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@ ✉ Correspondence author
Volodymyr P. Pasternak
pasternak65@ukr.net
86 Hryhoriy Skovoroda st., Kharkiv, 61024, Ukraine

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Patterns of natural regeneration of pine forests in the Left-Bank Forest-Steppe of Ukraine

V. P. Pasternak[1], T. S. Pyvovar[2], A. V. Garmash[3]

The study of natural regeneration in pine stands, widespread in the Forest-Steppe of Ukraine, is crucial for transforming forest management towards sustainable, close-to-nature practices. This study aims to reveal the features of the natural regeneration of pine stands in the Left-bank Forest-Steppe of Ukraine, based on data from sample plots in Kharkiv and Sumy regions.

Natural regeneration in pine-dominated stands is characterized by an age of 4-8 years and a low number of plants per hectare (1,000 [500-2,000]), with few plots containing enough regeneration (over 3,000 plants per hectare) to form a new forest stand without additional planting. The regeneration in the plots varies by species composition: pure Scots pine (Pinus sylvestris L.*), pure English oak (Quercus robur* L.*), pine-oak mix in different proportions with accompanying species (Silver birch (Betula pendula* Roth.*), Small-leaved lime (Tilia cordata* Mill.*), or Scots elm (Ulmus glabra* Huds.*) or without any accompanying species.*

A statistical analysis revealed that only vegetation cover significantly influences the presence of regeneration: at lower vegetation cover, the occurrence of natural regeneration is significantly higher. No significant correlation was found between the amount of renewal and the relative density of parent stands. No significant correlation is found between the density of regeneration and the relative density of stocking, and ground vegetation cover. A significant difference in the density of regeneration depending on its species composition was shown: the lowest number was observed in pure pine regeneration biogroups, slightly higher in pine regeneration with the admixture of other broad-leaved species (without oak), and the highest number was in the most diverse regeneration, containing a mixture of pine, oak, and other broadleaved species. A significant decrease in the number of naturally regenerating plants was revealed during the observation period at the monitoring sites.

Key words: *species composition, Pinus sylvestris* L.*, density of stocking, ground vegetation cover, trophotop.*

Introduction. In the climate change conditions and increased anthropogenic impact, attention to the processes of forest regeneration, their substantiation, and practical implementation is increasing (Vacek et al., 2016; Маурер, Кайдик, 2016). Scots pine-dominated stands in the Left-bank Forest-steppe of Ukraine are widespread, they cover more than 240,000 hectares (Terentiev et al., 2023), with a significant portion of pure even-aged stands. Such stands are not resistant to pests (bark beetles) and have the highest wild fire

[1] *Volodymyr P. Pasternak* – Full Member of the Forestry Academy of Sciences of Ukraine, Doctor habil. (Agricultural Sciences), professor, the G. M. Vysotsky Ukrainian Research Institute of Forestry and Forest Melioration, 86 Hryhoriy Skovoroda st., Kharkiv, 61024, Ukraine. E-mail: pasternak65@ukr.net ORCID: https://orcid.org/0000-0003-1346-1968

[2] *Tetiana S. Pyvovar* – Corresponding Member of the Forestry Academy of Sciences of Ukraine, PhD in Agricultural Sciences, Senior Researcher, the G. M. Vysotsky Ukrainian Research Institute of Forestry and Forest Melioration, 86 Hryhoriy Skovoroda st., Kharkiv, 61024, Ukraine. E-mail: pyvovar@ukr.net ORCID: https://orcid.org/0000-0001-7250-8549

[3] *Anna V. Garmash* – Senior Teacher of the Department of Forest Cultures, Melioration and Horticulture, State Biotechnological University, 44 Alchevskyh st., Kharkiv, 61002, Ukraine. E-mail: garmash1505@gmail.com ORCID: https://orcid.org/0000-0003-1874-094X

hazard. At the same time, according to V. Meshkova (2021), the area of Scots pine stands has halved over the last decade. Considering the projected decrease in Scots pine areas in Central European forests under the expected climate change (Buras, & Menzel, 2019; Vacek et al., 2016), and the current pine mortality rate in Ukraine, it is expedient to transform the existing pure Scots pine stands to mixed forests (with admixture of *broadleaved* species).

