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BALANCE OR IMBALANCE OF A RAISED BOG IN A CHANGING ENVIRONMENT?

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SUMMARY

Based on high resolution analyses of bulk density, carbon (C) content and a detailed radiocarbon dating program, we examined changes in C accumulation across two late Holocene bog ecosystem transitions evidenced by clearly visible recurrence surfaces (RY´s) around 1000 and 2800 cal BP in a peat sequence from Store Mosse in southern Sweden. The results revealed large differences in the rate of change across the respective transitions. Hence, whereas a gradual increase in C accumulation was found across the lower RY as part of a generally increasing trend, abrupt and significant short term changes were detected across the upper RY.

INTRODUCTION

Peatlands provide significant stores for carbon (C) derived from the atmosphere, but C-accumulation rates varies over time dependent of factors such as climate, vegetation and hydrology. Climate changes are expected to alter natural ecosystems and their carbon balance, and studies of past ecosystem transitional phases may provide important information for the evaluation of possible future consequences. Recurrence surfaces (or RY´s; from the Swedish term ‘rekurrensyta’) are characteristic in peat profiles from raised bogs, where peat is formed by *Sphagnum* mosses. RY´s constitute distinct transitions from peat with a high degree of humification to peat with a low degree of humification. Based on the contrasting depositional environments reflected by the surfaces, RY´s are traditionally interpreted to reflect rapid climatic shifts towards wetter conditions. Granlund (1932) described five RY´s for southern Sweden: RY I (c. 1200 AD), RY II (c. 400 AD), RY III (c. 600 BC), RY IV (c. 1200 BC) and RY V (c. 2300 BC). The timing of the respective surfaces described by Granlund was based on pollen analytical correlations and an archaeological chronology. It is thus uncertain whether apparently synchronous surfaces from different localities actually reflect regional changes with different spatial extent, or whether they reflect several and temporally close but more local changes (Rundgren, 2008). Regardless of the timing, abrupt changes from high humified to low humified peat in raised bogs, are however well described with the term recurrence surface or RY.

At Store Mosse in southern Sweden, two particularly well developed RY´s have previously been described, based on a comprehensive study on the overall Holocene stratigraphy of Store Mosse (Svensson, 1988a; Svensson, 1988b). These were demonstrated to represent major ecosystem transitions across the bog. In 2009 we returned to Store Mosse in order to conduct an in depth study of one selected core point in the southern part of the bog. High resolution sampling and examination of paleoecology and biogeochemistry in combination with an extensive dating program across the two RY´s allowed for a detailed assessment of changes in C-accumulation during the relatively rapid shifts in the bog ecosystem as represented by the RY´s. Our high resolution approach reveals insights to short term changes in C-accumulation during major ecosystem transitions of a raised bog.

MATERIAL AND METHODS

Store Mosse (57°15´N, 13°55´E; altitude 170 m; size ~100 km^{-2}) is the largest (almost 10,000 ha) ombrotrophic bog in southern Sweden, and is situated c. 10 km NW of Värnamo in Småland (Fig. 1). In May 2009 a 5.4 m sequence was retrieved in the southern part of the bog, using a Russian corer equipment with a diameter of 7.5 cm. Individual cores were correlated visually based on distinct stratigraphical changes. 1 cm contiguous samples were concentrated around the central part of the sequence containing the significant changes in peat stratigraphy that are the focus of the present study. The relative importance of major peat components (leaves and stems of different *Sphagnum* moss species, rootlets of vascular plants, woody plant remains and fine

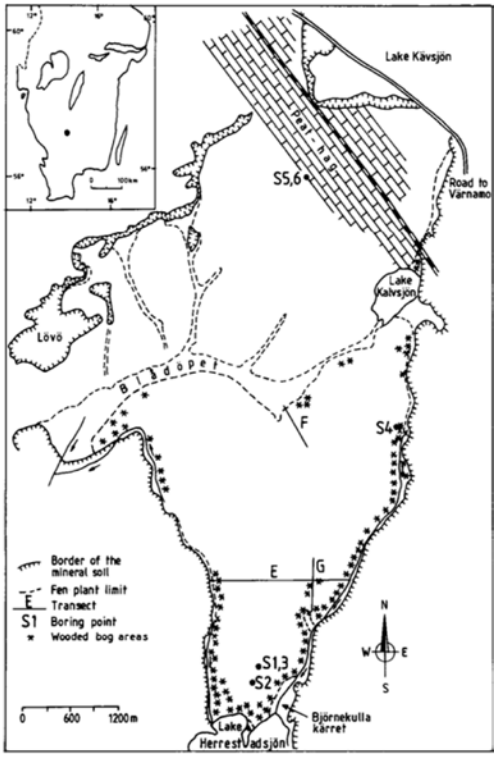

Figure 1. Maps showing Store Mosse and its location in southern Sweden (from Svensson, 1988a). The sequence analysed in this study was retrieved from the central part of transect E in the southern part of the bog.

detritus resulting from decomposition of plant material) was determined in selected samples under a stereo microscope. An age model was constructed based on 30 radiocarbon dates and processed in OxCal 4.1(Bronk Ramsey, 2009) (unpublished data). Subsequently, linear interpolation between midpoints of calibrated and modeled ages was applied in order to calculate the peat deposition rate, in turn required for the calculation of the C-accumulation rate. Water content was determined by drying subsamples at 105^{o}C overnight. After determination of the volume of the total wet subsample and weight, the dry bulk density of each sample could be estimated by subtracting the content of water from the wet weight of the total sample. Carbon content was analyzed through combustion of freeze dried subsamples using a Costech 4010 elemental analyzer. Dry bulk density, peat deposition rate and C content could then be used to calculate the C accumulation rate.

