Dependence of natural regeneration of forest-forming species on the structure of the ground cover on postagrogenic lands in the Leningrad region

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Abstract. Regeneration and formation of productive forest stands of commercially valuable species are one of the most important tasks faced by the forest industry. The study of the influence of the ground cover structure on natural regeneration contributes to the appropriate and timely execution of forestry activities. The research was carried out in the Gatchinsky district of the Leningrad region in 2016. In total, five sample plots were established with an area of 0.25 hectares each. In sample plots, all established seedlings were counted. To study the structure and species diversity of the ground cover, the generally accepted method of square sample plots with an area of $1 \, \text{m}^2$ was used. As a result of the study, a direct relationship was established between the number of seedlings and the structural and quantitative indicators of the ground cover.

1. Introduction
Regeneration and formation of productive forest stands of commercially valuable species are one of the most important tasks faced by the forest industry. Ground cover vegetation is an important element of the forest biogeocenosis. Forest phytocenosis resistance to external influences is generally determined by stability of all its components [1-5], including the lower vegetation layers stability. Lower vegetation layers accumulate nutrients that have not been used by forest trees, bind and draw them into the system of the small cycle [6-8]. The study of the influence of the ground cover structure on natural regeneration contributes to the appropriate and timely execution of forestry activities [8-14].

At the same time, post-agrogenic lands have a huge potential for cultivation of highly productive tree plantations. Previous studies demonstrated that fertility of lands that have been out of agricultural use for 15 years or more was similar to the fertility of forest soils of oxalis and blueberry types of growing conditions, on which stands of high productivity grow.

The results of the study make it possible to reveal some features of the regeneration processes occurring in phytocenoses of postagrogenic lands, and will be especially valuable in the development of these lands for the purposes of growing highly productive forest stands.

2. Methods and Materials
The research was carried out in the Gatchinsky district of the Leningrad region in 2016. The objects of research were five sample plots (figures 1 and 2) with an area of 0.25 hectares each. The plots were established on fallow lands adjacent to the floodplain of the Oredezh River and bordering on a pine
and spruce forest. Soil was agrozem of different thickness (from 30 to 45 cm), sod-podzolic, ferruginous illuvial on sands.

In sample plots, all established seedlings were counted. When assessing the ground cover vegetation, the generally accepted method of plant counting on one-meter plots was used [15]. The plots were uniformly distributed along the diagonals of the surveyed area. Further, the projective cover was assessed by individual species on each sample plot and on the research object as a whole.

First of all, at each plot, the total projective cover of the grass-dwarf shrub and moss-lichen layers, and then the projective cover of each species were assessed. All plants of the grass-dwarf shrub layer were split into the following groups: dwarf shrubs; herbs; sedges (*Carex nigra* L., *Carex sylvatica* L., *Eriophorum vaginatum* L.), grasses (*Poa pratensis* L., *Calamagrostis epigèios* L.), and rushes (*Juncus filiformis* L., *Luzula sylvatica* (Huds.) Gaudin).

The total projective vegetation cover of the ground layer was calculated by a simple summation of the corresponding numbers for all species [8].

Also, the distribution of the lower layer species by ecological groups was carried out in accordance with the classification of M D Sibiryakova [5].

![Figure 1](image1.jpg)

**Figure 1.** Sample plot 2. Natural regeneration of Scots pine (*Pinus sylvestris* L.).

![Figure 2](image2.jpg)

**Figure 2.** Sample plot 4. Natural regeneration of European spruce (*Picea abies* (L.) H.Karst).
3. Results and Discussion

Considering in more detail structural changes (figure 3) occurring in the grass-dwarf shrub layer of the study objects, it can be noted that the share of herbs was the largest of all groups. The share of grasses and sedges was much smaller. This suggests that there was no lack of mineral nutrients and no waterlogging in the plots, since mesotrophs and mesophytes grew successfully.

![Figure 3](image3.png)

**Figure 3.** The projective cover of the grass-dwarf shrub layer on the sample plots.

Figures 4 and 5 show the distribution of the ground vegetation into ecological groups. In relation to soil fertility, plants belonging to mesotrophs prevailed, and in relation to soil moisture, mesophytes prevailed.

![Figure 4](image4.png)

**Figure 4.** The proportion of oligotrophs, mesotrophs and megatrophs in the total projective cover.

On all plots, the total projective cover does not exceed 100%, which is associated with the presence of dead ground cover zones (table 1). The layering was not pronounced due to the absence of shrubs.
Figure 5. The share of mesophytes and hygrophytes in the total projective cover.

