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Comparison of Scots pine growth dynamics in Polissya and Steppe zone of Ukraine

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Abstract: The goal of the study was to compare the dynamic changes in individual biometric indices of Scots pine in different natural zones of Ukraine, Polissya and Steppe. Scots pine stands were mainly concentrated in the Polissya zone, and their area was 3.6 times larger than that of forests in the Steppe zone, and the total wood stock by 4.6 times. The regression equations for biometric indices of artificial modal stands were developed. A comparison of the average height, diameter, and wood stock for pine stands of site index I[a], I, and II growing in Polissya and Steppe was made. It was found that the average differences in the average height (from 1.9 to 2.6 m) are observed at the age of 15–20 years. For the average diameter, the difference increases with age and the growth of the site index. The difference in the average stock is constantly increasing with age. At the age of 20 years this difference is 20–30 m^3, and at the age of 120 years from 100 to 120 m^3 depending on the site index. The developed growth models can be used in planning and prioritizing appropriate forestry activities for pine stands growing in specific regional conditions.

Key words: growth tables; *Pinus sylvestris* L.; biometric indices; natural zone of Ukraine

Productivity of forest stands consisting of the main forest-forming species depends on the influence of many factors. Recently, changes in weather and climatic conditions that occur at the global and regional levels have been recognized as predominant influencing factors. Adaptation of forest ecosystems to climate change can lead to significant fluctuations in their productivity parameters. This determines the relevance of developing tables of growth progress and studying the dynamics of biometric indices of forest stands in different natural zones of Ukraine which significantly differ in abiotic climatic conditions.

Climate change and ecosystem services have highlighted the limitations of traditional growth and productivity prediction tools. The developed growth and yield tables should be used when planning and prioritizing the relevant forestry interventions in forest-forming species stands. Forest management planning relies heavily on mathematical models evaluating the performance of forest stands. Modern dynamical system theory provides a framework for flexible representation of varying environments, as well as of responses to intensive silviculture and natural disturbances (García 2013b).

Appropriate growth models based on advanced modelling techniques are not available but they are necessary for the successful management of Scots pine stands in Ukraine.

Registration of dynamic processes occurring in forest ecosystems is one of the most important inventory tasks, since using such data it is possible to

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develop forecasts of changes in forest stands over time and space and to determine integral indicators, in particular productivity and carbon balance, which allow assessing the variation of forest ecosystem components.

The papers of European authors were devoted to studying the features of growth processes and the development of growth tables. Pretzsch et al. (2015) studied the growth of Scots pine (*Pinus sylvestris* L.) and European beech (*Fagus sylvatica* L.) in mixed stands versus pure ones on 32 triplets located along a productivity gradient through Europe, reaching from Sweden to Bulgaria and from Spain to Ukraine. In the study Vysotska et al. (2021) assessed the current state and evaluated the productivity of white poplar (*Populus alba* L.) stands per natural zones within Ukraine. Blanco and Blanco (2021) developed representative linear and polynomial equations to estimate the volume of poplar plantations within Spain.

The resulting growth and biomass model allows estimation of current growth and predicts future bioproductivity in volumes and aboveground biomass arising from thinning treatments for teak (*Tectona grandis* L.) in the Colombian Caribbean (Tewari et al. 2014; Torres et al. 2020). In the study (Rédei et al. 2014) growth rate and yield were determined, and a local numerical yield table for pure black locust stands in Hungary was developed. Pérez et al. (2005) investigated the interactions between temperature, precipitation, and radial and height growth in Scots pine. A biologically inspired whole-stand growth and yield model was developed for even-aged thinned or unthinned stands dominated by trembling aspen (*Populus tremuloides* Michx.) in Canada (García 2013a). The results of these studies are important for many countries and culminated in the creation of yield tables for different tree species and regions.

Scots pine is a coniferous species that is the most largely distributed worldwide. Its native areas include Scotland, Scandinavia, northern Europe, and northern Asia (Kudish 1992). It was introduced into many areas within the United States and Canada, and it was naturalized in the Northeast and the Great Lakes states. In Europe and Asia, Scots pine forms a boreal forest type with Norway spruce (*Picea abies*). Scots pine is planted for erosion protects (Kurtz et al. 1991). It is used to reforest the coal mine spoils. Scots pine is widely distributed as an ornamental tree, for windbreaks and to monitor the effect of air pollution on plants (Cunningham, Van Haverbeke 1991). Scots pine is usually managed with a shelterwood or uniform compartment system. Scots pine requires high light intensities for good growth, but it has modest nutritional demands (Sviridenko et al. 2004). Certain ground vegetation types are used as site quality indicators for Scots pine in Europe (Nieppola 1992).

