A Simple Device for Sampling of Volumetric Forest Soil Cores

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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.

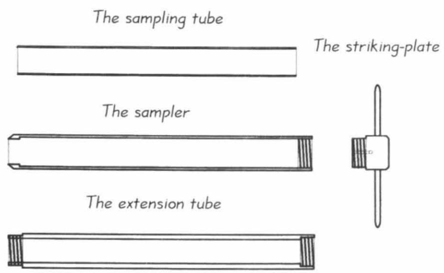

Fig. 1. The device consisting of 1) the PVC sample tube, 2) the sampler made from a quenching and tempering steel tube, 3) the striker-plate with a pressure outlet and a handle and, 4) the extension tube fitting between the sampler and the striker-plate.

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.

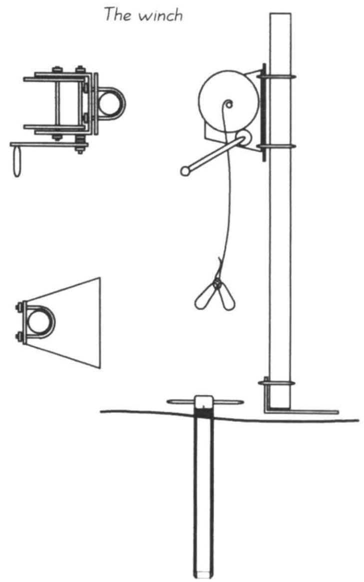

Fig. 2. A small winch attached to an aluminium tube is used to pull the sampler free of the soil. The winch, standard equipment used on boat trailers, has 1:4.1 gearing giving 550 kp traction.

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

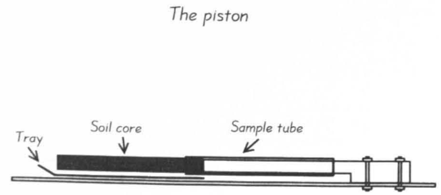

Fig. 3. A wooden pole (40–45 mm diameter) clamped to a heavy table is used to pull the sample tube off the sample, leaving the soil core on a tray.

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) basal 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

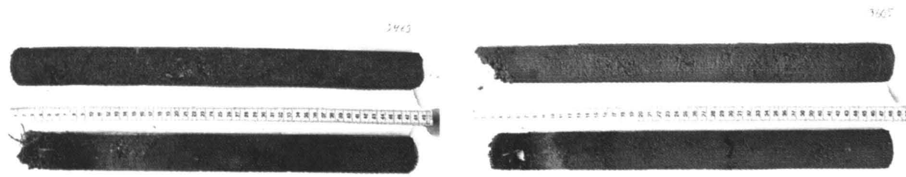

Fig. 4. Soil cores from coarse sand (sample 3463) and sandy top soil on a silty till layer (sample 3605).

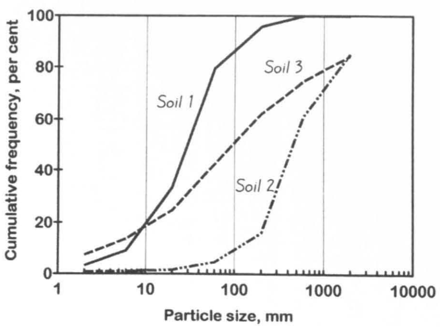

Fig. 5. Particle size distribution curves for soils studied. Particle size distribution determined according to Elonen 1971.

measured from the soil face at each sampling point. In the laboratory the length of the sample core and thickness of individual soil horizons were then measured. Further, for soil moisture content and bulk density measurements each core sample, starting at the upper end of the alluvial mineral soil horizon, was divided into three 10 cm long sub-samples. The sub-samples were weighed in fresh condition and again after drying to constant weight (105 °C).

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.

Site	Mean	Min	Max	CV
1	40.0	34.0	45.0	11.3
2	43.2	37.0	46.0	8.9
3	44.0	42.0	46.0	3.6

The total length of the soil cores obtained with the 50 cm long sampling tube varied for all fifteen samples between 34 and 46 cm being on an average 42.4 cm. In the sorted coarse grained soils coherent cores could not always be obtained from the non-cemented C horizon material. Thus these cores are on an average shorter and of more varying length than the cores from the till soil (Table 1). The low soil moisture content in deeper soil layers of the sorted soils also contributed to this result (Table 2).

Table 2. Bulk density ($g \cdot cm^{-3}$) and soil moisture content (v/v) at sampling in three consecutive 10 cm thick soil layers (I–III). Mean values and coefficient of variation calculated for five observations.

	Bulk density						Soil moisture content					
Site	I	CV	II	CV	III	CV	I	CV	II	CV	III	CV
1	0.91	2.9	0.98	5.9	1.07	2.2	17.3	4.9	15.1	8.4	15.1	10.7
2	1.06	11.4	1.19	6.9	1.47	5.7	18.9	3.4	14.8	17.1	10.3	13.5
3	1.04	9.7	1.08	9.9	1.27	7.0	20.7	7.7	22.0	5.4	22.5	7.1

Table 3. Thickness of podzolic soil horizons (cm) measured in field (H_F, A_F, B_F) and on soil cores in the laboratory (H_L, A_L, B_L) Mean values and coefficient of variation calculated from five observations.

Site	H_F	CV	H_L	CV	A_F	CV	A_L	CV	B_F	CV	B_L	CV
1	4.8	17.4	4.9	18.3	4.7	9.5	4.8	26.1	16.2	22.8	16.0	20.3
2	6.0	11.8	5.5	6.4	7.4	23.1	5.5	27.3	23.0	4.3	18.4	14.7
3	5.8	13.1	5.5	17.0	4.5	69.4	5.0	44.7	21.2	13.1	22.8	14.7

Table 4. Soil bulk density values ($g \cdot cm^{-3}$) for podzolic soil in Finland (n = 30). Samples taken manually from horizon with a 150 cm^{-3} cylindrical corer (unpublished data by Westman).

Horizon	Mean	Min	Max	CV
A	1.16	0.96	1.37	8.7
B1	1.21	0.98	1.43	10.1
B2	1.41	1.18	1.63	8.8
C	1.58	1.37	1.82	6.1

A comparison between soil horizon thickness measured in the field and in the laboratory (Table 3) showed no compacting 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 face. However, there is a great spatial micro-variation in soil horizon depth influencing on measuring accuracy (Table 3), and substantial horizon tonguing 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 $g \cdot cm^{-3}$ in the 0.10 cm layer to a maximum of 1.59 $g \cdot cm^{-3}$ 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 cm^3 corer (Table 4). However, the low bulk density values for the 20–30 cm soil layer for soil 1 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 best fitted for sampling on sorted soils low in stone content, but even on till soils sampling has been conducted successfully (Westman et al. 1994, Liski 1994, Westman and Sirola 1994).

The sampling device was developed in co-operation with Mr. L. Karppinen from Helake Ltd. Finland, and is now obtainable from Terra-Team Ltd, Juvan Teollisuuskatu 18, FIN-02920 Espoo, Fax +358 0 852 2180.

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