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VOLUME AND MASS BUDGETS OF BLANKET PEAT IN THE NORTH OF SCOTLAND

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The ground surface was 0.5 m lower under a 22-year-old lodgepole pine (*Pinus contorta*) plantation than in the adjacent unplanted ride. The peat was much drier beneath the trees than in the ride. The depth of peat under the trees, adjusted so that each layer had the same dry bulk density as the originally equivalent depths in the ride, effectively reversing shrinkage due to drying, was 2 cm greater than our best estimate of its original depth and the depth in the ride was 8 cm greater than in 1966. The original depths, surveyed in 1966 had too large an uncertainty (± 15 cm) for the changes to be significant.

Keywords: Carbon stores, peatland forestry, *Pinus contorta*

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INTRODUCTION

Blanket peats in the north of Scotland go through a drying and shrinking process when conifer forests are grown on them (Binns 1968, Burke 1978, Pyatt 1976, 1987, Howell 1984). The process starts slowly and accelerates at canopy closure. The water table in the peat is lowered first by ploughing and drainage and later by evaporation and transpiration. Aeration of the newly unsaturated layer of peat may lead to increased microbial oxidation of organic matter. This would represent a loss of carbon to the atmosphere, but not necessarily a net loss from the ecosystem, or even from its below-ground component.

Here we describe a study of peat depth and its water content and bulk density beneath a pine forest and an adjacent unplanted ride. We compare the depth of peat under the forest, adjusted to the same dry bulk density, layer by layer, as the unplanted peat, with its depth 24 years earlier, before the trees were planted. The dry bulk density adjustment reverses the effect of shrinkage due to drying, so that any difference is due to organic matter loss or gain. We also compare the mass of dry matter in the peat under the forest with that in the unplanted peat. We have to take account of the different original depths and the fact that the unplanted peat may have continued to accumulate over the last 22 years. Under the forest peat growth has stopped but tree roots have been growing.

METHODS

This work was done on blanket peatland at Bad a'Cheo research area of Rumster Forest, Caithness, in the north of Scotland (58°26′N 3°25′W). The vegetation was dominated by *Sphagnum* species (mainly *S. capillifolium, papillosum* and *cuspidatum*) and *Trichophorum cespitosum*, with lesser amounts of *Eriophorum angustifolium, E. vaginatum, Erica tetralix, Cladonia* spp., *Narthecium ossifragum* and *Calluna vulgaris*. The upper 0.1 m of the peat contained fairly undecomposed

Sphagnum and some tough fibres in a matrix of dark brown material; its von Post humification value is 3–5. The underlying pseudofibrous peat is 3–5 m thick and is soft and gelatinous, with a humification value of 7–9. A survey of the vertical height of the ground surface at nodes of a 50 x 50 m grid was done in 1966, before ploughing and drainage began.

Lodgepole pine (*Pinus contorta*) trees were planted in ploughed and drained plots in 1968 as part of a cultivation and drainage experiment. The work reported here began in 1990. We set up 3 transects, each starting 12 m inside one of the experiment plots, crossing a 1.2 m deep drainage ditch at the plot edge, running across a 20 m wide unplanted ride and ending 9 m inside a shelter belt of trees. The trees in the experiment plot were 9 m tall and their canopy had closed, shading out all ground vegetation. Those in the shelter belt were only half as tall due to less intensive draining and fertilising and their canopy had not yet fully closed.

We surveyed the height of the ground surface at intervals of not more than 0.5 m along the transects and recorded the width and depth of the tear cracks which were present in the plough furrows of the experiment plot. We probed the peat depth at roughly 1 m intervals along the transects.

We used a square corer (Cuttle & Malcolm 1979) to sample the upper 90 cm of peat at 14 points along each transect and cut each core into 0.10 m long sections. At the centre of the ride and at a point 10 m inside the experiment plot we used a Russian semi-cylindrical corer to sample the lower layers, from 90 cm depth down to the base, 3 m below the surface. These samples were cut into 15 cm long sections. The unsaturated samples (usually the upper 90 cm) from the 6 long cores were wrapped in cling film for measurement of their volume using Archimedes principle (Pyatt & John 1989). The water content of all the samples was found by oven drying for 3 days at 105°C. We calculated the specific volume of the unsaturated samples from the long cores from their fresh mass and volume and their water content. For the remaining (saturated) long core samples we estimated their specific volume from their water content using the relationship:

$$V = Ø\ Vw + Vs \quad \text{(Pyatt \& John 1989)}$$

where V is the specific volume of peat, Ø is the gravimetric water content, Vw is the specific volume of water, taken to be 1 $dm^3\ kg^{-1}$, and Vs is the specific volume of solids, taken to be 1/1.46 or 0.685 $dm^3\ kg^{-1}$.

