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**AGE STRUCTURE OF THE BIRCH STANDS**  
**IN THE LEFT-BANK FOREST-STEPPE OF UKRAINE**

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The aim of this work was to define the features of the age structure of the silver birch stands in the Left-Bank Forest-Steppe considering forest site conditions, origin, site index and proportion of this species in the forest composition. Survival of silver birch in almost all age classes was the lowest in the relatively poor forest site conditions. The mean weighted age classes of silver birch are IV.8 in vegetative stands and IV.6 – in artificial seed stands. For all origins, the mean weighted age classes are V.1 for Sumy Region and IV.6 – for Kharkiv and Poltava Regions. The stands of the lower productivity have the least longevity. Survival of pure and almost pure stands (silver birch make 90 % of all the trees) is the lowest. At that, it is the highest in Sumy Region.

Key words: silver birch (*Betula pendula* Roth), forest site conditions, origin, site index, forest composition.

**Introduction.** Silver birch (*Betula pendula* Roth) in the forest fund of the State Agency of Forest Resources covers only 5.7% from the forest-covered area (Zahalna kharakterystyka 2016). Considering a high ecological meaning of this species (Meshkova & Koshelyaeva 2015, Goychuk et al. 2018), its proportion should be increased. However, due to its lower productivity and cost compared with pine and oak species, a silver birch is also underutilized as a source of valuable wood. At the same time, recently the health condition of silver birch has worsened in many regions (Skrylnik & Koshelyaeva 2015, Goychuk et al. 2018). Our studies showed that among the trees with the diameter over 20 cm, a diameter of dead trees exceeded a diameter of living trees (Meshkova et al. 2018). This indirectly indicates that the standard age of maturity and, accordingly, the age of the main felling in birch stands is overstated. Due to the small proportion of the birch in the stands and its relatively early mortality, the valuable properties of this species are far from being fully utilized. We assumed that to evaluate the maturity age in unfavourable conditions for many forest species, it is necessary to take into account not their productivity dynamics only, but also the risk of worsening of their health condition with age, which is accompanied by the deterioration in the quality of timber products.

*The aim of this work* was to define the features of the age structure of silver birch stands in the Left-Bank Forest-Steppe considering forest site conditions, origin, site index and proportion of this species in the forest composition.

**Materials and Methods.** We analyzed the Production Association “Ukrderzhlisproekt” Database (by 01.01.2011) for the State Forest Enterprises which are located in the Left-Bank Forest-Steppe. Sumy Region was represented by two State Enterprises, namely Okhtyrskе Forest Economy (FE) and Trostianetske FE. Poltava Region was represented by three State Enterprises: Gadiatske FE, Myrgorodske FE and Poltavskе FE. Kharkiv Region was represented by six State Enterprises: Vovchanske FE, Gutianske FE, Zmiyivskе FE, Chuguyevo-Babchanske FE, Skrypayskе Training & Experimental Forest Economy of Kharkiv National Agrarian University named after V. V. Dokuchaev (Skrypayskе TEFE) and Kharkivska Forest Research Station of the Ukrainian Research Institute of Forestry and Forest Melioration named after G. M. Vysotsky (Kharkivska FRS). Their territory varies from 49°35' N (Poltavskе FE) to 50°28' N (Trostianetske FE) by latitude and from 33°36' E (Myrgorodske FE) to 36°56' E (Vovchanske FE) by longitude (Table 1). The proportion of stands with silver birch as the main forest-forming species was the lowest in Skrypayskе TEFE and Chuguyevo-Babchanske FE (0.2 and 0.4 % respectively) and the highest in Poltavskе FE (2.2 %). The oldest silver birch stands were in the VIII age class in Zmiyivskе FE only, in the IX age class – in five forest enterprises, in the X age class – in three forest enterprises and in the XI age class – only in two forest enterprises Trostianetske FE and Gadiatske FE, which are in the most northern part of the analyzed territory (Table 1).

