Interrelations between soil fertility and vegetation in taiga forests in the Northwest Russia

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The aims of the study

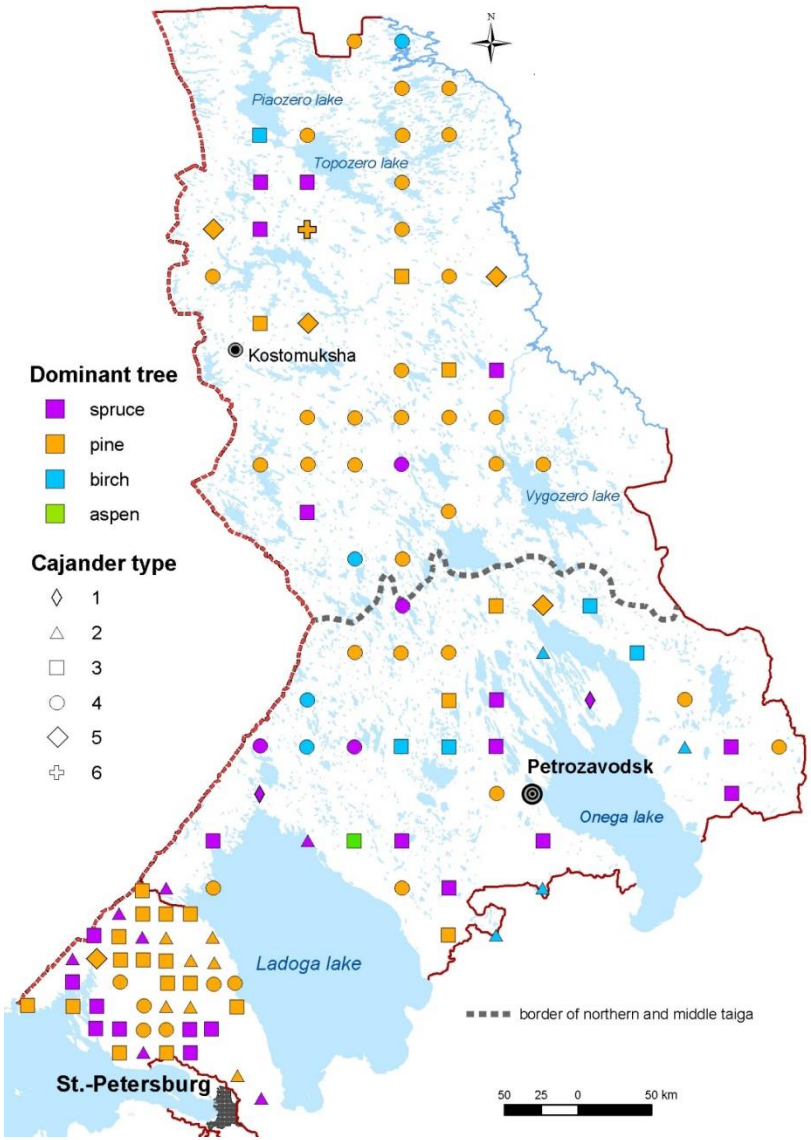
Identification of relationships between forest vegetation and soil fertility in taiga forests in the northwest Russia

The specific questions:

(1) What are the main factors influencing the soil fertility and vegetation composition in taiga forests of the northwest Russia?

(2) What are relationships between the soil fertility parameters and forest sites/types in the northwest Russia?

Study area



The ICP Forests rectangular grid 16x16 km in the Karelian Isthmus (**MKI**) and 32x32 km in the northern and middle taiga of the Republic of Karelia (**NK** and **MK**)

66 Scots pine (*Pinus sylvestris*) plots

37 Norway spruce (*Picea abies*) plots

16 birch (*Betula pendula, B. pubescens*) plots

Field measurements

- **The ground vegetation assessment**

All vegetation measurements were made on plots of 100 m^2. The sampling area of 400 m^2 was reached as the sum of four plots of 100 m^2. All vascular plants as well as terricolous bryophytes and lichens were recorded and their covers were estimated. The lists of species were completed for sampling area of 400 m^2.

- **Sampling and analysis of soil**

The four samples of each soil horizon (FH, E/A, B, BC) were combined to give one composite sample per plot.

