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A METHOD TO ESTIMATE THE EFFECT OF FOREST DRAINAGE ON THE CARBON STORE OF A MIRE

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Mires are sinks for carbon. Drainage enhances the aerobic microbial decomposition of the surface peat, which may transform mires into net sources of carbon to the atmosphere. However, the increase in the growth of the tree stand and consequent fixation of carbon after drainage may be expected to have a compensating effect. The effects of drainage on the carbon stores of a mire are not easy to establish. This paper discusses a method that can be used to assess the changes in cases where part of the mire has been left in the virgin condition. The method is based on bulk density and carbon content profiles measured along a transect running from the undrained part to the drained part of the mire. The carbon store of the peat in each case is calculated for the peat depth in which drainage is considered to have caused changes. The subsidence at each measuring point on the drained side is subtracted from the original peat depth before carbon store calculations.

Keywords: Boreal zone, carbon stores, peatland forestry

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INTRODUCTION

In the virgin state, peatlands are accumulators of carbon. Drainage enhances soil microbial activity, accelerating the decomposition and mineralisation of the peat and release of CO_2 to the atmosphere. The drainage of peatlands for agricultural and forestry purposes reduces storage and may transform peatlands from a net sink into a net source of carbon to the atmosphere (e.g. Armentano & Menges 1986, Gorham 1991).

Peatland drainage for forestry in the boreal and temperate zones has been extensive — about 14 mill. ha of peatlands and wetlands. Over 90% of this activity has been concentrated in the Nordic countries (Finland, Sweden and Norway) and the former Soviet Union. In Finland, the area drained for forestry, including paludified upland forests, is approximately 5.7 mill. ha. (Päivänen & Paavilainen 1990). In spite of this amount of peatland drainage activity, little data exists about the effects on the carbon balance (see however, Vompersky & Smagina 1984, Silvola 1986, Braekke 1987, Laine et al. 1991, 1992, Laine & Laiho 1992).

Drainage for forestry initializes a shift in biomass production away from the field and bottom layer plant communities to the tree layer. Simultaneously, soil microbial activity is enhanced and the decomposition and mineralization (decay) of the peat is accelerated. Whether drained peatlands act as sources or sinks for carbon depends on the ratio between the accumulation of organic matter, mainly from the litter production of the tree layer, and the decay of previously accumulated peat.

The aim of this paper is to describe and evaluate a method for studying the effect of drainage for forestry on the carbon store of a mire. The study is part of a larger research project, "The Carbon Balance of Peatlands and Global Climatic Change", which is a subproject of the Finnish Research Programme on Climate Change, and is financed by the Academy of Finland.

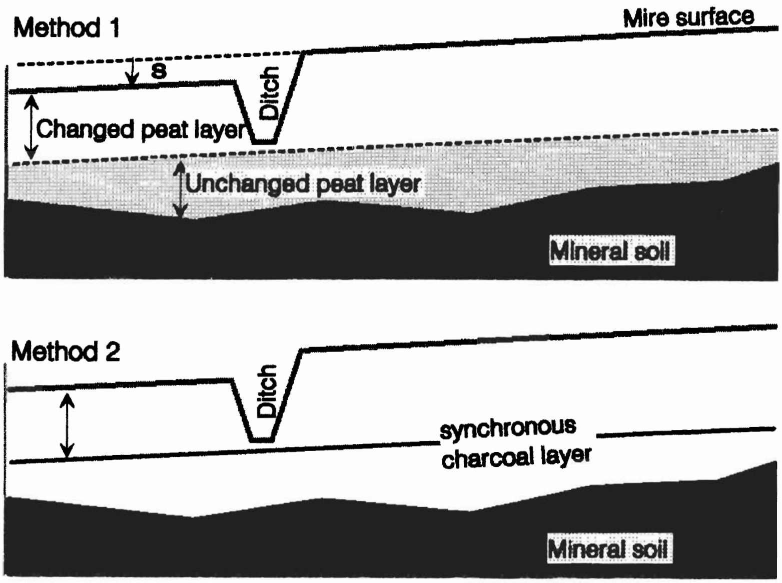

Fig. 1. The principle behind the determination of subsidence (S) and carbon stores. Subsidence is measured as the difference between the post-drainage mire surface and the extension of the smoothed surface of the undrained mire along the transect. The carbon stores have been calculated for the changed peat layer in the drained part and for the corresponding layer in the virgin part (Method 1). In method 2 the carbon stores are calculated for the peat depth above the base line (e.g. a synchronous charcoal layer).

