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DETERMINATION OF RECENT APPARENT CARBON ACCUMULATION IN PEAT USING DATED FIRE HORIZONS

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Two charcoal layers, originating from two forest fires, were found at between 7 and 58 cm in the peat of Lakkasuo mire. Using dendrochronological techniques and fire scars on Scots pine (*Pinus sylvestris* L.) stumps, the date when these two layers was deposited could be estimated. The earlier fire swept over the mire about 1780 A.D. and the later fire, which seems to have been limited to the eastern part of Lakkasuo, occurred in 1845 A.D. Knowing the thickness of the peat layer above the dated charcoal layers, its bulk density and carbon content, the rate of carbon accumulation during the last 212–147 years could therefore be calculated for different site types in the Lakkasuo mire complex. These values ranging from 39.8 to 80.7 g C $m^{-2}a^{-1}$ can be compared to those (28.5–42.8 g C $m^{-2}a^{-1}$) of the peat layer down to a still older fire horizon dated using the AMS radiocarbon "wiggle matching" technique at 1040 ± 90 B.P.

Keywords: Carbon accumulation, charcoal, dating, dendrochronology, fire

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INTRODUCTION

Knowledge of the rate of peat accumulation is necessary for understanding and modelling the dynamics of carbon in peatland ecosystems. However, it is difficult to obtain accurate values for recently accumulated peat (100–1 000 years old) because of the lack of a sufficiently precise dating method. In this paper we show how dendrochronology can be applied successfully for this purpose.

MATERIAL AND METHODS

Three seemingly synchronous charcoal layers (A and B) were found below the surface in the peat of virgin and drained sites on the Lakkasuo mire complex, in central Finland (Figs. 1, 2). The mire is one of the principal experimental areas of the mire research project "SUOSILMU" (Carbon Balance of Peatlands and Climate Change). Layer A, actually consisting of two close fire horizons in the eastern part of Lakkasuo, was located at between 7 and 58 cm depths in peat, while the third layer B was found at the depth of about 1 m.

Charred wood or fire scars appear on numerous stumps both above ground and buried in the peat. Fire marks on stumps were assumed to be connected with the last mire fire and thereby the uppermost charcoal layer (A). Charcoal layer B, however, must be associated with an older mire fire (Tolonen et al. 1992a). Dating the last mire fire in stumps would thus allow estimation of the rate of (apparent) carbon accumulation (Tolonen et al. 1992b) since the fire.

Tree ring widths of several living Scots pines and of four stumps on the mire and one stump from the mire margin were measured microscopi-

