Ecological and forestry features of broad leaved forest and their role in the conservation of biodiversity in the Novgorod region

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Abstract. The article provides information on the distribution and condition of broad leaved forest in the Novgorod region. A semi-landscape distribution of broad leaved forest sections is presented. Based on the data of 143 sample plots, the biological diversity of broad leaved forest was estimated.

1. Introduction
If the composition of the tree stand is dominated by trees of oak, elm and its species, ash, linden or maple, then such forests are classified as deciduous. Despite a small share in the vegetation cover of the Northwest of the European part of Russia, they have important natural and economic importance. Broad leaved forest usually have a high level of biodiversity [1]; they often perform protective and recreational functions. Interest in valuable wood of deciduous species and non-timber forest products remains relevant. Thus, the study of the distribution patterns of broad leaved forest, their status and biodiversity, is of particular relevance.

Oak forests and other broad leaved forest of the North-West of Russia prefer heavy loam and clay, often mixed with limestone. Topographically, they are associated with various elevations, but are also often found along the shores of lakes, rivers, and in floodplains.

The historical distribution of broad leaved forest was much wider [2, 3]. Grazing, uprooting and cutting down have fundamentally affected the reduction of oak forests. On the territory of the Novgorod region to date, broad leaved forest have formed as a result of prolonged anthropogenic impact. The construction of cities, fortifications, paving of city streets required large volumes of high quality forest, which in the XI-XIII centuries led to a significant reduction in the area of forests with a predominance of oak. The arriving population from the southern regions, choosing places for arable land on the most fertile soils, cleared more and more area, primarily forest tracts on the site of oak groves. Before the invention of soda, potash - potassium salt (mainly potassium carbonate), extracted from the ashes of burned wood of trees of different species, was widely used in households and crafts. The most suitable for potash were hardwood - elm, oak, beech. A huge amount of wood was used in the XVIII-XIX centuries for the construction of the Russian Navy.

As a result of human activity, at present, the forest fund of the coniferous-deciduous forest zone is composed mainly of small-leaved forests (birch, aspen). Such secondary forests are characterized by a
poor species composition of biota, a low level of biodiversity, and they have a simplified tree stand structure. Even the introduction of a conservation regime for forest areas with deciduous species as part of plantings does not fully ensure the restoration of their natural functions.

2. Materials and methods

Based on the data collected, an idea of the current distribution of broad leaved forest in the Novgorod region is obtained (Table 1).

In local areas of broad leaved forest (32 sites), field work was carried out on 143 sample plots, including 105 – in stands with a predominance of deciduous species (in floodplain conditions – 40, in slope conditions – 32 and on open land – 33), also 38 trial plots in deciduous, small-leaved and deciduous-coniferous stands. For the experimental objects, an assessment of the forestry and typological characteristics was carried out, a complete count of the stand was made, taxation indicators of the stands and the state of the stands were determined, and the level of biodiversity was revealed. To clarify the characteristics of the location, we performed soil sections, 112 soil descriptions and 160 soil analyzes were made. Computer programs MS Excel, MS STATISTIKA 6.0. were used for statistical processing of the data collected.

To assess the current state of broad leaved forest in the Novgorod region, we had the opportunity to determine the level of their biodiversity by identifying the botanical diversity of two categories - alpha (species diversity of vegetation) and gamma (typological diversity of plant communities within the landscape). Simultaneously the level of potential biodiversity was also determined through an assessment of habitat features.

We used the Simpson index to characterize the alpha diversity of the vegetation cover. The Simpson index (criterion) is often used to study the species diversity of vegetation, as an indicator that allows taking into account the abundance of species that make up the forest community, along with a simple indicator of species richness [4]. The number of identified plant associations was considered as an indicator of gamma diversity. The identification of deciduous forest associations was carried out in accordance with the principles of the dominant-floristic approach. To determine the level of potential biological diversity of the habitats, we used the Swedish biodiversity accounting methodology, which was finalized and tested by us while working in the Valdai National Park under the Dancee project.

3. Results and discussion

Analyzing the distribution factors of broad leaved forest in the Novgorod region, we associate their modern topography with three large landscape categories:

1. floodplain and floodplain territories (hereinafter - floodplain), the landscape characteristics of which are largely determined by the proximity of large water bodies, such as Lake Ilmen and the Volkov River - landscapes of the Ilmen-Volkov landscape district;
2. the Valdai Upland slope (hereinafter - slope) within the landscapes of the North Valdai, South Valdai, most of the Prevaldai landscape districts;
3. Upland (plakor) habitats located on elevated flattened watersheds (uplands) - in the landscapes of the Polist-Lovat and Luga-Shelon districts.

The predominant concentration of broad leaved forest in floodplains and floodplain areas has been identified. The microclimatic conditions of the floodplain are more favorable for the growth of broad-leaved tree species; there is higher humidity, warmer and less temperature fluctuation. For various landforms, the influence of human activity on forests was not the same: most strongly on uplands (plakors), to a lesser extent on slopes and in floodplains, since these areas are inconvenient for economic use.
Table 1. Identified areas and typological diversity of broad leaved forest by landscape districts and individual landscapes in the Novgorod region.

