Plant-induced variability in soil nutritional status in the forest –tundra ecotone in Khibiny mountains

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Building on the concept of plants as ecosystem engineers, it has been suggested that soil can be considered as a part of the extended phenotype of a plant. The effects of plant species on soil nutrient status vary according to the different processes involved, e.g. nutrient uptake, chemical weathering of the parent material, nutrient inputs in litterfall, and, in case with tree plants, in stemflow and throughfall , influence on the organic matter decomposition and mineralization rates.

This work is aimed at study of plant-induced variability in soil nutritional status in the forest –tundra ecotone in Khibiny mountains, Kola peninsula, Russia.

The predominant soil types in the study areas are podzol and cambic podzol developing on unsorted till and on eluvium-deluvium of nepheline sienites.

Podzol, transition zone tundra-forest-tundra

Podzol, Um'echorr

Cambic podzol, forest, Tuliok

Cambic podzol, forest, Tuliok


Podzol


Cambic podzol

Soil samples have been taken in Um’echorr and Tuliok sites in the west and east of Khibiny mountains and in Kanentjavr in forest-tundra ecotones in the vicinity of 13 strips of 10 x 50 m for which field mapping has been carried at the scale of 1:20 for determination of contribution of different tesseras to vegetation-soil cover. For comparison soil samples taken in Kuelporr (central Khibiny mountains) have also been analyzed. The soil acidity parameters, total and plant-available concentrations of nutrients, total carbon concentrations have been determined

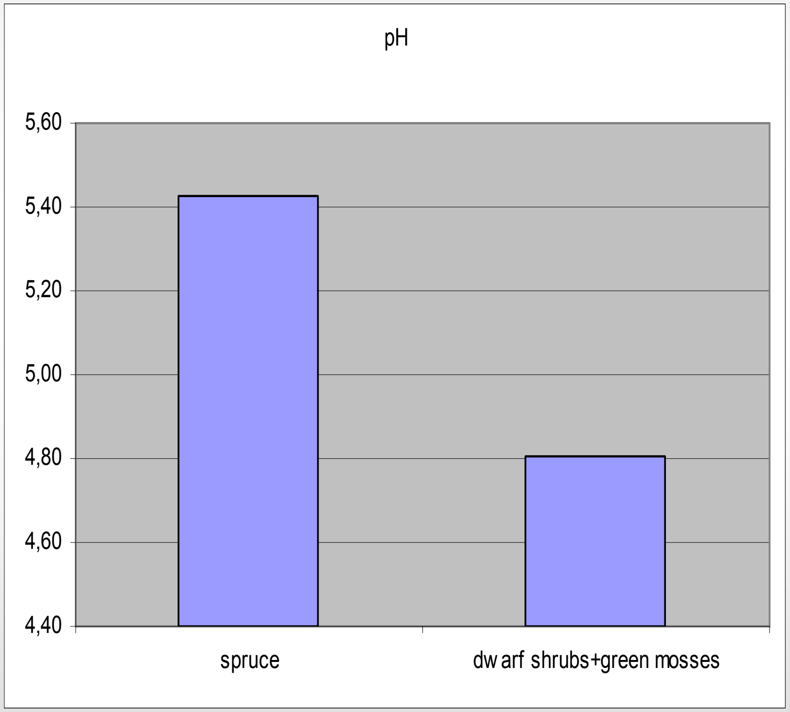
- To understand the effects of plants on soil nutritional status we study the relationships between the vegetation and soil cover. The question arises about the elementary units of vegetation and soil cover for study of these relationships. Our works have demonstrated that the elementary units for the investigations of these relationships could be tessera (element of mosaics).
- The borders of tessera could be identified by distribution of the predominant plant species.
- We sampled soil taking into account the key tesseras. In total 11 tesseras in Tuliok and 31 tesseras in Um’echorr were tested.

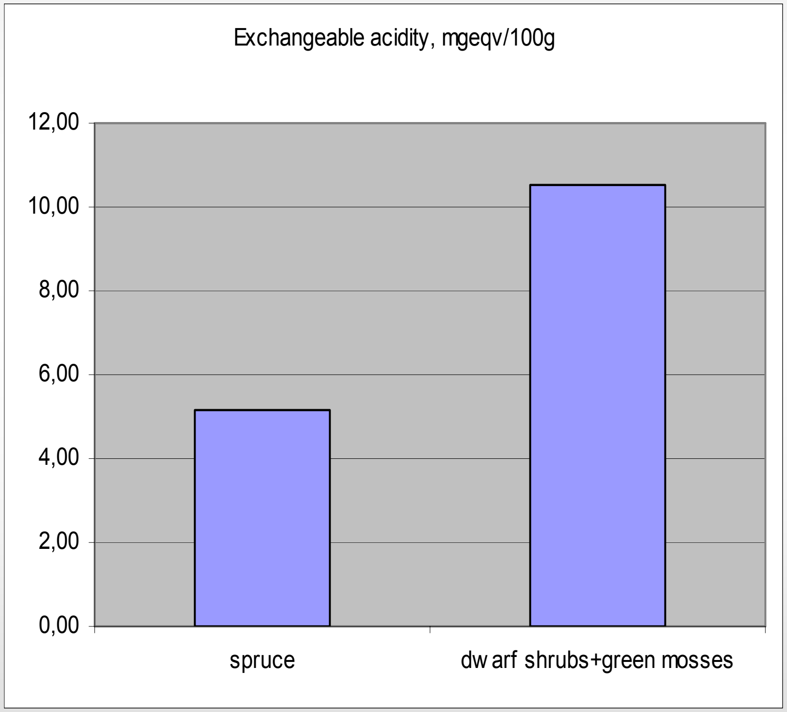
Comparisons between the tesseras

Tesseras with:

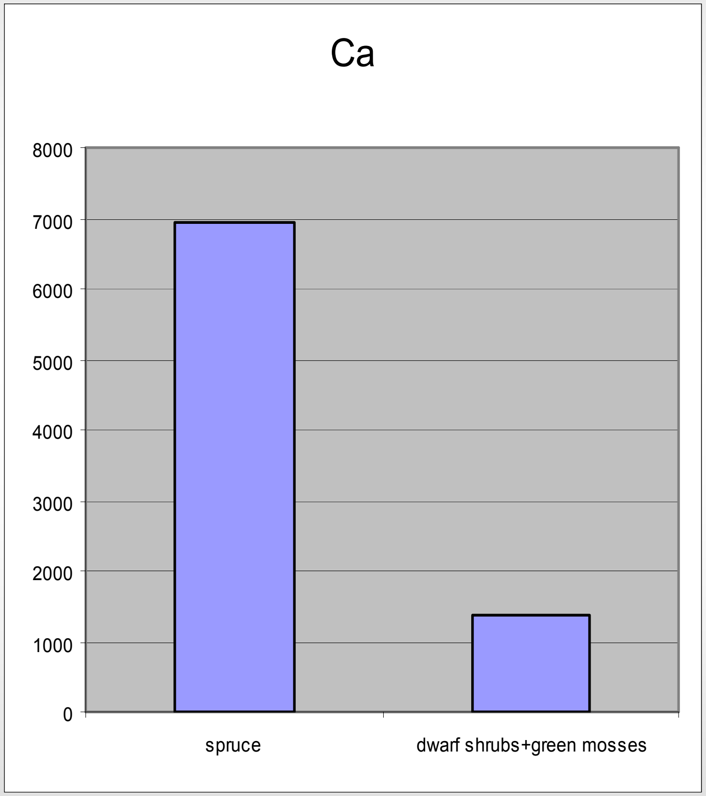
Norway spruce, Scots pine, Betula pubescens, dwarf shrubs, shrubs, green mosses, lichens, low herbs, tall herbs, barrens.