According to the functional purpose of forest stands, the studied natural zones show significant differences. So, within the Polissya zone 64.2% of the area is classified as exploitable forests, but forests of this group are absent under conditions of the Northern Steppe. But the stands of the Northern Steppe zone are represented in the largest number (40%) by recreational forests of green zones.

This paper is devoted to comparative analysis and modelling of the dynamics of the main biometric indices of pine stands in the natural zones of Polissya and the Northern Steppe of Ukraine. The aim of this research was to establish statistical differences between biometric parameters of pine stands growing in natural areas Polissya and Northern Steppe of Ukraine. Also, the growth models according to the main biometric parameters (average height, average diameter and growing stock per 1 ha) for these regions and comparative analysis of the dynamics of biometric indicators of pine stands in different climatic zones of Ukraine were developed.

MATERIAL AND METHODS

Study area. Ukrainian Polissya is located in the north of Ukraine. It occupies the south-western part of a large zone of mixed forests of the Eastern European plain. The Steppe natural area covers the south, centre, and east of Ukraine (Adamenko 2014). Northern Steppe Ukraine is located in the moderate climatic belt in the area of moderately continental climate. The climate of Ukrainian Polissya is less continental and more humid than that in other physical and geographical zones of Ukraine, with warm and humid summers and mild, cloudy winters (Halik, Basyuk 2014). According to the agroclimatic zoning of Ukraine, Ukrainian Polissya belongs to a humid, moderately warm zone (Gensiruk et al. 1981; Hensiruk 2002).

Annual precipitation in Polissya is 500–600 mm, most of which (about 70%) falls from April to October (Kulbida et al. 2013). Evaporation does not exceed 400–450 mm. The average annual pre-

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cipitation within the Steppe is 400–500 mm. The moisture coefficient or precipitation-evaporation ratio for the Polissya zone is 1.9–2.8, while for the Steppe it is 0.8–1.0 (Lipinsky et al. 2003). The average annual temperature in Polissya is 6.4–6.8 °C, in Steppe conditions from 7.5 °C to 11 °C. About 70% of the Polissya territory is covered with ashy (podzolic) soils, and 15% with swamp and peat-swamp soils. The soil cover of the Northern Steppe zone of Ukraine is represented by common chernozems, which cover 81% of the area; soddy gley, meadow chernozem soils, meadow-marsh soils, and solonetz are also common within the territory.

A comparative analysis of the main biometric indices of Scots pine stands in these two climatic zones of Ukraine was previously carried out to assess the growth rate of pine stands. Pine forests of artificial origin were chosen as the basis for constructing growth tables since in the conditions of the Steppe region the share of pine forests of natural origin reaches only 18% (Lovinska, Sytnyk 2016). The area of the forests in the Polissya zone is 480 196.7 ha with a total growing stock of 151 million m^3. The area of forests in the Steppe zone is 3.6 times smaller, and its total wood stock is 4.6 times smaller than that of the Polissya zone. The site index is an important parameter that characterizes the productivity of stands. The establishment of forest site index was carried out using a scale developed by M. M. Orlov (Kachpor, Strochynskiy 2013) when the indicators of the stand age and height were taken into account. Using the stand-wise database of forests of Ukraine of the State Forest Inventory Enterprise the analysis of distribution of the areas of pine stands in classes of the site index was carried out (Table 1).

As can be seen from the presented data, both in Polissya (43.3%) and in the Northern Steppe (39.2%), Scots pine stands grow in the greatest number according to site index class I. A significant share of the forest stands growing in the conditions of both studied areas is also taken by pine forests of site index class I^a and II. So, it is these three site index classes, i.e. I^a and I and II, that were later used for comparative analysis of pine stands growing in two different natural zones.

In terms of completeness, pine stands of both Polissya and Steppe zones are most fully stocked (43% each), with an average relative density of 0.8. Since the yield tables for modal stands are compiled for a certain modal relative density, this value 0.8 was taken as modal in further studies of the growth of Scots pine stands.

Data collection. In the Polissya zones (Volyn, Zhytomyr, Kyiv, Rivne, Sumy, and Chernihiv regions) to assess the course of growth, 74 temporary sample plots (TSP) were laid in pure artificial pine stands; 25 TSP were laid in the Northern Steppe zone (Dnipropetrovsk region) (Figure 1).

