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Restoration of Forest Live Cover and Understory in Pinetum of Former Agricultural Lands

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Abstract

The article presents the study of the restoration processes of vegetation in stands of pine and spruce on lands formerly used for agricultural purposes. The standard methods used in phytocenological and pedologic studies are used. It is noted that a high content of organic matter can not be a limiting factor in the growth and development of living soil cover and does not affect its projective cover.

Depending on the care of stands by applying fertilizers and using herbicides, the species composition of forest live cover varies while the dominant species are preserved. The number of woody species is considerably large in pure pine cultures in comparison with those of experimental sites, where fertilizers and herbicides were applied and understory is completely absent. It should be noted that more intensive recovery is observed in pine stands treated with herbicides. In cultures of old-age pine and spruce, the natural recovery of spruce is constrained by the vegetation of understories and the canopy of forest stand. After the formation of the closed canopy of forest stand, forest site factor and heterogeneity of the soil cover are mitigated by low light under the canopy. Thus, forest live cover becomes more uniform.

Keywords: forest cultures, pine, spruce, postagrogenic lands, pH, organic matter, species composition of understory and forest live cover, fertilizer and herbicides

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1. Introduction

Related study of the dynamic trends of homogeneous forest and the stages of their development, the dynamics of vegetation cover and restoration of the original forest vegetation is an important stage in the development of modern forest restoration, forest management and forest phytocenology when creating stands on postagrogenic lands [1--3, 5]. The relevance is also explained by the need in development of measures to improve the efficiency of use of agricultural land withdrawn from agriculture [3, 4].

The vegetation of tree strands created on post-agrogenic lands is very dynamic, especially before the development of a tree-shrub canopy and crown closure. From the first years, significant differences are observed in vegetative cover of such sites in comparison with vegetation of the original forest types [4, 9-11]. New species appear. Moreover, the increase in productivity of many heliophilic species, pioneer and initial that are not affected by sharp change in environmental conditions is observed and high degree of illumination contributes to their sharp development.

Development stages, characterizing the most significant changes in their composition and structure of forest stands, have been determined to study the succession of vegetation in forest stands.

At the first stages of succession, the developments of strands features are largely determined by the technology of creation and the features of growing. The value of seed propagation in changes in forest live cover can only be estimated only if there is information about the development of seedlings of its most common components. [7, 9, 11]

The adaptation of biota elements to new living conditions is accompanied by a change in the number of species, their demographic structure, and cenotic significance. In coniferous species, this is especially evident among plants of the second growth, understory, and it is especially noticeable among herbs. The latter, greatly expanding and conquering the territory, form synusia, which affect the light regime of the soil cover, hydrothermal soil conditions, and plant recovery processes [1, 2].

The influence of herbaceous plants, in particular cereals, on seedlings of tree species is represented by the suppression of the latter by the ground part of cereals, their damage due to snowfall on dying grass, as well as the competition for food, moisture, etc.

Artificially forest regeneration minimizes the negative consequences of the transformation of the forest ecosystem and restores its restoration time. However, the experimental data on this matter are almost absent in literature sources, and there are few records and observations of the development of seedlings of herbaceous plants in natural conditions. After the creation of forest stands at defrosted sites, the processes of changing the vegetation cover become more intensive and the restoration of the forest environment is accelerated [4]. Abrupt changes in forest live cover lead to cenotic stresses, the consequences of which have many-sided negative natures [2].

2. Methods and Equipment

Pine species on the former agricultural lands of different ages were selected as objects of research in order to trace the diversity of species dependence in forest live cover on the age of forest stands.

We have carried out geobotanical studies of common pine cultures in various types of habitat conditions in the Gatchina region in the Leningrad area.

