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PEAT INCREMENT IN THE OLD MIRES OF THE GREEN BELT OF FENNOSCANDIA IN KUHMO - KOSTAMUS WATERSHED AREA

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SUMMARY

Development history of mires is important for the understanding of the present biodiversity of mires and forests as well as the consequences of the ongoing human-induced climatic change. The area of the Finnish-Russian Friendship Nature Reserve was deglaciated from the latest Valdai (Weichsel) glaciations approximately 11 000 calibrated years BP, and the formation of mires and forest vegetation started. There are old deep (up to 8 metres) mires in tectonic depressions. In flat terrain peat layers are much shallower. The peat increment varies over time periods being up to 0,8 mm/yr in the deepest mires while in the aapamires and eccentric bogs of flat terrain it is between 0,2 and 0,5 mm/yr as a mean. In the surface layer of 30-50 cm the increment appears to be much higher, but it must be pointed out that the layer is not yet real peat but decomposing plant remnants.

KEY WORDS: Holocene, carbon accumulation, acrotelm biomass, aapamire, Friendhip Nature Reserve

INTRODUCTION

Mires are normally understood as systems, where peat is accumulating and ecologically mires are then habitats, where the plant communities are living on the top of peat. On the other hand, peat is an ecological substrate to the existence and thriving for plants communities. And because of the big variety of ecological conditions, the number of different plant communities is high. On the other hand these plant communities produce the basic raw material as dead plant remnants, which are then later gradually, turn into peat. Without the activity of plant communities there will be no peat. And the specific ecohydrological conditions on mires prevent the primary production from totally decomposing. In that sense mires are unique and specific ecosystems. So it is also important to understand that the whole deposit of peat has been produced by plant communities of respective time periods of the formation of the deposit. Our study is a part of studies to increase the understanding of the functioning of boreal ecosystems at present and under the Holocene period.

MATERIALS AND METHODS

Peat sampling

Peat cores were collected from the deepest sections of two deep mires, using either an 8 cm-diameter and 20 cm-long volumetric piston sampler or a standard Russian peat corer (500 x 50 mm). Peat layers (thickness to 5–25 cm) were visually-identified and described in the field. Samples were obtained for the following: stratigraphic profiling (from eight peat cores, two from the Härkösuo Mire and six from the Isosuo Mire); thin stratigraphic layer (5–25 cm) profiling (one sample taken from the middle section of the layer); pollen analysis and radiocarbon dating (a total of 17 deep core samples taken from both mires); and macrofossil and pollen analyses (from approximately 100 g of fresh peat)

Radiocarbon ages

The ^{14}C samples generally represented a peat layer with a vertical thickness of 2–6 cm. Radiocarbon dating was carried out at the ^{14}C laboratory (Su) at the Geological Survey of Finland and at the Poznan Radiocarbon Laboratory (Poz). Thoroughly cleaned of rootlets and other possible organic impurities, the samples were analyzed as bulk sediment. The measuring technique involved proportional counting of CO_2 and the application of pulse-shape discrimination, as described in Äikää et al. (1992). The ^{14}C ages obtained from the samples were then converted to calendar years by the program CALIB REV 4.0 (Stuiver & Reimer 1993). The age–depth model was obtained using a method similar to that described by Goslar et al. (2005).

A Leco CHN 600 analyzer was used to determine the carbon content as a percentage of the total dry matter. The long-term (apparent) rate of carbon accumulation (g C m^{-2} yr^{-1}) was calculated using peat cores of known bulk density and age (see Tolonen & Turunen 1996).

Peat increment and carbon accumulation

Peat increment was calculated for layers were identified from palaeo-communities classified by peat botanical composition diagrams. This was followed by the determination of the time intervals of their existence through calibrated radiocarbon dating and pollen diagram zoning, and the calculation of peat increment for each palaeo-community.