*Table 1*

**Characteristics of birch stands in the territory of forest enterprises**

State Forest Enterprise (FE)	Latitude, N*	Longitude, E	Proportion of silver birch stands, %**	Age class limits for birch stands*
Okhtyrskе FE	50°18'	34°54'	0.9	I–X (V.1)
Trostianetske FE	50°28'	34°28'	1.4	I–XI (V.1)
Vovchanske FE	50°17'	36°56'	0.6	I–X (V.2)
Gutianske FE	50°08'	35°21'	1.5	I–IX (IV.3)
Zmiyivske FE	49°42'	36°22'	0.6	I–VIII (IV.1)
Skrypayske TEFE	49°44'	36°31'	0.2	II–IX (V.5)
Chuguyevo-Babchanske FE	49°52'	36°44'	0.4	I–IX (III.9)
Kharkivska FRS	50°09'	36°31'	1.5	II–IX (V.0)
Gadiatske FE	50°22'	33°59'	2.0	I–XI (IV.8)
Poltavske FE	49°35'	34°32'	2.2	I–X (IV.3)
Myrgorodske FE	49°57'	33°36'	1,6	I–IX (IV.7)

\* Latitude and longitude for each forest enterprise were evaluated as centroids of respective contours of the territory using MapInfo Mapping Package.

\*\*Proportion of birch stands from area of forest covered lands, %.

We studied the data for subcompartments with silver birch as the main forest-forming species according to 10-year age classes for different forest site conditions, origin (natural and artificial seed origin, vegetative origin), site index, and proportion of silver birch in the stand composition.

The probability of stand survival up to the mentioned age class was modeled by means of the method of Yu. P. Demakov (Demakov 2000), which was successfully tested in the analysis of the pine plantations survival in Sumy Region (Tovstukha 2012). According to this method, the area proportion of each 10-year age class was evaluated for each sample of subcompartments with respective forest site condition, origin, site index, and proportion of silver birch in the stand composition. Then we evaluated the proportion of stands' area which survives up to a certain age.

To analyze the data, we applied MS Excel. Coordinates for forests of each forest enterprise were evaluated as centroids of respective contours of the territory using MapInfo Mapping Package.

**Results and Discussion.** We analysed silver birch stands from subcompartments with all forest site conditions, origin, site index and birch proportion in the stand and found out that in the IV age class from 30.5 % (Chuguyevo-Babchanske FE) to 74.3% (Skrypayske TEFE) of the trees survived (Table 2).

*Table 2*

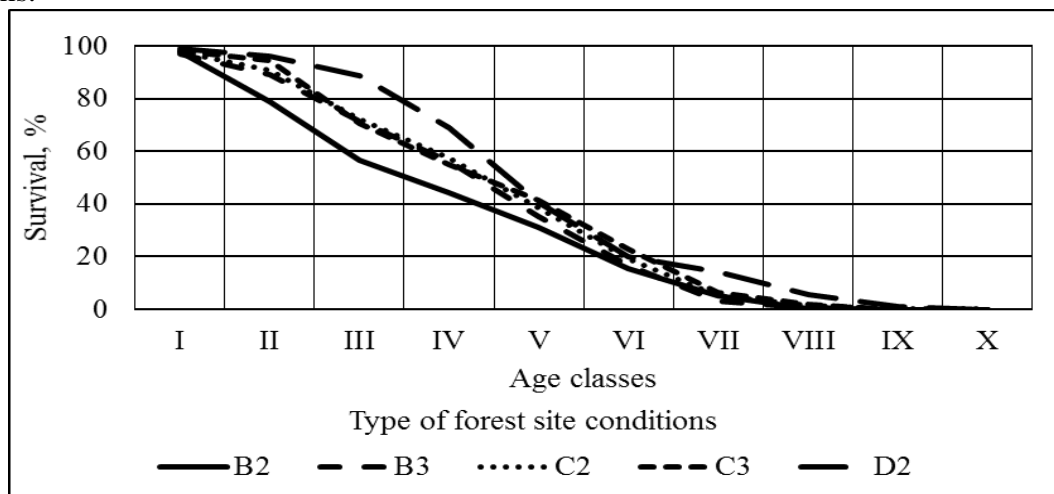
**Survival of birch stands in the forest fund of certain forest enterprises of the Left-Bank Forest-Steppe (all origins, site indices and forest site conditions)**