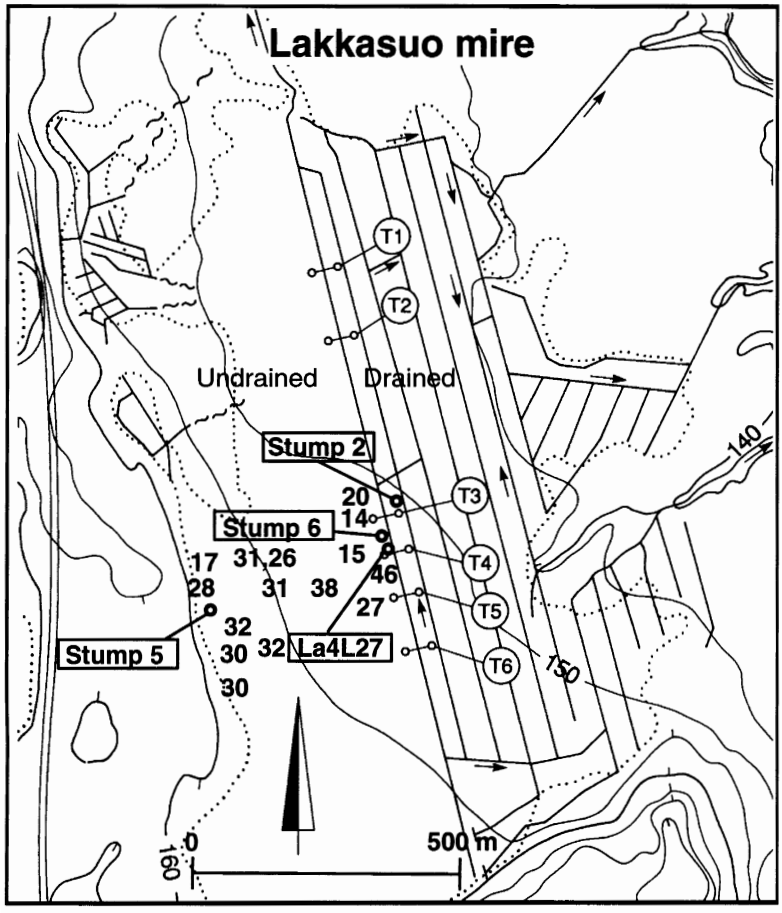

Fig. 1. Location of stumps #2, #5 and #6 and the depth of the visible close fire horizons in peat west of and along study transects 3 through 6 in Lakkasuo mire dated to 1780 A.D. and 1845 A.D. The position of site La4L27, which has been dated using AMS radiocarbon dating (Tolonen et al. 1992b), and ditches also shown.

cally (± 0.01 mm). A local chronology for upland Scots pine was constructed from numerous cores taken from five >300-year-old living trees. For reference, tree ring data from old living mire pines (Alm 1989, Nyblom et al. 1989) and a dendrochronological master curve for upland pines from the eastern part of Finnish North Karelia (Zetterberg 1987) were used. The tree-ring width series were compared using the Catras computer program (Aniol 1983). Catras applies cross-correlation t-test values of filtered (5-year moving average) tree-ring series to find matching years; the test value tends to peak at the correct dating position. All dendrochronological datings were ascertained by visual inspection of the curves.

The carbon content of the peat samples was determined by weighing assuming 50% carbon in dry weight. Mineral content of the samples was extremely low.

RESULTS AND DISCUSSION

The local (Hyytiälä) upland site chronology fitted well with both the North Karelian upland and mire chronologies. Lakkasuo stump #2 connected reasonably well with the local upland chronology (t = 4.19, n = 176) resulting in a date of 1845 A.D. for the last bog fire in the eastern part of the mire. Similarly, stump #5 from the western part of the mire dated the last fire to some decades after 1758 (t = 4.93, n = 78). Stump #6 in eastern part of the mire shows scars from two fires; the earlier fire dating to about 1780 A.D. Uncertainty is due to the presence of resin which obscured a few tree rings near the fire scar. Hence, the uppermost charcoal layer (A) originated from a fire that occurred some 65 years earlier in the western part of the mire than the latest fire in the eastern part. One of the stumps on the mire failed to statistically fit to any of the chronologies,