Soil parameters measured in the study: actual and exchangeable acidity, total C, N, C/N ratio, exchangeable ($BaCl_2$ extraction) nutrients (Ca, Mg, K) and Al, extractable P (aqua regia extraction)

Forest site/type classifications

A.K. Cajander (1879-1943)

A.K. **Cajander** considered the understory vegetation to be more sensitive indicator of environment conditions and potential productivity of sites than the tree layer composition

In the **Sukachev**'s forest type classification, along with the understory vegetation, the tree species composition is also taken into account

Sukachev V.N. (1880-1967)

Vladimir N. Sukachev wrote: *"If we divide the Cajander's types according to the tree species composition, these units will mostly match the types we accepted"*.

The Cajander site types

The **Cajander site types** were identified according to composition of understory vegetation and occurrence of indicator species by Juha-Pekka Hotanen (Natural Resources Institute Finland)

1. OMaT – *Oxalis-Maianthemum*
2. OMT – *Oxalis-Myrtillus*
3. MT – *Myrtillus*
4. VT – *Vaccinium vitis-idaea*
5. CT – *Calluna*
6. ClT – *Cladonia*

Statistical analysis

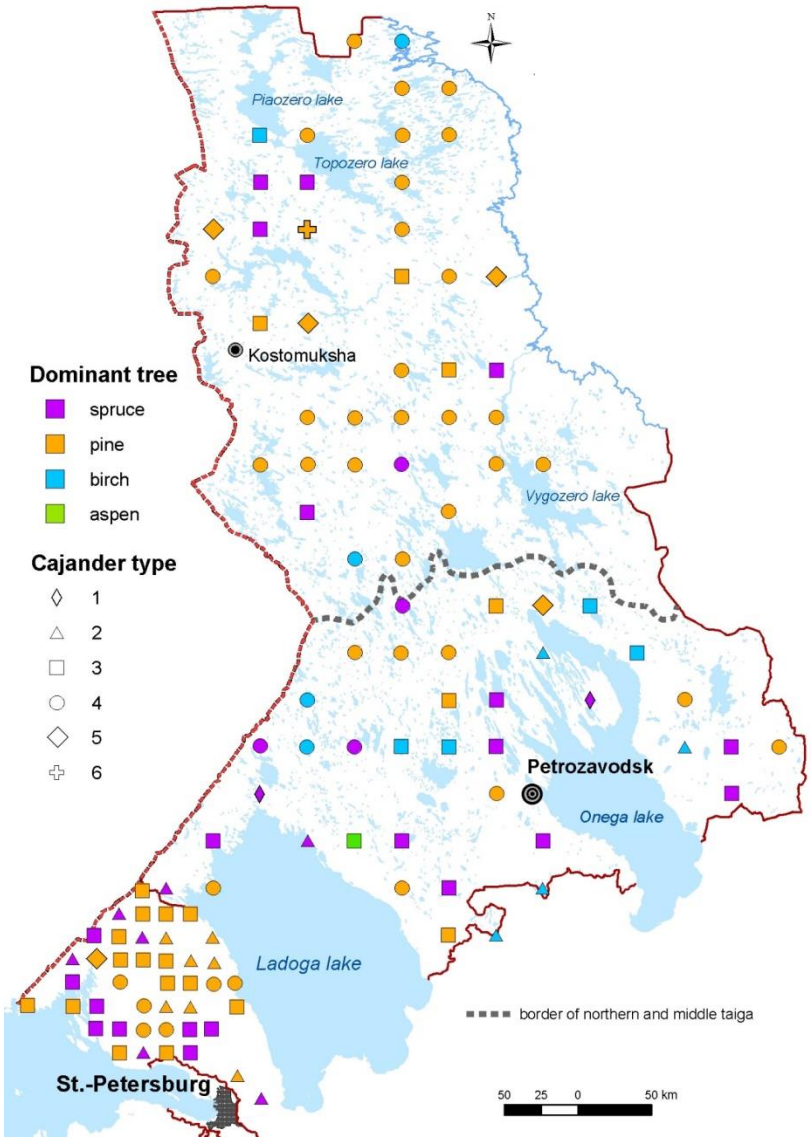
- **Non-metric Multidimensional Scaling (NMDS)**

342 species within 119 plots on regular network were used to find the ordination pattern of the vegetation. Non-metric Multidimensional Scaling (NMDS) was performed on log-transformed species abundances using metaMDS in the vegan package of the R environment (R Core Team 2015).