State Forest Enterprise (FE)	Mean age class	Survival up to				
		IV age class	V age class	VI age class	VII age class	VIII age class
Vovchanske FE	V.2	58.6	41.3	31.5	23.4	5.4
Kharkivska FRS	V.0	66.7	39.6	3.3	2.0	2.0
Gutianske FE	IV.3	45.0	32.6	17.4	4.3	0.1
Chuguyevo-Babchanske FE	III.9	30.5	19.7	12.0	2.7	1.2
Skrypayske TEFE	V.5	74.3	48.0	29.6	2.8	2.8
Zmiyivske FE	IV.1	43.1	21.8	6.9	1.6	0.0
Trostianetske FE	V.1	65.1	38.5	13.6	6.2	1.7
Okhtyrskе FE	V.1	65.6	37.3	26.7	9.9	5.0
Gadiatske FE	IV.8	51.4	34.4	16.2	6.0	1.1
Poltavske FE	IV.3	46.6	33.5	16.5	2.9	0.8
Myrgorodske FE	IV.7	53.6	38.6	16.7	5.4	1.0

We also found that the part of the stands preserved in the V age class is from 19.7 % in Chuguyevo-Babchanske FE to 48 % in Skrypayske TEFE and 41.3% in Vovchanske FE. Up to the VIII age class which is suggested as the age of maturity, 5.4 and 5.0 % of silver birch stands

survive in Vovchanske FE and Okhtyrskе FE respectively. There are no such stands in Zmiyivske FE, and they cover less than 1% of the area in Poltavske FE and Gutianske FE (Table 2).

Grouping data showed that the survival of silver birch in almost all age classes is the lowest in the relatively poor forest site conditions, while it is the highest in the age before the V age classes and after the VII age classes in fresh fertile forest site conditions (Fig. 1). It happens due to the fact that fertile sites are more favourable for many tree species. However, the silver birch is often removed from pine-birch stands in fresh relatively poor forest site conditions during thinning operations.



**Fig. 1 – Survival of birch stands in the particular forest site conditions in the forest fund of analyzed forest enterprises of the Left-Bank Forest-Steppe (all origins, and site indices) (B<sub>2</sub> – fresh relatively poor forest site conditions (fsc); B<sub>3</sub> – moist relatively poor fsc; C<sub>2</sub> – fresh relatively fertile fsc; C<sub>3</sub> – fresh relatively fertile fsc; D<sub>2</sub> – fresh fertile fsc)**

We compared the results of evaluation by administrative regions and found out that the silver birch survival was the lowest in the Forest-Steppe part of Kharkiv Region and the highest in the Forest-Steppe part of Sumy Region almost in all forest site conditions (Table 3).

*Table 3*

**Survival of birch stands in the particular forest site conditions in the forest fund of analyzed forest enterprises of the Left-Bank Forest-Steppe grouped by regions (all origins, and site indices)**

