Donetsk RFHMA prefers dry and fresh fertile FSC types, in the Kharkiv RFHMA – fresh fertile FSC types, in the Sumy RFHMA – fresh relatively poor, relatively fertile, and fertile FSC types. *U. pumila* in the Donetsk RFHMA prefers dry relatively fertile FSC, in the Kharkiv RFHMA – fresh fertile FSC, in the Sumy RFHMA – fresh relatively poor FSC, fresh relatively fertile FSC, and moist fresh relatively fertile FSC. *U. glabra* prevails in moist relatively fertile FSC types, and in the Kharkiv RFHMA it is also common in fresh fertile FSC types (Meshkova et al., 2021).

An analysis shows, that the maximum age of *U. minor* is 120, 117, and 91 years in the Donetsk, Kharkiv, and Sumy RFHMA, respectively. The mean and the maximum ages of *U. minor* and *U. glabra* tend to decrease in the Donetsk–Kharkiv–Sumy RFHMA row (see Figs 1-3). This may be due to the fact that forest site conditions are more favorable for growing more economically valuable forest species in the forest zone (the north of Sumy region), they are less favorable in the forest-steppe zone (the south of Sumy region and the north of Kharkiv region), and the least favorable conditions are found in the steppe (the south of Kharkiv region and Donetsk region) (Генсірук, 2002; Загальна характеристика лісів України, 2022).

For the same reason, *U. minor* stands of natural origin prevail in all three regions and also decrease in the Donetsk–Kharkiv–Sumy RFHMA row (see Table 1). The proportion of *U. laevis* is larger in man-made plantations than in natural stands, however, in natural stands it increases in the Donetsk–Kharkiv–Sumy RFHMA row. *U. glabra* prevails in natural stands. *U. pumila* in Donetsk region grows mainly in man-made plantations.

A decrease in the area of newly formed *U. minor* stands in the Donetsk RFHMA occurred after the 1950s, and in the Kharkiv RFHMA – after the 1960s in both artificial and natural stands. In the Sumy RFHMA, this also happened in the 1960s in man-made plantations but only in the 1990s in natural stands. A decrease in the area of new *U. laevis* natural stands occurred after the 1940s in the Donetsk RFHMA and after the 1950s in the Kharkiv and Sumy RFHMA. Such a decrease in the man-made plantations occurred after the 1950s in the Sumy RFHMA, in the 1960s – in the Kharkiv RFHMA, and in the 1980s – in the Donetsk RFHMA. A decrease in the area of new *U. glabra* natural and artificial stands occurred after the 1960s. Such a decrease in man-made plantations of *U. pumila* occurred after the 1960s in the Donetsk RFHMA and after the 1980s – in the Kharkiv RFHMA (*see* Figs 4-7, Table 2). These data are consistent with publications on the spread of DED in Europe in the 1950s. and 1960s (Menkis, Östbrant, Wågström, & Vasaitis, 2016; Jürisoo, Adamson, Padari, & Drenkhan, 2019), which reflected in the age spectrum of elm stands (Heybroek, 2015; Napierała-Filipiak et al., 2016).

Survival of stands up to perfect age class is an important parameter that can be used for the evaluation of the maturity age of certain tree species. Such an approach has been successfully tested in the analysis of the survival of pine stands in Sumy region (Tovstukha, 2012), English oak (*Quercus robur* L.) (Meshkova, & Didenko, 2017), European ash (*Fraxinus excelsior* L.) (Meshkova, & Borysova, 2019) and silver birch (Meshkova, & Koshelyaeva, 2019) in the Left-bank Forest Steppe of Ukraine. Our research shows that the survival rate of stands depends on elm species, stand origin, and region (*see* Table 3). However, to obtain more exact data, it is necessary to consider also the dependence of survival rate on the type of forest site conditions, the proportion of various elm species in the stand composition, and some of their other features.

Conclusions. In the forest fund of the Donetsk and Kharkiv RFHMA, four species of elm are forest-forming ones: *U. minor*, *U. laevis*, *U. glabra*, and *U. pumila*. In the Sumy RFHMA, there are three species: *U. minor*, *U. laevis*, and *U. glabra*. Elms as the main forest-forming species and are most represented in Donetsk and Kharkiv regions. The maximum age of *U. minor* is 120, 117, and 91 years in the Donetsk, Kharkiv, and Sumy RFHMA, respectively. The mean and the maximum age of *U. minor* and *U. glabra* tends to decrease in the row Donetsk–Kharkiv–Sumy RFHMA. The proportion of *U. laevis* is larger in man-made plantations than in natural stands, however, in natural stands it increases in the row Donetsk–Kharkiv–Sumy RFHMA. *U. glabra* prevails in natural stands. *U. pumila* in Donetsk region grows mainly in man-made plantations.