Numbers of variables – climatic and forest inventory data, soil data for different horizons – were fitted as environmental vectors to the NMDS ordination using the function envfit in the vegan package. The goodness of fit statistic was R^2.

In addition, we have calculated Pearson's correlation coefficients between climatic, tree stand, soil variables, on the one side, and functional group species cover and species numbers, one the other side.

Results



There was a clear difference in the proportions of the site types within 3 areas.

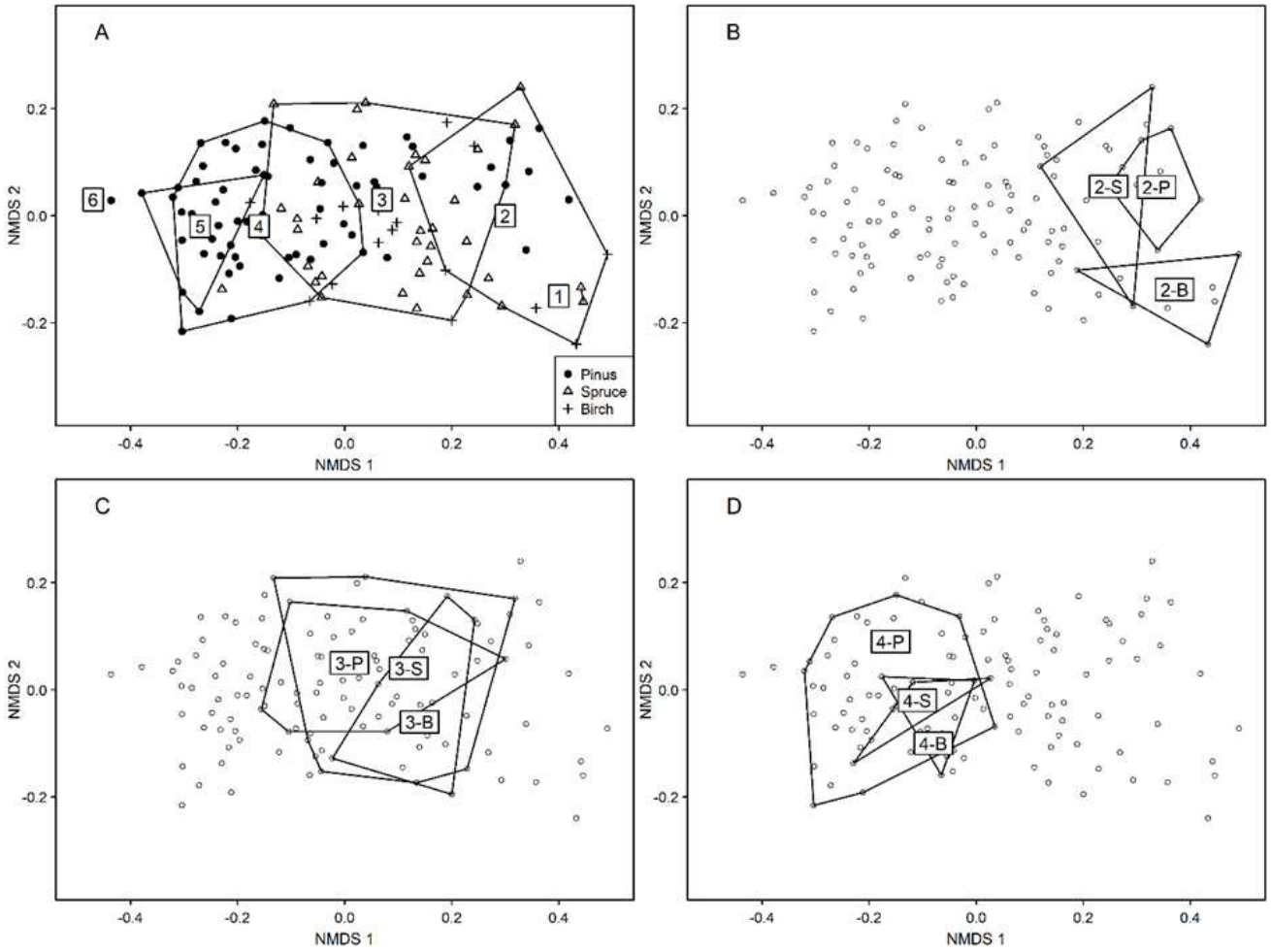
In NK the most common site types were *Vaccinium* (67%) and *Myrtillus* (23%).