The first forestry site was created in 1901. Pure pine cultures were planted on the former arable land along furrows dug with pine sapling. Today, the soil is defined as sodded former agro-soil on red-colored boulder loam. At present, two generations of natural regeneration of spruce are observed in this area. The first generation is 80 years old and the second is 100 years old. During the growing period, the care was only represented by cleaning of dead tree trunks. The second section of pine cultures was created on the former hayfields, the soil from sod-podzolic to peaty, in 1976. According to the forest growing conditions, the northern part of the territory is grassy on drained peat bogs; the southern part is elevated and drained, represented by gramineous/grassy meadow with significant participation of mosses in microhill. Pine species were created by strata which in turn were created by a forest plow, with a density of 3800 pieces per ha. Different care modes are included into variant of tests: ``fertilizers'', ``fertilizers + herbicides'', ``control''. Pipes of 15 years old at all experimental plots, except for control, were subject to thinning up to density of 1.5 thousand pieces/ha.

Table 1: Stratum characteristics of experimental sites.

No. of experimental site	Area, ha	Composition	Age, years	Height, average, m	Diameter, average, cm	Degree of cover	Reserve, m3/ha
1	1.5	6P4S+B	P-125 S-80/100	32 26-30	44 28-36	1.0	620
2	4.8	10P	S-38	18	18-20	0.9-1.0	250-300

Note: P - pine; S- spruce; B -- birch.

In order to consider and characterize the understory and undergrowth of at least 5 sites evenly distributed over a sampling plot and occupying 5% or more of its total area is arranged on a sample plot under the forest canopy.

In this case we use visual-taxation and enumeration method for accounting under-growth (discount area method). The first of them is used in forest surveying and gives an accuracy of 30- 40%. The method of discount areas (circular, rectangular, strip) is used for researching purposes [8].Sample plots 1x1 m are arranged and the forest live cover is recorded on them. The projective cover degree of forest live cover is calculated in % of

the total area of sample plots with a gradation of 5% [8]. Undergrowth and undergrowth are recorded on circular plots with a radius of 1.78 m and an area of 10 m2. Undergrowth is measured by: species, origin, age and vitality groups.

To characterize the soil complex at studied objects, samples were taken from a depth of 0-10 and 15-25 cm. The total organic matter content was determined in the selected samples by the Tyurin method and the potentiometric pH $_{(KCl)}$ method [7].

3. Results

Level of pH of sample plot treated with fertilizer is low, which indicates the high acidity of the soil in this area. This can be explained by the large share of acidic litter of pine in forest floor. However, the high acidity of this horizon did not affect the composition and projective cover of the forest live cover, since a horizon of 15--25 cm already has an acidity close to neutral. The soil acidity of remaining variants in pure pine, mixed pine and spruce cultures is close to neutral, which is favorable for the development of vegetation cover and has affected the projective cover degree of LFC. In terms of organic matter content, the soils of experimental sites are high soils with high humus content in the low drained swamps. The humus content ranges from 8% to 20%, i.e. based on this indicator, the organic matter content in the experimental sites cannot be a limiting factor in the growth and development of forest live cover and cannot affect its projective cover degree.

Table 2: pH indexes of soil and content of organic matter on experimental sites.

Depth selection	70% Pine 30% Spruce	100% Pine			
		Control	Fertilizers	Herbicides	Fertilizers + herbicides
pH $_{(KCl)}$					
0-15 cm	5,82	5,47	3,38	5,56	6,04
15-25 cm	6,43	6,5	6,02	6,53	6,39
Humus					
0-25 cm	9,91	12,94	20,95	16,4	8,57

Average projective cover of FLC by experimental sites in pure pine cultures, which prevail on all sample plots and occupy more than 40% of the soil surface (Fig. 1-5), is represented by green mosses.

In context of pure pine forests samples, there are significant amounts of forest geranium (Geránium sylváticum), occupying from 10 to 30% of the surface. In the control, there is forest goutweed (Aegopódium podagrária), meadowsweet (Filipéndula ulmária),

meadow rougish grass (Póa triviális) occupying 15 -20%. There are also small amounts of wood rush (Luzula pilosa), raspberry (Rúbus idáeus), marsh violet (Víola palústris), chickweed (Stellária média), white deadly (Lámium álbum), wild strawberries (Fragaria villera forest) and wild chervil (Anthríscus sylvéstris). There are also few amounts of blueberries (Vaccínium myrtíllus), bush vetch (Rúbus saxátilis), crow pea (Vicia sepium), tormentil (Potentílla erécta) and cowberry (Vaccínium vítis-idaéa). The percentage of their coverage is less than 1.