Table 1. Relationship between the ground vegetation projective cover and tree species numbers.

| SP number | Herbaceous species | Projective cover, % | Total projective cover, % | The number of seedlings of tree species, ind./ha |
|-----------|--------------------|---------------------|---------------------------|---------------------------------------------|
|           | Grasses | Sedges | Herbs | Dwarf shrubs | Mosses |                               |
| 1         | 9.6     | 75.0   | 0.04  | 3.86         | 88.5   | Pine 2684                     |
|           |         |        |       |              |        | Spruce 1105                    |
|           |         |        |       |              |        | Birch 58                       |
|           |         |        |       |              |        | Aspen 121                      |
|           |         |        |       |              |        | Willow 8                       |
|           |         |        |       |              |        | Alder 100                      |
|           |         |        |       |              |        | Total: 4076                    |
| 2         | 24.22   | 57.18  | 0     | 1.9          | 83.3   | Pine 3020                     |
|           |         |        |       |              |        | Spruce 1160                    |
|           |         |        |       |              |        | Birch 16                       |
|           |         |        |       |              |        | Total: 4196                    |
| 3         | 0.4     | 40.3   | 0     | 30.4         | 71.1   | Spruce 3142                    |
|           |         |        |       |              |        | Birch 2212                     |
|           |         |        |       |              |        | Aspen 48                       |
|           |         |        |       |              |        | Willow 2807                    |
|           |         |        |       |              |        | Alder 133                      |
|           |         |        |       |              |        | Total: 8342                    |
| 4         | 1.71    | 30.8   | 0     | 20.8         | 53.31  | Pine 92                       |
|           |         |        |       |              |        | Spruce 4642                    |
|           |         |        |       |              |        | Birch 2360                     |
|           |         |        |       |              |        | Willow 4460                    |
|           |         |        |       |              |        | Total: 11554                   |
| 5         | 36.3    | 50.66  | 0     | 6.0          | 92.96  | Pine 74                       |
|           |         |        |       |              |        | Spruce 2557                    |
|           |         |        |       |              |        | Birch 475                      |
|           |         |        |       |              |        | Aspen 656                      |
|           |         |        |       |              |        | Willow 1623                    |
|           |         |        |       |              |        | Total: 5385                    |
As the data in table 1 show, there is a relationship between the number of tree species seedlings and the total projective cover of the ground vegetation.

A close relationship between the total projective cover and the number of seedlings is manifested in the following: the smaller the total projective cover, the greater the number of seedlings with the simultaneous absence of grasses and sedges (for example, on plot 4).

The smallest total projective cover of the ground vegetation was recorded on site 4 (53.31%). The largest projective cover was noted on plot 5 (92.96%).

The species composition was very diverse; a total of 50 different plant species were found (not counting tree and shrub species). The greatest species diversity of the ground cover was observed on plots 1 and 5. This is probably due to the increased illumination and a sufficient amount of mineral nutrients.

The share of herbs, grasses and sedges in the total projective cover had a significant effect on the natural regeneration of tree species. Competition for light and elements of mineral nutrition takes place between natural regeneration of tree species and the herbaceous layer. An increase in the proportion of grasses and sedges in the total projective cover entails a decrease in the number of seedlings.

The share of mosses increases only on two plots (3 and 4), which can be explained by the increased wetness of these plots, due to which mosses develop actively. At the same time, an increase in the proportion of moss cover in the plots studied does not have a negative effect on the number of seedlings, since on the plots where an increase in the proportion of mosses was noted the total projective cover decreases, which in turn benefits natural regeneration.

Ground cover and grasses in particular, adversely affect the appearance and development of natural regeneration, which is proved by the fact that natural regeneration in all sample plots was either sparse or of medium density.

Due to the absence of dwarf shrubs, no relationship between those and the number of seedlings was found. However, it should be noted that both herbs and shrubs in general create favorable microclimatic conditions in the surface air layer for the appearance and development of natural regeneration. Their presence affects the lighting conditions, and temperature and water regimes of the lower layers of the biogeocenosis and soil. They protect the soil from desiccation, waterlogging and cooling, and reduce temperature fluctuations.

4. Conclusion
As our studies have shown, the success of natural regeneration of tree species in the studied areas was primarily influenced by the herbaceous cover, and the proportion of grass and sedge plants. With an increase of these groups of plants in the total projective cover, the number of seedlings decreases significantly.

In the surveyed areas, there is currently a successful natural regeneration of economically valuable species: pine, spruce and birch.

Under these soil conditions, a stage of young mixed natural regeneration with a predominance of pine following the meadow stage of ruderal vegetation is formed on fallow lands.

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