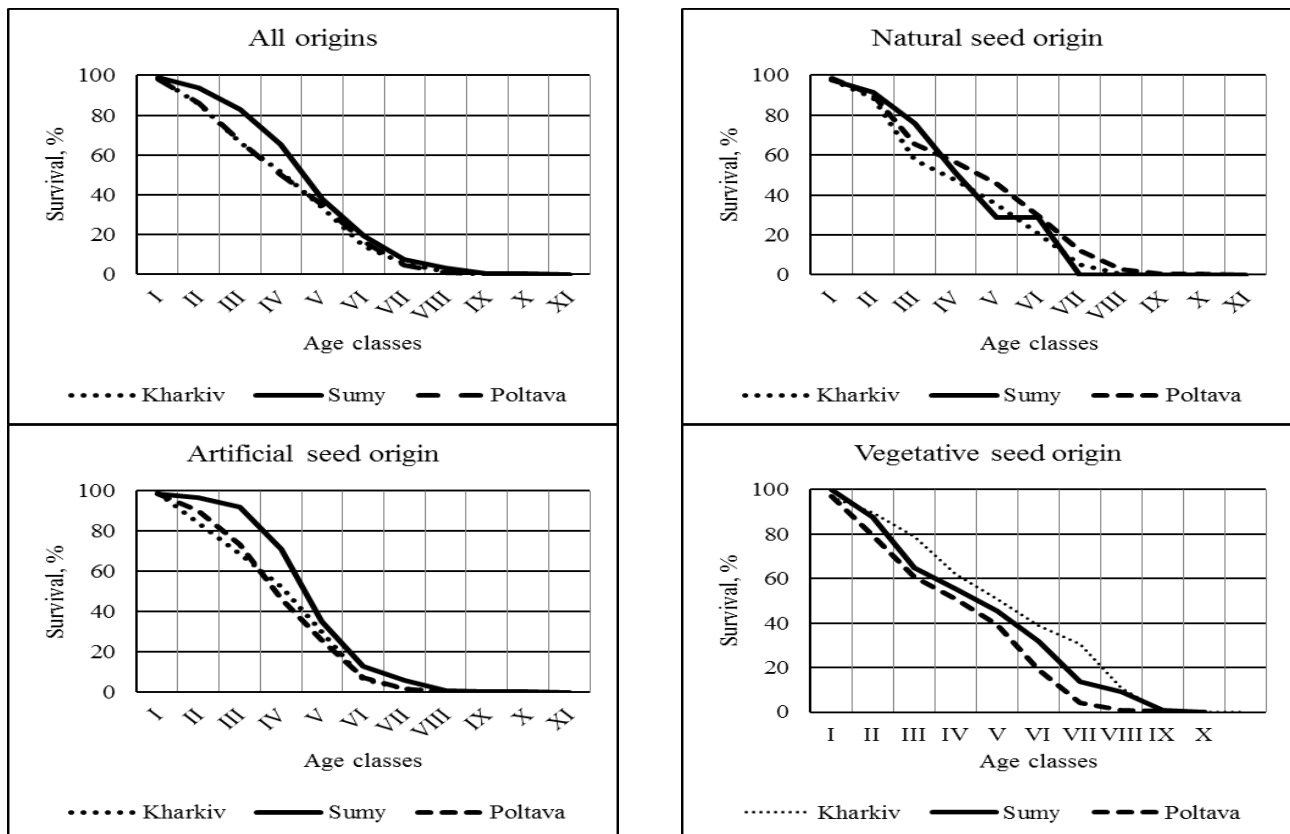
Region	Mean age class	Survival (%) up to				
		IV age class	V age class	VI age class	VII age class	VIII age class
<b>B<sub>2</sub> – fresh relatively poor forest site conditions</b>						
Kharkiv	III.2	16.3	9.6	5.8	3.6	0.0
Sumy	V.1	68.0	51.4	18.2	5.1	1.3
Poltava	IV.6	51.4	35.7	19.7	5.7	0.2
<b>B<sub>3</sub> – moist relatively poor forest site conditions</b>						
Kharkiv	IV.5	53.9	32.8	22.6	2.5	0.0
Sumy	IV.7	62.5	28.4	15.3	0.0	0.0
Poltava	IV.7	55.7	37.9	15.1	4.3	1.2
<b>C<sub>2</sub> – fresh relatively fertile forest site conditions</b>						
Kharkiv	IV.7	57.5	36.5	20.0	2.8	0.8
Sumy	V.0	64.3	33.3	14.6	5.5	2.2
Poltava	IV.8	54.6	42.4	20.5	6.5	1.2
<b>C<sub>3</sub> – fresh relatively fertile forest site conditions</b>						
Kharkiv	IV.6	50.2	36.5	16.0	3.7	0.6
Sumy	VI.0	83.1	60.1	48.1	23.0	4.3
Poltava	IV.9	52.2	40.9	22.7	4.7	2.4

*Table 1. Continued*

Region	Mean age class	Survival (%) up to				
		IV age class	V age class	VI age class	VII age class	VIII age class
D <sub>2</sub> – fresh fertile forest site conditions						
Kharkiv	V.9	73.5	60.3	37.3	32.8	8.4
Sumy	V.2	62.2	26.7	15.8	10.8	7.8
Poltava	V.1	71.3	37.8	11.1	3.6	1.9

However, in the fresh fertile forest site conditions, such relations are actual up to the IV age class only and in higher age classes of silver birch stands in Kharkiv Region.