Features of pine natural regeneration are quite well studied in the Ukrainian Polissia (Білоус, 2006; Сєндонін, Білоус, 2013; Siruk, Turko, & Pechenjuk, 2017; Захарчук, 2017; Маурер, Кімейчук, 2020; Бородавка та ін., 2021, 2023) and less so in the Forest-Steppe zone (Салтиков, 2014; Гармаш, 2019; Garmash et al., 2023), Western Ukraine (Roztochia area) (Lavnyy et al., 2022) and the Steppe zone (Салтиков, 2014; Дубина, Рева, Шульман, 2018).

In the Forest zone (Polissya), according to the study of Borodavka et al. (2023), it was shown that in sparse pine stands, natural regeneration of oak-pine biogroups occurs with better growth of oak regeneration. The authors proposed the use of oak natural regeneration for reforestation of pine stands, which is in line with the principles of close-to-nature forestry. On lands unsuitable for agricultural production in the Chernihiv Polyssia, relatively satisfactory regeneration of pine occurs in stripes 70-100 m wide adjacent to the forest (Білоус, 2006). A study in Finland (Rouvinen, & Kouki, 2011) showed, that even small gaps in stand canopy can be used to create the diverse structure of the dominant species: Scots pine and silver birch.

Studies conducted by Ukrainian researchers on the natural regeneration of Scots pine in different forest site conditions of Polissya and the Forest-steppe (Сєндонін, Білоус, 2013; Маурер, Кайдик, 2016) show that natural regeneration is most productive in fresh fairly poor and poor forest site conditions, where competition with grass cover is not so high. The success of natural regeneration depends on the spatial location of the felling area in relation to the cardinal points and the location of the forest border. To reduce the competition with the ground vegetation and to achieve the formation of stands of optimal composition, further tending treatments are required. Similar conclusions are made by scientists from Poland (Przybylski et al., 2021), who showed that the regeneration potential of pine stands in Central Europe depends mainly on the habitat and the competitive pressure. Also, the authors revealed a correlation between genetic features and the regeneration potential of pine. In the Steppe zone of Ukraine, the presence of litter has a positive effect on English oak and Scots pine germination in pine stands (Дубина, Рева, Шульман, 2018).

Our previous studies showed that under the canopy of a forest stand with a relative density above 0.7, the natural regeneration is not successful, primarily due to competition for light. Small canopy gaps provide more favourable conditions for natural regeneration, while in large gaps, conditions for natural regeneration are less favorable due to increased competition with ground vegetation (Гармаш, 2019; Garmash et al., 2023). Viable natural regeneration was recorded in all forest types, but it is mostly clustered. In some sample plots in fairly fertile forest site conditions (C_2), there was no regeneration due to a dense understorey layer (Гармаш, Пастернак, 2022).

The analysis of the latest research on this issue revealed gaps in knowledge about the process of natural regeneration in the Forest Steppe of Ukraine.

The aim of the study is to reveal the quantitative and qualitative features of pine stands natural regeneration in the Left-bank Forest-Steppe of Ukraine.

Material and methods. The processes of the formation of natural regeneration were studied under the canopy of Scots pine-dominated forests and in open non-forest areas located near pine stands. The study used data from 33 sample plots in pine stands and from 5 sites located in non-forested areas in Sumy and Kharkiv regions of Ukraine. The dynamics of natural regeneration was analysed based on observations in the 2011-2023 period in 10 intensive monitoring plots in Kharkiv region (State Specialised Forest Enterprise (SE) "Forests of Ukraine" (branch "Zhovtneve Forestry"), SE "Skrypaivske educational and research forestry" (Skrypaivske ERF), National Nature Park "Slobozhanskyi".

The region of study is located in the Left-bank Forest-Steppe of Ukraine: according to forestry zoning at the East European Forest-Steppe and part of the Left Bank-Dnieper (Northern and Southern regions of the Poltava plain) forest-steppe districts of the Forest-steppe region (Генсірук, 2002) and within the Prydonetsky and Vorsklo-Pselsky sectors of the Slobozhansky district of the forest typological region of the fresh temperate climate (Остапенко, 2003).

The sample plots in the pine stands are located in the most common forest types: B_2-oak-pine, C_2-lime-oak-pine (Table 1). The pine stands in sample plots have the following average evaluation characteristics: B_2-oak-pine – 79 years old, relative density of stocking 0.75, site class Ia,7, C_2-lime-oak-pine – 76 years old, relative density of stocking 0.75, site class Ia,1.