RESULTS

Dynamics of Härkösuo Mire

Härkösuo Mire started to develop in terrestrial conditions. In the first short stage of the mire's development, starting 10 240 yr. cal. B.P. Peat increment was very quick, amounting to 1.67 mm yr^{-1}. This was followed by another short stage (600 years) of poor fen community with a clearly lower peat increment of 0.58 mm yr^{-1}. A period of change lasting for more than 1 000 years then took place. Peat increment was again higher (1.08 mm yr^{-1}). Subsequently, a rich fen period with a string-flark pattern established for 4 000 years. Then, a wet period began, about 4 000 years ago, marked by low peat increment (0.42 mm yr^{-1}). The site became rich once more 1 900 years ago. During the last 850 years, a rich fen community prevailed, with again higher peat increment.

Dynamics of Isosuo Mire

In the beginning of the development of Isosuo Mire, there was a short stage (800 years) of rich flark level fen. The bottom layer (10 720 years B.P.) belongs to the oldest terrestrial peat layers found in the area of Green Belt of Fennoscandia. In the first stage, peat increment was rather low, at 0.50 mm yr^{-1}. Subsequently, for 600 years, an intermediate fen was established. Then there was a long period (2 500 years) of an intermediate flark fen. Peat increment in this stage was somewhat higher, 0.70 mm yr^{-1}. In the following 2 600 years, the mire turned into a poor flark fen. A wet period ensued over the next 2 500 years , and poor wet fens prevailed, succeeded by an even wetter mire (likely with stagnant water). Overall, in the last 6 800 years, peat increment was relatively stable, at 0.50-0.59 mm yr^{-1}.