DESCRIPTION OF THE METHOD

Carbon stores are determined at intervals along transects that span both the undrained and drained parts of the mire. The sampling points along the transects are levelled and the mire surface marked with "root poles" that act as 0 levels for measurements and sampling. At each point, the peat depths are measured and a set of undisturbed peat samples of known volumes taken, starting from the mire surface and continuing until the mineral soil interface is reached. The bulk densities of the peat samples are calculated from the dry mass and fresh volume values, and total carbon concentrations determined.

The amount of subsidence on the drained side of the transect is estimated assuming that the slope of the pre-drainage mire surface, drawn from the levelling data, is contiguous on both sides of the border-ditch. Thus, the difference between the present surface of the drained peat and the extension of the slope of the undrained mire surface to the drained part gives the subsidence caused by the drainage (Method 1).

The lower level of the surface peat layer used in the carbon balance calculations is based on the depth at which there was no further significant increase in bulk density in the drained part of the transect. Mean depth is calculated for the drained part of the transect and a line, parallel to the slope of the mire surface, drawn through this mean depth. The depth from the mire surface to this level defines the surface peat layer and the carbon stores along the transect are calculated for this layer (Fig. 1).

The carbon store is calculated for each sampling point using the bulk density and carbon concentration profiles. The effect of drainage is estimated by subtracting the mean carbon store value of undrained sampling points from each carbon store value.

The effect of drainage on the carbon stores along the transect can also be determined using another approach (Method 2). Instead of using the extrapolation of the smoothed mire surface to determine the subsidence and the depth of the remaining peat layer on the drained side, these can be measured from a synchronous layer in the peat (Fig. 1). A charcoal layer or an abrupt change in the pollen ratios (Fig. 2) can be used as such a base line, provided it can be traced along the transect. For the rest of the carbon store calculations, the same principles as in Method 1 are followed. Locating a synchronous layer requires the use of detailed microscopic analyses of the peat columns in 1-cm slices, and is thus very time consuming.

DISCUSSION

Preliminary calculations on the changes in carbon stores after drainage using Method 1 have been presented from the Lakkasuo mire complex, which is one of the areas of intensive research in the SUOSILMU-project (Laine et al. 1992). Experience has shown that the determination of the subsidence of the mire surface on the drained part of the mire by extrapolating the present surface of the undrained mire is not unambiguous in all cases.

Fairly small errors in the determination of the subsidence, such as ± 2 cm, cause deviations in the carbon store calculations that are large in relation to actual changes that take place after drainage. This means that measurements and samplings should always be carried out using the same 0 levels ("root poles") and which do not fluctuate with the mire surface. In Method 2, the synchronous layer, which serves as a base line, can be determined to an accuracy of ± 1 cm. This makes possible more accurate calculations and results which are more reliable.

The methods are so time consuming that it is rarely possible to acquire so much data that statistical analyses would be meaningful. Thus, the method is best suited to studying the carbon store changes of a certain site, where its results can be related to other measurements. Statistical comparison of the carbon stores between drained and undrained parts of the mire are possible where a large number of points can be sampled on both sides. This approach is useful, especially, in rather shallow peats where the smoothness of the mineral soil bottom can be ascertained.