In sample plots and intensive monitoring plots, natural regeneration was assessed in two circular subplots with an area of 10 m^2 each, where the distribution of regeneration by tree species, age groups, height class and viability groups was assessed. The following age groups were used: 1-3 years, 4-8 years, 9 years, and older; three height classes were used: small (up to 0.5 m), medium (0.51-1.3 m), and large (above 1.3 m). The total ground vegetation cover and its species composition was evaluated within the entire area of sample plots and its impact on natural regeneration and unmanaged forest crops was analyzed.

The number of naturally regenerated trees is given after recalculation of the number of plants per sample plot into the number of plants per hectare. For the

analysis, we divided our sample plots into classes: presence or absence of regeneration, regeneration density classes (0,500-1,500, 1,600-2,900; 3,000-4,900; 5,000-8,500 plants per hectare), relative density of stocking of parent stand (0.5-0.64, 0.65-0.74, 0.75-0.92), ground vegetation cover classes (15-30 %, 40-50 %, 55-65 %, >75 %), categories of regenerating species composition (Pine (*Pinus sylvestris* L.); English oak (*Quercus robur* L.); Pine with admixture of other spp.; Pine and Oak; Pine, Oak and other spp.).

Table 1. **Distribution of sample plots by forest site conditions and relative density of stocking**

TFSC	Relative density of stocking					Total
	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1	
B_2	1	6	10	6	2	25
C_2	1	1	2	3		7
C_3			1			1
Total	2	7	13	9	2	33

TFSC – type of forest site condition according to Alekseev-Pogrebniak

Standard statistical methods were used to determine the normality of the distribution (Shapiro-Wilk's test). According to it, the distribution of regenerating plants is not normal ($W = 0.7549$; $P < 0.0001$). Therefore, we used the non-parametric method – Kruskal–Wallis's test to compare regeneration abundance between groups. For the assessment of regeneration abundance dynamics, we used the Wilcoxon Signed-Rank Test, for categorial variables distribution we used the Chi-square method. Spearman's and Kendall's rank correlations were applied. For all analyses, we used the software MedCalk (free version).

Results and discussion. After analyzing the obtained data, it can be noted that the natural regeneration of pine is successful only under certain ecological conditions, and first of all, in the canopy gaps, along the edge of meadows.

Out of 33 sample plots in Scots pine-dominated forests, natural regeneration was revealed in 27 plots (81.8 %). The studied natural regeneration mainly belongs to the age group of 4-8 years, with single older regenerating trees, which is associated with increased competition. The plants are mostly growing in biogroups. The species composition of natural regeneration in the surveyed pine stands is quite variable ranging from pure Scots pine, and pure English oak, to Scots pine and English oak mixtures in different proportions with or without other accompanying broadleaved species, particularly silver birch (*Betula pendula* Roth.), small-leaved lime (*Tilia cordata* Mill.), and Scots elm (*Ulmus glabra* Huds.) in more fertile forest site conditions (Table 2). Pine in regeneration occurred in 21 sample plots, oak was the second most frequent (19 out of 27 plots).

Table 2. **Species composition of natural regeneration and its density**

Categories of species composition	Number of plants per hectare				N (plots)
	Min	Max	Median	Percentile [25-75]	
Pine	500	1,000	500	[500-500]	6
Pine + other spp.(non-Oak)	2,000	2,000	2,000	[2,000-2,000]	2
Pine and Oak	1,000	8,500	1,500	[1,375-2,000]	9
Pine, Oak + other spp.	1,500	5,500	3,000	[1,750-4,750]	4
Oak	500	2,500	1,250	[500-2250]	4
Oak + other spp.	1,000	3,500	2,250	[1,000-3,500]	2
All with regeneration	500	8,500	1,000	[500-2,000]	27

Pine – *Pinus sylvestris*, Oak – *Quercus robur*, Other – *Betula pendula*, *Tilia cordata*, *Ulmus scabra*

The Kraskell-Wallace test revealed a significant difference in the number of plants by groups of species composition (Kraskell-Wallace = 22,7675; $P = 0.000667$). Particularly, the lowest number of plants is observed if regeneration is formed exclusively by pine, further, the number is slightly increasing in pine with an admixture of other broadleaved accompanying species (without oak), and in the case of pure oak regeneration. The highest density of regeneration is observed in more diverse biogroups – the mixture of pine, oak, and other broadleaved species (see Table 2).

