Edaphic conditions for the formation of larch crops in the Petrovskaya larch grove of the Leningrad region

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Abstract. Larch is a valuable species, therefore, its breeding in areas that are wider than the natural range of this species is fully justified. In the conditions of the North-West of Russia, there are examples of successful cultivation of larch. Comprehensive long-term studies are being carried out in these areas. In this work, the prevalence of larch crops in the Leningrad region of Russia, including in unique natural monuments, such as Lindulovskaya grove and Petrovskaya larch grove, has been investigated. The ground cover and soil conditions in larch crops have been studied. The results of studies of morphological and chemical properties of soils and their fertility have been presented. The necessity of choosing rich soil conditions for the cultivation of highly productive larch plantations in the North-West of the Russian Federation have been proved.

1. Introduction
The history of the creation of Sukachev's larch cultures in the north-west originates from the Lindulovskaya grove, which, according to I S Melekhov, “was the first example of the success of larch cultivation outside its natural range” [1]. In the European part of Russia Siberian larch (Larix sibirica LEDEB) is distributed to the east of Lake Onega and the White Sea and extends to the southern foothills of Ural. The wide range of this breed is due to its rather wide ecological range. It tolerates both low and high temperatures, it is found in permafrost conditions and in sphagnum bogs. However, it reaches the highest productivity only on fertile, well-drained, fresh loamy and sandy loam soils [2].

Soil conditions as part of the ecotope are one of the fundamental factors in the formation of the stand and phytocenosis in general. Forest types are mainly confined to certain soil and hydrological conditions.

2. Methods and Materials
The object of the study was selected Siberian larch cultures in the Kirov forestry of the Leningrad region, namely the Petrovskaya larch grove, which is a botanical natural monument. These cultures are named after the nearby village "Petrovshchina" and located not far from the so-called Archangelogorodsky tract, which runs along the edge of the Baltic-Ladoga Glint. This road turned out to be unclaimed after the construction of the Murmansk highway in the 50s of the last century. However, it is suitable for use, as it goes along the outcrops of Ordovician and Devonian rocks and remains passable and strong. Forestry workers and the local population lay routes along it.

The cultures were planted around 1856-1859 and belong to areas with relict tree species excluded from final felling. Documents confirming the time of planting or information about who planted it...
were not found, but there is an opportunity to study the growing conditions of this breed, unique for the northwest. First of all, it turned out to be interesting to study the soil conditions of larch growth.

Now, the area of the grove is about 2.5 ha, although the original planting area was 1.5 ha. The studied plantings have a stand composition - 10 larch trees, age - 161 years, forest site type - A2, yield class - I. Forest site type is A2 - cowberry forest, however, during a reconnaissance survey, we found that the type of forest is close to forbs (figures 1, 2).

**Figure 1.** Larch cultures.

**Figure 2.** Live ground cover.

The live ground cover is represented by numerous herbaceous plants: caustic buttercup (*Ranunculus acris* L.), wild chervil (*Anthriscus sylvestris* L., HOFFM), snapdragon (*Antirrhinum* sp.), meadow timothy (*Phleum pretense* L.), cocksfoot (*Dactylis glomerata* L.), common dandelion (*Taraxacum officinale* L.), bird vetch (*Vicia cracca* L.), wild strawberries (*Fragaria vesca* L.), wild strawberries (*Fragaria vesca* L.). Megatrophs are often found, such as Greek valerian (*Polemonium caeruleum* L.), common lady's
mantle (*Alchemilla vulgaris* L.) and base vervain (*Veronica chamaedrys* L.), and the plants included into the endangered-species list, for example, spotted orchis (*Orchis maculata* L.)

The cultures are located in the upper part of the Baltic-Ladoga Glint, which stretches from the Volkhov River to the Paldiski city and further along the bottom of the Baltic Sea to the coast of Sweden. It is an essential element of the relief of the northern part of the East European Plain and separates the Ordovician plateau from the Cambrian (Preglint, Primorskaya) lowland. [3] The Ordovician Plateau is located in the western part of the Leningrad Region south of the Gulf of Finland in the interfluve of the Luga and Tosna rivers. The parent rocks of the Ordovician plateau are Quaternary glacial and water-glacial deposits. Most of the moraine deposits are of the bottom moraine type, especially strongly enriched in calcareous boulders. A characteristic feature of these deposits is the participation of dolomitized limestones in their composition.

The limestones of the plateau rarely come out on the day surface; they are mainly located on the tops and slopes of moraine ridges. In this case, the soils are formed on the eluvium of limestone [4].

The composition of the rocks composing the Glint is the same throughout its entire length: its lower part is Cambrian clays, above it lies the Cambrian-Ordovician sandy stratum, overlain by Ordovician limestones on which strata of Quaternary deposits were formed, namely boulder loams and clays.

During the 17th-18th centuries, Glint limestones were mined for construction. Numerous foundations of buildings in St. Petersburg and its environs were built from limestone (figure 3).

![Figure 3. The foundation of the Gauswald mansion on Kamenny island.](image)

The foundations of houses in nearby villages are also made from this limestone. In appearance, limestone is of a variegated color and its density is quite high, which determines the durability of products made from it. According to its mineralogical composition, limestone is organogenic, the content of dolomite in it reaches 25%, the structure is crystalline with inclusions of glauconite grains up to 20% with separate small leaching voids. Single crystals of quartz and the presence of phosphates up to 2% are observed [3, 5]. Subsequently, the production was stopped, and the territory was overgrown with grasses and was used as hayfields. Larch cultures were planted on some of the hayfields, the rest of the territory is still used for haymaking.