In MKI the most common site types were *Myrtillus* (55%) and Oxalis-Myrtillus (29%).

In MK *Vaccinium* and *Myrtillus* site types had similar proportions.

Results

NMDS ordination of the vegetation data



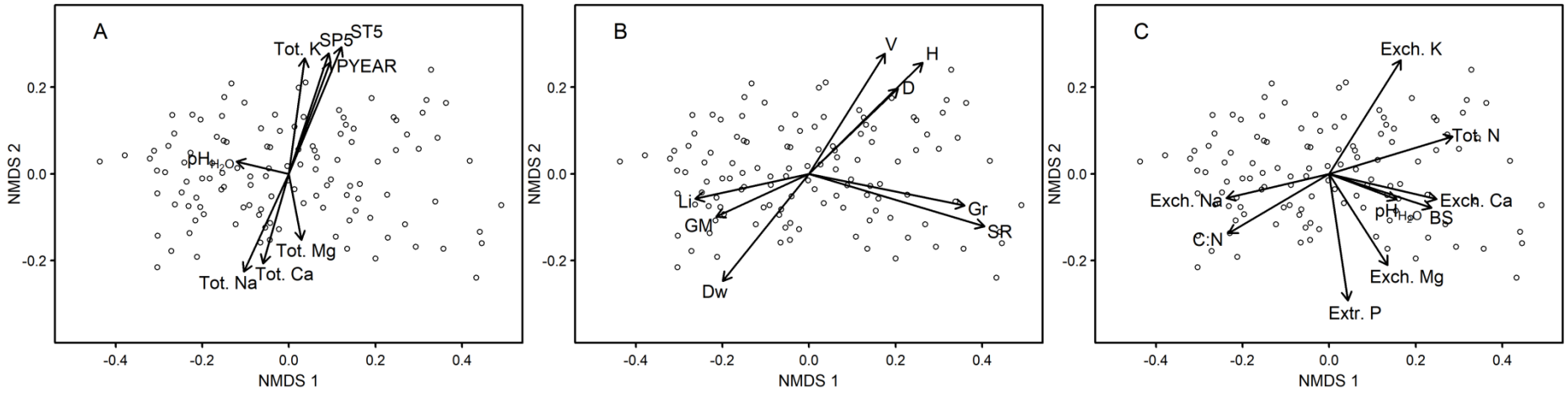
A. Convex hulls enclose the Cajander forest site types