The positive effects of species diversity on regeneration success are consistent with the theory of niche differentiation, which suggests that species with different ecological requirements can coexist more effectively, reducing direct competition and enhancing overall ecosystem productivity. These findings underscore the importance of promoting species diversity in forest regeneration efforts to achieve more resilient and productive forest ecosystems.

Regeneration is viable, the number per hectare ranges from 500 to 8,500 plants (see Table 2). According to standards for reforestation and acceptance of natural regeneration for the Forest-Steppe (Інструкція з проектування..., 2010) the sufficient density of regeneration is considered as >=3 000 plants per hectare, and such amount does not require additional planting. Among the study plots, only four ones (14.8 %) have a sufficient number of plants of natural regeneration (3,500-8,500 plants per hectare). It means, that rather a low share of natural regeneration can form new forests without additional planting of forest seedlings. There is a risk that Scots pine forests will degrade, either due to replacement by broadleaved trees or by conversion into non-forest ecosystems without silvicultural activities to support natural regeneration and planting of partial forest crops.

The analysis of density of natural regeneration depending on relative density of stocking of parent stand showed that median amounts of natural regeneration per hectare in sample plots (Table 3) are the highest at lower relative density of stocking (0.5-0.64), and decrease with increasing density of parent stands. However, the statistical analysis (using the Kraskell-Wallace criterion) did not reveal any significant differences in the amount of regeneration by classes of the relative density of stocking (Table 3) ($P > 0.05$).

Table 3. **Number of regenerating plants per hectare by relative density of stocking classes**

Density of stocking class	Median	Percentile [25-75]	N
0.5-0.64	2,000	1,500-2,500	6
0.65-0.74	1,750	500-2,000	10
0.75-0.92	500	0-1,500	17
Kraskell-Wallace test	5.4		
P	0.06		

Natural regeneration density is higher in B (fairly poor) and lower in C (fairly fertile) trophotopes (Table 4), however the difference in classes is not significant (according to the Kraskell-Wallace criterion) ($P > 0.05$). The same situation is with ground vegetation cover (Table 5).

Table 4. **Number of regenerating plants per hectare by trophotop classes**

Trophotop class	Median	Percentile [25-75]	N
B	1,500	500-2,000	25
C	500	0-1,500	8
Kraskell-Wallace test	2.16		
P	0.14		

Table 5. **Number of regenerating plants per hectare by ground vegetation classes**

Vegetation cover, class	Median	Percentile [25-75]	N
15-30%	1,250	0-2,000	14
40-50%	750	500-1,500	12
55-65%	1,750	1,500-2,500	6
75%	2,000	2,000-2,000	1
Kraskell-Wallace test	3.3		
P	0.3		

The graphical analysis of natural regeneration distribution depending on the relative density of stocking and total cover of ground vegetation did not reveal any regularities (Fig.).

There is a trend to negative correlation (both Spearman and Kendall) between the relative density of stocking and density of natural regeneration, but it is not statistically significant at the 0.05 level (Table 6). For the ground vegetation cover the correlation analysis also did not reveal a significant correlation.

Table 6. **Results of rank correlation analysis of regeneration density with relative density of stocking and vegetation cover**

Statistics Index	Relative density of stocking	Vegetation cover
N	33	33
Spearman coefficient (rho)	-0.339	0.234
P	0.0534	0.1899
Kendall's τ coefficient	-0.236	0.215
P	0.0516	0.0815

