Growth features of rare species of the Fabaceae l. family on sod-carboconate soils in the flora of the Novgorod region

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Abstract. The results of geobotanical description of natural landscapes are provided in this paper. The agrochemical characteristics of soils on the studied areas are given. The habitats of rare and genetically significant species of legumes in the flora of the Novgorod region were identified. The soil cover of the Novgorod region is extremely complex and diverse, which is due to the large heterogeneity of the terrain, the diversity of soil-forming rocks and the difference in the bioclimatic situation in its areas. Millennial anthropogenic activity also left its strong imprint on the soil pattern. In the soils of the region, depending on the features of the parent rocks and other conditions, the nature of the horizon also changes. In some cases, it is metamorphic, in others - eluvial-illuvial or illuvial. Morphological differences are reflected in the chemical and physical properties of the respective layers. The development of sod-podzolic soils on carbonate moraine, common in all natural areas of the region and known as sod-podzolic residual carbonate, is characterized by varying degrees of secondary saturation of the bases of the upper horizons or only weak unsaturation with distinct morphological podzol content. The deceleration rate of the podzolic process depends both on the intensity and method of cultivation, and on the saturation degree of rock carbonate content, the depth of the carbonate occurrence and its nature. The features of formation, structure, properties and classification of sod-carbonate soils of the Novgorod region are observed in this research. Data on agricultural use of various subtypes of sod-carbonate soils in comparison with sod-podzolic soils are presented below.

1. Introduction

The presence of carbonates in the soil profile along the banks of the Msta river contributes to a greater accumulation of humus, a decrease in acidity and the development of a soil-forming process other than podzolic [3]. Depending on the depth of carbonate occurrence in automorphic conditions, sod-carbonate or sod-podzolic soils develop.

Widespread depletion of the plant genetic pool leads to disruption of the normal functioning of natural ecosystems. Currently, bioecological studies of species and their ecological-ecenotic confinement are carried out, which is one of the components of the modern ecological forecasting of the development of natural cenoses [5, 7]. The stability and natural renewal of plant populations are essential factors expedite the floristic diversity of vascular plants in the flora of the region.

The aim of the research was to conduct geobotanical studies of meadows located on sod-carbonate soils to preserve the biological diversity of plant communities and maintain high productivity of natural forage lands.
2. Methods and Equipment
For 15 years, geobotanical studies were conducted to describe the flora of the Novgorod region by the method of geobotanical studies of the All-Russian W. R. Williams Fodder Research Institute (1971). Structural analysis was carried out in 50 plants during harvesting, the length of the sprout was measured, the number of sprouts in a bush was counted, the number of branches of the first order, the length of the internode, the number of internodes, the length and thickness of the main sprout were calculated. The weight of the plant, the weight of seeds from the plant, the degree of leafiness of plants (%) were determined.

The obtained data of floristic studies became the basis for the preparation of the Red List of Threatened Species and the organization of complex work of specially protected natural areas of the Novgorod region. The herbarium fund of the department of Crop Production, Biology, and Biological Chemistry of the Yaroslav-the-Wise NovSU School of Agriculture and Natural Resources, the department of Botany of St. Petersburg State University, as well as the herbariums of the L.V. Komarov Botanical Institute of the RAS, N.I. Vavilov All-Russian Research Institute of Plant Industry were supplemented. The created information retrieval system and computer database are used when working with the herbarium at the departments of Crop Production, Biology and Biological Chemistry of the Yaroslav-the-Wise NovSU School of Agriculture and Natural Resources.

3. Results
The species of plants with high environmental sustainability and their communities were formed in the process of natural selection. Each plant species has different habitat requirements and performs certain ecological functions in specific phytocenoses, so the inventory of flora is of scientific and practical importance [1]. The strategy for the conservation of plant species in Western Europe also focuses on the regional level. Around the world, special attention is paid to the conservation of in situ and ex situ habitats of cultivated plants and their wild relatives.

Coenoses with the dominance of Medicago falcata in the flood meadow of the Msta River were identified. The valley of the Msta River is very heterogeneous for 445 km of its way. In the area from Opechenskiy Posad to Borovichi, the floodplain is poorly developed, the riparian strip and the islands in the channel with the height of 1.0–1.5 m, not subjected to grazing, are occupied by communities with the predominance of Medicago falcata, especially in the area of Bobrovichi Mountains. This formation occupies different heights – from 30 to 40 m above the low water, often directly at the channel, and sometimes retreating deeply into the floodplain at 150–200 m.