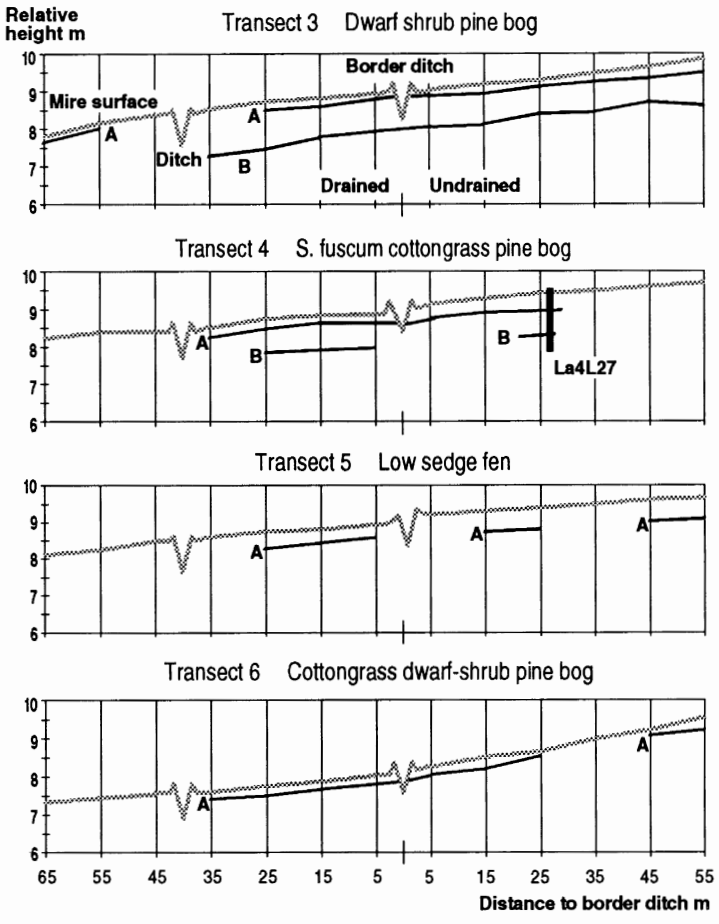

Fig. 2. Depth of the dated two fire horizons (within charcoal layer A) and an older fire horizon (layer B) in the peat along study transects 3 through 6 in eastern Lakkasuo mire. The position of site La4L27, which has been dated using AMS radiocarbon dating (Tolonen et al. 1992b), and ditches also shown.

but inspection of the diagrams did show similarities visually. A more accurate search for missing rings will probably solve the problem. The ring width diagrams of the living mire trees thus far measured also show similarities to that of the local upland series.

Dating the fire layer (A), actually two very close layers, by dendrochronology as described

Table 1. The average rate of apparent carbon accumulation (g C $m^{-2}a^{-1}$) in Lakkasuo mire above the fire horizons dated to 1845 and 1780 A.D. (Index 1) and to 1040 ± 90 B.P. (Index 2).

Mire site type	Index 1 ×	Index 1 S.E.	Index 1 n	Index 2 ×	Index 2 S.E.	Index 2 n
Hummock and hollow pine bog (KeR)	80.7	2.3	5	28.5		1
Cottongrass pine bog with *S. fuscum* (RaTR)	75.8	5.1	5	42.8		2
Hummock and hollow pine bog, drained (KeR)	73.4	3.1	3	32.2	0.4	6
Spruce mire (VK)	60.7	1.7	4			
Dwarf shrub pine bog (IR)	52.1	2.6	14	34.0	0.7	28
Cottongrass pine bog with *S. fuscum* (RaTR), drained	55.6	3.8				1
Short sedge pine fen (LkR)	49.4	5.4	6			–
Herb-rich spruce–hardwood fen (RhK)	41.4	4.5	4	..	–	
Dwarf shrub pine bog (IR), drained	39.8	5.2	15	34.9	0.6	20

above, enabled estimates of the average apparent rate of carbon accumulation (RCA) in surface peat to be made (Table 1). The RCA values obtained for the peat layer above the 1780 and 1845 A.D. fire are higher than those for the layer above the older fire (at about a 100-cm depth). At the La4L27 site (*Sphagnum fuscum* hummock), the deeper charcoal layer it is at 128 cm and has been dated to 1040 ± 90 B.P. (Tolonen et al. 1992a). Conventional ^{14}C dating is poor for this age of material, but the application of "wiggle matching" accelerator mass spectrometric dating (Clymo et al. 1990) for this core resulted in good agreement with our dendrochronology dating at a 58-cm depth.

CONCLUSIONS

Charcoal layers in the peat could be dated by applying dendrochronology to date the associated fire scars observed on tree stumps on the mire. If older layers can be dated with a good precision, the average rate of RCA and thus the carbon loss can be compared in different peat layers.

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