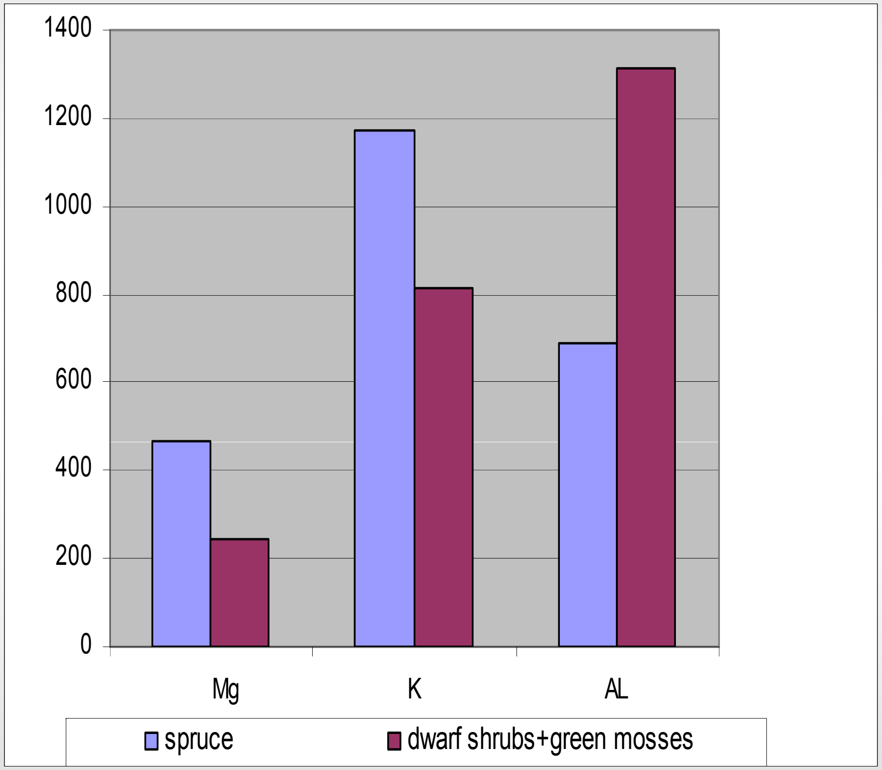
Tuliok, spruce forest, organic horizon



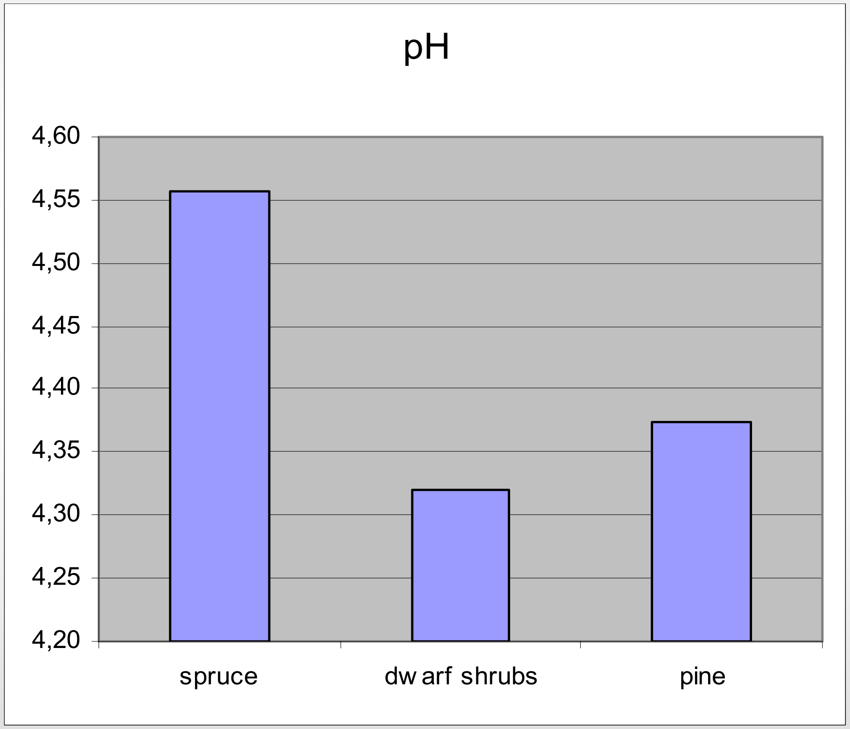


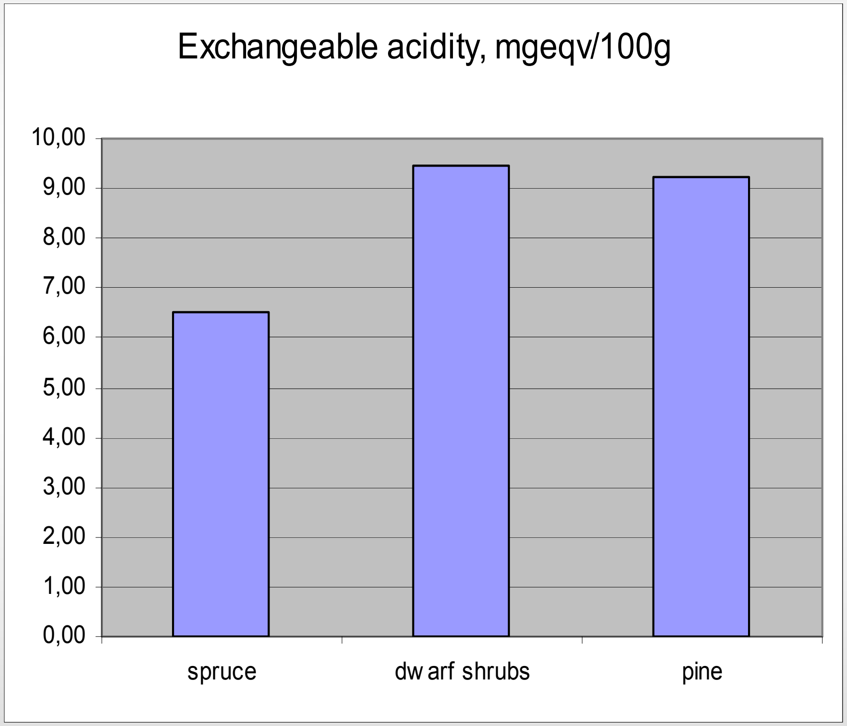
Tuliok, spruce forest, organic horizon



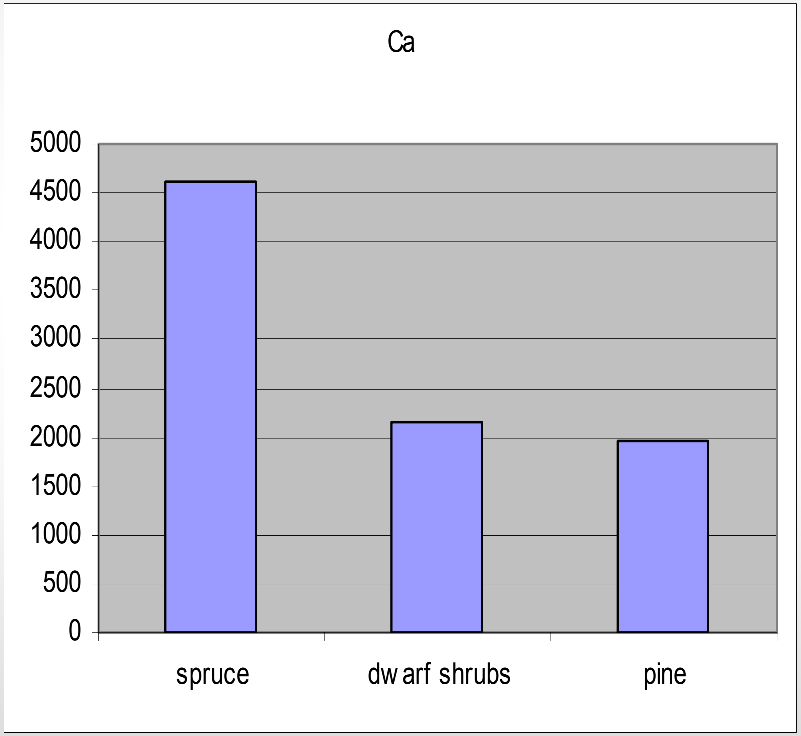


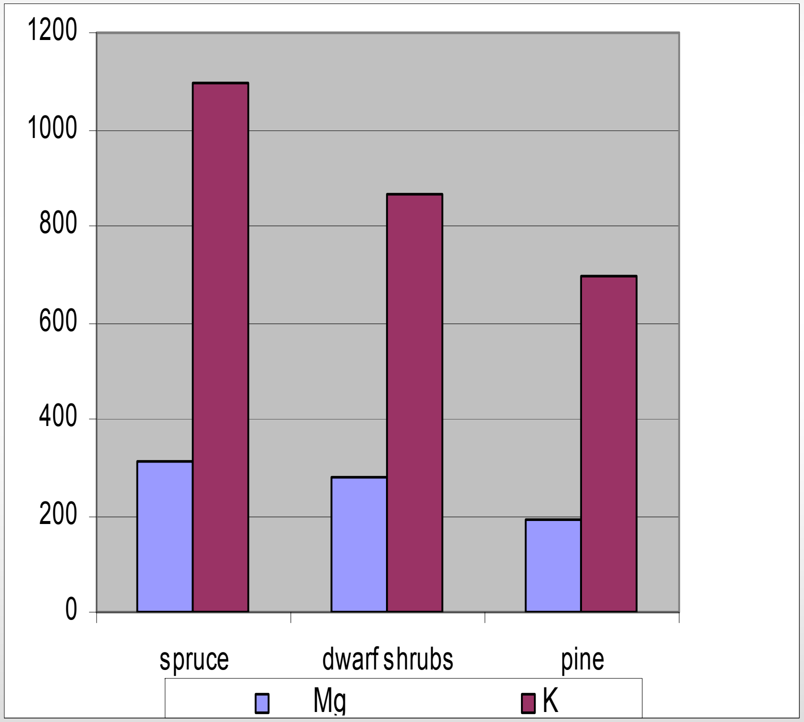
Um'echorr, spruce forest, organic horizon





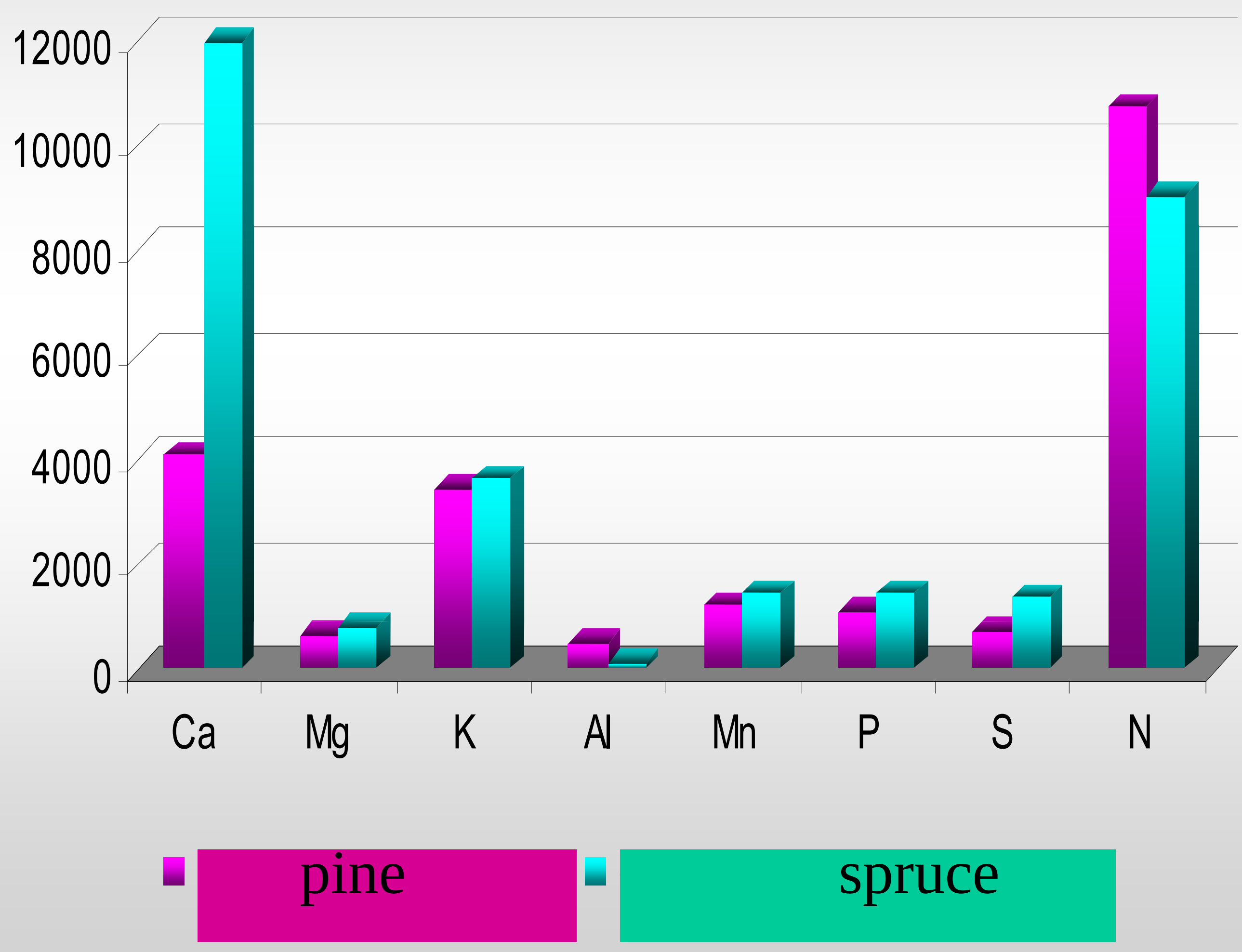
Um’echorr, spruce forest, organic horizon, mg/kg



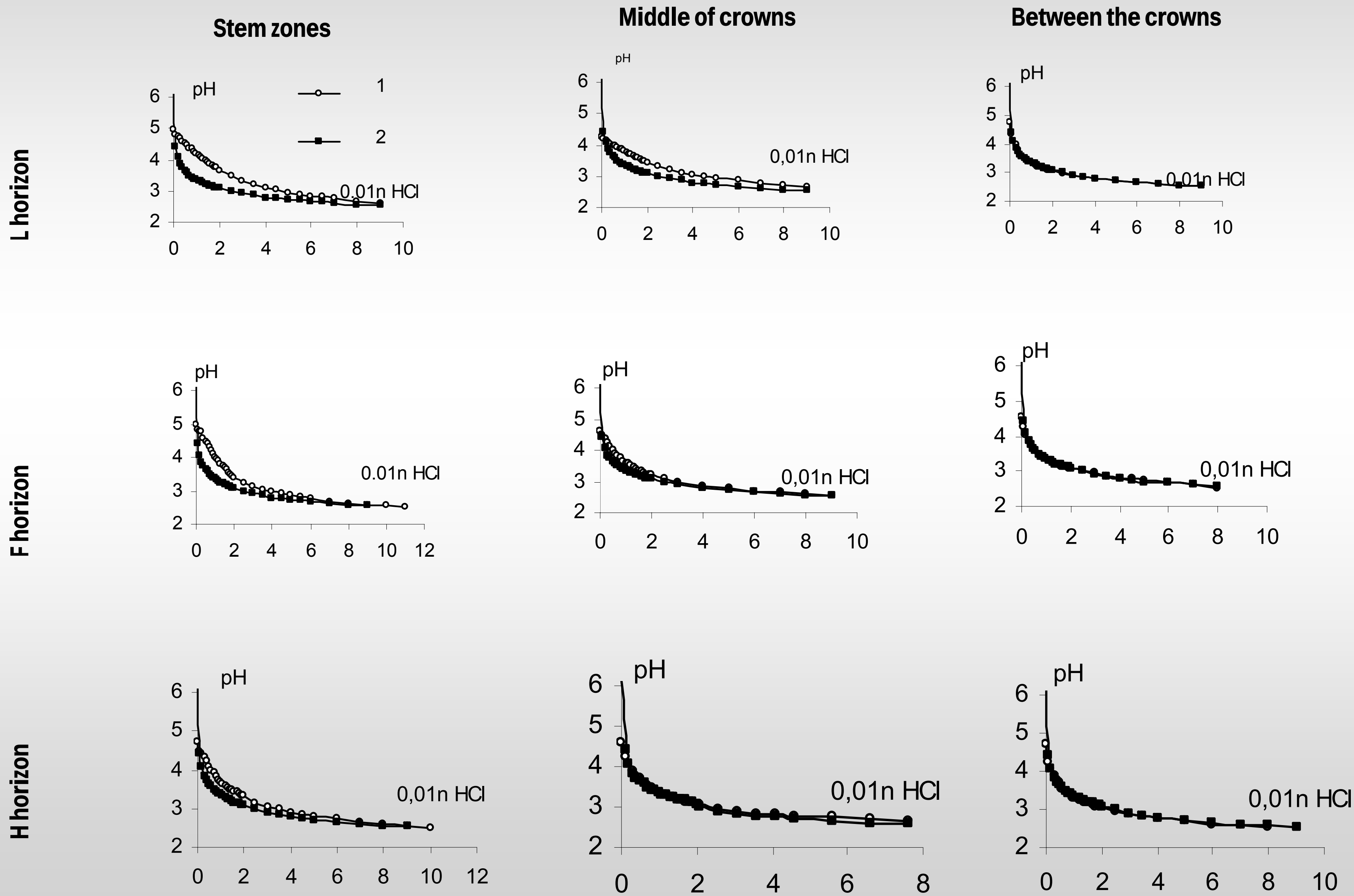


We considered that this phenomenon was caused by (1) significantly higher Ca concentrations in the senescent needles of spruce (up to 13 g/kg), (b) a smaller amount of precipitation reaching the forest floor below the denser, longer crowns of spruce compared to that in pine and between the crown tesseras . The lower precipitation resulted in considerably lower leaching of base cations from the organic horizons below the crowns of spruce.

