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THE CAPACITY FOR FOREST PRODUCTION OF SOD-PODZOLIC SOILS IN EASTERN AND CENTRAL POLISSYA

M. M. VEDMID, candidate of agricultural sciences, associate professor, Ukrainian Research Institute of Forestry & Forest Melioration (URIFFM)
S. P. RASPOPINA, candidate of agricultural sciences, senior researcher, URIFFM
O. V. ZBOROVSKA, junior researcher, Polissya branch of URIFFM

A comparative analysis of forest fertility of sod-podzolic soils on glaciofluvial and glacial sands under pine forests was carried out in the different subzones of the Forest zone of Ukraine – Eastern and Central Polissya. It was proved that the overall level of fertility of sod-podzolic soils of Eastern Polissya has increased in comparison with Central Polissya. Growth of soil fertility was caused by increase the proportion of fine sand and clay particles, as well as by increase the content of total phosphorus and potassium. Acidity and nitrogen content in the soil of subzones was virtually unchanged. The humus content was a little greater in the soils of Central Polissya. We analyzed the change of the productivity of pine forests, depending on the level of soil fertility. The increase of soil fertility in Eastern Polsssya becomes the cause of increased productivity of pine forests. This increases the proportion of pine stands with high productivity (II bonitet and higher) and a decrease in the proportion of trees with low productivity (III bonitet and lower).

The sod-podzolic soils, fertility, productivity of pine forest.

Humid climate, flushing water regime, dominance of carbonate-free rocks of light granulometric composition (fluvioglacial, glacial (morainal), alluvial sands), as well as pine forests, which everywhere cover the territory of Ukrainian Polissya, promote the development of sod-podzolic soils. The level of podzolity depends on mineralogical and granulometric composition of soils and on humidity of sites. The main part (about 60 % of total area) of sod-podzolic soils of Ukrainian Polissya is characterized by non-significant podzolity (low and middle level) [2]. Moderate activity of podzolic process is connected primarily with sand granulometry of mother rock.

In general, both sod-slightly-podzolic and sod-middle-podzolic soils in result of very low supply of nutrients, insignificant humus content, high acidity of medium, are characterized by low fertility for the majority of agricultural crops. However, forest vegetation on these soils, especially Scots pine (*Pinus sylvestris* L.), which is the typical oligotrophic plant, completely satisfies its demands in nutrients. In result of it Scots pine forms the stands of high productivity on such soils. In spite of usually low fertility, capacity for forest production of sod-podzolic soils depends on their

certain properties. Evaluation of quantitative characteristics of soils in Eastern and Central Polissya, which bring to the change of trophic level of sites and their capacity for forest production, is rather actual task, especially in context of implementation of the State special-purpose program "Forests of Ukraine" up to 2015 concerned creation of 415 thous. ha of forest plantations at the expense of recently accepted former agricultural lands [9].

The aim of investigations was to study the peculiarities of physical, physical & chemical and agrochemical properties of sod-podzolic soils in the zone of Eastern and Central Polissya and to evaluate their capacity for forest production.

Materials and methods. Investigation of soil cover was carried out according to basic methods of forest typology, forest science and soil science [1, 7] for the lands of the following State Forest Enterprises (physiographic regions are given in brackets).

Eastern Polissya, Chernigiv administrative region:

– "Korukivske forest&hunting economy" (Koryukivsko-Shchorsky region);

– "Kholmynske forest&hunting economy", «Semenivske forest&hunting economy" (Kholminsko-Kostobobrivsky region);

– «Gorodnyanske forest&hunting economy" (Dobryansko-Gorodnyansky region).

Central Polissya, Zhitomir administrative region:

– "Malynske forest economy" (Irshansko-Malynsky region);

– "Zhitomirske forest economy" (Chernyakhivsko-Korostyshevsky region);

– "Lugynske forest economy" (Korostensko-Chopovytsky region).

Network of sample plots covers prevailing site conditions for pine stands (A_2, B_2, B_2-C_2). In unevened pine stands (IV–X age classes) 36 sample plots were based. Forest valuation was carried out, soil cover was described for them; over 160 soil samples were analyzed. Granulometric composition of samples was evaluated by pipette method. Humus content was evaluated by Turin method). Contents of total N, P, K was evaluated by Ginzburg method in concentrated sulfuric extract. Actual and potential acidity was evaluated by potentiometry [4, 5, 10].