The forestry planted cultures of Scots pine, European spruce and Siberian larch on the agricultural area in 2008. At this point, the result can be assessed visually (figure 4).
Figure 4. Forest stands: (a) pine, (b) spruce, (c) larch.

2.1. Methodology and scope of work
The work program provided for the study of the morphological and chemical properties of the soil. To study the morphology, two sections were laid in two experimental plots: experimental plot 1 - part of agricultural land, experimental plot 2 - Siberian larch culture. Simultaneously with the morphological description of the soil, soil samples were taken for chemical analysis, carried out in the laboratory of the Department of Soil Science according to standard methods [6].

3. Results and Discussion
The morphological description of the soil section embedded in the crops is given in Table 1.

| Index  | Depth (m) | Morphological description of the soil horizon                                      |
|--------|-----------|-----------------------------------------------------------------------------------|
| O      | 0-3       | Forest litter, dark brown, grasses, strongly decomposed, smooth transition.        |
| ACa    | 3-16      | Humus, black-brown with white spots, granular, loose, light loamy, roots, clear transition. |
| ACa    | 16-39     | Transient, light with white spots, coarse, dense, light loamy, roots, smooth transition. |
| C_Ca   | >39       | Limestone                                                                         |

3.1. Soil: Sod-calcareous typical light loamy on limestone
In the laboratory, the granulometric composition was determined from the selected samples of the mineral horizons. The soils are light loamy. Soddy-calcareous soils are found fragmentarily and are confined to territories composed of carbonate rocks - dolomites, marls, marbles, limestones [7].

3.2. Laboratory research results
The data of the conducted agrochemical studies are shown in Table 2.

The indicator of the potential acidity of the soil makes it possible to classify them as mildly alkaline, which is typical for soils of this type.

In terms of the content of organic matter, the studied soils are classified as well-supplied (table 2). The humus index on average reaches 12%, and the humus content drops sharply with depth, while maintaining high values, which is typical for soddy-calcareous soils. Such soils are favorable for the formation of megatrophic vegetation and good growth of larch.
Table 2. Agrochemical indicators of the studied soils.

| No| Hiᵇ | Hdᶜ | Hcᵈ | Meᶜ | Ph | Ph | Bsᵈ | Meᶜ |
|---|-----|-----|-----|-----|----|----|-----|-----|
|   | Caₐ | Caᶜ | Caᶜ | Caᶜ | Caᶜ | Caᶜ | Caᶜ | Caᶜ |
| 1 | 4-20 | 16.3 | 5.07 | 45.2 | 7.5 | 7.2 | 89.9 | 19.7 |
| 1 | 20-36 | 2.5 | 0.17 | 47.5 | 7.8 | 7.7 | 99.6 | 32.0 |
| 2 | 3-16 | 16.7 | 1.05 | 48.7 | 7.8 | 7.4 | 97.8 | 21.5 |
| 2 | 16-39 | 7.3 | 0.17 | 46.5 | 7.9 | 7.7 | 99.6 | 17.5 |

ᵃNo – No of soil section, ᵇHi – Horizont index, ᶜHd – Horizont depth, ᵈHc – Humus content, %, ᶜⁿMe – Milligram equivalent per 100g of soil, ⁴Ha – Hydrolytic acidity, ⁵Bs – Base saturation, %

In terms of potassium content, the soils are poorly supplied, the potassium content does not exceed 7.6 mg equivalent per 100 g of soil.

The content of available phosphorus in these soils is high, which also favorably affects the forest stand and phytocenosis in general.

The degree of base saturation ranges from 90 to 99%, which makes it possible to classify the studied soils as base saturated.

4. Conclusion

Studies of the edaphic growth conditions of Siberian larch cultures in the Leningrad region are quite interesting, since the formation of such stands occurs outside the natural range of this breed. Larch is a soil-improving species, its litter quickly decomposes, which leads to the accumulation of humus and an increase in mobile forms of phosphorus in such stands, therefore, planting of larch is necessary to improve the soil.

Studies of the Petrovskaya larch grove showed that soddy-calcareous soils of light composition contribute to the active growth of larch, the condition of the pine is worse, and the spruce gives the least growth. The soils are rich in humus content, which is facilitated by the presence of herbaceous cover and larch litter, which decays annually. The soils are characterized by high levels of base saturation, which is provided by the underlying limestone, as well as high levels of phosphorus content. The supply of potassium is low, which is quite typical for soils in general.

A survey of the live ground cover showed that it is represented by species related to megatrophs and mesotrophs. The high soil fertility is facilitated by the underlying dolomitized limestones and the presence of Glint, an upland that provides good drainage. The rich edaphic conditions make it possible to speak about the uniqueness of the territory where rare plants of the Red List are found.

Compared to the soil conditions typical for the Leningrad region as a whole, the soils of the Petrovskaya grove are more favorable for the growth of larch. And the presence of a large species diversity makes it possible to carry out comprehensive research and refer this territory to specially protected natural areas.

References
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