The vegetation of the studied natural meadows located along the Msta river was formed without purposeful human intervention [2]. Soils of these meadows differ in fertility, soil solution reactions and the content of mobile forms of phosphorus and potassium (table 1). Currently, the agricultural use of these meadows is characterized by rare and not regular mowing.

According to table 1, the soil is sufficiently provided with mobile forms of phosphorus, slightly lower potassium content, especially in the soils of dry meadows – 5 mg/100 g of soil. The highest nitrogen content was observed in the floodplain meadow of the middle level of waterlogging. In general, the high content of humus indicates a high level of fertility of these soils. All these differences had a certain influence on the formation of ecotopes of wild legumes in the Novgorod region. Lowland meadows are the most characteristic forage lands for the Novgorod region. They are usually located on sod-gley, gley and marsh-podzolic soils; close location of groundwater to the soil surface is regarded as the determining factor of the water regime. As a result, there is a short-term (up to 15 days) waterlogging of the meadow. In this ecotype, meadow timothy-marsh-bluegrass association with the dominance of Poa palustris L. was formed. Trifolium pratense L., T. hybrida L., Lotus corniculatus L., Vicia cracca L., Medicago falcata L., as well as representatives of such herbs as Tanacetum vulgare L., Cirsium setosum Willd grow in dry areas. Considering the abundance of growing species, this plant formation was referred to the herbaceous-legume type. A specific feature of this meadow is bushification. The scrub constitutes about 23 % of the total area of the meadow. The possible yield of such meadows is 1.5 tons of hay per 1 ha.
Table 1. Agrochemical characteristics of soil on study areas.

| Study area                                | Humus, % | pH in KCl | N, %  | Soil content mg /100 g |
|-------------------------------------------|----------|-----------|-------|------------------------|
| Floodplain meadows of average level of waterlogging | 7.2      | 5.6       | 0.39  | 14.5 14.2              |
| Floodplain meadows of high level of waterlogging | 3.4      | 5.4       | 0.23  | 14.3 13.8              |
| Upland meadow                             | 5.0      | 5.7       | 0.28  | 19.2 5.0               |

The water regime of the upland meadows located on plains and slightly lowered territories of watersheds is determined mainly by moisture of atmospheric precipitation. In the spring there is accumulation of melt water, so these meadows are temporarily excessively moistened. The herbage of these meadows is dominated by Phleum pratense L. In certain years, a hybrid-clover-meadow-timothy association is formed. The floristic composition of the herbage includes such species as Deshampsia caespitosa L., Festuca pratensis L., Poa pratensis L., Trifolium pratense, T. hybridum, Achillea inundata L. – motley grass-legume-cereal herbage. These meadows are used for mowing and grazing of farm animals.

It is known that the underground karst caverns are continuously eroded by water, the terrain is constantly and unpredictably changing. Investigation of dry riverbed of the Paneretka, for example, showed that the banks are overgrown with trees and shrubs. The pattern of a constant decrease in the water content of this underground river is also noted. Back in the 60s, the karst cavities were shallow, and now their depth has increased to 4-6 meters. Mountain Msta is a unique corner of nature which needs a close and constant study and – necessarily – protection. There is a rare combination of different types of soils formed on the sands and clay, carbon deposits brought by the glacier, a lot of different meadows with rich vegetation. We were particularly struck by the Bobrov Mountains, where you can see the whole range of meadow communities, on terraces exposed to winds and erosion, small “hanging swamps” from the springs. It is the habitat of rare species of Astragalus danicus L. and root-spray forms of Medicago falcata L., Lathyrus sylvestris L. [3].

Borovichi district is rich in species diversity (26 species of which 3 are rare ones). The village Rodnoe (meadow of low-lying terrace of the river Msta) is the habitat of such rare species as Astragalus danicus L.; coniferous slopes in lichen ecotope is the habitat of A. arenarius; the village Egla (left bank of the river Msta) is the habitat of Anthyllis macrocephala. During the research period, it was found that the number of plants in the juvenile period increased from 2 to 4, immature - from 4 to 5, virginal - from 3 to 9, generative from 10 to 20 species. Among the studied species, the maximum number of plants at generative age was noted in Anthyllis macrocephala, which indicates its stability, since the community contains species of all age groups and provides regular seed supply (table 2).