Results. Soil cover of inspected plots is represented by soddy hidden podzolic soils on pseudofiber fluvioglacial and morainal sands, as well as by soddy moderate-podzolic gleyey soils on morainal sands.

Typical profile of soddy hidden podzolic soils and soddy moderate-podzolic gleyey soils has such structure: level of mellow litter (Ho) with depth not over 4 cm, then gray or pale gray humic light eluvial level (He) of loamy&sandy composition. Depth of He level make up 15–30 cm at an average 20.5 cm. Humus level is followed by yellow & brownish sand with signs of illuviation, which gradually comes to mother rock – fluvioglacial sand, penetrated by interrupted pseudofibres. Rock is bedded not deep, that is 80 cm from soil surface.

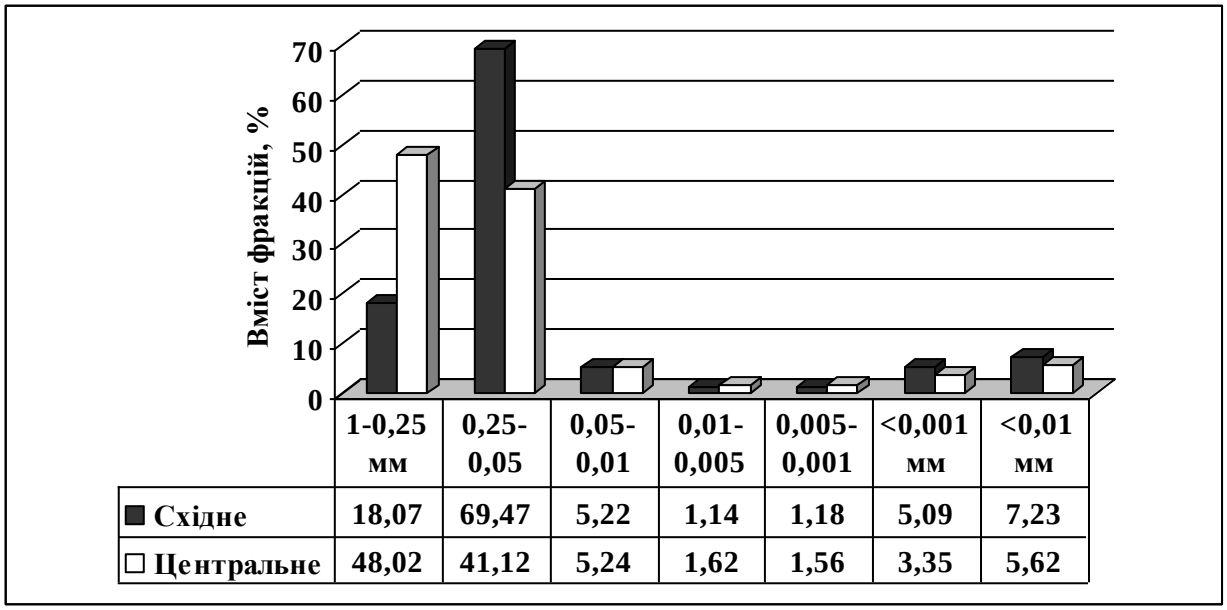
In the soil cover of inspected lands (especially in Eastern Polissya), soils of different level of gleization are widespread, which is proved by occurrence of ferric interlayers (pseudofibres and ortzand) in the lower part of soil profile. Except these new formations, also ferric-manganese punctuation, rust-ocherous spots on the background of washed sand and *per se* washed from colloids layer of blue-gray sand are the signs of gleization. These signs prove short-term moistening of soils, which repeats periodically. During it Fe periodically transforms to oxid or protoxid compounds.

At general low trophic level sod-podsolic soils of investigated lands have some peculiarities (in morphological, petrographic and chemical composition), which affects their capacity for forest production.

The soils of inspected lands have mainly formed on fluvioglacial and glacial depositions of light granulometric composition – sands and loamy sands, sometimes sandy loams, which is the cause of absolute domination of sand fraction in their granulometric composition. That is, the content of the sand fraction in the soils of both regions is almost equal and makes up 88–89 % (Fig. 1). However, the sands have peculiarities by the size of quartz grains.

One must mention, that during long time the territory of Polissya was the place of accumulation of large amount of water of alluvial and fluvioglacial genesis. It caused the spread of different varieties of washed sand deposits: fluvioglacial, glacial,

ancient alluvial and modern alluvial ones. We have found, that very much washed fine-sand moraine and fine-grained fluvioglacial sands dominate in the objects of Chernigiv region. Coarse-grained fluvioglacial sands and sanded coarse-grained moraine dominate in the objects of Zhitomir region.