All trees within the TSP were subject to a continuous list in terms of their thickness. The height of 15–20 trees was measured to plot the height curve. To analyse the growth rate in height, the trees that occupied a dominant position in the stand, which had the tallest height and belonged to the category of industrial wood, were selected. Model trees were selected from the proportion of upper trees with a diameter rank of 75.0% or higher. The rank of diameter is a consecutive row of trees in stands from the thinnest to the thickest (from 0 to 100%). To study the growth of stands in height, 222 trees in the Polissya zone and 75 trees in the Steppe zone were cut down and measured. Before cutting down, the selected model trees for the average diameters were measured. To do this, measure the projection

Table 1. Distribution of pine stand areas by forest site index classes

Site index	Natural zone			
	Polissya		Steppe	
	area (ha)	(%)	area (ha)	(%)
I^b and higher	12 316.1	3.2	1 233.8	1.0
I^a	103 950.7	22.6	11 971.3	9.8
I	220 483.5	43.3	54 997.9	39.2
II	103 048.4	21.3	43 127.8	33.0
III	29 023.4	6.9	17 092.1	13.9
IV	9 179.3	2.2	2 925.6	2.7
V and lower	2 195.3	0.5	289.9	0.3

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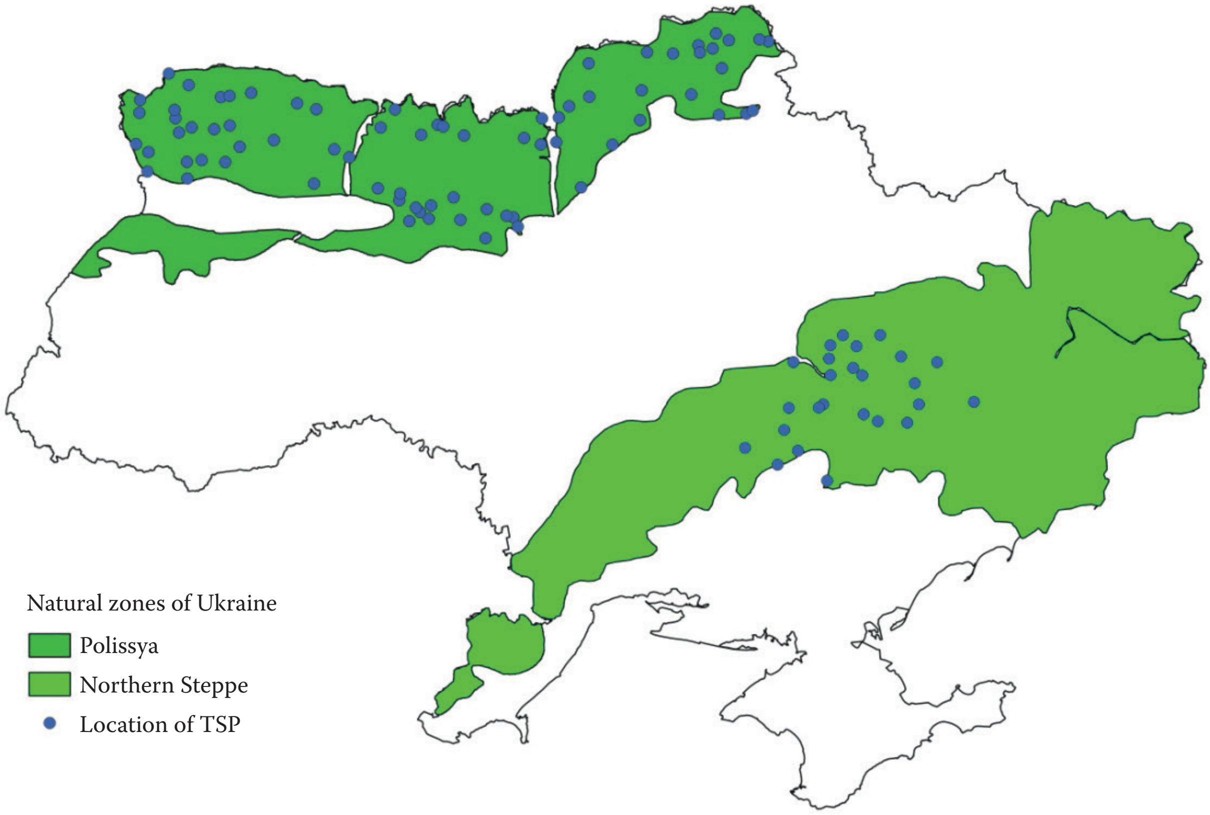

Figure 1. The location of the study area

of the tree crown to the cardinal directions and record the mark at breast height (1.3 m). The model tree was then cut down as close to the root neck as possible to determine the age with the highest accuracy. The felled timber was released from the branches and the trunk length was measured, as well as the distance to the first living branch of the tree (Lakyda 2002). The trunk of model tree was divided into 2 m sections. Disks for tree annual ring counting (2–3 cm thick) were selected in the middle of the labelled sections, marked, and transported to laboratory.