RESULTS

Two RY´s were initially identified based on visual detection of changes in peat humification at 270 and 176 cm, but when geochemical data became available they revealed that each RY consists of a zone rather than an isolated surface. The lowermost RY_{lower} thus extends from 280-270 cm and formed ca. 2800 cal BP, and the uppermost RY_{upper} extends from 183-176 cm and formed ca. 1000 cal BP. The two RY´s mark the transitions between major bog stages on Store Mosse that traditionally have been named after the dominant *Sphagnum* species (Svensson 1988a); RY_{lower} from the *Sphagnum fuscum* to the *Sphagnum rubellum-fuscum* bog stage and RY_{upper} from the *Sphagnum rubellum-fuscum* to the *Sphagnum magellanicum* bog stage (Svensson 1988a). In our peat sequence, *Sphagnum rubellum-fuscum* was however dominant not only in the mid but also in the early part of the upper bog stage, likely indicating that it was taken in a hummock from the last bog stage (Svensson, 1988a). Both transitions between the respective bog stages are preceded by strata of highly humified peat. The C accumulation rate varies very differently across the two transitions. Across RY_{lower} the C accumulation rate increases from ca. 10 to ca. 20 gC/cm^2/yr, as part of what seems to be a generally increasing trend, but no abrupt changes are detected that can be directly related to RY_{lower} (Fig 2). In contrast, the C accumulation across RY_{upper} shows drastic changes, both during and after the transition. Hence, at the onset of RY_{upper}, the C accumulation rate increases rapidly from 25 to 55 gC/cm^2/yr followed by a decrease back to 10-20 gC/cm^2/yr during the later part of RY_{upper}, when an abrupt increase is registered to a C accumulation around 70 gC/cm^2/yr during the bog stage above RY_{upper}.

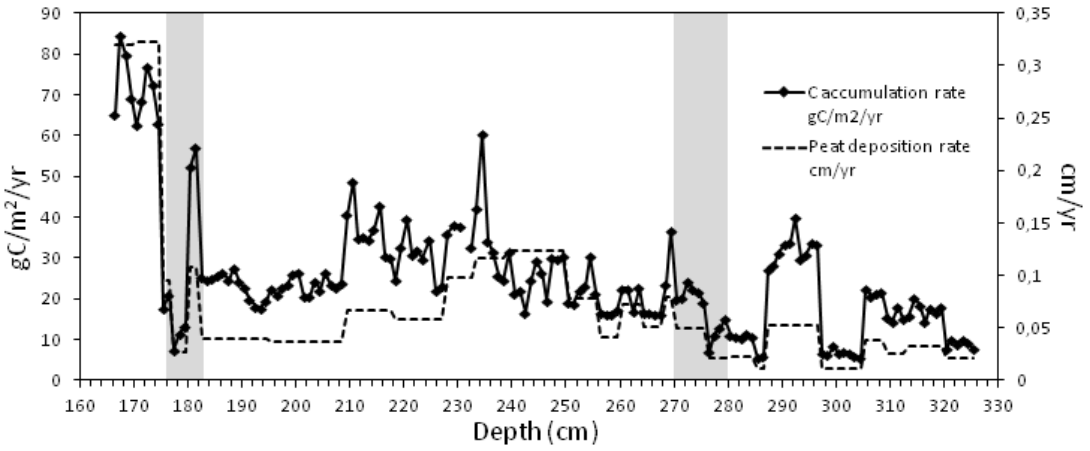

Figure 2. Peat deposition rate and C accumulation rate across two major and late Holocene bog ecosystem transitions (blue panels; RY_{lower} and RY_{upper}) at Store Mosse.

DISCUSSION

The abrupt increase in C accumulation associated with the onset of the bog stage above RY_{upper} is consistent with previous results. Malmer et al. (1997) thus reported an abrupt increase in the accumulation of organic matter at the onset of the uppermost *Sphagnum magellanicum* bog stage. Our high resolution approach however provides new insights to abrupt, short term changes in C-accumulation during major ecosystem transitions of the bog. Hence, very different C-accumulation patterns were found across the two RY transitions, despite their similar appearance, and in particular large variability was found across RY_{upper}. Part of the explanation may lie in the different succeeding bog vegetation assemblages above the two RY´s, but the large difference in the C accumulation may further indicate the influence from differing climatic and environmental situations. The changes in vegetation and humification across the RY´s at Store Mosse both indicate a shift towards wetter conditions. The RY_{lower} around 2800 cal BP correlate with a shift towards wetter and/or colder conditions documented in bogs in NW Europe, whereas correlations to other bogs indicating wet shifts correlating with RY_{upper} around 1000 cal BP are less clear. Pollen analyses from Store Mosse show that the RY_{upper} coincided with a distinct change in the catchment vegetation, whereas a similar change in the catchment vegetation was not observed in connection with RY_{lower} (Svensson, 1988a). These observations likely point to different climate situations and forcings relating to RY_{lower} and RY_{upper}, respectively, and warrant cautiousness when estimating past changes in C accumulation across major ecosystem transitions identified in peat records.

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