A decrease in the area of newly formed *U. minor* stands in the Donetsk RFHMA occurred after the 1950s, and in the Kharkiv RFHMA – after the 1960s in both artificial and natural stands. In the Sumy RFHMA, this also happened in the 1960s in man-made plantations but only in the 1990s in natural stands. A decrease in the area of new *U. glabra* natural and artificial stands occurred after the 1960s. An epiphytoty of the Dutch elm disease, well-known in Europe in the 1960s, could be also the cause of elm decline in the eastern part of Ukraine.

Survival of stands depends on elm species, stand origin, and region. However, to obtain more exact data, it is necessary to consider also the dependence of survival rate on the type of forest site conditions, the proportion of various elms species in the stand composition, and some of their other features.

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Вікова структура насаджень *Ulmus* L. у східних регіонах України

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Метою досліджень було визначити особливості вікової структури природних і штучних насаджень *Ulmus* L. залежно від виду й походження деревних видів та від регіону. Співвідношення площі насаджень природних і штучних насаджень кожного виду в'язів за 10-річними класами віку оцінювали у лісовому фонді Донецького, Харківського та Сумського обласних управлінь лісового та мисливського господарства.

За переліком виділів, де основними лісоутворювачами є окремі види в'язів, розраховували статистичні показники розподілу насаджень за віком (середній, мінімальний, максимальний вік і стандартне відхилення). Це дало змогу статистично оцінити відмінності видового складу насаджень із різними головними лісотвірними породами роду *Ulmus*.

Розраховано площу насаджень кожного виду в'язів за 10-річними класами віку та її розподіл. Під часу аналізу враховано також роки створення насаджень.

Частку площі насаджень, що збереглися до певного віку, визначали з урахуванням відпаду дерев в окремих класах віку.

У лісовому фонді Донецького та Харківського ОУЛМГ представлені чотири лісотвірні види в'язів (*U. minor*, *U. laevis*, *U. glabra*, та *U. pumila*), а в

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лісовому фонді Сумського ОУЛМГ – лише три види: *U. minor*, *U. laevis* та *U. glabra*. Максимальний вік насаджень за участю *U. minor* становить 120, 117 і 91, *U. glabra* – 73, 56 і 20 років у лісовому фонді Донецького, Харківського та Сумського ОУЛМГ відповідно. Середній вік *U. minor* (64, 51 і 49 р.) та *U. glabra* (54, 37 і 20 р.) також має тенденцію до зниження у напрямі Донецьке–Харківське–Сумське ОУЛМГ.

Частка площі насаджень за участю *U. laevis*, як лісотвірного виду, є більшою у лісових культурах, ніж у насадженнях природного походження. Водночас, у природних насадженнях ця частка також збільшується у напрямі Донецьке–Харківське–Сумське ОУЛМГ (34, 38 і 45 %). Як лісотвірний деревний вид *U. glabra* трапляється переважно у насадженнях природного походження, а *U. pumila* – зазвичай у лісових культурах Донецького ОУЛМГ.

Площа насаджень *U. minor,* створених штучно чи сформованих природно, у лісовому фонді Донецького ОУЛМГ зменшилася після 1950-их, у лісовому фонді Харківського ОУЛМГ – після 1960-их років. У лісовому фонді Сумського ОУЛМГ таке зменшення площі насаджень за участю *U. minor* після 1960-их років відбулося в лісових культурах. Площа насаджень за участю *U. glabra,* створених штучно чи сформованих природно, також зменшилася після 1960-их років. Вірогідно, причиною всихання в'язів у східній частині України стала голландська хвороба, яка поширилася у лісостанах Європи саме в 1960-их роках.

Частка площі насаджень, що збереглася до певного віку, залежала від виду в'яза, регіону та походження деревостану. Водночас для уточнення кількісних показників збереження насаджень за участю Ulmus L. необхідно брати до уваги також тип лісорослинних умов, частку в'язів у складі насаджень та деякі інші особливості, які є предметом наступних досліджень.

Ключові слова: *Ulmus minor* Mill.; *Ulmus laevis* Pall.; *Ulmus pumila* L.; *Ulmus glabra* Huds.; лісові культури; насадження природного походження; голландська хвороба в'язів; виживання.