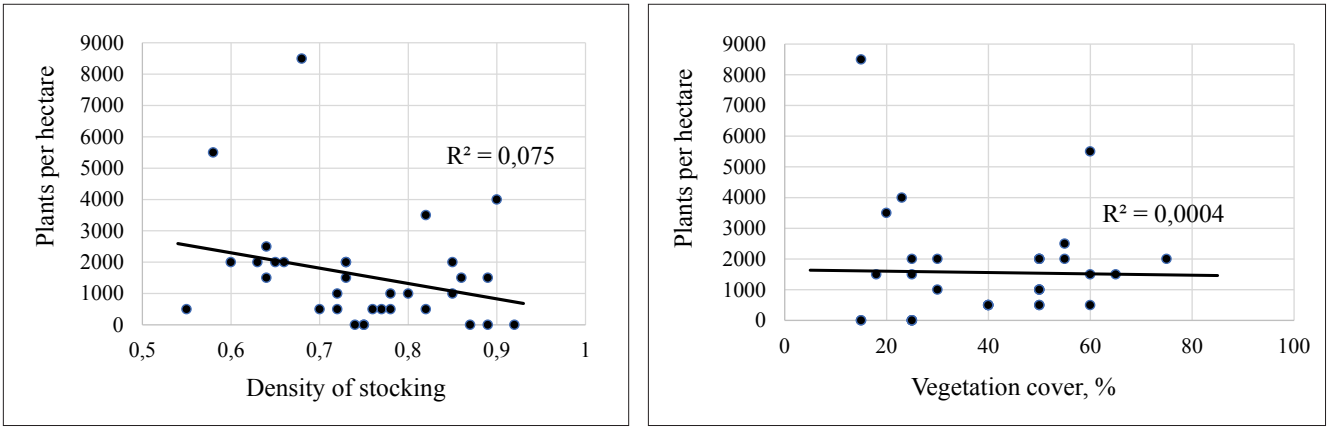

Fig. Distribution of the number of natural regeneration per hectare in Scots pine stands by the relative density of stocking (left) and ground vegetation cover (right)

The statistical analysis by the Chi-square method of regeneration presence/ absence by the relative density of stocking classes of parent forest stand revealed that only the frequencies of species composition categories of regeneration differ significantly (Chi-square = 21.684; P = 0.0412).

The study of natural regeneration in dynamics based on the repeated observations in the monitoring plots showed that a small regeneration (age 1-2 years) often forms a brush, but most of it does not live to be 3-4 years old. Ground vegetation has a particularly negative effect on small regeneration growth. For 4 years between observations in 10 monitoring plots, the number of regenerating plants in most plots decreased by more than 30% due to unfavourable conditions of lighting and moisture, development of the ground vegetation and damage to seedlings (Гармаш, Пастернак, 2022) (Table 7).

Table 7. **Dynamics of natural regeneration number in monitoring plots**

ID	Trophotop	Relative density of stocking	Plants per hectare		Species composition of regeneration	
			1*	2*	1*	2*
327	B	0.63	2,000	2,000	Pine & other	Pine & Oak
351	B	0.64	2,500	1,500	Oak	Oak & other
637909	B	0.65	2,000	1,000	Pine & Oak	Pine & Oak
631309	B	0.68	8,500	6,000	Pine & Oak	Pine & Oak
32485	B	0.7	500	1,000	Pine	Pine
33760	B	0.77	500	500	Oak	Oak
409	C	0.82	3,500	1,000	Oak & other	Oak & other
333	B	0.85	2,000	1,000	Oak	Oak & other
341	B	0.86	1,500	1,000	Pine, Oak & other	Pine & Oak
352	B	0.9	4,000	3,000	Pine, Oak & other	Pine & Oak & other
Median			2,000	1,000		
Percentile [25-75]			[1,500-3,500]	[1,000-2,000]		

* cycle of observation

The revealed decrease in regeneration density is significant (according to the Wilcoxon Signed-Rank Test (P = 0.0156)). No significant changes in species composition categories were revealed, while the proportion of species changed in 2 plots.

An analysis revealed that regeneration presence/ absence distribution by ground vegetation cover classes is significantly different (Chi-square = 9.952; P = 0.0190): at lower vegetation cover the occurrence of natural regeneration is significantly higher than in higher vegetation cover. There was no significant difference in the presence of regeneration according to both forest site condition and stocking density classes.

Considering the results, we studied the influence of ground vegetation on natural regeneration in various environmental conditions.

Ground vegetation in sample plots is variable, but quite often it is represented by wood small-reed (*Calamagrostis epigeios* (L.) Roth). In large gaps in the forest stand, ground vegetation increases phytomass due to the better light regime. Intensive vegetative reproduction, the appearance of seed specimens, allows them to quickly take over the territory and prevent the development of natural regeneration, usually, single individuals of the regeneration survive in such areas.