In contrast to the control, the coverage of wood crane is two times lower in the area treated with fertilizers and the herbicides. Goutweed (Aegopódium podagrária), on the contrary, occupies twice as much space as compared to the control. The percentage of coverage with meadowsweet (Filipéndula ulmária) is approximately equal to the control variant. Meadow rougish grass(Póa triviális) occupies only 1% of the surface. Wood rush (Luzula pilosa) and raspberry (Rúbus idáeus) and marsh violet (Víola palústris) occupy about 10% each. Less than 1% is occupied by species such as wild apple (Óxalis acetosélla), french willow (Chamaenérion angustifolium), cowwheat (Melampýrum pratense), tormentil (Potentílla erécta), and European starflower (Trientális europaéa). The coverage of wood crane (Geránium sylváticum) in the plot treated with herbicides is almost 10% more than that of control. Approximately 10% of the surface is occupied by species such as meadowsweet (Filipéndula ulmária), male shield fern (Dryópteris fílix-mas) and wild apple (Óxalis acetosélla). 5-6% are covered by goutweed (Aegopódium podagrária), meadow rougish grass (Póa triviális), wood rush (Luzula pilosa), marsh violet (Víola palústris) and stone bramble (Rúbus saxátilis). Less than 5% of the projective cover is occupied by raspberries (Rúbus idáeus), chickweed (Stellária média) and tormentil (Potentílla erécta).

In areas treated with fertilizers, species such as wood crane (Geránium sylváticum), goutweed (Aegopódium podagrária), meadowsweet (filipéndula ulmária), male shield fern (Dryópteris fílix-mas), raspberry ordinary (Rúell idáeáus) and French willow (Chamaenérion angustifolium) cover 10-15% of the surface. Meadow rougish grass (Póa triviális) and forest sour (Óxalis acetosélla) have 5 and 7%, respectively, of projective cover. One percent or less is occupied by species such as: marsh violet (Víola palústris), wild strawberry (Fragária vésca), crow pea (Vicia sepium) and tormentil (Potentílla erécta).

The same situation is observed at control sites in pure pine cultures as well as on sites treated with fertilizers and herbicides. Green mosses also prevail and occupy 58%. Wood crane (Geránium sylváticum), meadowsweet (Filipéndula ulmária), bluegrass (Póa trivіális) and goutweed (Aegopódium podagrária) are found in significant amounts. Plants

such as raspberries (Rúbus idáeus), violet (Víola palústris), wood rush (Luzula pilosa), wood louse (Stellária média), nettle (Lámium álbum), peas (Vicia sepium), lingonberry (Vaccínium vítis-idaéa) are also present in small quantities.

4. Discussion

In pure pine cultures, treated with fertilizers, the variety of species increased, but green mosses prevailed significantly more than all other plant species and occupy almost the entire soil surface (76%). The following species are present in small quantities: wood crane (Geránium sylváticum), goutweed (Aegopódium podagrária), raspberries (Rúbus idáeus), wood louse (Stellária média), rose bay (Chamaenérion angustifolium) and meadowsweet (Filipéndula ulmária). Less than 1% is occupied by species such as: peas (Vicia sepium), strawberries (Fragária vésca) and cinquefoil (Potentílla erécta).

In the same pure pine cultures where the soil was treated with herbicides, the main part is occupied by green mosses (Hylocomium splendens, pleurozium schreberi, dicranum polysetum, Ptílium crísta-castrénsis, Rhytidiadelphus triquetrus) (76%). There are also a significant amounts of geranium (geranium sylváticum) (30%), plants such as wild apple (Óxalis acetosélla), meadowsweet (Filipéndula ulmária), violet (Víola palústris), bluegrass (Póa triviális), chickweed (Aegopódium podagrátária), white deadly (Lámium álbum) are present in lesser quantities. At the experimental site treated with fertilizers and where soil was treated with herbicides, the predominance of green mosses on is preserved and they occupy more than 70%. Wood crane (Geránium sylváticum), goutweed (Aegopódium podagrária), meadowsweet (Filipéndula ulmária) and violet (Víola palústris) are present in lesser amounts. Less than 2% are occupied by bluegrass (Póa triviális), wild strawberries (Fragária vésca), lily of the valley (Convallária majális), bloodroot (Potentílla erécta) European starflower (Trientális europaéa), peas (Vicia sepium) and wild apple (Óxalis acetosélla).