Chemical composition of the senescent needles of pine and spruce, mg/kg

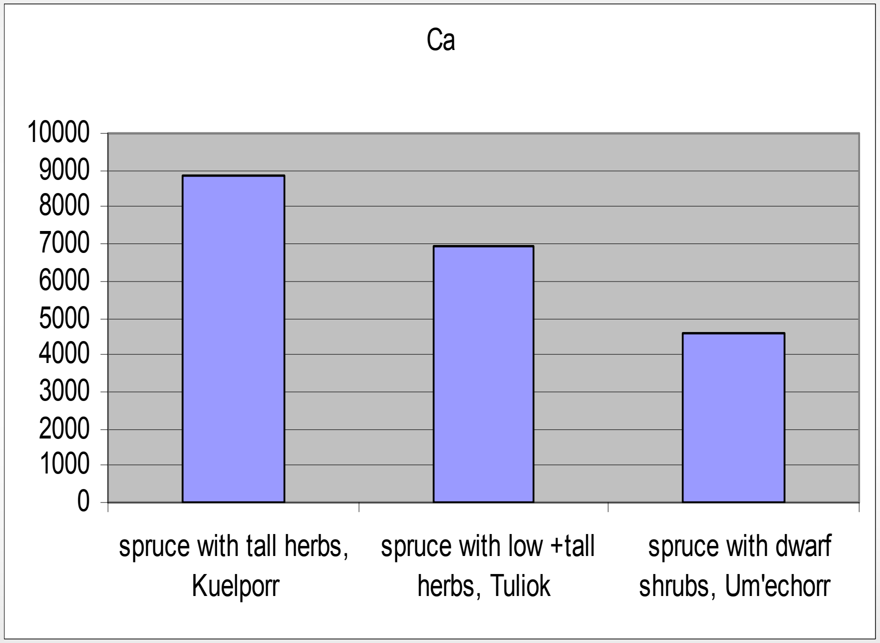


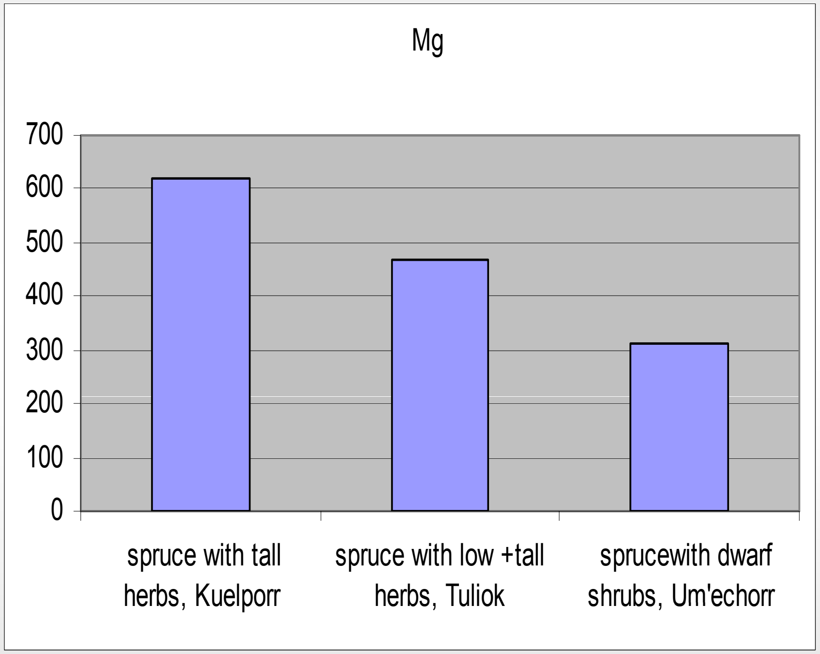
Potentiometric titration by acid of water extracts from the organic layers



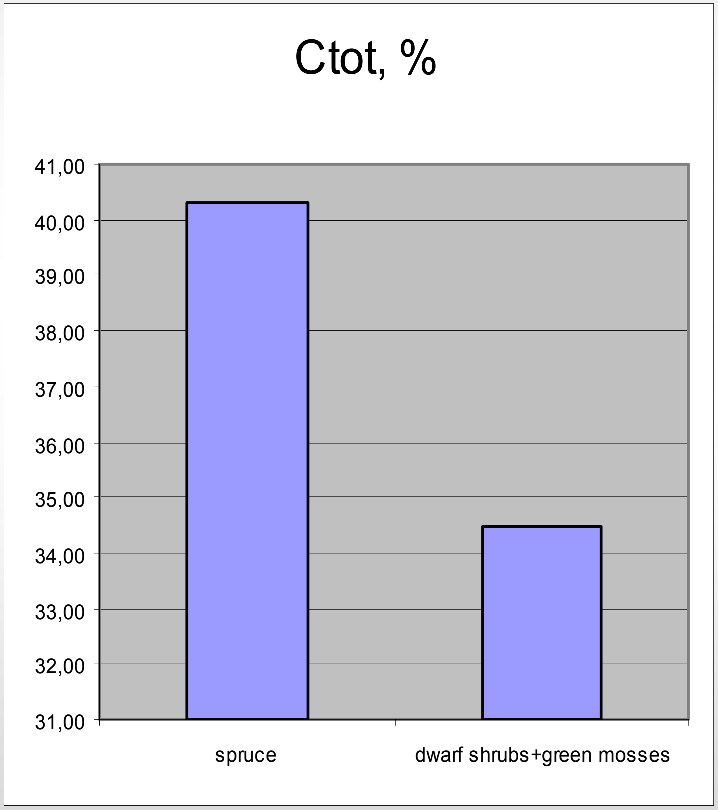
Higher buffering capacity in L and, partly, F horizons of spruce tesseras may be due to the higher concentrations of salts, formed between strong bases and organic acids like citric or oxalic in these horizons below the crowns. The neutralization mechanism in H horizons are probably cation exchange and/or non-exchangeable protonation of organic matter.

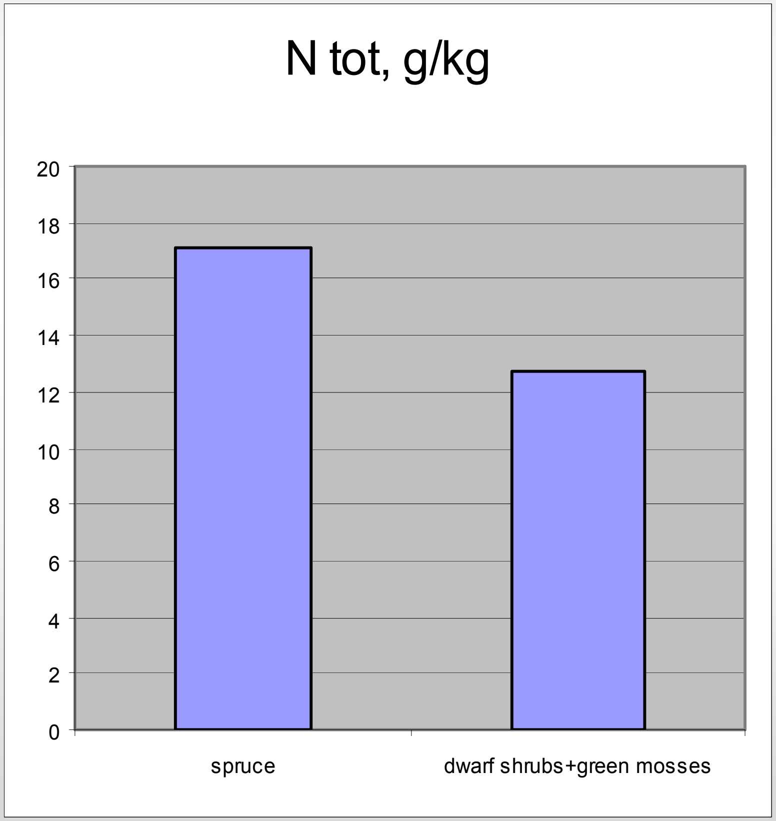
Comparison of spruce tesseras in different types/succession stage of forest, mg/kg