We reconstructed the peat depth for each of the long cores within the experiment plot by adjusting the specific volume of each sample to match that of the originally equivalent layer of the unplanted peat. The reconstructed depth could then be compared to the original depth to find out if any depth had been lost other than through shrinkage due to drying.

RESULTS

The ground surface and underlying mineral surface heights along Transect 2 are shown in Fig. 1; the other transects were similar. In all 3 transects the ground surface in the experiment plot was 0.4–0.6 m lower than the unplanted ride and in the shelter belt it was 0.2 m lower than the ride. The surface of the mineral substrate was almost flat.

Peat water content beneath Transect 2 is also shown in Fig. 1. In the unplanted ride the peat was driest near the surface and wettest between 0.5 and 2.0 m depth. In the experiment plot the surface layers were much drier, water contents were 2–3 $kg\ kg^{-1}$ dry matter compared with 8–9 $kg\ kg^{-1}$ dry matter in the ride. The shelter belt had an intermediate water content but the drying appeared to extend out into the unplanted ride, perhaps because tree root spread was not restricted by a drain.

The reconstructions of the peat depth in the experiment plot are illustrated in Fig. 2. A further 15 cm had to be added to the total depth of the sampled peat to allow for the layer which could not be sampled with the Russian corer, giving reconstructed peat depths of 3.29 m, 3.26 m and 3.35 m for Transects 1–3 respectively.

The original peat depth at each of the 6 long cores was estimated from the 1966 survey by interpolating between nodes on the 50 m square grid. These have an uncertainty of ± 0.2 m because the shape of the ground between nodes was not known and the depths at the nodes were only recorded to the nearest 0.3 m. Estimated depths for the 6 long core positions are given in Table 1. Comparison of the estimated original depth and the present depth, which has an uncertainty of ± 0.1 m indicates that the peat depth in the unplanted ride has increased by an average of 8 cm over the last 24 years, while comparison of the original depth with the reconstructed depth indicates 2 cm increase in the peat depth under

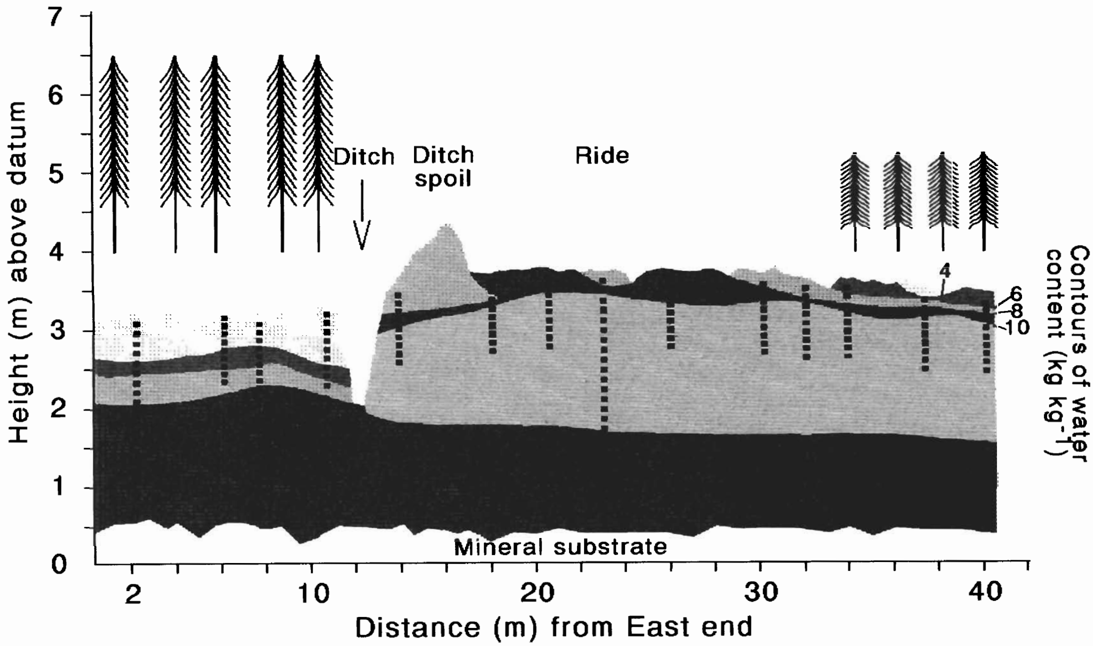
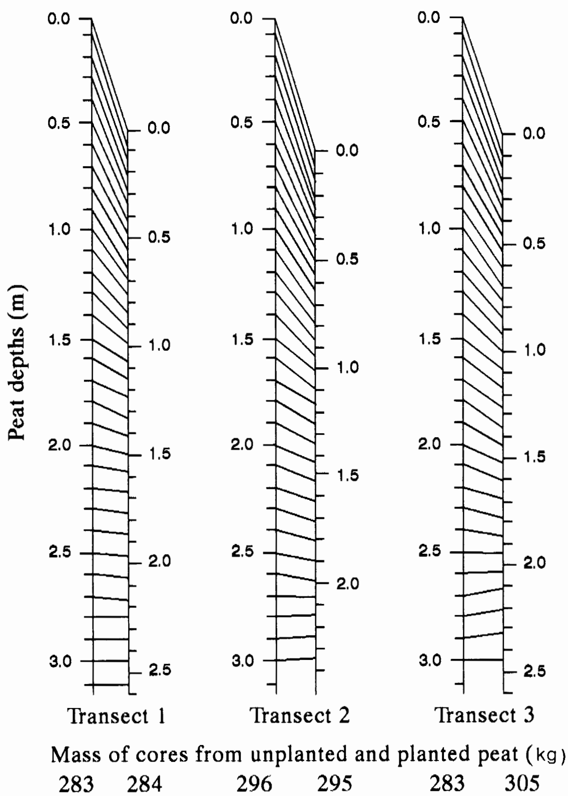