In the areas where the control of the development of the scaffolding was carried out with the help of herbicides, the projecting cover of vegetation is more than in the control facilities at which the control of the development of the scaffolding was not carried out. On the test areas in pure pine crops, where mineral fertilizers were used projective coating of live ground cover was more than, on the control version without leaves.

In pure pine crops, the control version of the scaffolding is significantly larger than the test sites where fertilizers were introduced and the herbicides of the scaffolding were not fully available (Fig. 6). However, the number of species of wood and spruce subgrowth is found on the control trial area, where the development of spruce subgrowth is not

damaged in chemical control of spruce. Birch and oak and donkey subgrowth are found in small numbers at the facilities. The resumption of pine at the experimental facilities is not currently observed. In old-age pine crops, the natural resumption of spruce is constrained by the vegetation of the lower tiers and the maternal flat of the tree stand.

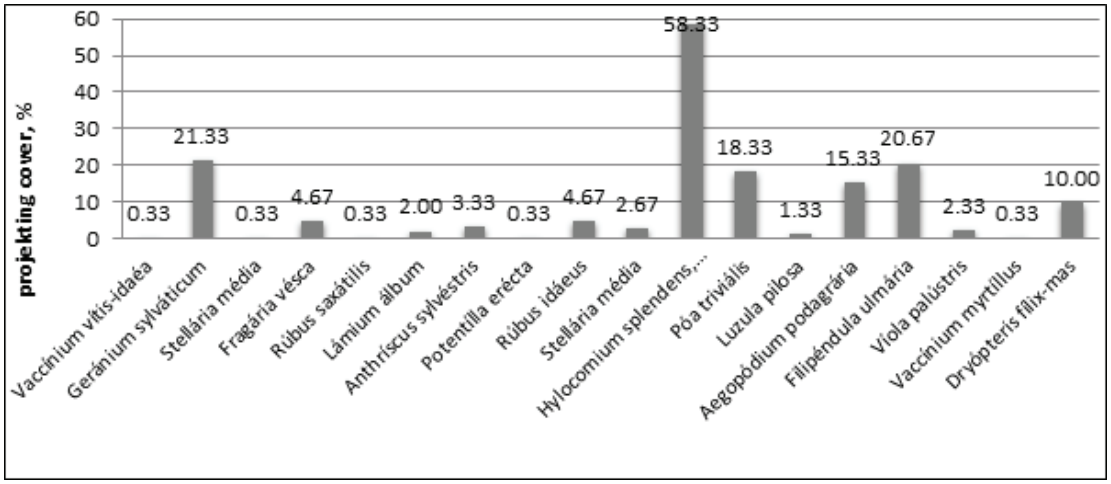

Figure 1: Projecting cover of live ground cover on test area of 100% pine on control test area.

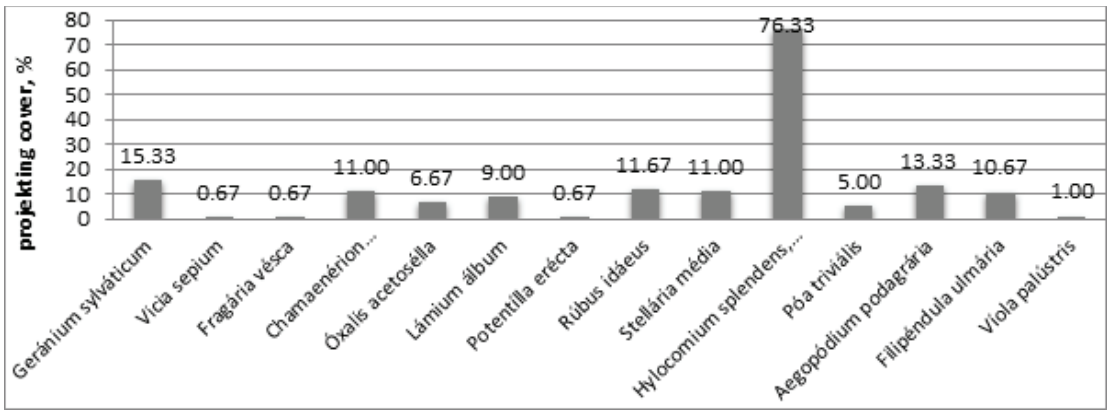

Figure 2: Projecting cover of live ground cover on test area of 100% pine by application of fertilizers.

