

TREE BIOMASS AND SOIL CARBON DENSITIES AND STOCKS FOR A SMALL FORESTED CATCHMENT IN EASTERN FINLAND

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1. INTRODUCTION

Carbon (C) densities (mass per unit area) and stocks (mass) of tree biomass and soil organic carbon are becoming increasingly available at both the stand and national scale (e.g. Ilvesinemi et al. 2002, Kauppi et al. 1997). However, there are no results integrating both biomass and soil C at the catchment scale. The aim of this paper is to describe the living tree biomass and soil C densities and stocks for a catchment in eastern Finland. The catchment comprises areas of both upland soils and peatland. The biomass and soil C densities can be compared to deposition, litterfall, soil leaching and stream water runoff C fluxes that have been determined at Hietajärvi (Starr and Ukonmaanaho 2003, Vogt et al. 2001).

2. MATERIAL AND METHODS

2.1 Site description

The Hietajärvi catchment is located in the Patvinsuo National Park, North Karelia (63° 10' N, 30° 43' E, 165 m a.s.l.). It has a total area of 464 ha, of which 23 % is covered by lakes and small ponds, 30 % by peatland (forested and open), and 47% by upland forest soil. Iso Hietajärvi is the largest lake (83 ha) and is from where the catchment discharges northwards. The forests, which are mainly mature or old Scots pine stands, have been protected from management, slash and burn cultivation, and tar production since the beginning of the 20th century. The last major forest fires occurred about 150 years ago. Besides peatland (Histosols), the soils are mainly Haplic Podzols. The biogeochemistry of Hietajärvi has been intensively studied since 1988 as part of the UN-ECE Integrated Monitoring programme (see Bergström et al. 1985, Boreal Environmental Research 1998 volume 3(3), Ukonmaanaho 2001 and papers therein).

2.2 Forest stand survey and soil sampling

We estimated the C density and stock of each forest stand unit in the catchment using a forest inventory map produced by Metsähallitus (Forest and Park Service) in 1994 and detailed stand measurements and soil sampling we carried out at 43 plots (30 upland forest, 5 forested peatland, and 8 open peatland). The 43 plots were centred on the intersections of a 100 x 100 grid throughout the catchment. Intersections were chosen so as to obtain a representative sample of site and stand types. Maps of site and vegetation types (Tuominen and Mäkelä 1995) and the forest inventory, and

aerial photographs were used to make an *a priori* selection of intersections. At each selected intersection all living trees within a 5.6 m radius (100 m²) and every third tree from within a 9.77 m radius (300 m²) were measured for breast height diameter, top height, crown height, and ground projection. The rest of the trees within 9.77 m radius had only breast height diameter measured. Samples of the humus layer (upland sites only), 0-10, 10-20 and 20-30 cm soil layers were taken at c. 7 m from the plot centre in each of the four cardinal compass directions and bulked by layer. The samples were dried in a ventilated drying chamber at 40-60 °C, the humus layer and peat samples milled to a fine powder, and the mineral soil samples passed through a 2 mm sieve. Total C concentrations were determined using a LECO CHN-600 analyser.

2.3 Calculation of C densities and stocks

The forest stand C density at each plot was calculated from estimates of biomass (kg dry matter), which were estimated using allometric biomass functions (Marklund 1988). The biomass estimates include stem, branches, foliage, stump, and coarse root components. Assuming a C content of 52 %, we determined a linear relationship between biomass C density and stand (stem) volume ($R^2 = 99 \%$). Using the stem volume values from the forest inventory, we then calculated the stock of C in each stand unit. These values were then summed to give biomass C stocks for upland soil, forested peatland, open peatland, and total catchment. Soil C density values (t C ha⁻¹ to 30 cm depth) for each plot were calculated from the C concentration measurements, layer thickness, estimated bulk density values and stone contents. We used appropriate bulk density and stone content values from intensively monitored plots (Starr and Ukonmaanaho 2001) for the upland plots and values for the peat samples were taken from Westman et al. (1985). The sampled plots were classified as recessional moraine, till, sorted fine sand/silt, coarse sand/gravel esker deposits, or peat and the mean C density of each calculated (n = 5 to 18). Multiplying these mean values by the area of each type of surface deposit (Tanskanen and Starr 1995) gave the stock of soil C for each type of deposit.