The basic assumption behind the method is that the drained part of the mire has been similar to the present virgin part before drainage. This

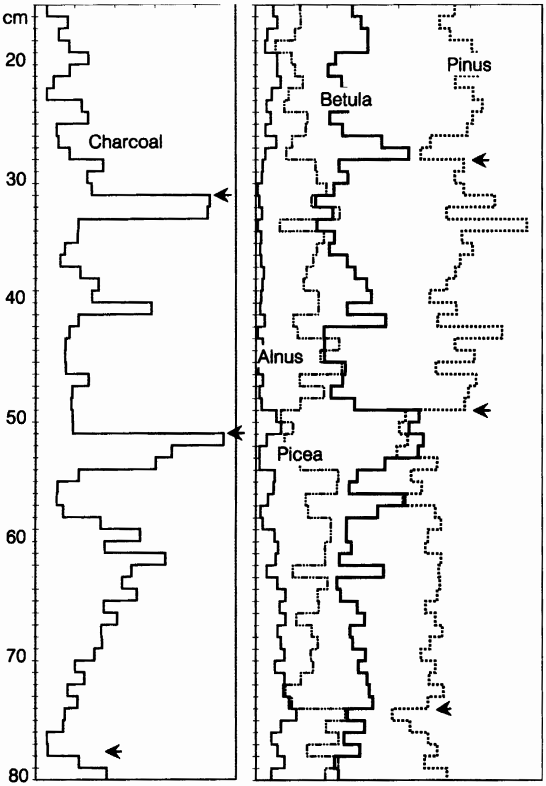

Fig. 2. For locating a suitable base line for C store measurements, the peat column is studied microscopically in 1-cm slices. The first 300 arboreal pollen grains (*Pinus*, *Picea*, *Betula*, *Alnus*) are counted along with the charcoal particles monitored until the counting has reached 300 pollens. The peat depths where the base line could be placed, if found synchronous in other sampling points, are marked with arrows.

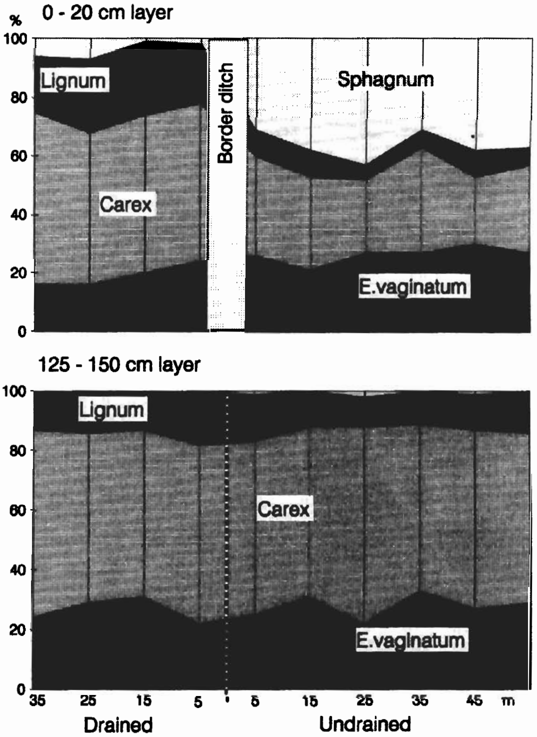

Fig. 3. Proportions of *Eriophorum*, *Carex*, *Lignum* and *Sphagnum* components along the transect in the surface (0–20 cm) and bottom (100–125 cm) peat layers. The floristic composition of peat along the transect is useful when judging the pre-drainage similarity of the drained and undrained parts of the transect. The proportions of *Sphagnum* and *Lignum* components in the surface layer have changed considerably after drainage, but the deeper layer is rather similar on both sides.

is not always easy to ascertain because the vegetation changes drastically, especially in the more nutrient rich sites. However, microscopic analyses of the peat can give reliable information on the past vegetation on both the drained and virgin parts of the mire (Fig. 3).

A rather similar method has been used in Scotland in studying the effects of drainage and afforestation on the carbon stores in peat (Anderson et al. 1992).

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