A study of vegetation showed that the typical forest ground vegetation is preserved only in the first year after clear-cutting. Wood small-reed usually has low abundance after felling. In the second year after felling this plant is actively mastering the living space, and in the third – it forms a solid carpet and powerful rhizome "pillows", the average height of the plants can exceed one meter. The species diversity of plants in the cutting area is sharply reduced, with the dominance of the wood small-reed (50-70%) (Table 8). The influence of grasses turned out to be one of the main factors inhibiting the growth and development of the regeneration. M. Bilous (Білоус, 2006) also draws attention to the negative impact of cereal vegetation on the processes of natural regeneration.

Table 8. **Dynamics of (*C. epigeios*) development in pine stands**

Site characteristics	The main indicators of the dominant plant	
	Vegetation cover, %	Average height, cm
Non-forest area	64.2±1.3	105.8±1.7
Canopy gaps	87.4±2.6	128.9±1.2
3 years after clear cutting	42.5±0.8	88.5±1.3
5 years after clear cutting	59.8±0.8	105.0±2.4
6 years after clear cutting	67.3±0.9	137.6±11.0

Scots pine is characterized by its wide ecological plasticity and genetic variability across its natural range (Didukh, 2011, Brichta et all., 2023), and it is one of the pioneer tree species, which can spread on non-forest lands.

On non-forest lands on the abandoned sand quarry surrounded by pine forest located in SFE "Forests of Ukraine", Branch "Zhovtneve Forestry" mean density of seedlings is 3,500-5,000 plants·ha^{-1}, which is sufficient for forming a new forest. The average age is 3-5 years, height – 0.3-1.0 m. Species composition is more diverse than in the case of natural regeneration under forest canopy: it includes Scots pine, silver birch, European ash (*Fraxinus excelsior* L.), aspen (*Populus tremula* L.), white poplar (*Populus alba* L.), several species of willows. Conditions at the site are favourable for regeneration growth, as moisture conditions are good – low relief, there is a lake nearby, which indicates a high level of groundwater, and a forest edge that serves as a seed source. Also, there is no dense grass cover.

In the treeless zone, 4 trial strip plots were laid out at different distances (10, 20, 40, and 60 meters) from the edge of the pine stand to study biogroups of natural regeneration. (SE "Skripaivske ERF" "Sheludkivski pisky", compartment 161) in fresh poor forest site conditions (A_2). At the site, the forest vegetation cover was disturbed due to the influence of anthropogenic factors. Regeneration biogroups are formed by Scots bine plants with 3 to 16 years and density from 7,700 to 1,300 plants·ha^{-1} (Table 9). The natural regeneration density gradually decreases with distance from the parent stand. The study showed that at the strip of 10-50 m near the forest edge, the amount of regeneration is sufficient (>3,000 plants per hectare) to form a new pine forest. Outside this 50-meter strip, seedlings' density decreases to 1,300 plants·ha^{-1}.

In non-forested areas, wood small-reed has less growth energy, because it competes with other plants. Within the canopy gaps, it usually progresses in small areas, especially at lighted sites.

Thus, our study showed that natural regeneration in pine stands is viable but often insufficient, and requires appropriate assistance measures.

In different eco-regions limiting factors for natural regeneration are different: for example, in Germany (Zerbe, & Kreyer, 2007) it is game browsing pressure. The study (De Frutos et al., 2022) indicates that water deficit is a major limiting factor for the natural regeneration of pine stands. Extreme climatic conditions exacerbating water stress can inhibit seed germination, seedling growth, and overall regeneration success. Our research showed that ground vegetation cover is a main limiting factor for regeneration growth.

Table 9. **Characteristics of regeneration in non-forest areas depending on distance from pine stand wall (Skripaivske ERF)**

Indicators	Distance from pine stand wall, m			
	10 m	20 m	40 m	60 m
Mean H, cm	231.7±5.50	288.4±8.07	302.9±11.10	155.5±36.50
Mean D, cm	2.0±0.16	2.9±0.19	3.6±0.27	1.6±0.07
Number of plants per hectare	7700	6400	4200	1300

Currently, natural conditions have changed and become unfavourable for the development of forest regeneration. For example, high relative density of stocking of forest stands guarantees the maximum use of typological potential during forest cultivation but does not provide the presence of canopy gaps for regeneration. The system of final fellings, namely clear-cut, also in most cases leads to the loss of natural regeneration positions, as it is favorable for ground vegetation and not for natural regeneration. The activities to support natural regeneration, which are used in the Polissya, are not always successful in the Left Bank Forest Steppe.