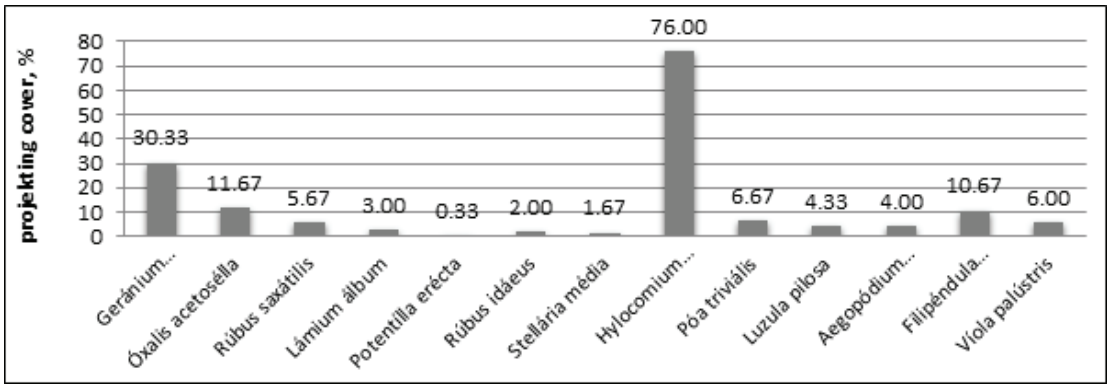

Figure 3: Projecting cover of live ground cover on a test area of 100% pine with herbicide treatment.

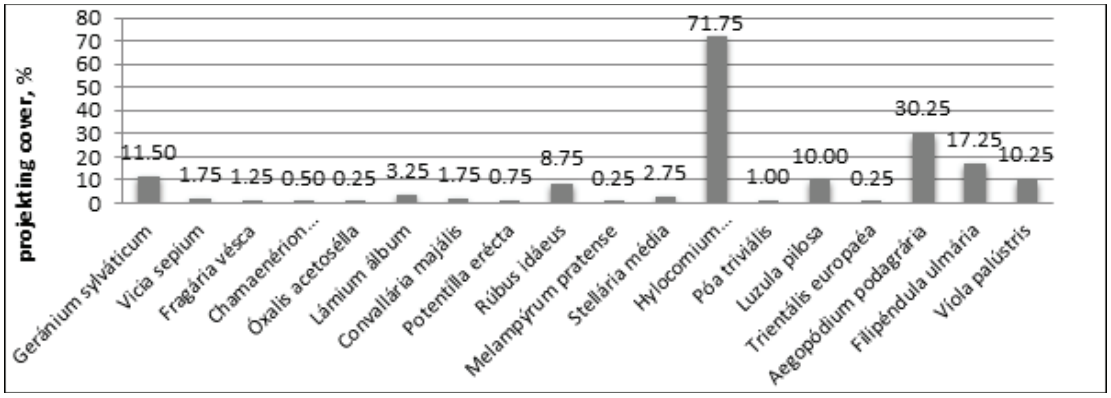

Figure 4: Projecting cover of live ground cover on test area of 100% pine with application of fertilizers and treatment with herbicides.

In the trial area in pine and spruce crops, which were created much earlier than in the rest of the trial areas, the diversity of live ground cover is represented mainly by species of forest vegetation such as: wild apple (Óxalis acetoséla), dog's-mercury (Mercuriális perénnis), buttercup (Ranunculus cassubicus). On all the other squares there are still partially weed herbs, such as wood rush (Luzula pilosa) and bluegrass (Póa triviális). The development of vegetation cover in pine crops passes through 2 phases: the phase of weed vegetation and the phase of forest vegetation.

