A Simple Device for Sampling of Volumetric Forest Soil Cores

Carl Johan Westman


A simple, manually-operated and easily portable device for sampling volumetric soil cores to a depth of 100 cm with a minimum of soil disturbance is described. The device consists of a sample tube, a sampler and an extension tube. A dead blow nylon mallet is used to force the sampler into the soil and a small winch attached to an aluminium tube pulls the sampler from the soil. The total weight of the equipment (sampler, mallet and winch) is 18.5 kilograms and may be carried in the trunk of a small car. Sampling is easily done by one person in good physical condition but four-handed operation is recommended as more efficient. The sampling device has been in heavy use during the summers of 1993–95 when several hundred soil cores have been successfully extracted on various sites all over Finland.

**Keywords** podzolic soil, repeated sampling, spatial sampling, soil density determination, fine root biomass determination.

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1 Introduction

Sampling of volumetric soil cores for soil density determinations, for measuring fine root biomass or soil hydraulic properties is laborious and time-consuming. Normally a soil pit is excavated and samples are taken by soil layer with the aid of small steel cylinders (100–200 ml). Excavating the working pit however usually results in major disturbance on the site to be sampled. Thus investigations of small-scale spatial variation in any soil property or repeated sampling for time-series investigations becomes almost impossible. In the SILMU project Carbon in Boreal Coniferous Forest Soil (Westman et al. 1994) tree stand spatial variation in soil carbon density and the density of carbon in the top soil layer of stands of differing fertility and differing climate have been of major concern. Repeated sampling within tree stands has also been conducted. To handle the field sampling in the project a special...
device fulfilling the following criteria was developed: (i) samples should be of known volume, (ii) sampling should be extended down to 100 cm depth, (iii) the equipment should be manually operated and easily portable and, (iv) repeated sampling and spatial sampling over short distances with a minimum of forest soil disturbance should be possible.

2 The Device

The device consists of a sample tube, a sampler and, an extension tube (Fig. 1). The sample tube is a 500 mm PVC tube with 50 mm diameter and 2 mm wall thickness. The sampler is made from a steel tube (quenching and tempering steel DIN 25CrMo4, SFS458, 58 mm diameter, wall thickness 6.75 mm). The inner surface of the tube is in 550 mm length bored to fit the outer diameter of the sample tube. The cutting end of the sampler is also bored to a diameter slightly less (0.5 mm) than the inner diameter of the sample tube. This is necessary to decrease friction between the soil core and the sampling tube. The cutting end of the sampler is sharpened, leaving the sampler with a straight cylindrical inner wall surface. After sharpening, the cutting edge is quenched (60 HCR). The upper end of the sampler is fitted with an inner batten thread (6 threads per inch) to enable the fitting of a striker-plate or an extension to the sampler. The striker-plate, having an outer thread, is fitted with a pressure outlet and a handle. The pressure outlet is necessary to prevent a pneumatic effect on the soil core from the air enclosed in the sampler. The extension tube is a 550 mm long steel tube with one inner and one outer thread to fit between the sampler and the striker-plate.

3 Sampling and Testing of the Device

Sampling is performed stepwise. First the surface layer (0–50 cm) is sampled and then with the aid of the extension tube a second sample (50–100 cm) is taken from the bottom of the open hole left by the surface sample. A sample tube is inserted into the sampler and locked in place by screwing the striker-plate tightly to the sampler. While doing so it is important to keep the joint clean and use some light spray lubricant to ensure easy closing and opening. A dead blow nylon mallet (Stanley 3" 10.5 lb.) is then used to force the sampler into the soil. During hammering the striker-plate must be tightly screwed into place or the thread may be damaged.

In most cases the sampler containing the surface sample (0–50 cm) can be pulled free of the soil by hand. However, when sampling deeper soil layers (50–100 cm) or till soils human strength does not suffice for lifting the sampler. For this purpose we used a small winch with a 1:4.1 gearing giving 550 kp traction, standard equipment used for example on boat trailers, attached to an aluminium tube (Fig. 2).

The total weight of the equipment (sampler, mallet and winch) is 18.5 kilograms and can be carried in the trunk of a small car. Sampling is easily done by one person in good physical condition but four-handed operation is recommended as more efficient.

In the laboratory a wooden pole (40–45 mm diameter) clamped to a heavy table (Fig. 3) is used to pull the sample tube off the sample, leaving the soil core on a tray, free for soil type description and further division into sub-samples. Providing that the cutting edge of the sampler is kept properly sharpened and the sample tube has the right inner diameter, a nice coherent soil core with natural volume is obtained (Fig. 4). However, on coarse non-coherent soils the bottom end of the core may be lost and, when taking consecutive samples the upper end of the deeper sample will be contaminated to some degree (e.g. core 3605 Fig. 4) and must be discarded. A moist deep frozen sample is easily divided into sub-samples suitable for even such things as water-retention determinations.

To demonstrate the functioning of the sampler, field sampling was conducted at three different sites. At the first site soil parent material was a windblown fine sand, at site two a glaciofluvial coarse sand with some 15 per cent gravel, and at site three a stony (Viro 1955) basalt till soil also containing some 15 per cent of gravel size material (Fig. 5). All soils were podzolised and the age of the soil was some 9000 years. At each site five replicate samples were taken on a row at 10 cm distance. After sampling a soil pit was dug and the depth of the soil horizon was
Table 1. Length of soil cores (cm) obtained with the 50 cm long sampling tube. Mean values and coefficient of variation calculated for five observations.

<table>
<thead>
<tr>
<th>Site</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40.0</td>
<td>34.0</td>
<td>45.0</td>
<td>11.3</td>
</tr>
<tr>
<td>2</td>
<td>43.2</td>
<td>37.0</td>
<td>46.0</td>
<td>8.9</td>
</tr>
<tr>
<td>3</td>
<td>44.0</td>
<td>42.0</td>
<td>46.0</td>
<td>3.6</td>
</tr>
</tbody>
</table>

A comparison between soil horizon thickness measured in the field and in the laboratory (Table 3) showed no compaction of soil horizons as a result of sampling. Paired t-tests between measurements showed a significant difference (p = 0.026) only for the B horizon in soil 2, which on inspection in the laboratory was found to be of lesser thickness than measured in the field from the soil horizon thickness data (Table 3) and substantial horizon thinning could be observed even on the soil cores (45 mm diameter). Generally, it was easier to measure soil horizon thickness under standard conditions in the laboratory than in the field.

The bulk density of the soil cores varies from a minimum of 0.89 g·cm⁻³ in the 0.1 cm layer to a maximum of 1.59 g·cm⁻³ in the 20–30 cm layer. The increase in soil density with increasing depth in soil is a result of the podzolisation process and mean soil densities given in Table 2 are generally within the range found for forest soils sampled by horizon with a 150 cm³ corer (Table 4). However, the low bulk density values for the 20–30 cm soil layer may be a result of cracking and loosening of the soil core when lifting the sample.

In conclusion, our device facilitates easy sampling of soil cores in natural volume with a minimum of site disturbance. The sampling device has, indeed, been in heavy use during the summers of 1993–95. Several hundred samples have been successfully extracted on various sites all over Finland. It is however obvious that the device is most suitable for sampling on sorted soils

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### References


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