Biodiversity of the Ilmen Klint

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Abstract. The Ilmen Klint is a geologically formed landmark located in the Shimsky and Starorussky districts of the Novgorod region. Its location area is the western part of the southern shore of Lake Ilmen and covers the delta of the Lovat and Shelon rivers. A characteristic feature of the soils of the banks of the Psizha river is the presence of laminated dense crystalline yellowish-brown limestones. In the upper part of the Ilmen Klint, near Buregi village, brown limestones have formed. The modern vegetation cover of the Ilmen Klint has resulted from a long historical process and now continues to undergo changes. The main role in this is played by the human, their economic activities. In 2001, the Ilmen Klint was accorded the status of a Specially Protected Natural Area (SPNA) of the Novgorod region in order to preserve and study its natural diversity and maintain its ecological balance. The carried out floristic studies made it possible to describe natural habitats with a rich floristic composition and equity participation of Lathyrus pratensis L., Medicago falcata L.: Medicago lupulina L., and Anthyllis macrocephala L. species. The meadows and outcrop areas of the Ilmen Klint are characterized by a high diversity of rare species with certain patterns of meadow community development. At a high coastal slope level, there is a dry meadow with a herb-foxtail community. In addition, the participation of crop wild relatives (CWR) in natural plant communities of the Ilmen Klint territory is considered. Species of the Fabaceae L family are the main source of CWR here. Human well-being depends on the conservation of biodiversity and biological resources, particularly plant resources.

1. Introduction

A unique element of the landscape of the North-West of Russia is the Ilmen Klint formed in the Starorussky district. The Ilmen Klint has the form of a cliff represented by the Devonian outcrops and is the only natural monument on Russian territory. The length of the coastline is 8 km, between the villages of Korostyn and Pustosh, the height is up to 15 m.

Natural outcrops are represented by clay, sand, and carbonate rocks and are relevant for further scientific research. In this area, the underlying rocks, on which leached and typical sod-calcareous soils have formed, are widespread. A number of authors have found that the granulometric composition of water-glacial deposits and the depth of the underlying rocks of the studied soils have unfavorable agrophysical properties [1, 2]. The dependence of organic matter content, water-physical quantities on the range of particles of physical clay is demonstrated [3, 4]. The preserved vegetation cover of the Ilmen Klint appeared long ago and is currently undergoing significant changes and anthropogenic impacts [5, 6]. Human economic activity plays the major role [7, 8]. This area is well developed, and the land is in agricultural use.
2. Material and research methods
The material for the research was personal herbarium collection and field observations carried out from 2017 to 2020. The research object was meadow communities, rare and calciphilous plant species growing in natural areas of the Ilmen Klint. The taxonomic affiliation of the growing species was identified using the manuals of N. A. Minyaev (1981) and N. N. Tsvelev (2000).

3. Discussion and results
In view of the high attendance of the Ilmen Klint and the agricultural development of the adjacent territories, the threat to natural populations, in which rare species grow, is increasing and their further preservation is necessary. The anthropogenic impact on natural communities is gradually growing; there is an abrupt change in climatic conditions, which in turn requires monitoring and protection of the CWR and valuable plant species [2, 3]. Currently, their conservation in the SPNA network of regional significance is becoming increasingly important. One of the monitoring stages is the inventory of plant species diversity for their further conservation.

The purpose of the research is to study the soil and vegetation cover of the Ilmen Klint and to identify plant species that need protection.

Over the centuries, the lands of the Starorussky uyezd were actively developed and considered one of the most fertile in the Novgorod province. The soil cover of the Starorussky district is diverse and depends on relief heterogeneity, parent rock diversity, and the bioclimatic features of the territory. The nature of the horizon depends on the nature of the parent rock, and morphological differences depend on the chemical and physical properties of the respective layers. In the territory, the amount of precipitation is higher than the evaporation rate, which had a significant effect on the leaching water regime in soils and on the podsol-forming process. Sod-podzolic soils on the carbonate moraine, widespread in the Ilmen Klint area, are characterized by the saturation of the bases of the upper horizons. The rate of development of the podzol-forming process depends on the use of soils, the method of increasing their fertility, the nature and depth of the parent (carbonate) rock.

The largest massifs of sod-calcareous soils are widespread in the Starorussky district since in this territory, bedrock carbonate sedimentary rocks of the Devonian age have been formed. Sod-calcareous soils, typical for the Ilmen Klint, have formed on the parent calcareous rock and loam with a small carbonate thickness, therefore, rubble soils have formed (figure 1).

![Figure 1. General view of the sod-calcareous soils of the Ilmen Klint.](image-url)
is located up to 60 cm, then such soils should be cultivated with the introduction of estimated doses of mineral and organic fertilizers and with obligatory liming. After liming, the acidity of the arable soil horizon decreases, which in turn contributes to better plant nutrition, mobile forms of K₂O and P₂O₅ become available, which leads to increased potassium fixation.

Plants with high environmental sustainability, as well as their communities, have formed in the process of natural selection. Each plant species has relevant requirements for growing conditions. All over the world, the conservation of plant species is carried out at the regional level; it is necessary to ensure nurseries and natural growing conditions of cultivated plant species and their CWR.

Plant species adapt to specific growth and development conditions. In the Starorussky uyezd, Lathyrus pratensis L. was considered the main component of the herbage. Attention was drawn to these plants, because they were dominant and had a significant effect on the herbage of the slope, where, despite the lack of soil moisture, they formed high fodder and seed productivity.