Fig. 1. Ground surface and peat water content of Transect 2. The surface is noticeably lower, and the peat drier, beneath the trees than in the ride. The vertical scale is 3.5 times larger than the horizontal.

Table 1. Original and present peat depths (cm) for the forest (reconstructed) and unplanted ride. The change between 1966 and 1990 is smaller for the forest than for the ride, but neither is significant because the 1966 peat depth survey was rather imprecise.

	Unplanted			Pine forest		
Transect	1966	1990	Change	1966	1990	Change
1	314	330	+16	326	329	+3
2	314	320	+6	328	326	−2
3	314	315	+1	329	335	+6
Mean	–	–	+8	–	–	+2

Fig. 2 (Right). Reconstructions of the peat depth beneath the trees for the 3 transects. The thickness of each layer was adjusted so that its dry bulk density was the same as the originally equivalent layer of the unplanted peat. The dry mass of 1 m^2 cores in the ride and under the trees is given at the bottom.



the trees of the experiment plot, when shrinkage due to drying is taken into account.

The dry mass of a 1 m^2 column of peat was calculated for each long core position using the specific volumes of each layer sampled. The specific volume measurements had an uncertainty of ±1% and the values derived from the water contents probably had about the same. These lead to an uncertainty of ±0.6 kg in the mass of the 1 m^2 columns. For the upper 1 m of peat in the experiment plot a correction factor was applied to take account of the horizontal shrinkage of the peat. The correction factors for each 10 cm layer were calculated from measurements of the average width and depth of the tear cracks in the plough furrows and cross drains. Applying the correction resulted in a 1% reduction in the mass of the peat column. The mass of the column is given at the bottom of Fig. 2 for each of the long cores. Only in Transect 3 is there a difference between the dry masses of the experiment plot and the unplanted ride.

DISCUSSION

This work highlights the importance (and difficulty) of knowing the original peat depths of the sites being compared. We were fortunate in having measurements of the original peat depth but these were not precise enough (± 15 cm) for the present purpose. An assumption that the original peat depths of the ride and plot were identical would have led to the conclusion that there was an overall slight increase in peat depth beneath the trees after allowing for shrinkage.

The estimate of an 8 cm increase in peat depth of the unplanted ride over the 24 year period is larger than would have been expected at a normal rate of peat growth (1 mm per year), and reflects the degree of uncertainty of the original peat depth. The increase of 2 cm beneath the trees will reflect the same uncertainty. The difference of 6 cm between the two sites has an uncertainty, mainly due to the original peat depth, of ±30 cm. Hence we cannot detect loss of peat depth due to oxidation that is smaller than this amount.

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