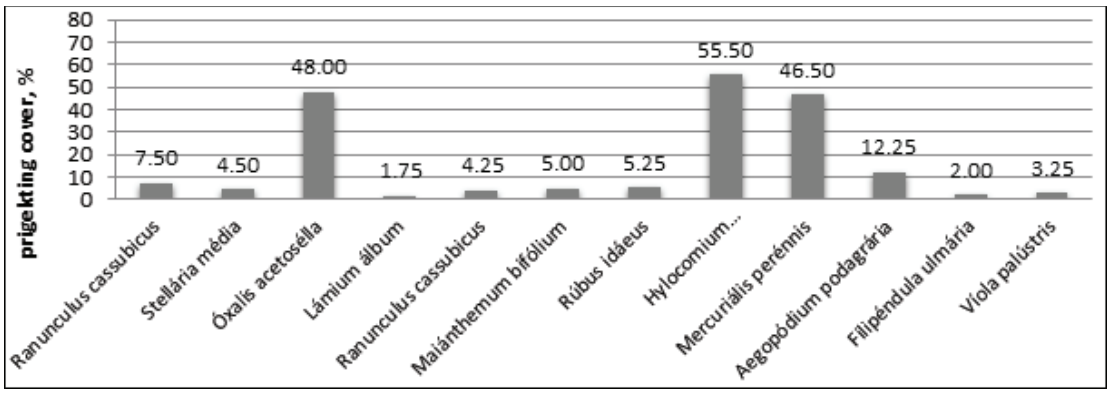

Figure 5: Projective cover of life forest cover on sample plots of 70% pines and 30% spruce.

5. Conclusion

- The land previously used in agriculture has a great potential fertility for the growth of grass, tree and shrubbery vegetation
- Humus content in soils at sample plots cannot be a limiting factor in the growth and development of forest live cover and cannot affect its projective cover.
- The variability of types of vegetation cover is higher in plots not treated with fertilizers or herbicides.

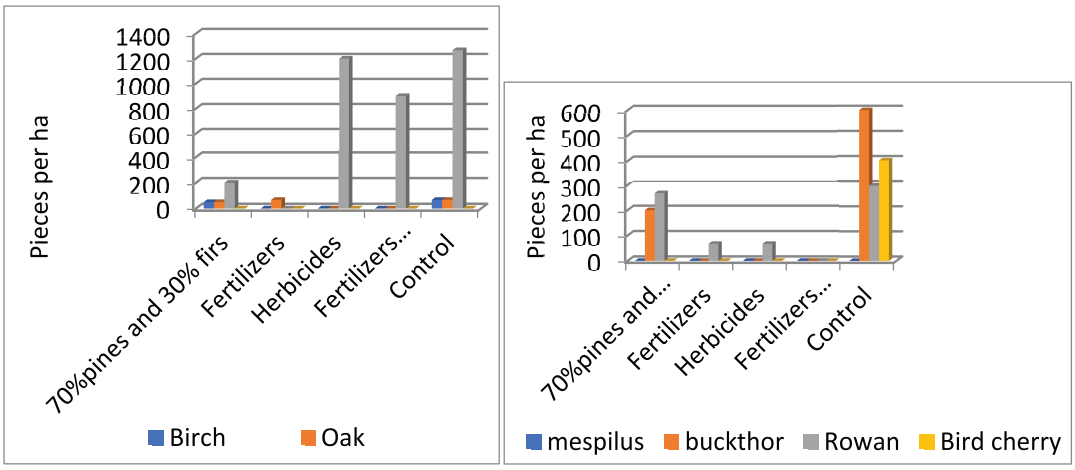

Figure 6: Quantity of wooden pieces at sample plots (pcs per ha).

- In pure pine cultures, the development of forest live cover is observed in the soil of all plots treated with fertilizer.
- The undergrowth development of tree species in plots treated with herbicides and control plots appears to be successful. Quantity of fir undergrowth on these sample plots may create the second growth.
- In plots treated with fertilizers without herbicides the undergrowth is virtually absent due to the development of forest live cover, which suppressed the undergrowth development.
- After the closed canopy, the differences in soil cover are leveled and become more uniform.

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Conflict of Interest

The authors have no conflict of interest to declare.

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