Laboratory investigation of the selected samples was started by drawing two mutually perpendicular lines to obtain four radii on which the tree annual rings were counted. The results of counting rings on cross-sections of disks were entered in special forms. Based on the obtained data, a curve of height changes with age was constructed.

Statistical analysis. Statistical characteristics of the main biometric indicators (average height, average diameter, average stock) which were later used in modelling modal stands, are presented in Table 2. To confirm the theory of equality of the studied samples, we used Student's t-test and the level of significance – P (Bala at al. 2019). The found value of t-test is equated to the critical one which is determined for the required level of significance (P = 0.05) and for a given number of degrees of freedom. Given the significant number of observations, the critical value of the t-test is 2. If the actual value of the t-test is greater than the critical one, then in this case the coefficient is significant and the theory of equality of samples is rejected. All calculations were performed on the basis of stand-wise database.

The results of statistical processing showed reliable indicators of the estimated parameters, with the exception of data obtained for pine stands older than 120 years. As a result of the preliminary analysis, modelling of biometric indices of forest stands was performed within up to 120 years.

In general, based on the comparison of biometric indices from the database and the establishment of a significant difference between them, it was decided that it is necessary to conduct independent modelling of Scots pine stand growth according to biometric indices within two natural and climatic zones, Polissya and Steppe.

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Table 2. Biometric parameters used for a comparison of the investigated groups of Scots pine stands

Biometric index	Mean value ± standard error		Mean standard deviation		*P*-value	*t*-test
	Polissya	Steppe	Polissya	Steppe		
Age group 1–20 years						
Mean height (m)	4.3 ± 0.018	3.5 ± 0.018	2.39	2.02	0.000	31.12
Mean diameter (cm)	5.4 ± 0.024	5.3 ± 0.003	3.11	3.26	0.000	2.58
Average stock ($m^3 \cdot ha^{-1}$)	34.2 ± 0.227	24.6 ± 0.213	29.62	23.37	0.000	30.98
Age group 21–40 years						
Mean height (m)	11.9 ± 0.019	11.4 ± 0.023	3.51	3.37	0.000	17.03
Mean diameter (cm)	14.4 ± 0.023	15.3 ± 0.030	4.11	4.36	0.000	–24.85
Average stock ($m^3 \cdot ha^{-1}$)	150.4 ± 0.380	140.6 ± 0.445	67.37	63.11	0.000	16.78
Age group 41–60 years						
Mean height (m)	18.2 ± 0.009	17.7 ± 0.011	3.79	3.01	0.000	35.05
Mean diameter (cm)	21.6 ± 0.012	20.7 ± 0.013	4.73	3.52	0.000	49.42
Average stock ($m^3 \cdot ha^{-1}$)	282.9 ± 0.218	267.2 ± 0.256	86.11	67.68	0.000	46.67
Age group 61–80 years						
Mean height (m)	24.3 ± 0.009	24.0 ± 0.020	3.17	2.17	0.000	14.92
Mean diameter (cm)	30.2 ± 0.014	28.5 ± 0.033	4.85	3.61	0.000	47.39
Average stock ($m^3 \cdot ha^{-1}$)	394.8 ± 0.225	378.9 ± 0.561	75.12	59.8	0.000	26.33
Age group 81–120 years						
Mean height (m)	26.8 ± 0.018	25.5 ± 0.095	2.66	2.18	0.000	13.25
Mean diameter (cm)	34.8 ± 0.029	34.8 ± 0.226	4.41	5.07	0.000	–0.40
Average stock ($m^3 \cdot ha^{-1}$)	408.6 ± 0.516	352.5 ± 3.263	76.1	74.4	0.812	16.59
Age group >120 years						
Mean height (m)	29.8 ± 2.787	29.8 ± 0.815	4.98	2.62	0.218	n.a.
Mean diameter (cm)	54.0 ± 5.016	49.9 ± 1.240	8.97	4.00	0.131	1.21
Average stock ($m^3 \cdot ha^{-1}$)	440.4 ± 114.2	333.1 ± 24.9	204.4	80.5	0.081	1.46

n.a. – not analysed

Modelling of biometric indices. For yield tables of pine stands created, their main biometric indices were subjected to comparison in the Polissya and Steppe zones, average height, average diameter, and average stock parameters were determined. To establish the dependence of the upper height of pine stands on age, modelling was performed using the Mitscherlich growth function (Equation 1):

$$H_h = a_0 \times \left(1 - e^{-a_1 \times A}\right)^{a_2} \qquad (1)$$

where:
H_h – the upper height of the stand (m);
A – average stand age (years);
a_0, a_1, a_2 – regression coefficients.