3. RESULTS AND DISCUSSION

Living tree stand biomass C densities ranged from 0 to 95 tons ha⁻¹ (Fig. 1). The smallest C densities were associated with the peatlands and the highest with upland forests, which had the highest stand volumes (average 173 m³ ha⁻¹). Soil C densities varied from 33 (coarse sand/gravel esker deposits) to 49 (recessional moraine) t ha⁻¹ for upland soil (Fig. 1). Peatland areas had the highest soil C densities, averaging 134 t ha⁻¹.

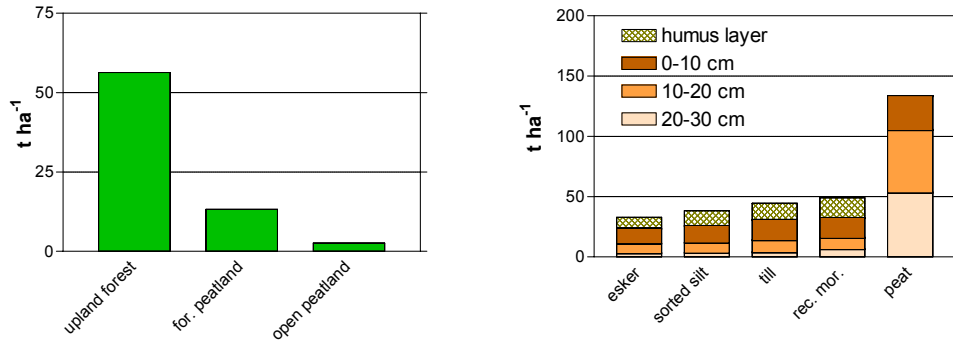


Fig. 1. Living tree biomass (left) and soil (right) C densities by layer at the Hietajärvi catchment.

Upland soil C densities decreased with layer depth, reflecting the depth distribution of soil C mass concentrations. Soil C densities for the peatland areas, in contrast, increased with layer depth, which shows that the depth distribution of soil C in natural peatlands is mainly determined by bulk density and not C mass concentrations.

Stocks of C in the living tree biomass for the entire Hietajärvi catchment totalled 12,757 tons, 91 % of which was accounted for by upland soil forests (Fig. 2). The catchment stock of soil C to a depth of 30 cm was more than twice that of the living tree biomass C stock, totalling 28,445 tons, 66 % being accounted for by peat (Fig. 2).

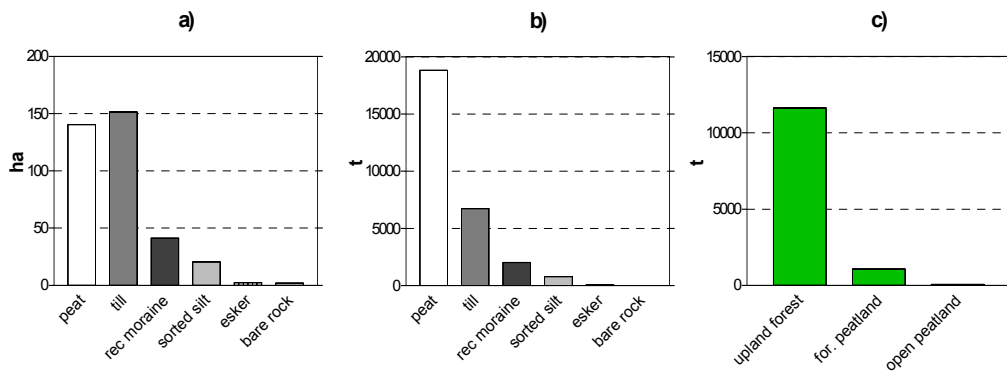


Fig. 2. Relative areas (a) and stocks of soil C by soil type (b), and stocks of C in the living tree biomass (c) at the Hietajärvi catchment.

However, our earlier surveys on permanent monitoring plots indicate that there are considerable amounts of dead standing and fallen trees, snags and coarse woody debris on the forest floor. We intend to estimate the C density and stock of this necromass in the future.

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