The Cajander forest site types: 1 - OMaT, 2 -OMT, 3 - MT, 4 - VT, 5 -CT, 6 - ClT

B, C, D: P - pine, S - spruce, B - birch

Results

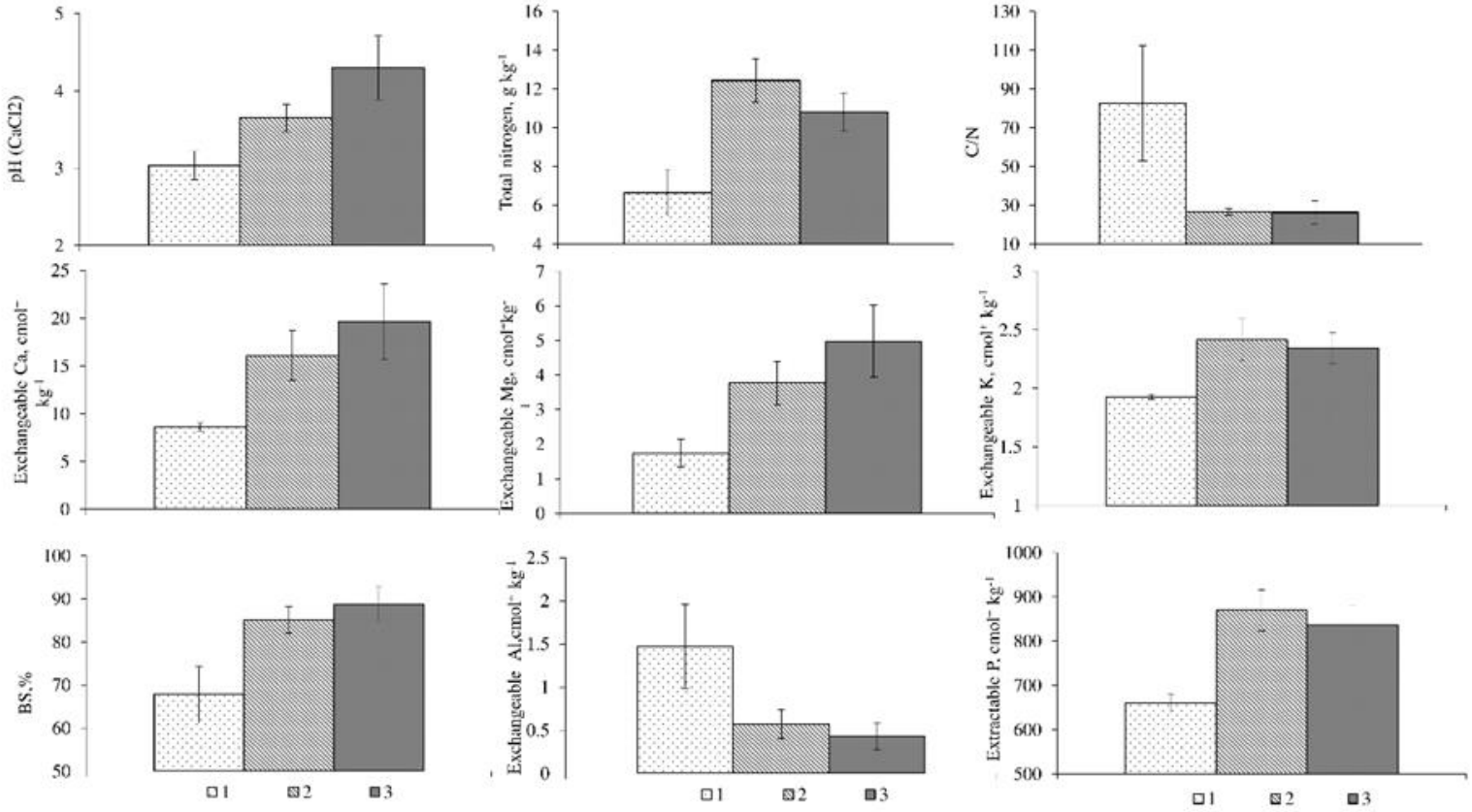
NMDS ordination of the vegetation data with fitted environmental vectors



The vectors show the direction and strength of the linear correlations of the environmental variables with the plot scores.

A. Climatic and BC characteristics: ST5 - effective temperatures sum, SP5- precipitation at the period of the effective t, PYEAR – total precipitation; pH, total Ca, total K, total Mg, total Na - characteristics of BC horizon.
B. Functional group covers, species richness and tree stand variables: Li – lichens, GM - green mosses, Dw – dwarf shrubs, Gr – grasses + herbs, SR – species density, V – stand volume, M – mean height, D – mean diameter.
C. Organic horizon characteristics, including C/N and nutrients