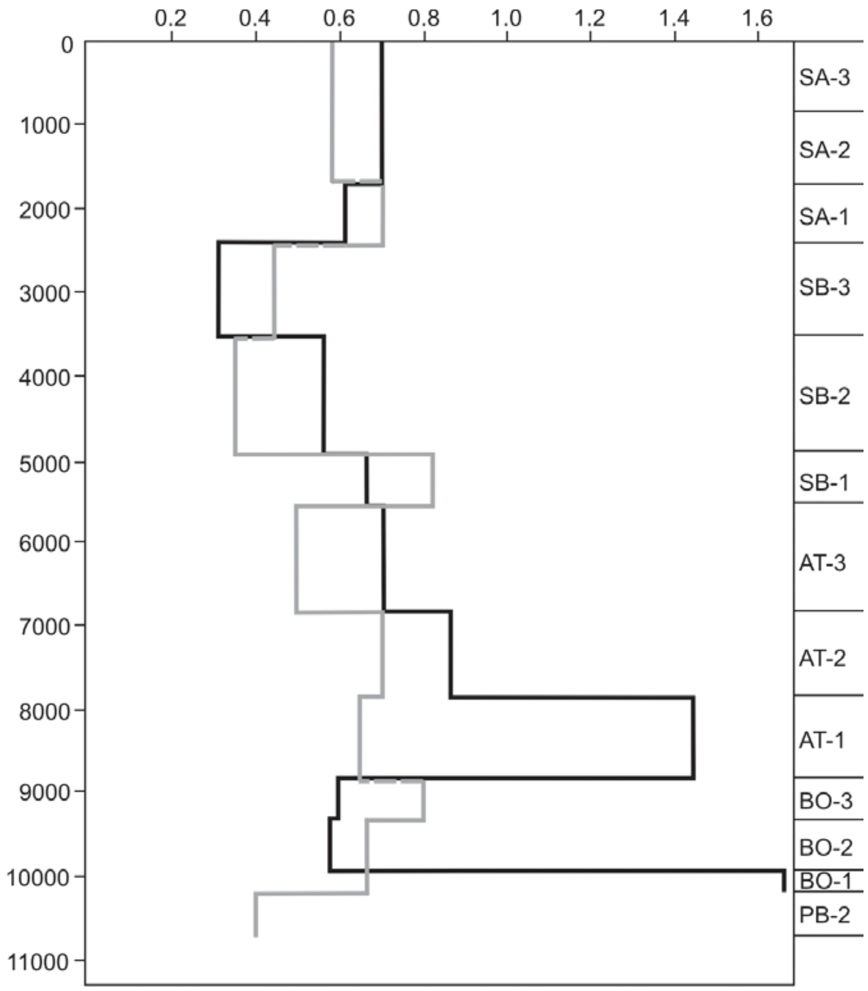

Figure 1. Peat increment (mm/year) in Isosuo (grey) and Härkösuo (black) mires from 11 000 years B.P. to present. The palaeoecological periods from bottom are: Preboreal (PB), Boreal (BO), Atlantic (AT), Subboreal (SB) and Subatlantic (SA).

Peat increment and peat property statistics

The Härkösuo and Isosuo mires have respective average peat increments of 0.76 mm yr^{-1} and 0.58 mm yr^{-1}. The average carbon content of peat deposit is 53.2% and 54.6% of dry weight, and average dry bulk density is 66.6 kg m^{-3} and 61.0 kg m^{-3}, respectively.

Carbon accumulation

The average carbon accumulation has been 26.7 g m^{-2} yr^{-1} and 18.9 g m^{-2} yr^{-1} in Härkösuo and Isosuo mires, respectively. The carbon accumulation dynamics in both mires is very similar. However, carbon accumulation is somewhat higher in the Härkösuo Mire, correlating well with the mire's higher peat increment. The most significant decrease of carbon accumulation in both mires occurred approximately 7 000 years ago. After that, the accumulation rates were very stable. The much higher carbon accumulation values over the last 300–500 years point to unceasing effective decomposition of plant remnants in the top 30–50 cm layer (corresponding to the acrotelm).

CONCLUSION

Peat increment and carbon accumulation

Peat increment and age values for the mires surveyed match those for mires developing in deep depressions, both in Finland (Mäkilä & Toivonen 2004) and Karelia (Kuznetsov & Mäkilä 2011). In Karelia, peat deposits thicker than 6 m have an age of 10 600-7 600 yrs, and a peat increment of 0.69–1.01 mm yr^{-1} (Kuznetsov & Mäkilä 2011). In Finland, in the case of the Isosuo Mire (which is at present a typical poor aapamire), the peat increment general trend through the Holocene follows the pattern described for the mires in eastern Finland, showing high values for the early Holocene, low values for the middle Holocene and a clear rise in values for the Subatlantic Chronozone (Tolonen & Ruuhijärvi 1976).

Carbon accumulation in the mires of the study area is slightly higher than average for aapa mires in Finland (Tolonen & Turunen 1996). The reason for this is a higher peat increment in deep and narrow depressions. The trend of carbon accumulation over the Holocene, however, is quite typical of aapa mires (Mäkilä et al. 2001, Mäkilä & Moisanen 2007), displaying the natural dynamics of these mires.

As discussed by many authors, the general trends of carbon accumulation are due to climatic changes in the past, though it should be acknowledged that the autogenic factors of mires have an important role in carbon accumulation. A lag in the decomposition phase is the key factor and not the high primary production in peat accumulation; moisture, oxygen, nutrient-cycling and most notably, nitrogen, are important factors (e.g. Tolonen 1979, Ikonen 1993, Damman 1996).

In many instances, the surface layers of mires are called surface peat or young layers of peat (e.g. Mäkilä 2006, Geological Survey of Finland 2012). However, in the acrotelm of mires, plant biomass is decomposing, and is not yet peat (Mäkilä & Goslar 2008). Thus we suggest that the term surface peat should not be used. In the surface there are living plants, dead plants below them, and then decomposing raw humus. Especially important peat producers are Sphagnum species (Lindholm & Vasander 1990). The primary production and peat formation are two different processes. Primary production in the young dying or dead layer of plant remnants in the surface, where also the plant roots are living, acrotelm, is not peat yet. Naming the layer as surface peat is an ecologically incorrect concept. Sometimes the living layer extends down to 230 cm from the surface of the mire in the form of living sedge roots (Saarinen 1996).

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