The upper height is an important indicator of plantings when determining the site index class and developing appropriate standards, but it is not often used during forest management. To reflect the growth dynamics of pine stands by height, the average height is modelled based on the curve guide of relative upper heights, and the following expression (Equation 2) is obtained:

$$H_{av} = H_h \times a_0 \times e\left(\frac{a_1}{A}\right) \qquad (2)$$

where:
H_{av} – average stand height (m);
H_h – upper stand height (m);
A – average stand age (years);
a_0, a_1 – regression coefficients.

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It was decided to use the growth model developed by the Department of Forest Taxation and Forest Management of the National University of Life and Environmental Sciences of Ukraine to calculate the average height of stands of artificial origin that grow in the Polissya zone (Strochinskiy et al. 1992). For the Steppe zone the growth model was developed using the data from TSP.

Modelling the growing stock was also carried out using the Mitscherlich growth function to establish the dependence of this value on the average height of the stand. To calculate the average diameter of the stand, an allometric step function was used.

RESULTS

Based on aggregation and modelling of data obtained from TSP, the following equations (Table 3) are obtained.

The presented models for estimating average height, diameter, and stock have high coefficients of determination and are statistically significant at the 5% level. The coefficient of determination indicates what proportion of the total variance is the variance of the calculated options. As we can see, it is close to 1, which indicates that this model almost completely describes the original experimental material. Comparative analysis of biometric parameters (average height, diameter, and growing stock) of pine stands in Polissya and Steppe developed of yield tables of modal plantings was carried out for the most common site index classes (I^a, I and II) in the studied regions for the use of analytical and graphical methods (Figures 2–4).

As can be seen from the presented results of dynamic changes in the average height, modal stands of Polissya turned out to be more productive compared to the Steppe, with the corresponding maximum values at 120 years of age: 33.0 and 32.2 m (Figure 2). Maximum discrepancies in absolute indicators of average height were established for young stands (15–60 years) and stands of the oldest classes of age (from 80 to 120 years). To a greater extent, the deviation between the results obtained was recorded for site index classes I and II, compared to I^a.

When comparing average diameters, the revealed trend of difference in absolute values is characterized by a more intensive increase in the indicator of changes starting from the age of 60 years (Figure 3). For this parameter, the absolute diameter index was also exceeded in the Polissya zone (the maximum value is 43.4 cm in Polissya and 35.7 cm in the Steppe zone).

The greatest difference when comparing the growth rate of the two natural and climatic zones was found in the average stock indicator (Figure 4). Relative indicators of the wood stock of Scots pine stands in Polissya exceed those in the Steppe to a greater extent for stands of site index classes I^a and I by 25–53% and 24–63%, respectively. The percentage of differences in indicators gradually decreases with age.

So, due to the fact that the average wood stock is most often a direct indicator of the bioproductiv-

Table 3. Regression equations for calculating biometric indicators of pine stands in different natural zones of Ukraine

Natural area	Regression equation	R^2
Polissya	$H_{av} = \dfrac{2.369 \times \left\{1 - \exp\left[-0.0158 \times A \times \left(1 - \exp\left(-0.112 \times A\right)\right)\right]\right\}^{1.012}}{1.028 + \dfrac{2.866}{A + 6.15}} \times H_{60}$	0.991
	$D_{av} = 0.865 \times A^{0.274} \times H_{av}^{0.744}$	0.876
	$M_{av} = 805 \times (1 - e^{-0.053} \times A)^{2.257}$	0.896
Steppe	$H_{av} = 1.797\left(1 - e^{(-0.031834 \times A)}\right)^{1.785} \times e^{\frac{-7.307}{A}}$	0.986
	$D_{av} = 0.679 \times A^{0.479} \times H_{av}^{0.546}$	0.845
	$\mathrm{M}_{av} = 469.073 \times (1 - \mathrm{e}^{-0.083} \times H)^{2.458}$	0.746

R^2 – coefficient of determination; H_{av} – average height; A – age; H_{60} – average height stands in 60 years; D_{av} – average diameter; M_{av} – average stock; H – height