	1-0,25 мм	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001 мм	<0,01 мм
■ Східне	18,07	69,47	5,22	1,14	1,18	5,09	7,23
□ Центральне	48,02	41,12	5,24	1,62	1,56	3,35	5,62

Fig. 1. Granulometric composition of sod-podzolic soils in Eastern (black rectangles) and Central (white rectangles) Polissya (X – fractions, mm; Y – content, %)

Results of granulometric analysis show, that the soils of almost all investigated objects of Central Polissya contain equal fractions of fine-grained and coarse-grained sand. Their content is stable in the whole soil profile and amounts 41 and 49 % respectively. In the soils of Eastern Polissya fine-grained sand dominates (69.5%), and coarse-grained sand makes up only 18 %. Simultaneously with the content of fine-grained sand, total content of fine particles increases in the soils of this zone. So, the content of physical clay amounts 7.2 % in Eastern Polissya and 5.7 % in Central Polissya (difference between these data and other data, presented below, is significant on 95 % level). Increase of the part of clay particles occurs due to twice increase of silty fraction (5.1 against 2.5 %) (Fig. 1).

In whole, investigated soils of Eastern Polissya varies by granulometric composition from loamy-sandy to light sandy-loam and sandy-loam. By this, the upper horizons (up to 50–60 cm) have, as a rule, light sandy-loam and sandy-loam

composition, and lower ones are transitional to mother rock, and the rock has loamy and sandy composition. Granulometric composition of the soils of Central Polissya varies less – from sandy (mother rocks and transition horizons) to loamy-sandy, occasionally to slight sandy-loam (humus horizons).

Thereby, granulometric composition shows that sod-podzolic soils of Eastern Polissya are able to have some higher capacity for forest production, because fine sand, as opposed to coarse sand, contains not only quartz, but also certain amount of loamy minerals (feldspar, mica). Increase of silty fraction enriches the sandy soils by minerals of montmorillonite and hydromica groups. All this together must influence positively on trophic level of soils, which is proved by the results of agrochemical analysis.

Increase of dispersibility of the soils of Eastern Polissya causes their higher trophic level comparing to the soils of Central Polissya. The soils of Eastern Polissya contain 2.5 times more phosphorus and twice more potassium, and their actual acidity is lower per 0.2 units pH) (Table 1). High content of phosphorus in some districts of Chernigiv region (up to 0.18 %) is very high for any soil type, especially for sandy soils. Such high content of phosphorus can be connected with high contents of phosphorus compounds due to phosphorite deposits of Krolevets field, which is located on the border of Chernigiv and Sumy regions that is not far from the objects of our investigations.

1. Agrochemical indices of sod-podzolic soils in Eastern and Central Polissya

Region	pH_{H2O}	Humus	N	P	K
		%			
Eastern Polissya	5.3±0.11	0.37±0.084	0.03±0.003	0.05±0.008	0.04±0.004
Central Polissya	5.1±0.11	0.54±0.138	0.04±0.008	0.02±0.003	0.02±0.002

As opposed to phosphorus and potassium, content of nitrogen in the soils of Eastern Polissya is less than in Central Polissya by 25 %, and contents of humus is less by 30 % in Eastern Polissya. Less supply of organic matter and consequently organogenic element – nitrogen in the soils of pine stands of Eastern Polissya is explained by low projective cover by herbaceous vegetation and higher soil humidity.

Pure dense pine stands (1.5 time higher than standard) are often almost free from any herbaceous vegetation, besides green mosses.

Extreme poorness of species composition of herbaceous vegetation and its low projective cover is the cause of very low content of nitrogen and low intensity of humus accumulation. At this, due to wash water regime of soils, intensive washing out of high mobile nitrogen compounds out of soil profile and transport of humus substances along it occurs. Just therefore, as well as in result of high content of loamy particles in the upper layer of sod-podzolic soils of Eastern Polissya, their humus horizon is extended (19 cm in Eastern Polissya, 12 cm in Central Polissya).

Thereby, the results of granulometric and agrochemical analyses prove the higher trophic level of more sod-podzolic soils of Eastern Polissya as compared with Central Polissya. Their higher trophis level is caused by higher content of physical loam, phosphorus and potassium, which are the markers of capacity for forest production of soils in the region. High information capability of these characteristics for evaluation of trophic level was proved by our numerous investigations, which are completely agree with results of other researchers [6].