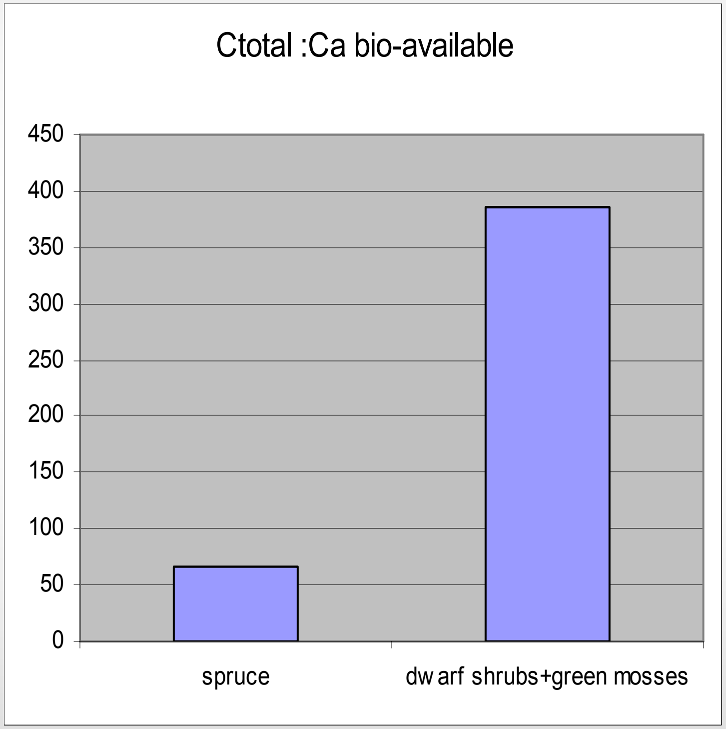


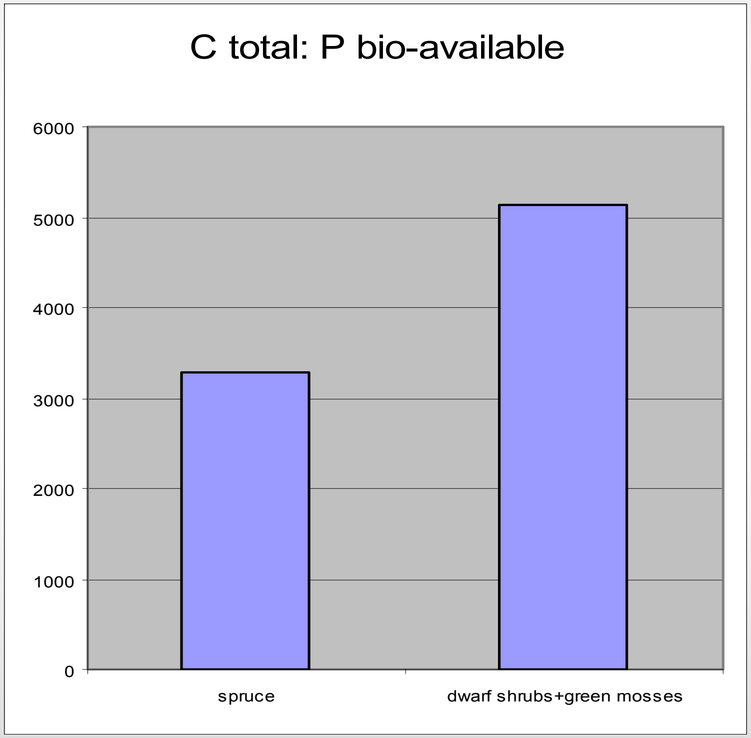
Tuliok, spruce forest, organic horizon



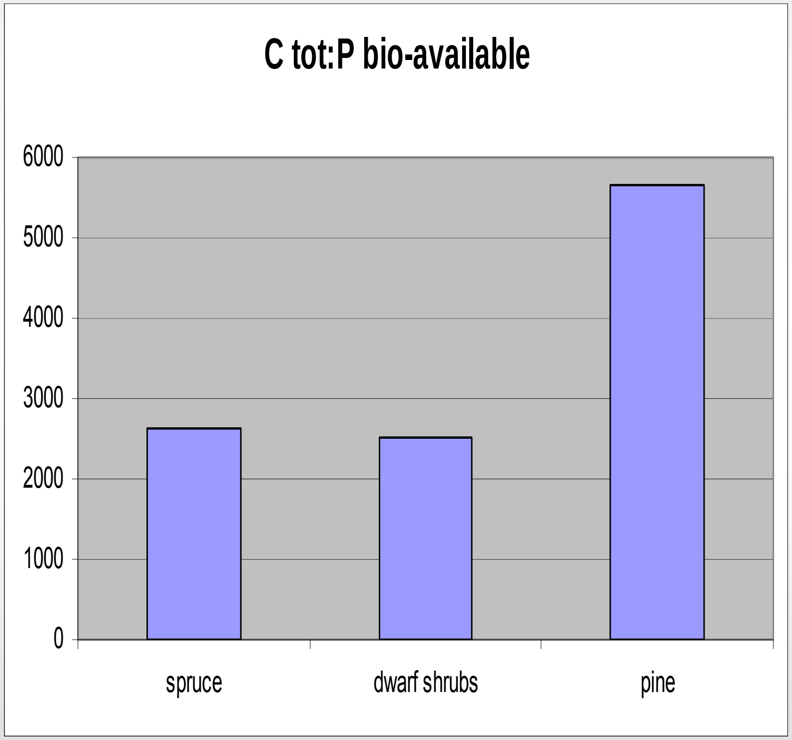


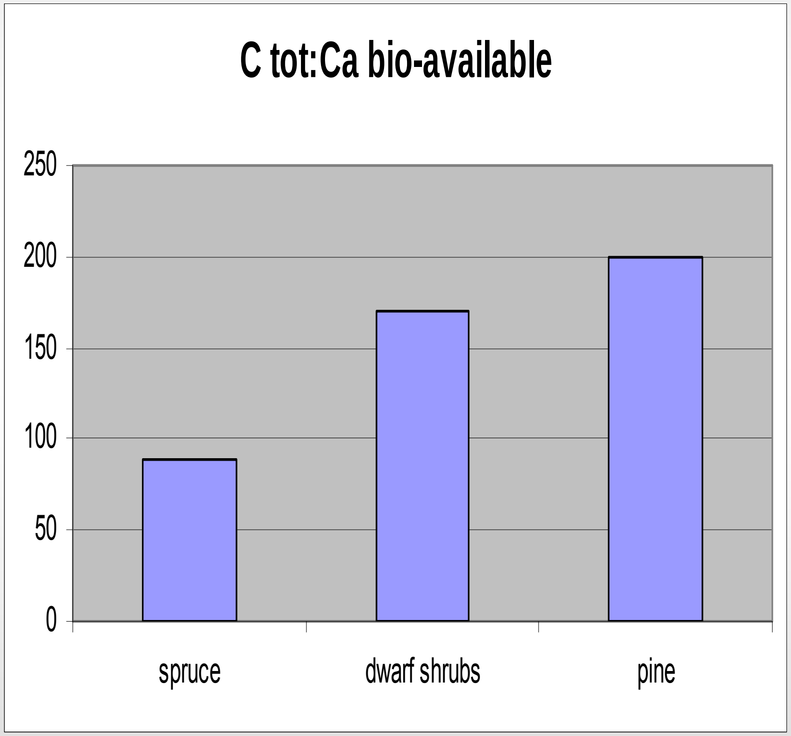
Tuliok, spruce forest, organic horizon



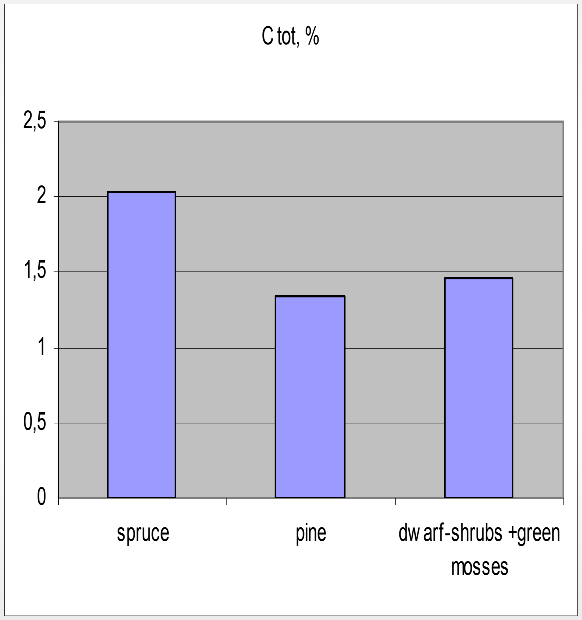


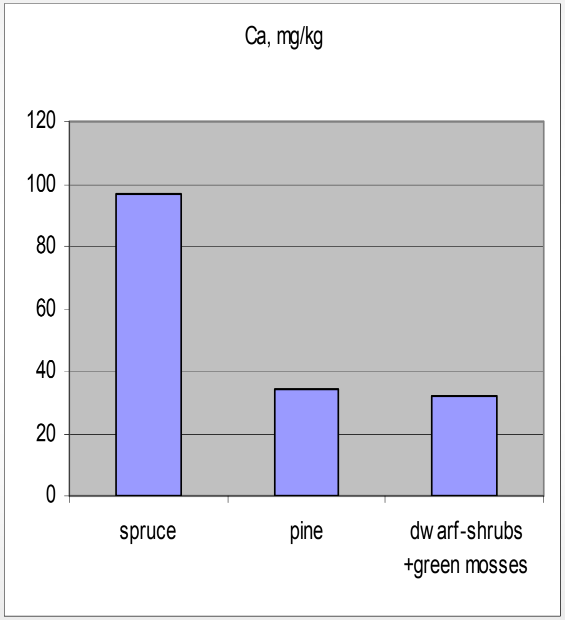
Um’echorr, spruce forest, organic horizon