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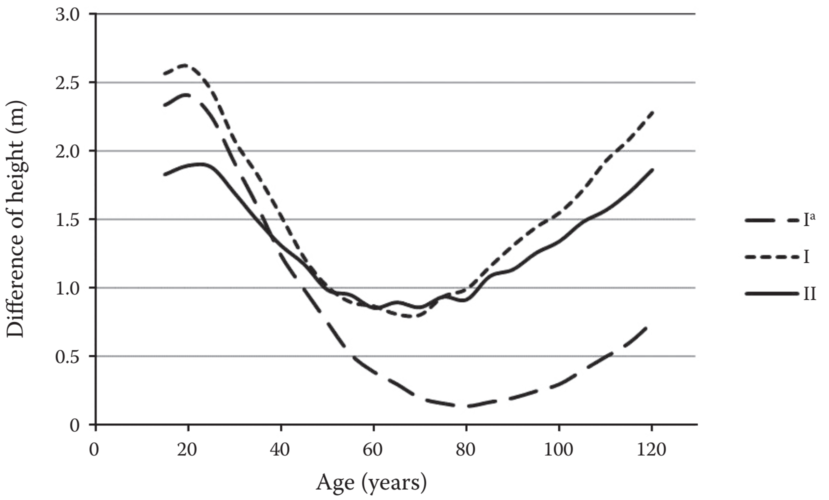

Figure 2. Differences in the average height dynamics of pine stands between Polissya and Steppe

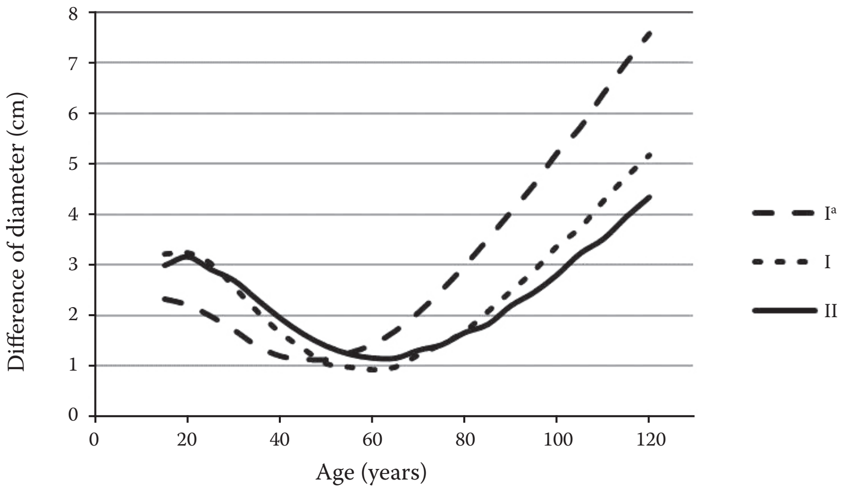

Figure 3. Differences in the average diameter dynamics of pine stands between Polissya and Steppe

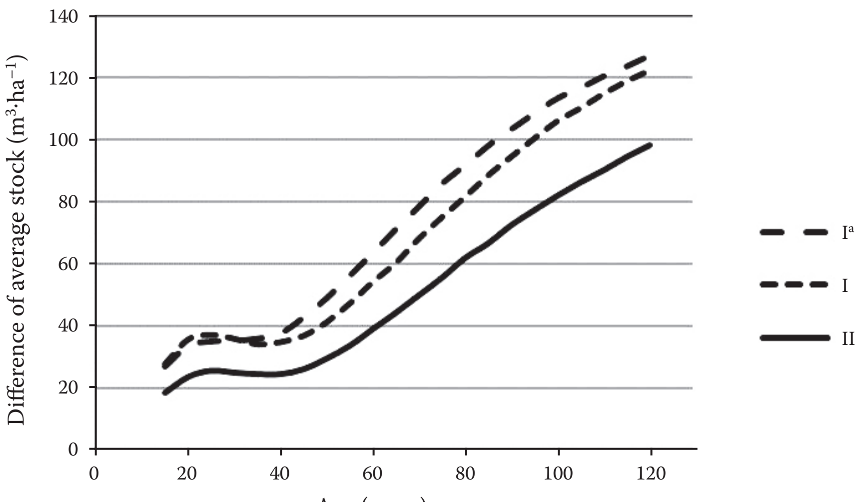

Figure 4. Differences in the average stock dynamics of pine stands between Polissya and Steppe

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ity of plantings, pine stands of site index classes I[a], I and II within Polissya have 24, 25 and 22% higher productivity, reaching 120 years of age, compared to the Steppe zone.

Our main conclusion about how exactly the stand is modified during growth in the conditions of the Polissya and Steppe zones is shown in Figure 5. The trend of dynamic changes in biometric indices is established in the context of the long-term prospects for the development of Scots pine stands in the two studied natural and climatic zones of Ukraine.

According to the established indicators, it can be seen that the most significant discrepancies between the predicted data are observed in the dynamics of changes in the average stock, while the smallest ones are observed for the average height indicator. A similar pattern in accordance with the studied biometric indices was established for two comparable natural zones, and with a significant predominance of the average reserve indicator in the Polissya zone.