Phosphorus and potassium have high meaning as indicators of trophic level for sites, because these elements the most often are present in the soil in the first minimum and therefore limit the productivity of forest stands. Nitrogen, which has exclusive meaning for plant life support, also has influence on their productivity. However, nitrogen nutrition of trees in forest ecosystems has some specificity connected with peculiarities of small circulation of nutrients, which has in practice closed cycle. Forest stands, as a rule, completely satisfy their demand in this element due to yearly transformation of phytodetritus, which has high abundance of nitrogen compounds. Meaning of nitrogen as nutrient growth in recently planted forest plantations. This meaning considerably decreases as forest environment (especially forest litter) forms. Forest litter in forest ecosystem is important source of energy and organic compounds, especially nitrogen. Due to mineralization of forest litter, organic nitrogen converts to mobile forms, migrates to soil and quickly assimilates there by mycorhiza and roots, and at once includes biological cycle of substances.

As opposed to nitrogen, which has overall organic origin, the content of mineral elements depends only on chemical & mineralogical composition of soil forming rocks. Deficit of mineral elements cannot be compensated at the cost of nitrogen by any natural way, whereas nitrogen supply can increase due to its assimilation from air by some microorganisms (nitrogen-fixing microorganisms). Among nutrient macroelements, content of total phosphorus in soils is the lowest, it amounts in very narrow range from 0.01 to 0.25 % [8]. Soils with high phosphorus content are almost absent in the nature, as opposed to soils with high nitrogen content (mould humus, meadow soils, dark-gray soils etc.). Content of phosphorus is especially low in light soils by mechanical composition. Unsatisfactory plant nutrition by phosphorus is connected with low solubility of its compounds.

Total content of potassium in soil is rather high as compared with nitrogen and especially phosphorus. It varies in wide limits (0.02–2.5 %) and is the highest in organogenic and sandy soils. It seems, that the plants should not sense potassium deficit. However, the most part of soil potassium (>90 % from total amount) is in the form of silicates and aluminosilicates, which are unavailable for plants at all. The part of soluble potassium (as sulfates, hydrocarbonates, carbonates, nitrates) from its total content makes up 0.05–0.2 %, the part of potentially soluble potassium makes up 0.5–2 % [8].

Higher trophic level of soils of Eastern Polissya as compared with Central Polissya has to influence positively on productivity of pine stands. We compared the results of soil analyses with productivity indices of pine stands obtained both by our measurements and forest inventory data. Forest inventory data on area distribution of conifer stands by productivity in different administrative regions are presented in Table 2 [3].

Taking into account, that Scots pine absolutely dominates among conifers in the both regions (99 % in Zhitomir region and 98 % in Chernigiv region), we can assume that presented data of forest inventory on distribution of conifers by classes of bonitet is identical to such distribution of Scots pine. We have analyzed these data for

convenience in relative units and obtained the distribution of area of pine stands by bonitet classes in percents from total area.

2. Distribution of area of conifer stands by bonitet classes by administrative regions in investigated zone

Region	Area, ha (numerator – all conifers, denominator – Scots pine)	Area of stands by bonitet classes, ha				
		II and higher	III	IV	V	V and lower
Chernigiv	217514 213742	211551	4900	930	125	8
Zhitomir	395987 391119	343404	33627	11203	4948	2805

Bonitet is the most informative index of trophic level of sites, because it is determined by height of trees. It was determined, that productivity of pine stands in Chernigiv region (Eastern Polissya) is higher, than in Zhitomir region (Central Polissya). In Eastern Polissya relative part of high productive stands (over II class of bonitet) is 97%, in Central Polissya it is 87 %. The part of stands with middle and low productivity (III and lower classes of bonitet) is considerably lower in Eastern Polissya (2.5%) and makes up 13.5% in Central Polissya (Fig. 2).