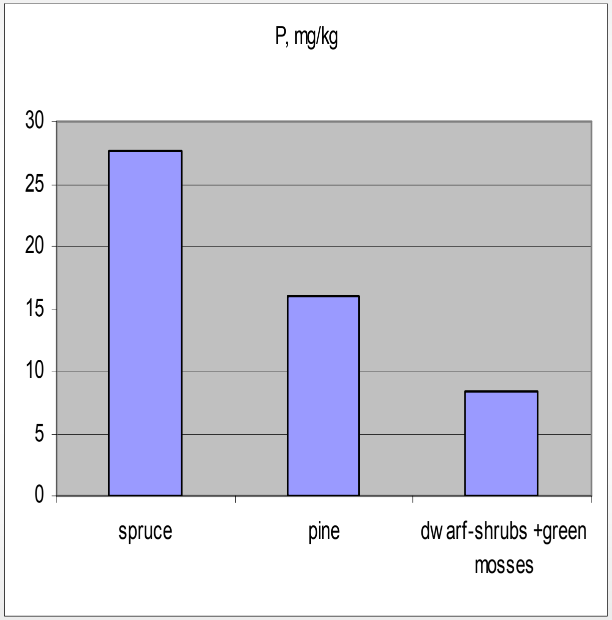




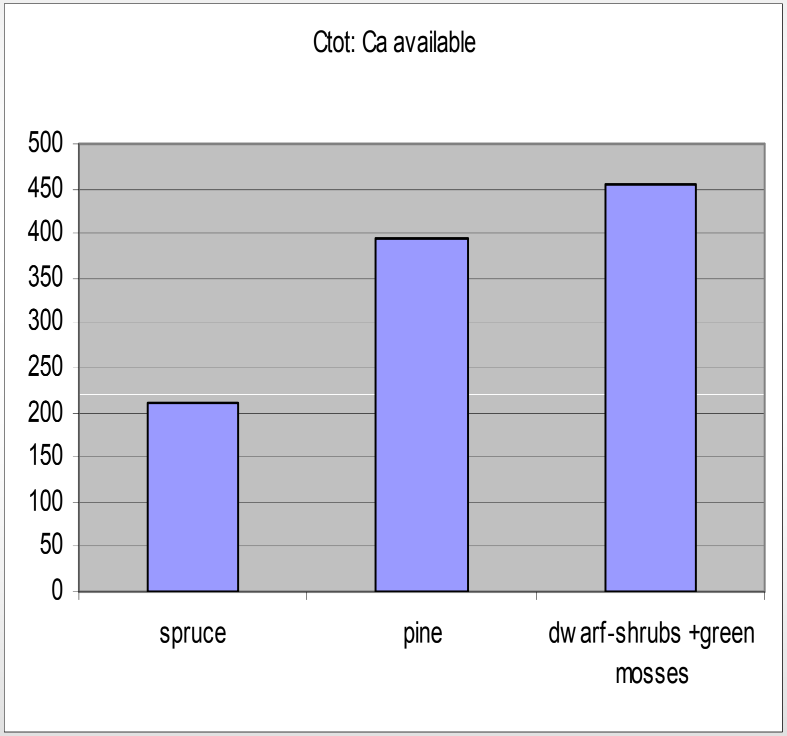
Um’echorr, forest, B-horizon

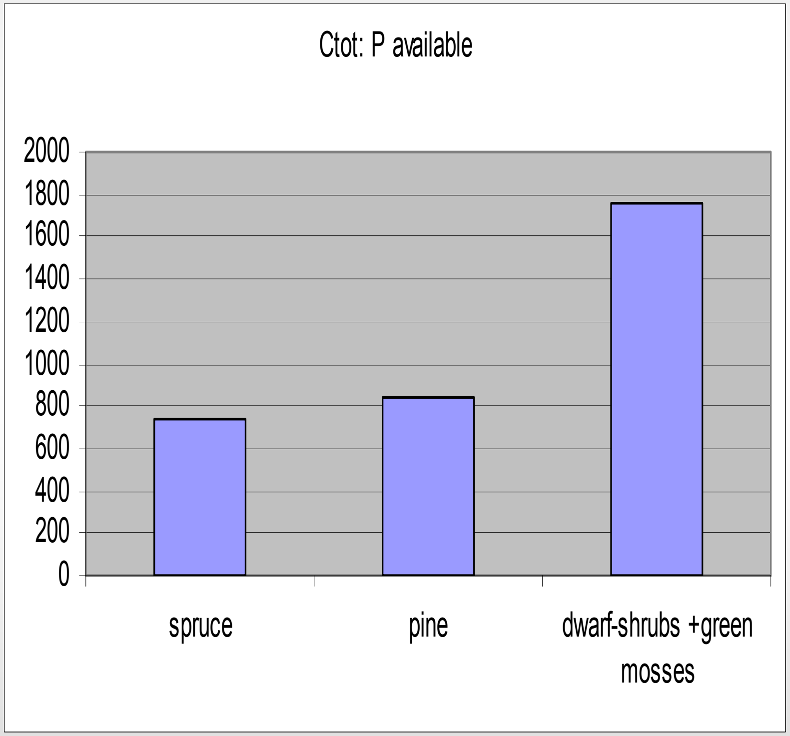




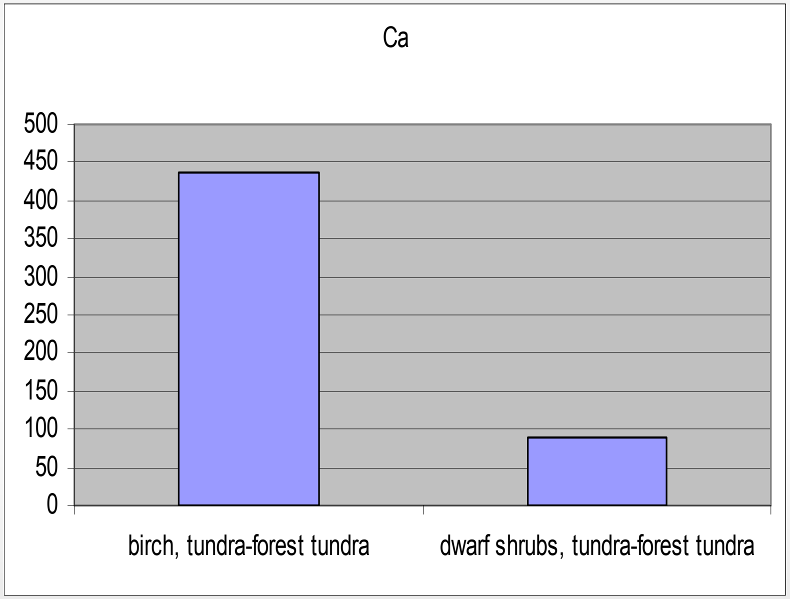


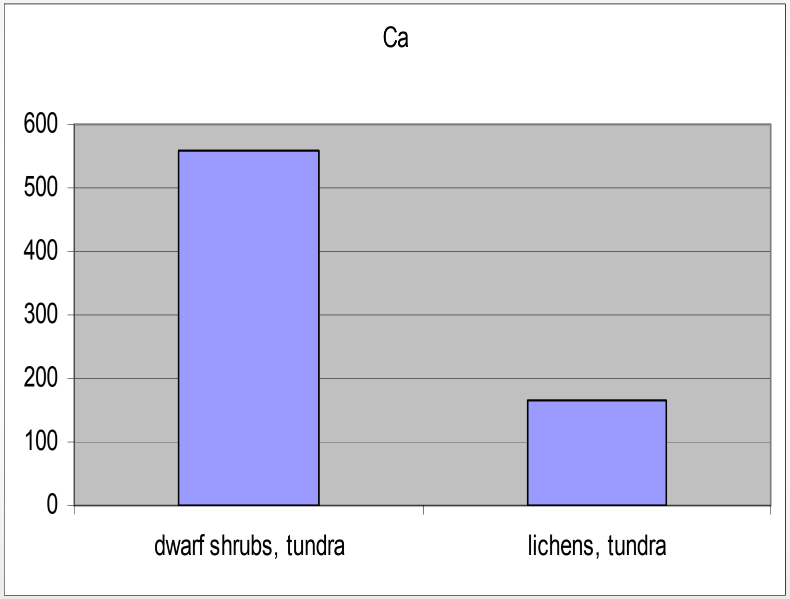
Um’echorr, forest, B-horizon



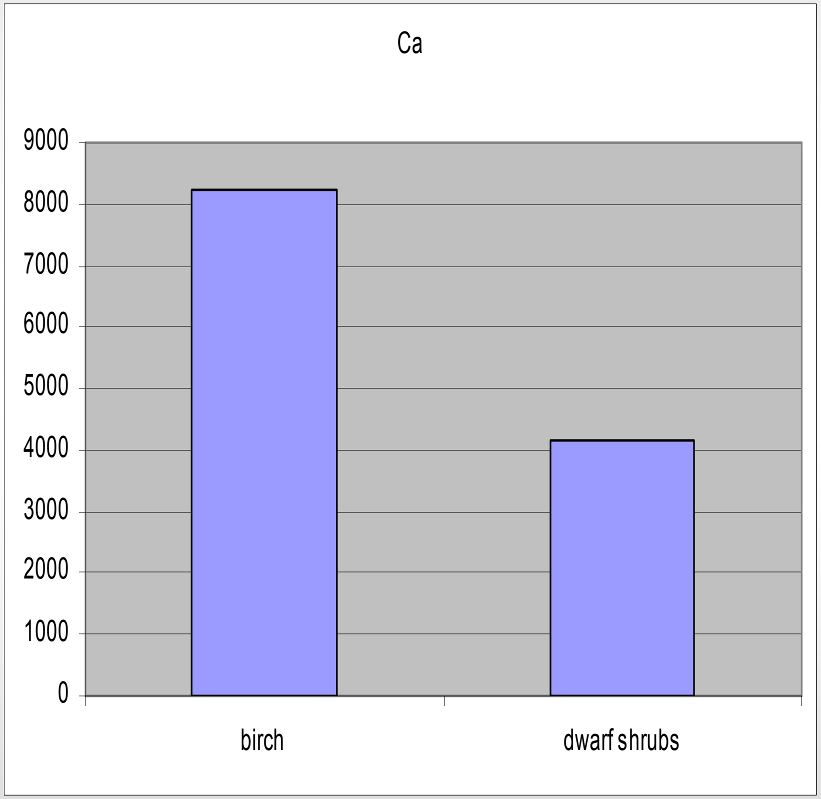


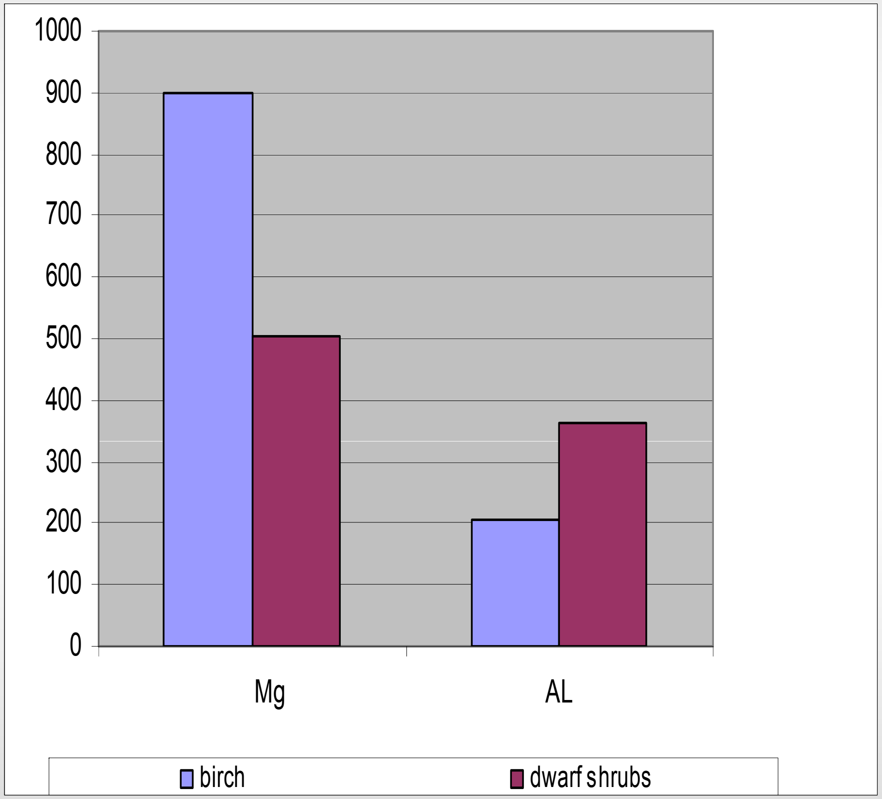
Um'echorr, B-horizon, mg/kg



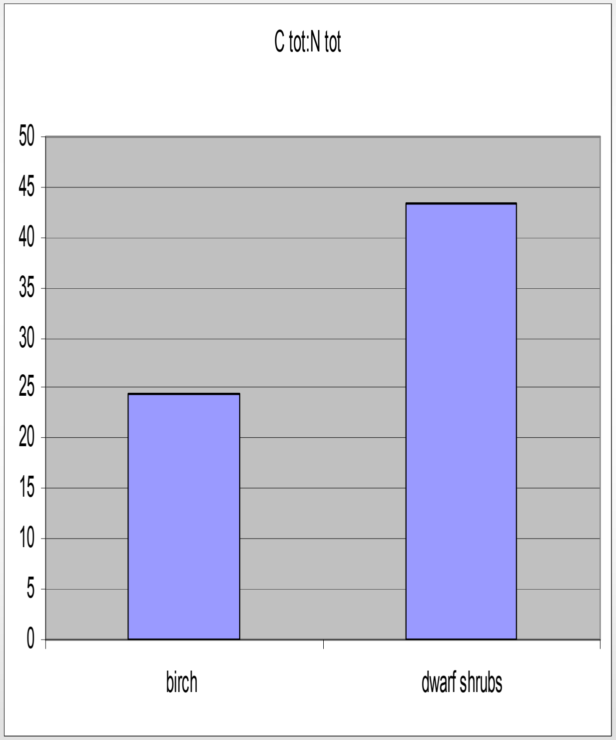


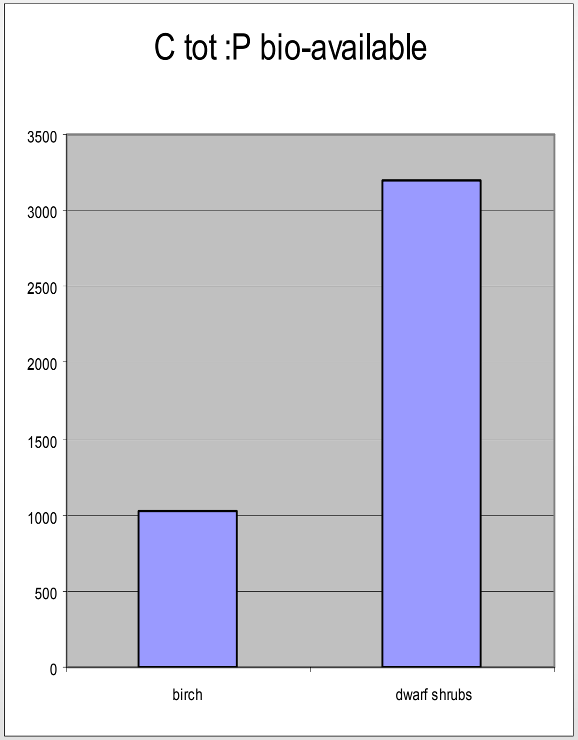
Tuliok, forest-tundra, organic horizon, mg/kg