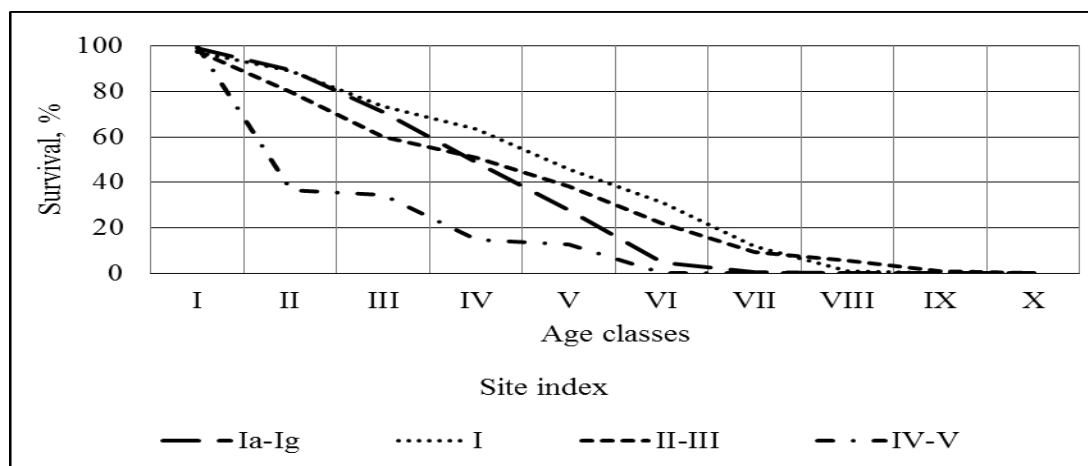
On calculating the survival of silver birch stands of different origin by plots (Fig. 2), we noted that the mean weighted age class of this tree species in the Left-Bank Forest-Steppe is IV.7. It is slightly higher in vegetative stands (IV.8) and little less in artificial seed stands (IV.6). For all origins, the mean weighted age class is the highest for Sumy Region (V.1) and is IV.6 for Kharkiv and Poltava Regions. The mean weighted age class for Kharkiv Region is the highest for vegetative stands (V.6), for Poltava Region – for natural seed stands (V.0), and for Sumy Region it is V.1 for vegetative and artificial seed stands and IV.7 for natural seed stands.



**Fig. 2 – Survival of birch stands of different origin in analyzed forest enterprises of certain regions of the Left-bank Forest-Steppe (all site indices and forest site conditions)**

A comparison of the survival for silver birch stands of different site indices showed that the stands of the worse growth have the least longevity (Fig. 3).

At the same time, we figure out that the stands with the best growth (site indices I<sup>a</sup>–I<sup>g</sup>) survive up to the VII age class only, while the stands of I–III site indices survive up to the X age class.



**Fig. 3 – Survival of birch stands of particular site indices in the forest fund of analyzed forest enterprises of the Left-Bank Forest-Steppe (all origins, and forest site conditions)**

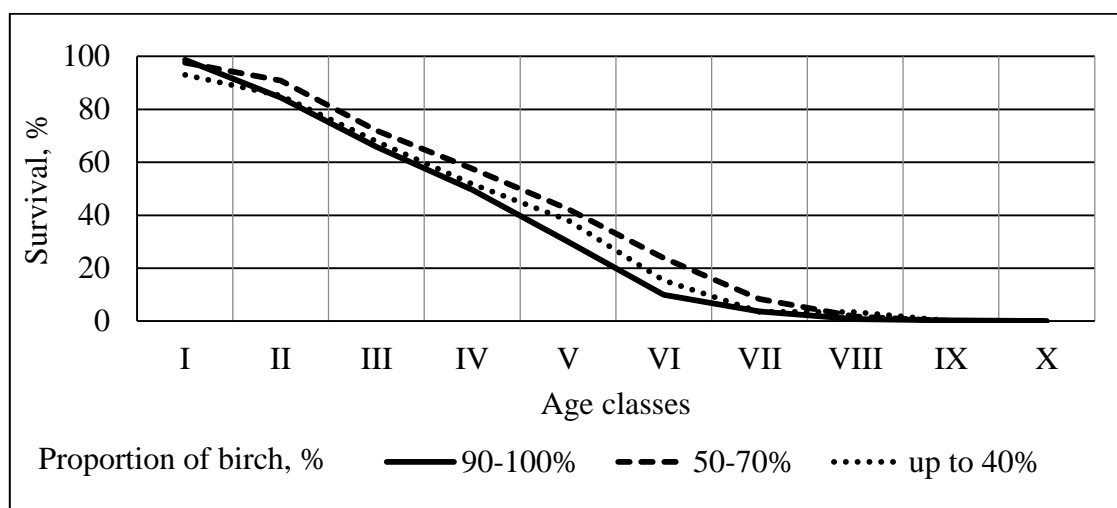
Such a conclusion is also true for certain regions (Table 4). There no silver birch stands of IV–V site indices in Sumy Region, they survive over 30 years in Kharkiv Region and up to V age class in Poltava Region. The stands of I<sup>a</sup>–I<sup>g</sup> site index survive up to VII age class in all analyzed regions. The survival of birch stands with the best growth is the highest in Sumy Region.