In Figures 5B and 5C clear differences in the diameter and especially in the average stock of Scots pine of the Polissya and Steppe zones are shown. Scots pine has a faster growth rate in Polissya conditions. According to the predicted data, pine trees in Polissya also grow faster in the long run and reach higher maximum sizes and productivity.

DISCUSSION

It is known that Scots pine is one of the most widely distributed forest-forming species in Europe (Houston Durrant et al. 2016). The duration of the growth period (radial increment growth) of pine plants is about three months (Vaganov et al. 2006) and depends on habitat conditions and seasonal weather conditions. However, the growth processes of pine are mostly related to the moisture supply of the area during the year, as this coniferous species has a long period of xylogenesis, up to seven months (Rossi et al. 2013; Martínez del Castillo et al. 2016).

The changes in climatic factors during the growing season lead to variations in the growth of woody plants, which is directly related to the accumulation of stem biomass (Zweifel et al. 2005; Swidrak et al. 2011; Gao et al. 2019). The climatic effect is obvious and present in the modelling of growth processes, and assessing the dynamics of biometric changes in stands is a necessary approach not only to modelling individual species, but also to developing management decisions in specific habitat conditions (Tewari et al. 2014).

All this points to significant contradictions between the developed models of growth tables, so there is a need to develop growth tables for the conditions of a particular region which more accurately describe the pine growth in the study area.

The results of biometric measurements obtained in different climatic conditions, which were based on direct field research, allowed to better understand how coniferous trees respond to very local habitat conditions.

Comparison of the developed growth tables of the Polissya and Steppe zone with existing tables of modal pines in the third climatic zone of Ukraine, Forest-Steppe zone, on the most indicative parameter for establishing bioproductivity, namely wood stock, showed the following (Pasternak et al. 2014). According to the growth tables, the wood stock for Polissya is smaller than that in the Forest-Steppe zone, including up to 40 years of pine age. With the growth of stands and the transition of this species to older age categories, the bioproductivity of the Polissya zone tends to more significantly increase the stock. The stock difference reaches 61 $m^3{\cdot}ha^{-1}$ up to 80 years of age. Comparison of this indicator in the Forest-Steppe and Steppe revealed its prevalence in the Forest-Steppe zone regardless of the stand age. Interestingly, more significant indicators of the difference are recorded in the young age group, compared with middle-age plantations (difference in stock 21 $m^3{\cdot}ha^{-1}$ at 80 years of age).

A comparative analysis of dynamic changes in the main biometric indices with similar ones was carried out, which are tabulated in the growth rate of pine stands in Forest-Steppe and North-Steppe ecoregions of the European part (Shvidenko et al. 2008) for stands and site index classes.

Also a comparison of the obtained results of average height and average diameter was carried out at the age of 80 years of Scots pine, which is determined by the scientifically based age of maturity for this species. The average height of pine forests in the European part (26.6 m) and Polissya (26.2 m) is actually the same, and in Steppe conditions it is lower by only ~5%. For average diameters, an identical trend was found in comparison with Polissya and the European part. As a result of the comparative analysis of the average stock of modal pine forests, it was found that this parameter of bioproductivity