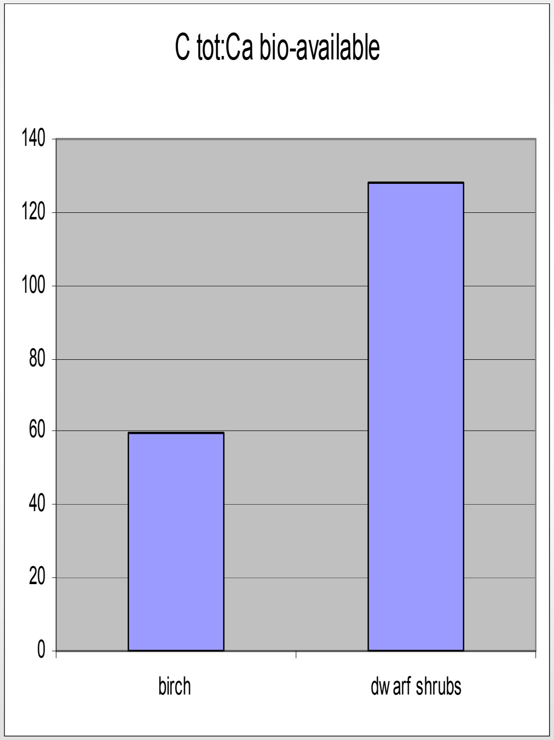




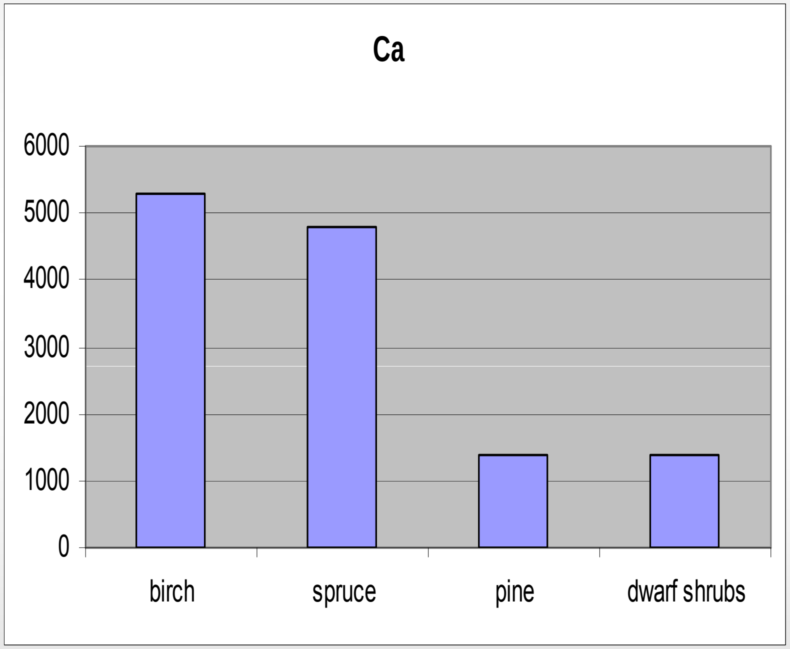
Tuliok, forest-tundra, organic horizon

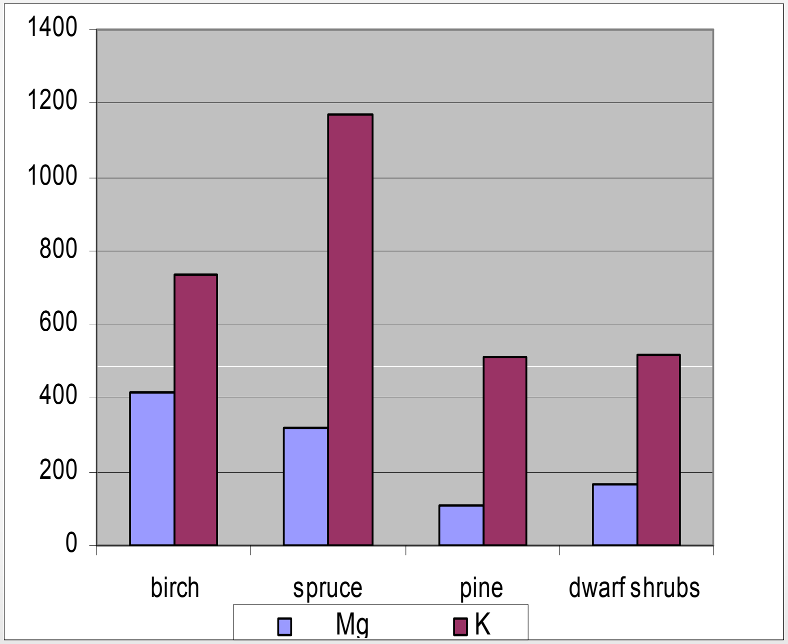




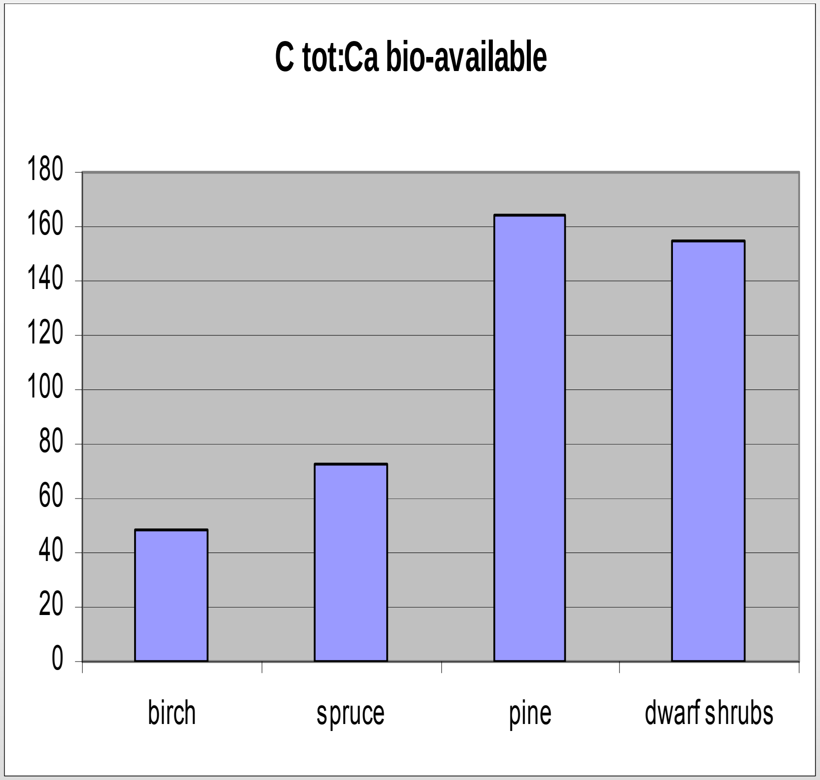


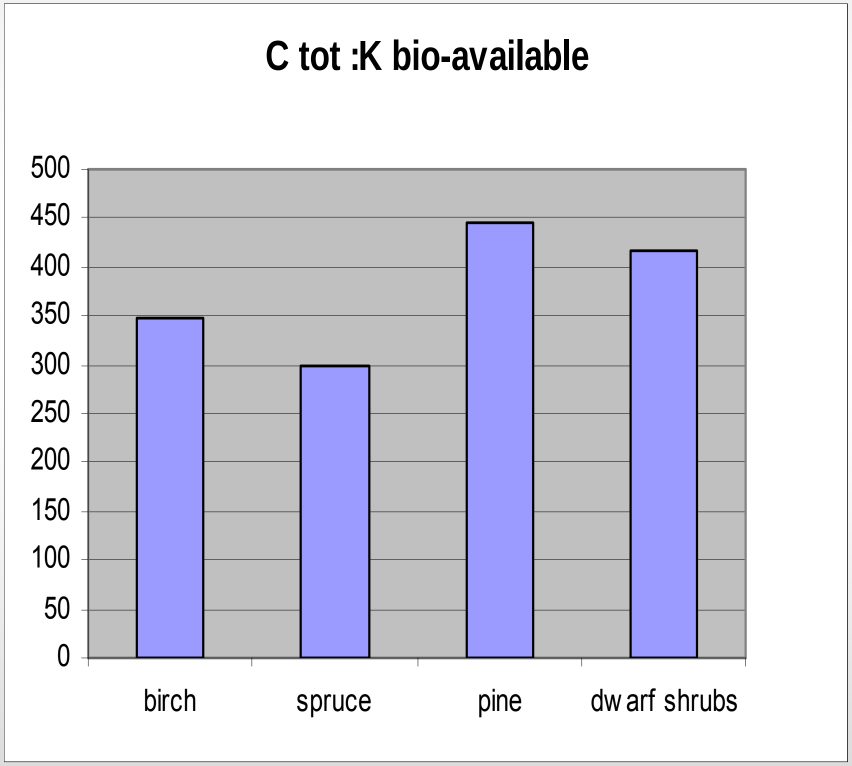
Um’echorr, transition tundra-forest –tundra, organic horizon, mg/kg



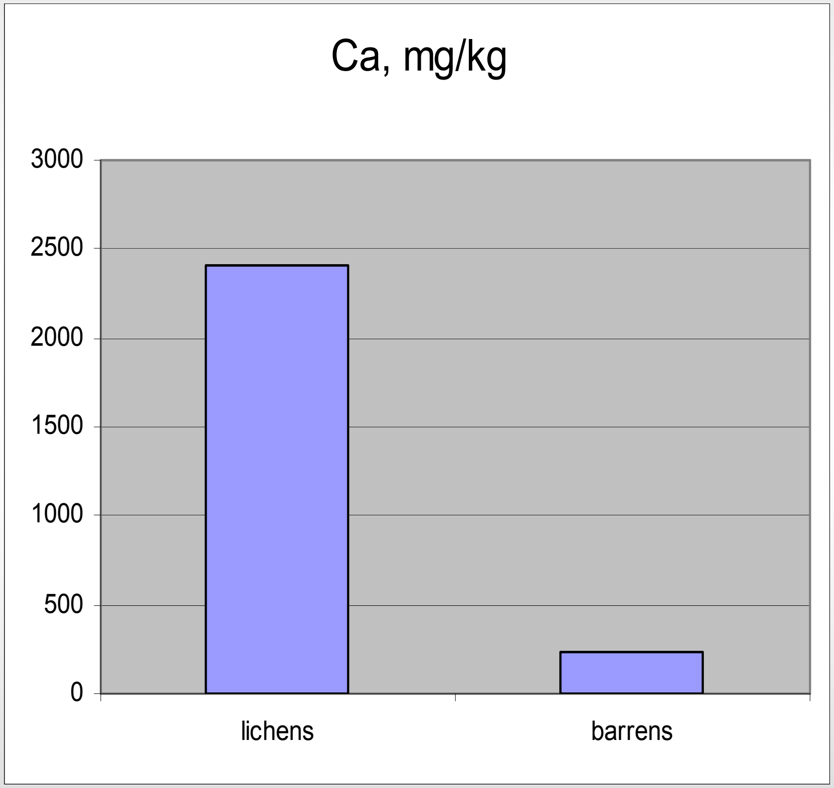


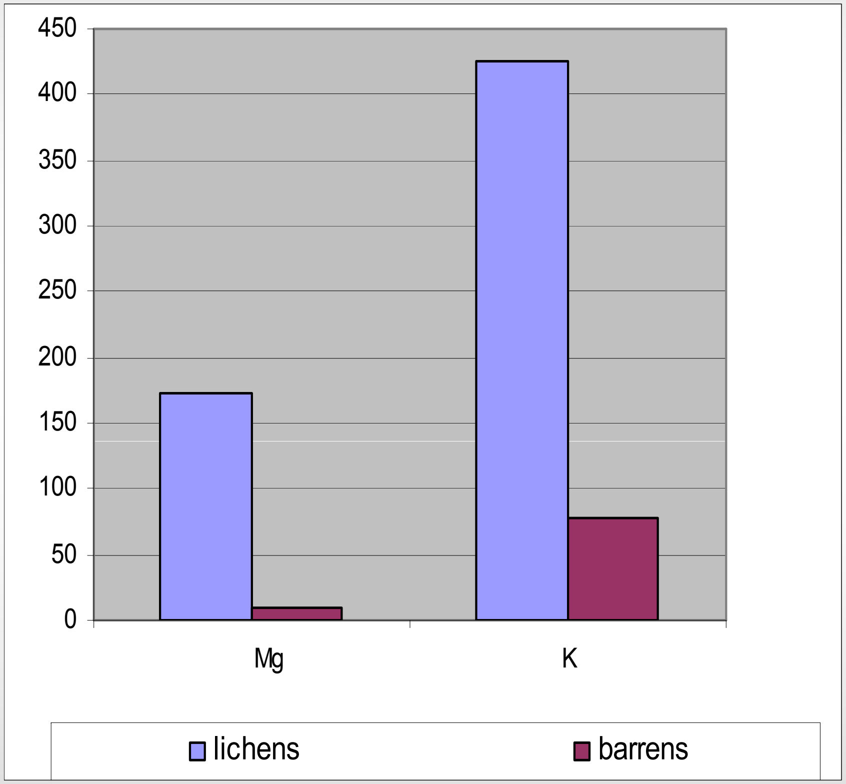
Um'echorr, transition tundra-forest –tundra, organic horizon, mg/kg