*Table 4*

**Survival of birch stands of particular site index in the forest fund of analyzed forest enterprises of the Left-Bank Forest-Steppe grouped by regions (all origins, and forest site conditions)**

Region	Mean age class	Survival (%) up to				
		IV age class	V age class	VI age class	VII age class	VIII age class
Site index I <sup>a</sup> – I <sup>g</sup>						
Kharkiv	IV.5	54.9	32.6	5.5	0.5	0.0
Sumy	IV.9	63.9	30.9	7.3	0.2	0.0
Poltava	IV.1	35.5	21.1	3.0	0.4	0.0
Site index I						
Kharkiv	IV.7	49.5	34.9	27.9	13.6	1.6
Sumy	V.7	75.1	49.6	38.8	18.1	2.2
Poltava	V.4	71.2	53.9	31.6	8.8	0.4
Site index II – III						
Kharkiv	IV.5	45.8	35.5	16.7	9.0	6.5
Sumy	V.0	55.3	46.4	33.8	20.2	16.8
Poltava	IV.6	51.9	37.9	21.8	7.3	3.1
Site index IV–V						
Kharkiv	II.9	0.0	0.0	0.0	0.0	0.0
Sumy	–	–	–	–	–	–
Poltava	III.0	17.4	14.8	0.0	0.0	0.0

A comparison of silver birch stands of different species composition showed that survival of pure (100 % of silver birch) and almost pure (90 % of silver birch) stands is the lowest (Fig. 4). The stands with 50–70 % of silver birch have the highest survival level. The stands with a low proportion of silver birch (up to 40 %) take an intermediate position.



**Fig. 4 – Survival of birch stands with particular birch proportion in the stand composition in the forest fund of analyzed forest enterprises of the Left-Bank Forest-Steppe (all origins, site indices and forest site conditions)**

We detected that the survival of pure and almost pure silver birch stands is the highest in Sumy Region (Table 5). Survival of stands with 50–70 % of silver birch is the highest in Sumy Region up to the IV age class only. Survival of the stands with a low proportion of silver birch (10–40 %) is the highest in Sumy Region after the VI age class.

*Table 5*

**Survival of birch stands with particular birch proportion in the stand composition in the forest fund of analyzed forest enterprises of the Left-Bank Forest-Steppe grouped by regions (all origins, site indices and forest site conditions)**

Region	Mean age class	Survival (%) up to				
		IV age class	V age class	VI age class	VII age class	VIII age class
Birch proportion is 90–100 %						
Kharkiv	IV.2	46.5	25.8	5.2	2.1	0.7
Sumy	V.2	73.0	40.1	17.1	7.3	2.5
Poltava	IV.3	44.0	29.8	11.2	3.7	0.3
Birch proportion is 50–70 %						
Kharkiv	V.0	58.1	44.2	24.6	10.4	1.2
Sumy	V.0	59.6	35.4	20.9	5.4	2.6
Poltava	IV.9	56.3	43.2	24.3	7.6	2.0
Birch proportion is up to 40 %						
Kharkiv	IV.1	41.4	32.4	7.5	0.8	0.8
Sumy	V.3	52.8	28.9	28.9	18.3	18.3
Poltava	IV.7	59.4	45.8	16.5	0.2	0.0

The results of the research showed that the survival rate of silver birch in the forest stands of the Left-Bank Forest-Steppe depends on the region, the type of forest site conditions, the origin, the site index of the stands, as well as on the proportion of silver birch in the composition. At the same time, the manifestation of various factors of the weakening of birch stands also depends on these factors. Therefore, one of the tasks of our subsequent research is to reveal the combination of factors most favourable for the long-term existence of silver birch forests. Furthermore, if there is a threat of mortality to silver birch plantations and/or a risk of timber quality decrease, it is necessary to provide in the regulatory documents the possibility of reducing the age of main felling in case of expectation of the deadline for the main felling in accordance with existing standards.