| Landscape district | Number of forest types | Number of identified plant associations | Landscapes | Area of identified deciduous forest sites |
|--------------------|------------------------|-----------------------------------------|------------|----------------------------------------|
|                    |                        |                                         |            | Ha | %                                    |
| Ilmen-Volkhov      | 3                      | 5                                       | Volkhov    | 1012.0 | 41.49                              |
|                    | 2                      | 6                                       | Low Msta   | 405.4 | 16.62                              |
|                    | 4                      | 6                                       | Near Ilmen | 295.5 | 12.12                              |
| Luga-Shelon        | 2                      | 4                                       | Upper Luga | 12.3  | 0.50                                |
|                    | 3                      | 5                                       | Low Shelon | 233.5 | 9.57                                |
|                    | 1                      | 1                                       | Volot      | 18.0  | 0.74                                |
| Polist-Lovat       | 2                      | 3                                       | Polist     | 123.8 | 5.08                                |
| Lovat              | 1                      | 3                                       | Beglovo-Viny | 4.8 | 0.20                                |
| Prevaldai          | 1                      | 1                                       | Kholova    | 8.7   | 0.36                                |
|                    | 1                      | 2                                       | Polomet    | 8.1   | 0.33                                |
|                    | 3                      | 4                                       | Kholm      | 17.9  | 0.73                                |
| North Valdai       | 1                      | 2                                       | Uver       | 50.0  | 2.05                                |
| South Valdai       | 4                      | 7                                       | Okulovka   | 137.9 | 5.65                                |
|                    | 3                      | 4                                       | West Valdai | 50.5 | 2.07                                |
|                    | 2                      | 5                                       | East Valdai | 60.8 | 2.49                                |

In the distribution of individual deciduous tree species, a certain relationship with soils can be traced. Soils, in turn, are also associated with the relief forms (Table 2).

According to the results of our research, a list of higher vascular plants of broad leaved forest was identified, which includes 66 families, 167 genera, and 256 species. About 20% of floristic diversity is represented in the studied sections of broad leaved forest; it is despite the fact that the modern area of broad leaved forest in the Novgorod region is less than 1% of the region’s area. Also, when describing the soil cover, we identified 12 species of mossy plants.

The distribution of the typological diversity of broad leaved forest by landscape categories and individual landscapes is presented in Table 1. The gamma diversity indicators of broad leaved forest (the quantitative diversity of plant associations) were presented as follows: oak forests – 12 associations in 5 different types of forests, ash forests and maple forests – 2 associations in 1 forest type, respectively, linden forests – 5 associations in three forest types; elm forests – 3 associations in 2 types of forests. Altogether, as a result of the typological classification of broad leaved forest, 24 different associations were identified; oak forests are the most typologically diverse.

Table 2. Distribution of deciduous forest area by prevailing tree species and landscape categories.

| Prevailing tree species | The proportion of the area occupied by broad leaved forest in certain landscape categories, % |
|------------------------|------------------------------------------------------------------------------------------------|
|                        | Uplands (plakor) | Floodplain | Slope |

3
Linden 71.5 2.5 17.3
Elm 11.5 2.0 -
Ash 10.5 0.7 6.6
Oak 6.5 94.8 66.5
Maple - - 8.4
Elm species - - 1.1

The most common indigenous types of deciduous forest associations are characteristic of the North-West, and also occur in the coniferous-deciduous forest zone of Russia and European states [5, 6, 7, 8, 9, 10].

Table 3. The biological diversity of broad leaved forest of the Novgorod region, calculated by various methods.

| Biodiversity criteria | Landscape categories of broad-leaved forest growth |
|-----------------------|--------------------------------------------------|
|                       | Slope                | Floodplain                   | Uplands                |
| Alpha diversity       |                      |                                 |                        |
| criteria              | Average number       | 31 (± 19)                     | 28 (± 16)              | 24 (± 14)              |
|                       | of higher plants     |                               |                         |                        |
|                       | species in the trial |                               |                         |                        |
|                       | plot                 |                               |                         |                        |
|                       | total number of      | 196                           | 183                     | 167                    |
|                       | higher plants        |                               |                         |                        |
|                       | species              |                               |                         |                        |
|                       | Simpson average      | 0.335 (± 0.22)                | 0.304 (± 0.08)         | 0.226 (± 0.13)         |
| Gamma-diversity       | 14                   | 10                            | 9                       |
| Potential biodiversity| 27 (± 6)             | 29 (± 11)                     | 18 (± 8)               |

To assess the potential biodiversity of broad leaved forest, 50 conditionally equivalent indicators were used for 7 categories of habitat conditions. As criteria for differentiation, we used the average indices for floodplain, slope, and upland broad leaved forest. We took into account groups of factors:

- presence and characteristics of dead and dying trees;
- characteristics of water bodies and the degree of moisture;
- general indicators of the stand diversity;
- features of relief and soil;
- taxation indicators of individual trees;
- characteristics of living ground cover;
- impact of animal and human activities.

The total number of recorded indicators for the trial plot was an index of potential biological diversity. The generalized results of the assessment of the biodiversity of broad leaved forest of the Novgorod region are presented in table 3.

4. Conclusion

Thus, characterizing the features of the biological diversity of broad leaved forest of the Novgorod region, we can draw the following conclusions:

- indicators of alpha diversity of vegetation (the number of species of identified plants) are highest for broad leaved forest on the slope of the Valdai Upland (196 species), the lowest (167 species) for upland (plakor) areas. The indicators of the Simpson criterion are consistent with these data and indicate that oak forests and other broad leaved forest associated with the slope of the Valdai Upland are characterized by a higher rate of polydominance;
– floodplain broad leaved forest are characterized by the highest value of potential biodiversity, and the minimum – in uplands (plakor);
– the gamma diversity of vegetation is dominated by sloping broad leaved forest (14 different associations), the least significant among the plakor forests (9 associations).

In general, in the broad leaved forest of the Novgorod region, plant diversity is higher for floodplain and slope plots. For upland (plakor) broad leaved forest, biodiversity is lower by all the studied criteria.

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