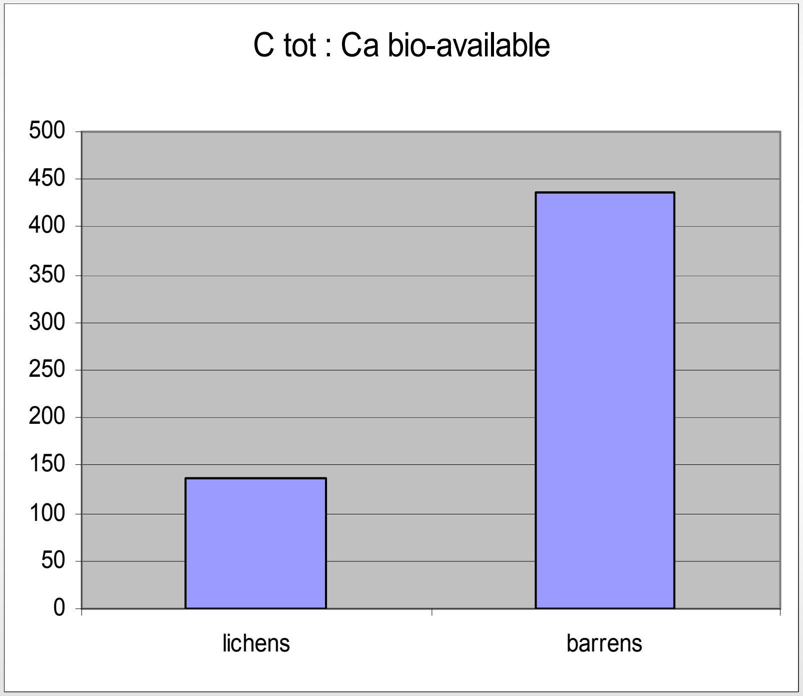


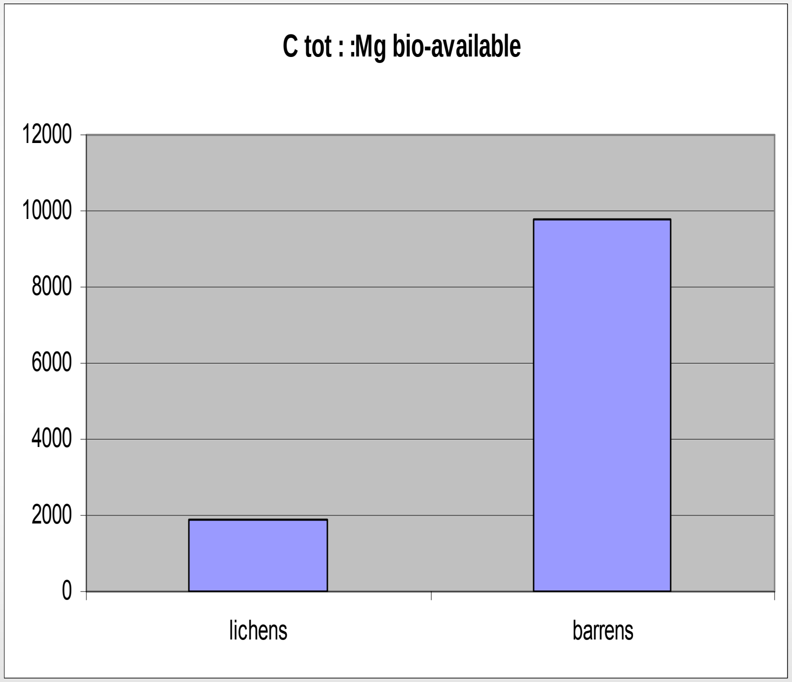
Tuliok, tundra, organic horizon, mg/kg



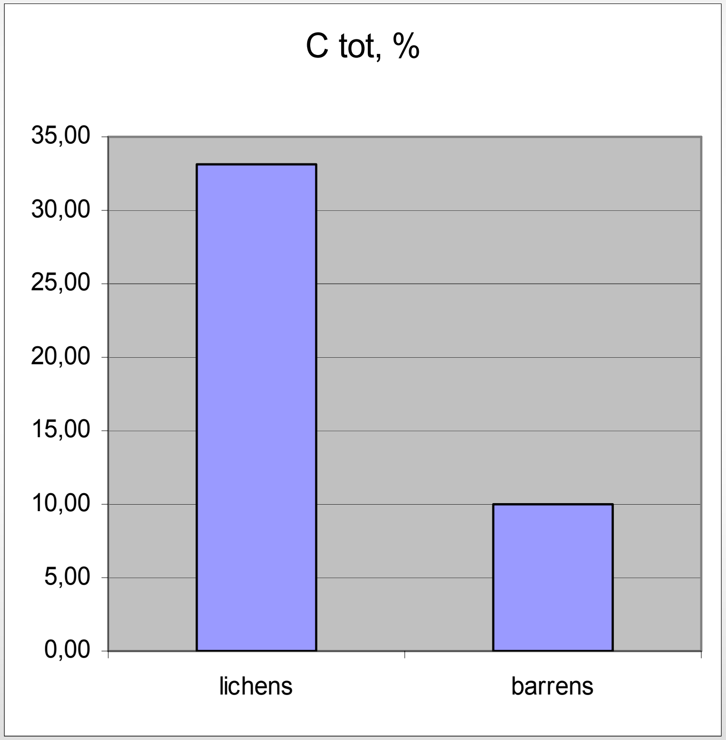


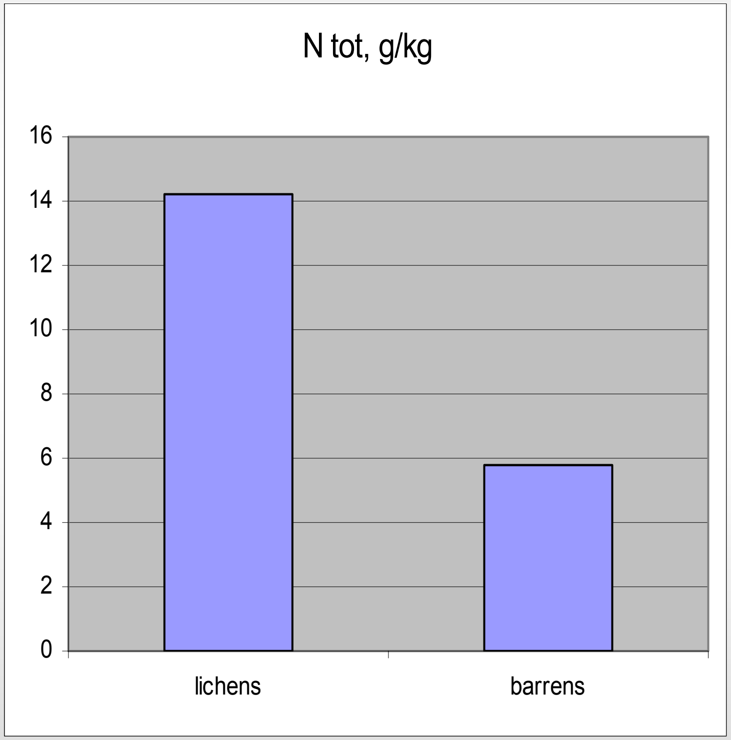
Tuliok, tundra, organic horizon



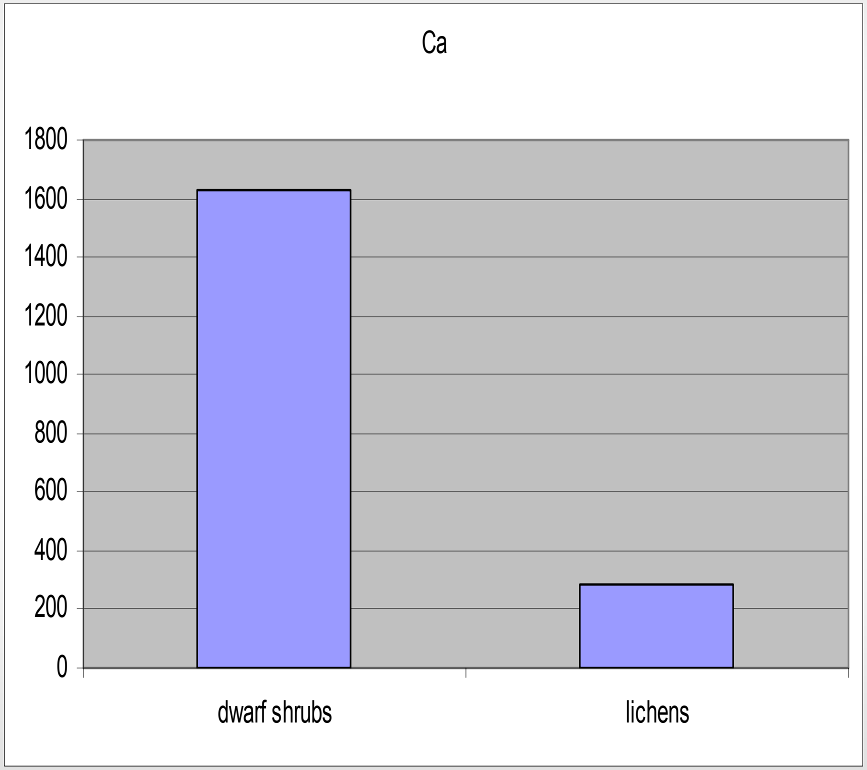


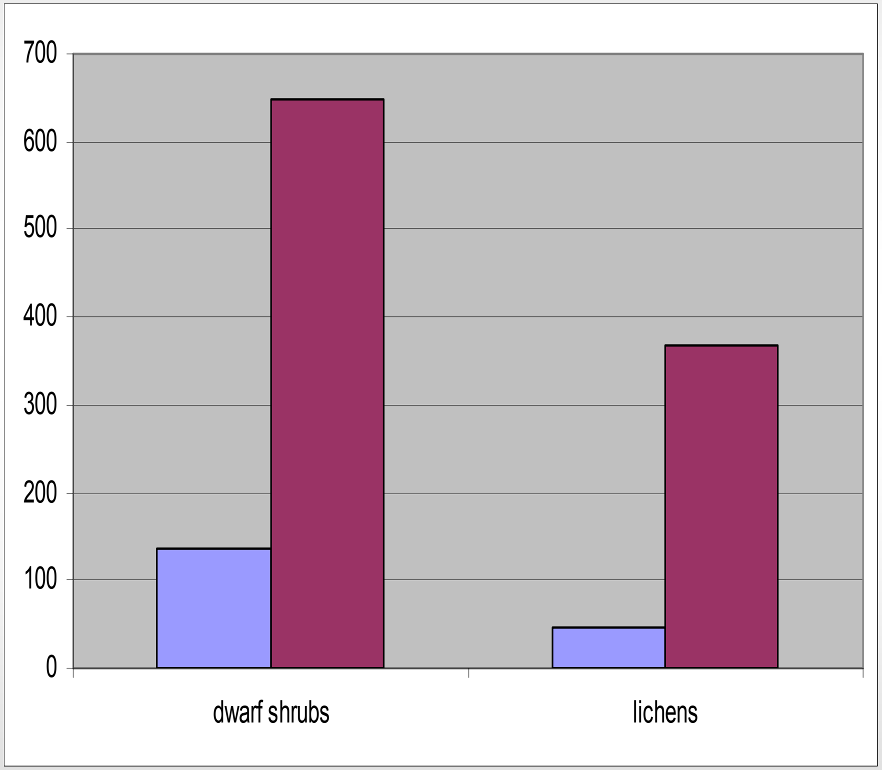
Tuliok, tundra, organic horizon





Um’echorr, tundra, organic horizon, mg/kg



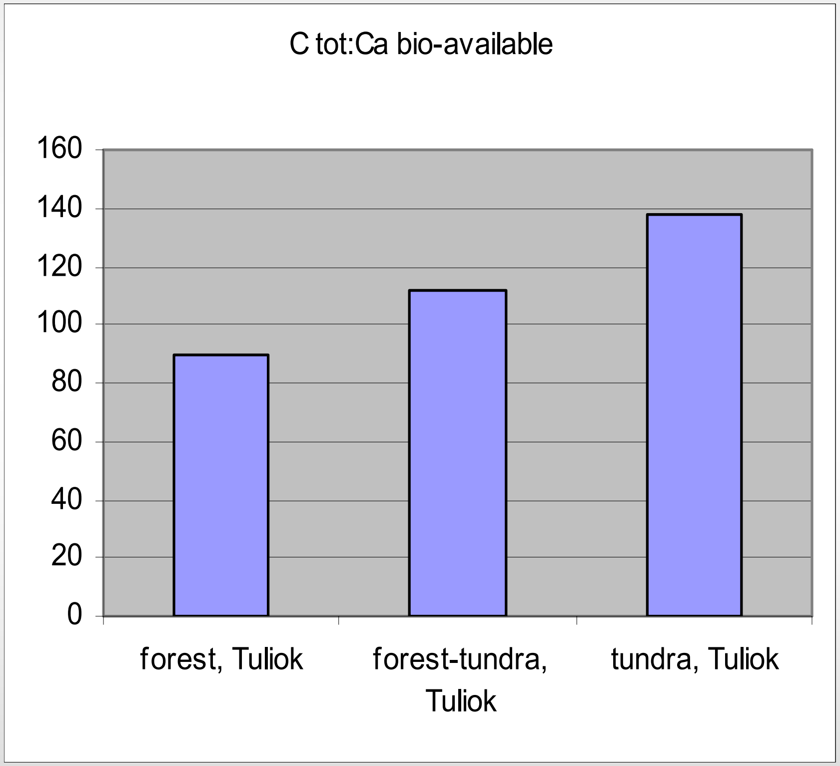


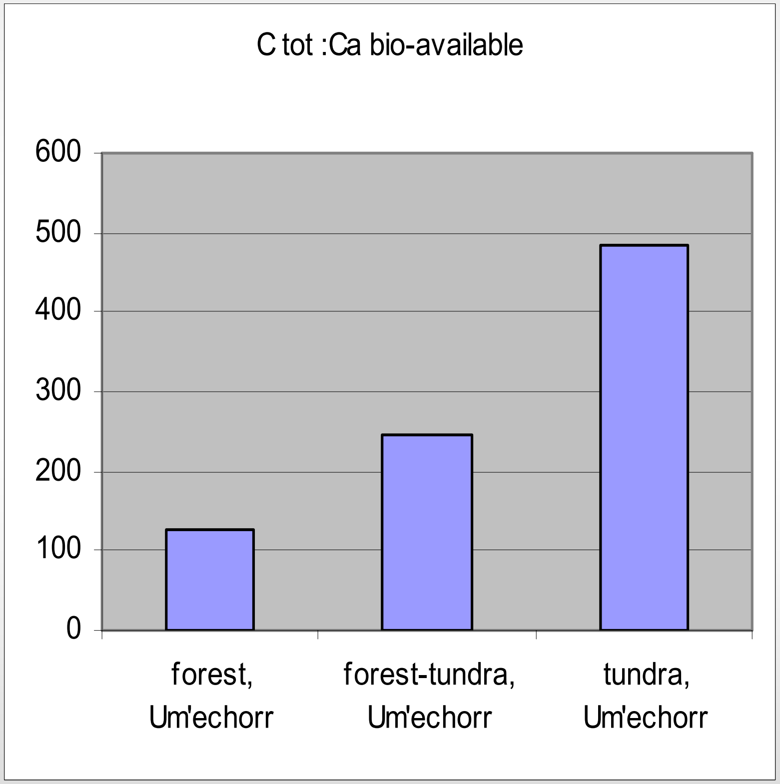
Comparisons between soil in forest- forest tundra- forest:

Organic horizons

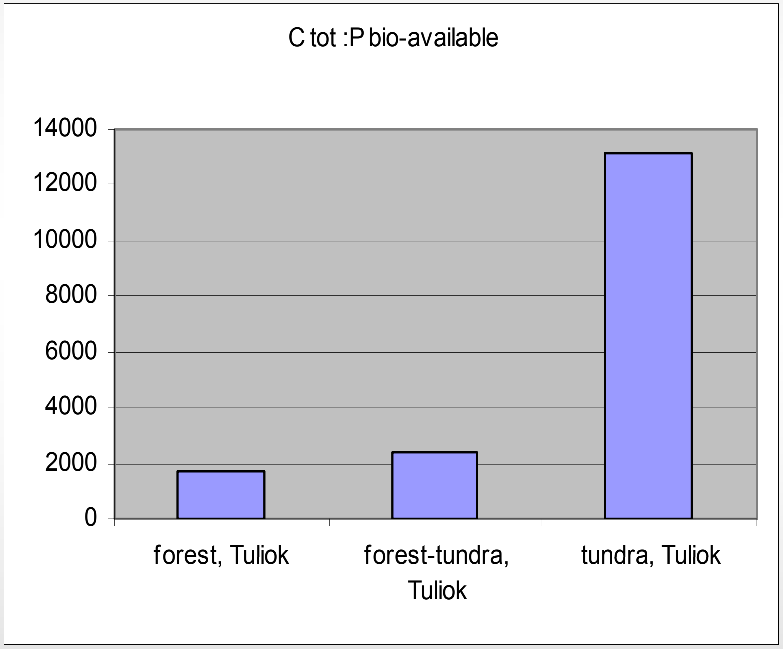
Mineral horizons

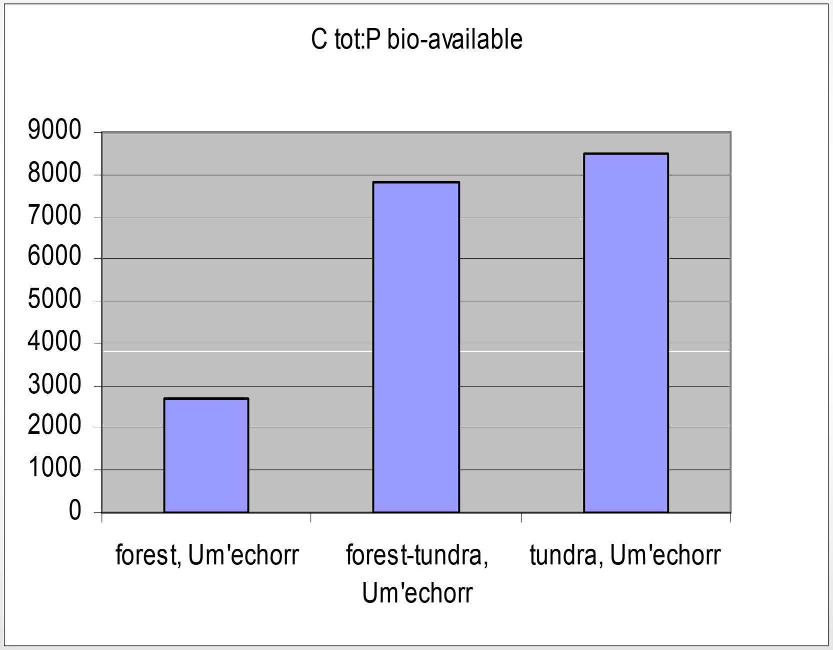
Ecotone comparison, organic horizon



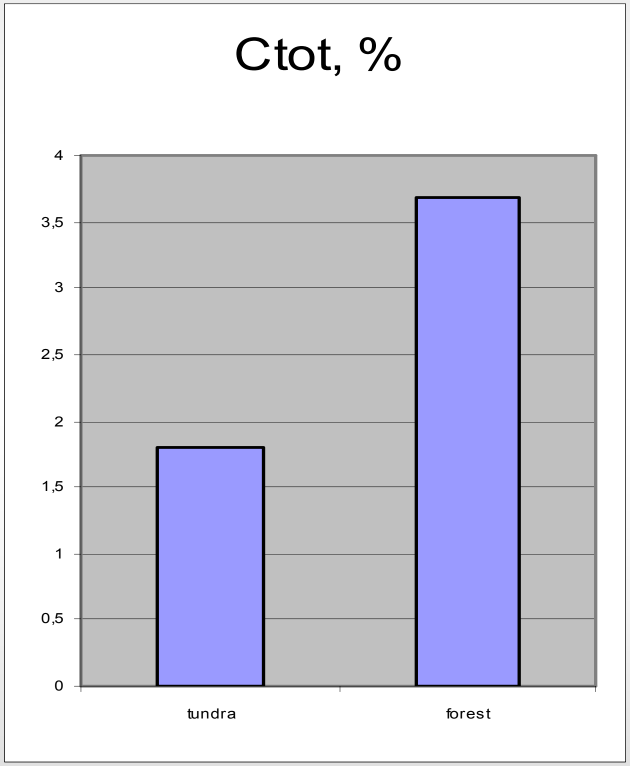


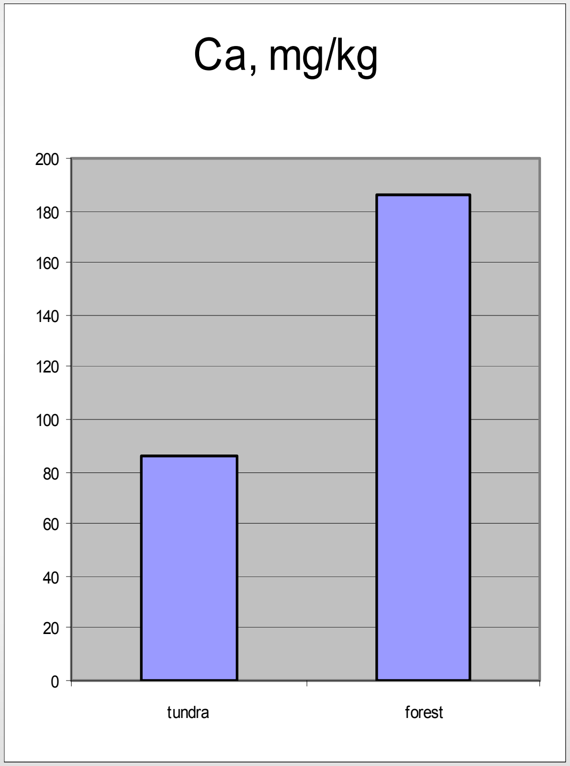
Ecotone comparison, organic horizon

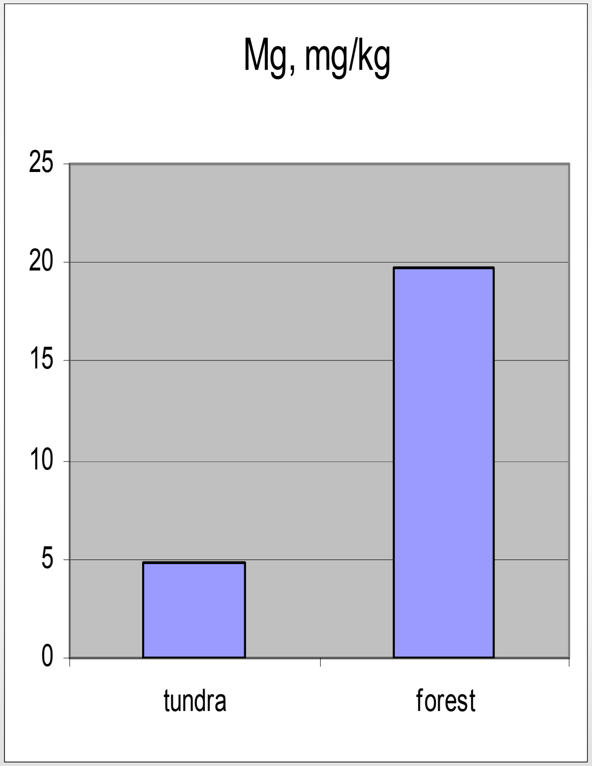




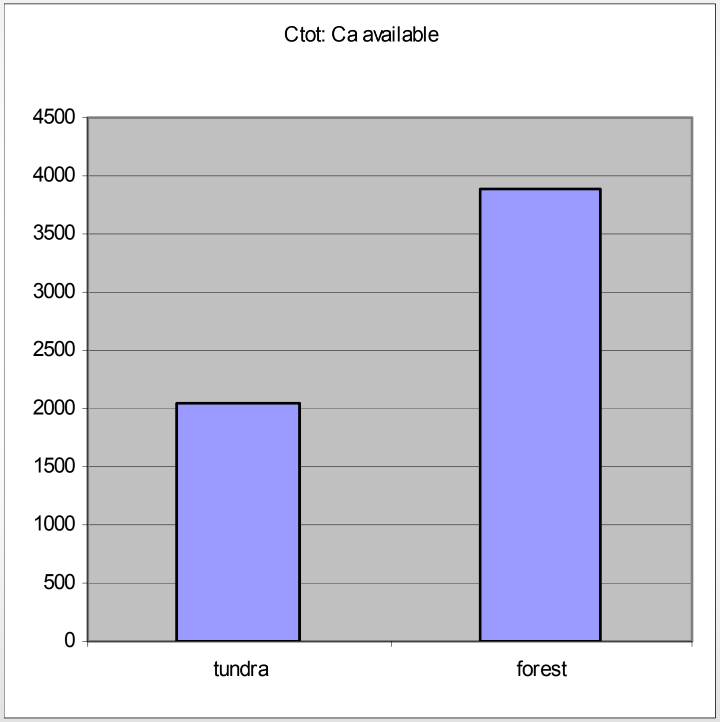
Ecotone comparison, B horizon

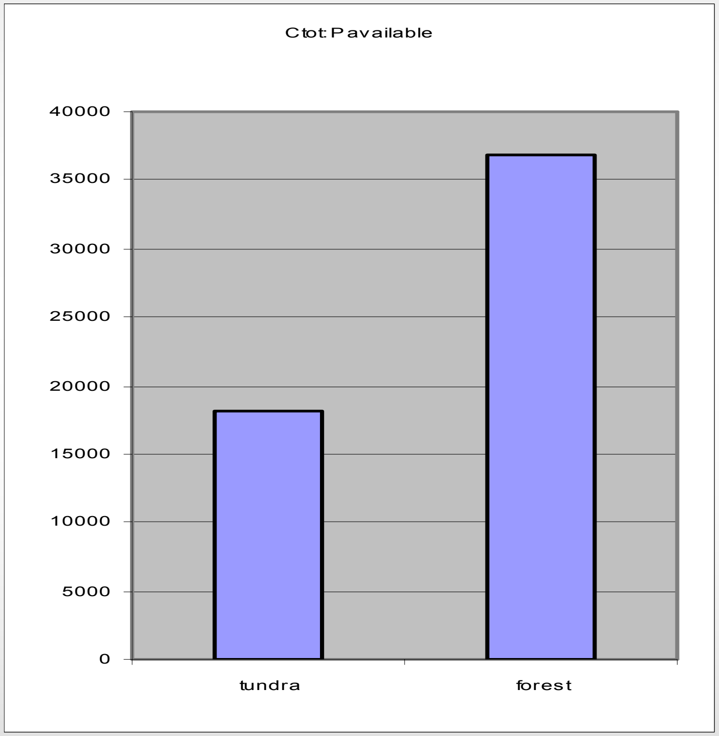






Ecotone comparison, B horizon





Conclusion 1

Comparisons between different tesseras in forest and forest-tundra showed that the concentrations of base cations, were higher in the organic horizons, and the acidity lower, below the crowns of Norway spruce than those below Scots pine, as well as between the crown tesseras with lichens, green mosses and low herbs.

Comparisons between different tesseras in forest and forest-tundra showed that the concentrations of organic carbon and nutrients in soil were higher in spruce tesseras.

Comparisons between different tesseras in tundra showed that the concentrations of nutrients in tesseras with shrubs and dwarf shrubs were higher than those in tesseras with lichens and barrens.

Conclusion 2

Comparisons of nutritional status in the tundra-forest ecotone allow us to conclude that contents of nutrients in forest soils, both podzol and cambic podzols, are higher than in tundra soil.

Conclusion

The advancing forest will alter element cycles because of differences in functions of key plants as ecosystem engineers. Indirect climate change effects through expansion of forest plants can be larger than direct effects on soil. Advancing tree line can, probably, increase nutrient availability.

Acknowledgements:

INEP KSC RAS : Galina Andreeva, Olga Denisova, Svetlana Sverchkova


Thank you for your attention !