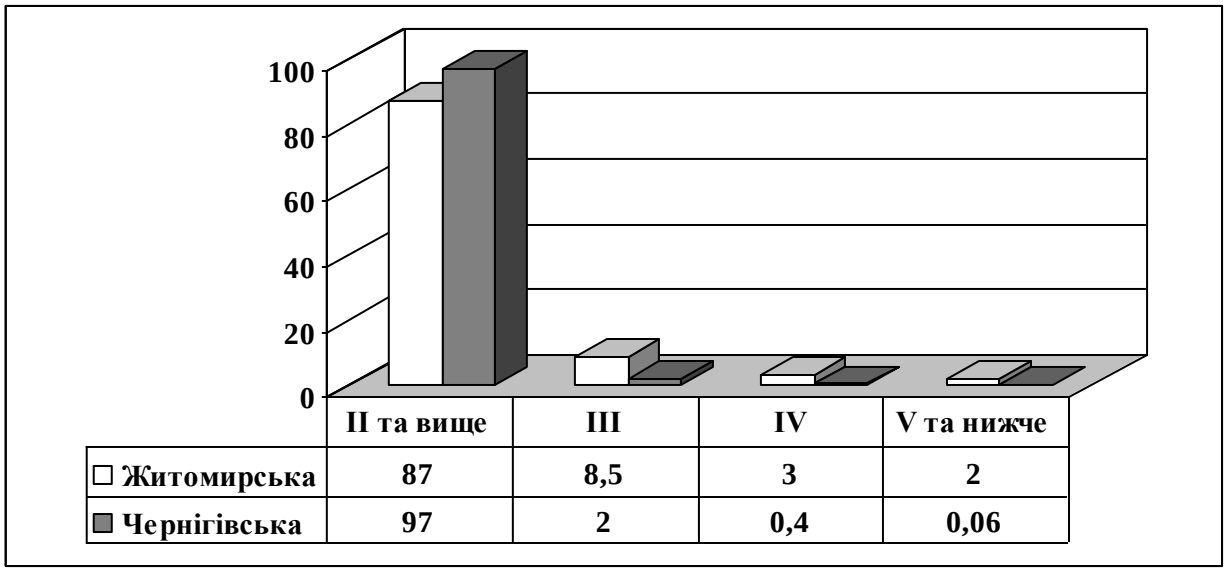
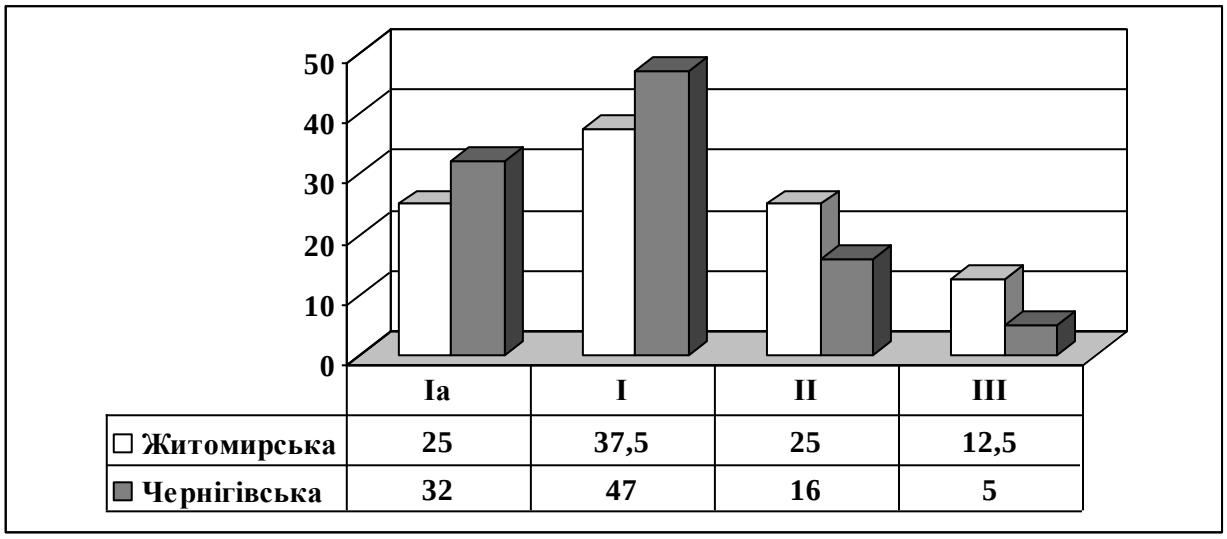


Fig. 2. Distribution of area of conifer stands by classes of bonitet (% from total area) by forest inventory data (Zhitomir – white rectangles, Chernigiv – black rectangles; X – classes of bonitet; Y – area, %)

Data analysis on productivity of pine stands in sample plots show, that in Chernigiv region the stands of the I bonitet class dominate (47 %), the part of stands

of Ia bonitet is 32 %. Stands of II and III classes make up 16 and 5 % (Fig. 3). In sample plots of Zhitomir region 25 % of stands have Ia bonitet class, 25 % of stands have II bonitet class, and 37,5 % of stands have I bonitet class (Fig. 3).