Lathyrus pratensis L. grows on fallow lands. Basal shoots appear, with the help of which vegetation is resumed. Spring aftergrowing occurs with pubescent shoots ranging in height from 78 to 112 cm. Vegetative shoots have the shape of vines and cling to other plants with tendrils. The shoots are ascending with subsequent branching up to 1 m long, indistinctly quadrangular. The leaves are paripinnately compound with a grooved stalk, oblong-lanceolate leaflets, and large ovate-lanceolate stipules. The flowering is long: from June to late July; the flowers are boat-shaped, yellow. The generative organs form from 3 to 12 racemes in the leaf axils. The fruits are oblong-linear and many-seeded: there are up to 10 seeds in the pod. The seeds are globular, yellow, brown or almost black with marble-like spots. In natural habitats, Lathyrus pratensis L. plants occupy a certain ecotope, population, or grow in clumps. Usually, its participation in the cenosis varies from 10 to 15 %; the number of the species depends on the weather conditions of the growing season.

Medicago falcata L. has a high level of participation in natural cenoses; it has long been considered one of the most valuable plants in the meadows with a high competitive ability [9, 10]. The morphological characteristics of the Medicago falcata L. population are determined by the interaction of its genetic potential and resistance to the environment, which includes factors of living and non-living nature. We have identified the Medicago falcata L. ecotypes: meadow-mesophytic.

Plants of a meadow-mesophytic ecotype have been characterized by numerous creeping shoots, tall (from 87 to 114 cm), without pubescence. The maximum number of internodes is up to 12. The number of shoots depends on the age of the plant. In mature Medicago falcata plants of 8-9 years, there is a gradual lignification of the shoot at the base of the root collar; renewal shoots are derived from the basal axillary buds formed on the main stems (figure 2). The leaves are three-lobed, the upper part is without pubescence, and the lower part is pubescent, the leaflets are oblong-ovate, the base is wedge-shaped, the serratures are pronounced along the edges. The flowers, arranged in multi-flowered inflorescences composed of 20–25 flowers, are yellow (bluish in buds), globular, lax, with long peduncles: from 1 to 3 cm. High up to 40 % setting of the pods. The pods are 1.5–2.1 cm long, crescent-shaped, light brown, bare; the number of seeds is from 5 to 6, the seeds are angular, dark brown.

The habitat of the meadow-mesophytic ecotype is the bank of the Psizha river in the Starorussky district. This ecotype prefers dry meadows, rich calcareous and well-drained soils, as well as areas with a disturbed natural cover and fallow lands.

We described the cenopopulation by the presence in its composition of individuals differing in age, viability, and by the number of individuals per unit area. The identified populations of Medicago falcata L. made it possible to describe the morphological characteristics of the plants and their relation to fodder productivity. The study and substantiation of the morphological features of Medicago falcata L. plants were based on a systemic analysis of the productivity, within which agrophytocenosis was studied as a single functioning system. Studying cenopopulation productivity elements, we have identified that one of the factors in the yield formation is the amount of photosynthetic active radiation (PAR) per crop unit and the amount of interaction with environmental conditions. This analysis will determine the relationship between the biological characteristics of growth and development with the production
process. In natural cenoses, the cenopopulation of Medicago falcata L. is located unevenly with a projective cover of up to 57%.

Obtained data on the age state of Medicago falcata L. plants, growing on the Ilmen Klint in Starorusskoy district, is as follows. Based on the results of our studies, we have identified that a high average daily growth, the percentage of leafiness, and the number of shoots were noted in the juvenile plants, and the duration of this period lasts up to three months. Well-formed juveniles turn into immature ones, which in turn form vegetative and young generative shoots. Plants with a large number of vegetative shoots are characterized by vegetative renewal and the aging is gradual, while plants with seed renewal form generative organs with high seed productivity. Medicago falcata L plants with vegetative propagation are recommended to be used as a starting material for the creation of varieties for pasture and haymaking use.

Medicago lupulina L. plants growing on fallow lands are represented as a long-term form of development, although they are found everywhere as an annual. This type formed up to 34 pieces, thin-stemmed, well-leafy shoots with a shortened internode (about 4 pieces), and a lax basal rosette (figure 3). In the flowering phase, its height reached 43 cm.

The leaves are ternate, obovate, with a wedge-shaped base, marginal, slightly dentate in the upper part. The inflorescence is oblong-ovate and composed of 18–25 small yellow flowers. Pods are reniform, from 0.2 to 0.3 cm long, single-seeded, black when ripe, covered with dense glandular hairs. The seeds are yellow-olive, elongated-elliptical, and are distinguished by high hardness. The plant blooms from June to the beginning of cold weather, bears fruit in July–September.

Based on the results of geobotanical studies, we have established a high proportion of annual and biennial forms of development of Medicago lupulina L. plants; in the Novgorod region, its perennial form, a very rare one, has been once noted and described.

The identified and described Anthyllis macrocephala L. is a perennial plant with thin erect shoots up to 59.4 cm high. Strong basal rosette with large leaves, leaf length is up to 4.2 cm, its width is 1.9 cm, and its quantity is from 3 to 4 pieces. On the stem, the leaves are located every 9 cm. The stem usually ends with 3 large fasciated inflorescences. The inflorescence is multi-flowered and composed of 14–16 flowers with 13 seeds per anthodium. The plant blooms from late June to July, bears fruit from July. In natural growing conditions, the number of Anthyllis macrocephala L. plants is small. In the flora of the Novgorod region, Anthyllis macrocephala L. is a rare endangered species; it is listed in the Red Data Book of the Russian Federation and must be protected in its natural habitat.
4. Conclusion
To identify the modern ranges of species, it is necessary to carry out floristic, ecological-cenotic, and botanical-geographical studies, to identify anthropogenic dynamics, population, which is important for establishing the most expedient and optimal ways of their preservation in the composition of natural ecosystems.

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