The density of species increased by 1 m². These species have become less vulnerable as the percentage of seed formation has increased from 3 to 25%. All other species have the maximum number of generative species. The maximum number of generative plants was noted in Astragalus danicus – 53.8% and Anthyllis macrocephala – 52.6 %. These species were found in one habitat – in the vicinity of the village Rodnoe (sandy riparian shaft meadow terrace on the right bank of the river Msta, bank of medium steepness, southern exposure). We suggest the area where several species of rare plants grow in a community at the same time, to be taken under protection and to create an ecological path.

High recreational load, pollution, economic activity are the threatening factors to these species, so it is necessary to conduct systematic observations and registration of their locations. The population of Lathyrus sylvestris is confined to the riparian terraces of the Msta river.
### Table 2. Age composition and number of rare species (from 2000 to 2007).

| Age group | Number | *Astragalus arenarius* | *Astragalus danicus* | *Anthyllis macrocephala* |
|-----------|--------|------------------------|----------------------|--------------------------|
| Juvenile (j) | absolute, species | 2 | 4 | 4 |
| | relative, % | 8.7 | 15.8 | 10.5 |
| Immature (im) | absolute, species | 4 | 5 | 5 |
| | relative, % | 17.4 | 19.2 | 13.1 |
| Virginal (v) | absolute, species | 7 | 3 | 9 |
| | relative, % | 30.4 | 11.5 | 23.7 |
| Generative (g) | absolute, species | 10 | 14 | 20 |
| | relative, % | 43.5 | 53.8 | 52.6 |

### 4. Discussion

The habitats of the vast majority of the identified legume species have probably already stabilized in the study area and there is no trend towards a wider distribution of these species, which certainly does not exclude such changes in the future. The dynamics of their vegetation is now expressed in the expansion of the range of their habitats, increase in the degree of naturalization, as well as the introduction of *Medicago varia*, *Trifolium sativum* in natural and semi-destroyed plant communities. *Medicago lupulina*, *Melilotus albus*, *M. officinalis*, *Lotus corniculatus* are confined to disturbed habitats formed under the influence of both natural and anthropogenic factors (riparian cliffs, gravelly slopes of river valleys, sandy wastelands, deposits), they also inhabit outcrops and limestone rocks.

Getting hillock, swampy with sphagnum mosses, high recreational load, environmental pollution, economic activity are the factors adversely affecting the species diversity of the meadows. Therefore, it is necessary to conduct systematic observations and environmental monitoring of meadow vegetation.

When deciding on the priority of development of sod-podzolic soils, the preference should be given to soils developed on carbonate rocks. The deeper the carbonate horizon lies, the harder, longer and more expensive the cultivation is. When the carbonate horizon lies below 110–130 cm from the surface, its influence on the overlying horizons becomes hardly noticeable. The most important agricultural activity in the cultivation of soils with a deep carbonate horizon (deeper than 60 cm), along with the introduction of mineral and organic fertilizers, is liming.

### 5. Conclusion

According to the results of geobotanical studies, it was found that the flora of the Novgorod region is represented by 33 families, 102 genera, 268 species. The largest families by the number of genera are *Poaceae* 24 (23.5%), *Fabaceae* and *Rosaceae* 10 (9.8%) and, respectively, by the number of species – 61 (22.7%), 42 (15.7%) and 36 (13.4%). The richest in species diversity was Batetsk, Borovichi and Soltzye districts were determined as the richest in species diversity areas of the Novgorod region.

Monitoring of plant species growing in natural cenoses allowed identifying new habitats of *Astragalus danicus*, *A. glycyphylus*, *Anthyllis macrocephala*, *Lathyrus palustris*, not previously mentioned in the “Inventory of Flora of the Novgorod Region” and describe their morphological characteristics and biological features of growth and development.

### Findings

The work was performed in 17 administrative districts of the Novgorod region in the period from 1998 to 2017. The collection of factual material was carried out during a route-reconnaissance survey of the
territory of the Novgorod region. The author personally made more than 2400 descriptions during the field seasons.

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