**Conclusions.** The probability of silver birch survival in the Left-Bank Forest-Steppe was evaluated depending on the region, the type of forest site conditions, the origin, the site index of the stands and the proportion of silver birch in the composition.

We came to the conclusion that survival of silver birch in almost all age classes is the lowest in the relatively poor forest site conditions and is the highest in the most of age classes in fresh fertile forest site conditions.

Moreover, the mean weighted age class of silver birch in the Left-Bank Forest-Steppe is IV.8 in vegetative stands and IV.6 – in artificial seed stands. For all origins, the mean weighted age class is V.1 for Sumy Region and IV.6 – for Kharkiv and Poltava Regions.

The stands of the worse growth have the least longevity.

A survival of pure (100 % of silver birch) and almost pure (90 % of silver birch) stands is the lowest. The stands with 50–70 % of silver birch have the highest survival level. The stands with a low silver birch proportion (up to 40 %) take an intermediate position. Survival of pure and almost pure silver birch stands is the highest in Sumy Region.

To conclude, it is necessary to provide the possibility to reduce the age of the main felling if there is a risk of decrease of the timber quality in case of expectation of the deadline for the main felling in accordance with existing standards.

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ВІКОВА СТРУКТУРА ЛІСОВОГО ФОНДУ БЕРЕЗОВИХ НАСАДЖЕНЬ ЛІВОБЕРЕЖНОГО ЛІСОСТЕПУ УКРАЇНИ

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Метою досліджень було виявлення особливостей вікової структури насаджень берези повислої Лівобережного лісостепу з урахуванням лісорослинних умов, походження, бонітету та участі цього виду в складі насаджень. Імовірність виживання берези повислої майже в усіх класах віку була найменшою у свіжому суборі. Середній зважений клас віку берези повислої – IV,8 у вегетативних насадженнях і IV,6 у штучних насінневих. Середній зважений клас віку березових насаджень у вибірках усіх походжень становить V,1 у Сумській області та IV,6 у Харківській і Полтавській. Насадження найгіршого росту є найменш довговічними. Імовірність виживання чистих і майже чистих (9 одиниць берези в складі) є найменшою. Цей показник є найвищим у Сумській області.

Ключові слова: береза повисла (*Betula pendula* Roth), типи лісорослинних умов, походження, бонітет, склад порід.

Мешкова В. Л.<sup>1</sup>, Кошеляева Я. В.<sup>2</sup>

**ВОЗРАСТНАЯ СТРУКТУРА ЛЕСНОГО ФОНДА БЕРЕЗОВЫХ НАСАЖДЕНИЙ ЛЕВОБЕРЕЖНОЙ ЛЕСОСТЕПИ УКРАИНЫ**

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Целью исследований было выявление особенностей возрастной структуры насаждений березы повислой Левобережной лесостепи с учетом лесорастительных условий, происхождения, бонитета и участия этого вида в составе насаждений. Вероятность выживания березы повислой почти во всех классах возраста была наименьшей в свежей субори. Средний взвешенный класс возраста березы повислой – IV,8 в вегетативных насаждениях и IV,6 в искусственных семенных. Средний взвешенный класс возраста березовых насаждений в выборках всех происхождений составил V,1 в Сумской области и IV,6 в Харьковской и Полтавской. Насаждения наиболее слабого роста являются наименее долговечными. Вероятность выживания чистых и почти чистых (9 единиц березы в составе) – наименьшая. Этот показатель наиболее высок в Сумской области.

Ключевые слова: береза повислая (*Betula pendula* Roth), типы лесорастительных условий, происхождение, бонитет, состав пород.

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