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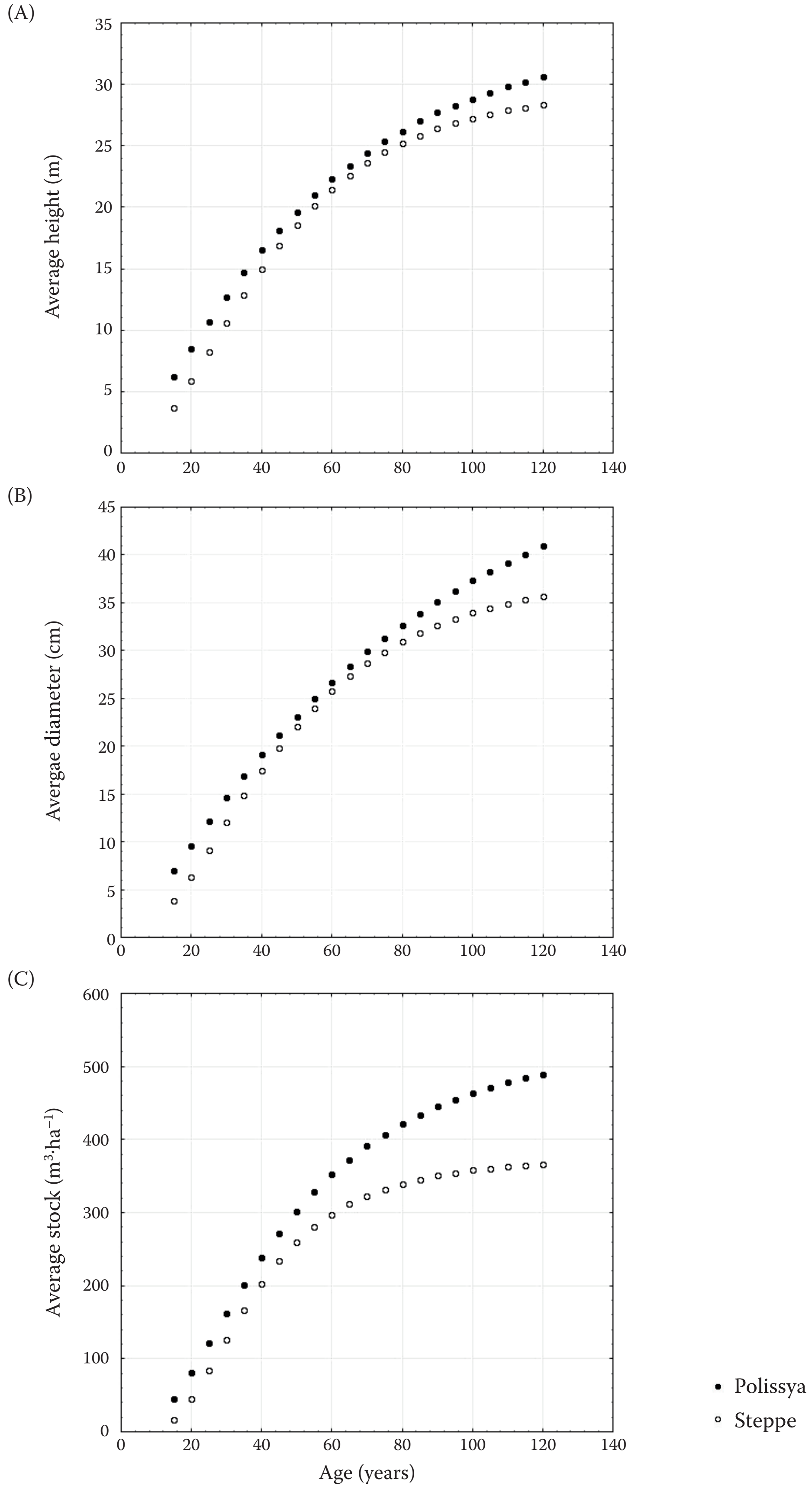

Figure 5. Scatterplot of predicted values for estimation of biometric indices (A – average height; B – average diameter; C – average stock)

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is lower for the Northern Steppe zone (European part) up to 40 years of age. With age, the difference in the average stock is levelled starting from 40 and 50 years; it exceeds the data by 8% (Shvidenko et al. 2008). Comparison of the obtained data on the average stock of pine stands in the Polissya zone showed a significant excess of this indicator compared to the Steppe (20%) and pine forests of the European part (by 26%).

In general, more significant deviations between the studied biometric indices are observed in young stands, which may be due to their more significant variability at this age. In addition to belonging to different natural and climatic zones, the identified discrepancies are explained by different methods of collecting and processing the experimental material.

CONCLUSION

Based on the results of aggregation and modelling of data from TSP, regression equations were obtained for calculating the average height, diameter, and growing stock of pine stands in various natural zones of Ukraine like Polissya and Northern steppe.

The trend of absolute values is characterized by a more significant difference in the average diameter, and especially in the average growing stock of the stand, compared to the height indicators. For all the studied parameters, an excess of absolute indicators in the Polissya zone compared to the Steppe was also found.

Compared to the Steppe zone, pine stands of Polissya have higher productivity of the average growing stock by 24% (site index class I^a), 23% (site index class I), and 22% (site index class II), reached at 120 years of age.

The simulated growth rate of modal pine stands based on the main biometric indices can be used in planning the volume of logging of the main use (in the Polissya zone) and cleaning cutting (in the Steppe zone).

The results obtained will make it possible to assess the current pine forest condition in the studied regions and predict the dynamics of their changes, which will allow objective implementation of forestry measures, taking into account the regional features of the formation of plantings of this species.

The comparative analysis of dynamic changes in biometric indicators of pine stands showed that two different studied natural zones of Ukraine require independent development of normative data of growth and yield tables.

The proposed models are a useful tool for effective management of pine stands in the conditions of the Polissya zone. Models of Scots pine growth indicators will have potential benefits in creating new plantings in the Northern Steppe, in an area where such a tool does not exist at all today.

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