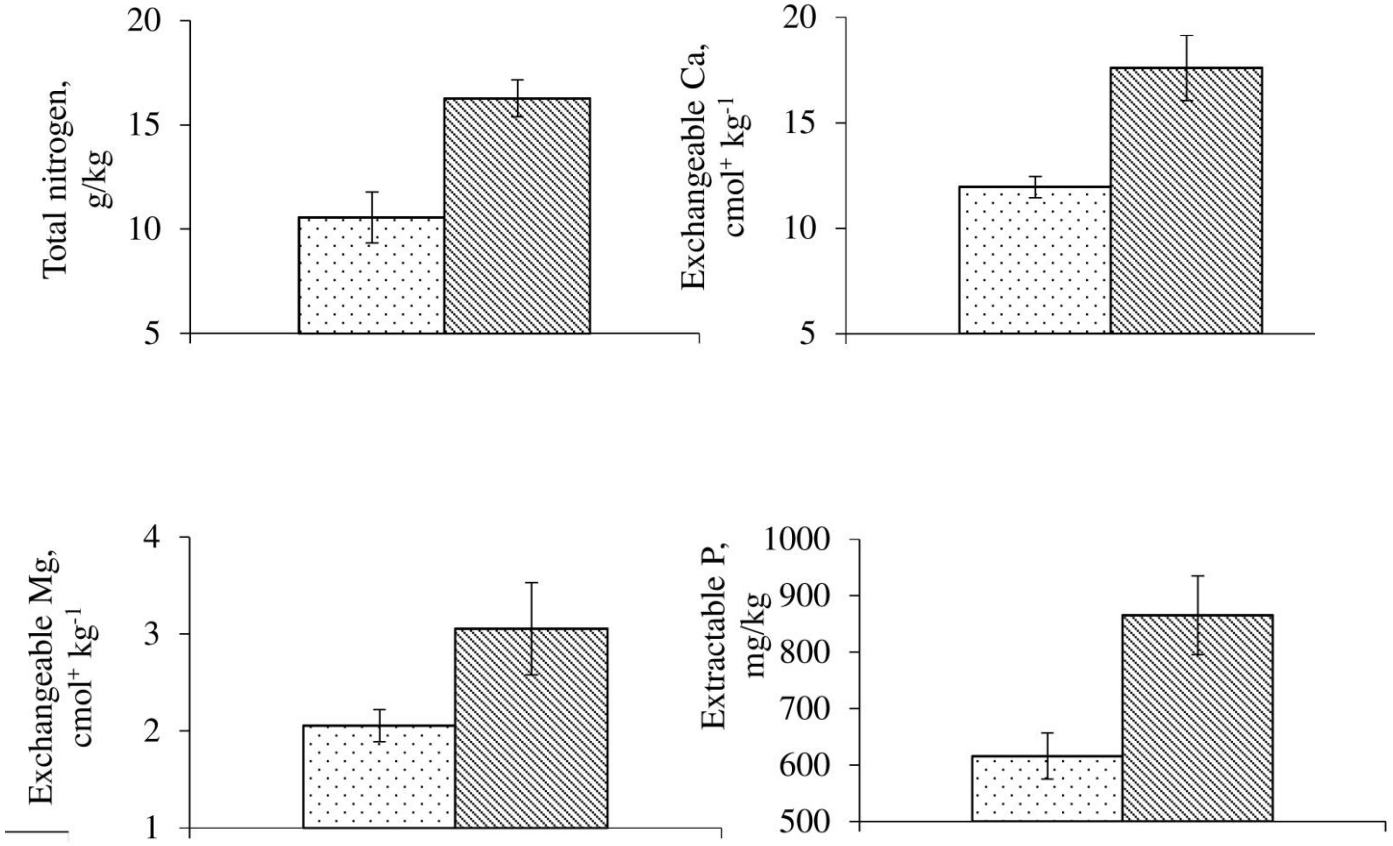
Results



The C/N ratio, acidity and nutrient concentrations in the organic horizon of the *Myrtillus* site type in the north and middle taiga of the Republic of Karelia

1 - pine forests, 2 - spruce forests, 3 - birch forests

Results



Concentrations of nutrients and acidity of the organic horizons of the *Oxalis-Myrtillus* in the Karelian Isthmus

1 - pine forests, 2 - spruce forests

Conclusions

The nutrient concentrations in the organic horizons increased from poor to rich Cajander site types. The most informative parameters were N, C/N ratio, exchangeable Ca, Mg, K, and base saturation.

Significant differences in soil fertility characteristics were identified between the Sukachev forest types. The dominant tree species effects were demonstrated with the *Myrtillus* and *Oxalis-Myrtillus* site types as the examples. The organic soil horizons of the same Cajander site types dominated by spruce or birch contained significantly more nutrients compared to those dominated by pine.

Along with litter quality, the effects of tree species could be related to the differences in crown structure regulating amount of precipitation penetrating through canopy and affecting the intensity of nutrient leaching from the soil.

Thank you for your attention!