Conclusions. Natural regeneration in Scots pine-dominated forest stands in relatively fairly poor (B) and relatively fairly fertile (C) forest site conditions in the Left-Bank Forest-steppe of Ukraine is characterized by the age of 4-8 years and a low number of plants per hectare (1,000 [500-2,000]), with few plots containing enough regeneration (over 3,000 plants per hectare) to replace forest stand without additional planting. The regeneration varies by species composition: pure Scots pine, pure English oak, pine-oak mix in different proportions with or without accompanying species (silver birch, small-leaved lime, or elm). A significant difference in the density of regeneration of various species composition was shown.

The presence of canopy gaps and low vegetation cover contribute to the success of natural regeneration in pine stands. Vegetation cover, particularly the dominance of wood small-reed (*Calamagrostis epigeios* (L.) Roth) is one of the main limiting factor for regeneration growth in a forest stand.

During the period of 2-3 years after clear-cutting of pine stands rapid substantiation of forest ground vegetation by wood small-reed is observed, which creates unfavourable conditions for the natural regeneration of pine, due to competition.

A significant decrease in naturally regenerating plants is observed within 4 years.

The growth of pine regeneration in non-forest areas is successful if certain conditions are met: the presence of a seed source nearby, a distance of up to 50 meters from the pine stand, ground water availability, and low or disturbed vegetation cover.

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Закономірності природного поновлення соснових лісів Лівобережного Лісостепу України

В. П. Пастернак[1], Т. С. Пивовар[2], А. В. Гармаш[3]

Вивчення природного поновлення в соснових деревостанах, які доволі широко розповсюджені у Лісостепу України, має важливе значення для трансформації лісового господарства у напрямі сталого, наближеного до природи лісівництва. Метою дослідження є виявлення особливостей природного поновлення соснових деревостанів у Лівобережному Лісостепу України на основі даних пробних площ і спостережень на ділянках моніторингу у Харківській та Сумській областях.

Природне поновлення у соснових лісах характеризується середнім віком 4-8 років і низькою кількістю рослин на гектарі (1000 [500-2000]). Густота підросту (понад 3000 рослин на 1 га) є достатньою для формування нового деревостану без створення лісових культур. підріст сформований двома деревними видами – *Pinus sylvestris* L. та *Quercus robur* L. або обома деревними видами у різних пропорціях разом із супутніми деревними видами – *Betula pendula* Roth*., Tilia cordata* Mill*., Ulmus glabra* Huds.

Статистичний аналіз виявив, що лише рослинний покрив суттєво впливає на наявність підросту. У разі меншого проективного покриття густота надійного підросту значно вища. Не виявлено значущої кореляції між кількістю підросту та відносною повнотою материнських насаджень. Виявлено значну відмінність у густоті природного поновлення залежно від видового складу: найменшим цей показник виявився у чистих біогрупах сосни звичайної, дещо більшим – у випадку поновлення сосни із домішкою інших деревних видів (окрім дуба), а найвищим – у найрізноманітніших за складом біогрупах, що містять підріст сосни, дуба та інших листяних порід. Встановлено значне зменшення кількості рослин природного поновлення протягом періоду спостережень на моніторингових ділянках.

Ключові слова: видовий склад; *Pinus sylvestris* L.; повнота деревостану; надґрунтове вкриття; трофотоп.

[1] *Пастернак Володимир Петрович* – академік Лісівничої академії наук України, 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: pasternak65@ukr.net ORCID: https://orcid.org/0000-0003-1346-1968

[2] *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: pyvovar@ukr.net ORCID: https://orcid.org/0000-0001-7250-8549

[3] *Гармаш Анна Василівна* – старший викладач кафедри лісових культур, меліорацій та садово-паркового господарства, Державний біотехнологічний університет, вул. Алчевських, 44, Харків, 61002, Україна. E-mail: garmash1505@gmail.com ORCID: https://orcid.org/0000-0003-1874-094X