	Ia	I	II	III
Житомирська	25	37,5	25	12,5
Чернігівська	32	47	16	5

Fig. 3. Distribution of pine stands by classes of bonitet (% from total number) in sample plots (Zhitomir – white rectangles, Chernigiv – black rectangles; X – classes of bonitet; Y – part, %)

Thereby, our data show, that the part of high productive (Ia–I bonitet classes) pine stands is rather higher in Eastern Polissya as compared with Central Polissya (79 and 62.5 % respectively), and the part of low productive stands (II–III) is lower (21 and 37.5 % respectively).

One can see that the results of distribution of pine stands by bonitet classes by sample plots are almost similar to forest inventory data. For example, in sample plots of Chernigiv region the part of pine stands of II and higher bonitet classes amounts 95%, in Zhitomir region it makes up 87.5 %, and after inventory data these parts make up 97 and 87 % respectively (Fig. 2–3). It means that our sample plots are representative for general distribution of productivity for pine stands in Eastern and Central Polissya.

Conclusions

Capacity for forest production of sod-podzolic soils in Eastern Polissya is somewhat higher than in Central Polissya. It is explained by peculiarities of granulometric composition of respective mother rocks (fluvioglacial and morainal

sands). Sands in Eastern Polissya mainly contain fine-grained fraction, and in Central Polissya they contain both fine-grained and coarse-grain fractions. Sands of Eastern Polissya contain also higher parts of loamy particles, total phosphorus and potassium, than in Central Polissya.

Higher trophic level of sandy sites of Eastern Polissya versus Central Polissya is the cause of higher productivity of pine stands of this region. In Eastern Polissya the part of high productive stands (over II bonitet class) is greater, and the parts of middle and low productive stands (III and lower bonitet classes) are lower.

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ЛЕСОРАСТИТЕЛЬНЫЙ ПОТЕНЦИАЛ ДЕРНОВО-ПОДЗОЛИСТЫХ ПОЧВ В ЗОНЕ ВОСТОЧНОГО И ЦЕНТРАЛЬНОГО ПОЛЕСЬЯ

Ведмидь Н.М., Распопина С.П., Зборовская О.В.

Проведен сравнительный анализ лесорастительных свойств дерново-подзолистых почв на флювиогляциальных и гляциальных песках под сосновыми лесами в зоне Восточного и Центрального Полесья. Определено, что общий уровень трофности почв Восточного Полесья в сравнении с Центральным несколько выше. Повышение уровня трофности почв связано с особенностями их гранулометрии (увеличение содержания фракции мелкого песка и глинистых частиц), а также более высоким содержанием общего фосфора и калия. Показано, что более высокий уровень трофности местообитаний зоны Восточного Полесья обусловливает более высокую производительность сосновых древостоев.

Дерново-подзолистые почвы, гранулометрический состав, трофность, производительность сосновых лесов.

ЛІСОРОСЛИННИЙ ПОТЕНЦІАЛ ДЕРНОВО-ПІДЗОЛИСТИХ ҐРУНТІВ У ЗОНІ СХІДНОГО ТА ЦЕНТРАЛЬНОГО ПОЛІССЯ

Ведмідь М.М., Распопіна С.П., Зборовська О.В.

Проведено порівняльний аналіз лісорослинних властивостей дерново-підзолистих ґрунтів на флювіогляціальних та гляціальних пісках під сосновими лісами в зоні Східного та Центрального Полісся. Визначено, що загальний рівень трофності ґрунтів Східнополіського регіону є дещо вищим у порівнянні з Центральним. Підвищення рівня трофності ґрунтів пов'язано з деякими особливостями їх гранулометричного складу (зростанням вмісту фракції дрібного піску та глинистих часток), а також більш високим вмістом загального фосфору та калію. Показано, що вищий рівень трофності місцезростань зони Східного Полісся зумовлює більш високу продуктивність соснових деревостанів порівняно з Центральною.

Дерново-підзолисті ґрунти, гранулометричний склад, трофність, продуктивність соснових лісів.

E-mail: vmm@uriffm.org.ua; raspopina@uriffm.org.ua