Forest Condition Monitoring in Finland – National report

Photo: Metla/Erkki Oksanen

Extensive forest soil monitoring

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Summary

Finnish forest soils have been inventoried in years 1986–95 and in 2006–2007. Our forest soils are coarse and acid, they contain more carbon but less heavy metals than soils, on average, in central Europe. Soil fertility, measured e.g. by nitrogen and base cation status and pH, tends to decrease from southern to northern Finland.

Background

The first inventory of upland forest soils in Finland was carried out during the years 1986-1995, to measure soil acidity and nutritional and heavy metal status of upland soils. Another round of the soil survey was accomplished in years 2006–2007 under the EU project BioSoil. These large scale soil monitorings were aimed to give information about soil types, texture, carbon, nutrients, acidity and heavy metals at the time of both inventories and to give a possibility to estimate possible changes in soil properties.

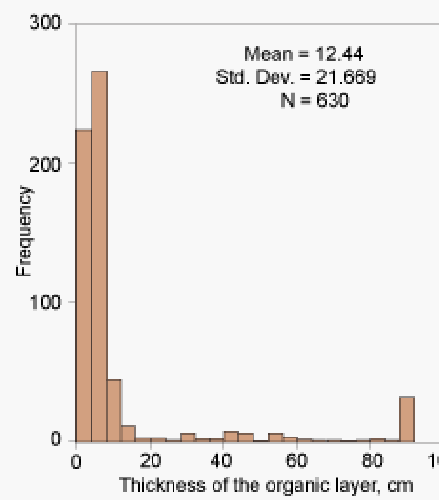

Figure 1. Frequency distribution of organic layer thickness on Level I plots.

Results

The arithmetic mean of organic layer thickness was 12.4 cm, although the median was only 4.8 cm (Fig. 1). The result is influenced by the fact that peatland sites with peat thickness of at least 90 cm were included in the sample. Distribution of humus types were typical for the boreal zone, i.e. mor and peat were dominating (Table 1). However, the proportion of upland sites, i.e. mineral soils, was higher, 84% vs. 76%, and the proportion of peatland sites was lower, 16% vs. 24%, than in average on forest land in Finland (Ylitalo, 2010).

Carbon

Amount of carbon in the organic layer on upland soils (thickness of the organic layer ≤ 10 cm) correlated best with variables measuring moisture, i.e. estimated moisture class (r = 0.22) and coverage of peat mosses (r = 0.37) and with age of tree stand (r = 0.18). There was no trend in south-north direction. In the mineral soil layer 0–20 cm the amount of carbon correlated negatively with northing (r = –0.38), site fertility class (r = –0.35; also Table 2) and stand age (r = –0.17) and positively with site moisture class (r = 0.29).

Parameter	Missing	Mor	Moder	Mull[a]	Peat
Mean	0.2	4.7	3.6	1.3	45.0
Median	0	4.4	3.4	0.1	41.6
n	10	456	39	11	124

Table 1. Mean and median thickness of the organic layer by dominating humus type. [a]=Mull was treated as mineral soil.

Although very moist and peat rich sites were removed from the material, the amount of carbon in surface soil tended to increase along moisture gradient. The amount of carbon tended to increase in the organic layer and decrease in the surface mineral soil when tree stands become older. It seems that the difference in organic matter concentration between the organic layer and the top-most mineral soil is smallest some years after regeneration and largest just before regeneration. The organic layer was missing most often on very fertile sites including afforested fields (n = 13) – humus form was mull – and on one very dry sandy site.

Layer	1	2	3	4	5	6	Average
Organic	16.9	17.3	23.6	21.4	19.5	17.6	21.4
Mineral soil layer	25.0	31.3	20.8	18.3	15.5	14.2	20.9
n	6	81	221	161	31	9	508

Table 2. Amount of carbon (Mg/ha) in the organic layer and mineral soil layer 0-20 cm by forest site type class, when the thickness of the organic layer was under 10 cm. 1-6= Forest site type class, 1=the most fertile, …, 6=the least fertile site

Nitrogen

Site fertility, measured by C/N ratio in the organic layer and nitrogen concentration in the mineral soil, tended to increase from north to south, correlation coefficients with northing were 0.48 and –0.55, respectively (see also Fig. 2). Correlation coefficient between organic layer C/N ratio and site fertility class was –0.59 and that between mineral soil nitrogen concentration and site fertility class 0.51. Soil nitrogen trends are more likely explained by climate and vegetation than nitrogen deposition.

Soil cations

Latitude showed a positive correlation with exchangeable acidity (H +) and potassium concentration in the organic layer (r = 0.29 and 0.37, respectively), and a negative correlation with organic layer pH, calcium concentration and base saturation (r = –0.29, –0.38, and –0.32, respectively). In the mineral soil layer 0–10 cm the acidity and all cation concentrations correlated negatively with northing (r = –0.20…–0.59). Higher acidity and higher cation concentrations in the southern part of the country may be explained by higher organic matter content in the mineral soil in southern than in northern Finland. Regional distribution of these variables can be seen in Fig. 3

Heavy metals

Heavy metal concentrations in the organic layer were quite low compared to e.g. Central Europe (Vanmechelen et al., 1997) . Lead concentration correlated best with northing (r = –0.51), to some extern with concentrations of cromium, copper, nickel and zink (–0.28 < r < –0.32), and only weakly with the concentration of cadmium (r = –0.12, p=0.003). The pattern of heavy metal concentrations corresponded well with the deposition measured using moss or lichen samples (Kubin et al., 1994; Poikolainen, 2004) (Fig. 4).

Material and methods

Finnish Level I plots are situated in a grid of 16 km*16 km in southern Finland and in a grid of 24 km*32 km in northern Finland. These monitoring plots were established in the course of the 8 th national forest inventory in 1985–86 and were located strictly systematically, i.e. the midpoint of an inventory plot may be situated e.g. on the border of two different sites, like peatland and upland sites or mature and seedling stands. However, only one, at least relatively homogenous compartment was sampled for soil survey.

In the second soil survey in 2006–2007, i.e. in the BioSoil project, the sampled soil layers were as follows: organic layers 0–10, 10–20, 20–40 cm and mineral soil layers 0–10, 10–20, 20–40 and 40–80 cm. From the organic layer, 10 or 20 subsamples were collected with a cylinder (d = 60 mm), depending on the organic layer thickness. From the mineral soil, five subsamples were taken with spades from the layers 0…40 cm, and only one sample from the deepest layer (40–80 cm). Mineral soil layers 0–10 and 10–20 cm were sampled with a volumetric cylinder whenever it was not an overwhelming task because of stoniness. Volumetric proportion of stones (d > 20 mm) in the mineral soil was estimated using a so-called steel rod method (Viro, 1952; Viro, 1958). If mineral soil bulk density was not measured, it was estimated using the equations of Tamminen and Starr (1994).

All soil samples from the second soil survey (BioSoil) have been analysed in the laboratory of the Finnish Forest Research Institute at Vantaa according to the Manual on the methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests, Part IIIa Sampling and Analysis of Soil, updated in 2006 (www.icp-forests.org/pdf/FINAL_soil.pdf).

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