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Late-Holocene vegetation dynamics in response to a changing climate and anthropogenic influences – Insights from stratigraphic records and subfossil trees from southeast Lithuania

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ABSTRACT

To increase our understanding of long-term climate dynamics and its effects on different ecosystems, palaeoclimatic and long-term botanical reconstructions need to be improved, in particular in underutilized geographical regions. In this study, vegetation, (hydro)climate, and land-use changes were documented at two southeast Lithuanian peatland complexes – Čepkeliai and Rieznyčia – for the Late-Holocene period. The documentation was based on a combination of pollen, plant macrofossils, peat stratigraphic records, and subfossil trees. Our results cover the last two millennia and reveal the existence of moist conditions in Southern Lithuania between 300 and 500 CE and from 950 to 1850 CE. Conversely, changes towards warmer and/or dryer conditions have been recorded in 100, 600, and 750 CE, and since the 1850s. Significant differences with other Baltic proxies prevent deriving a complete and precise long-term reconstruction of past hydroclimatic variability at the regional scale. Yet, our results provide an important cornerstone for an improved understanding of regional climate change, i.e. in a region for which only (i) few detailed palaeobotanical studies exist and which has, in addition, been considered as (ii) an ecologically sensitive region at the interface between the temperate and boreal bioclimatic zones.

1. Introduction

Over the last decades the development of proxy records and improvement of dating techniques permitted assessment of long-term climate reconstruction and a better documentation of responses of ecosystems to environmental forcing at the global scale (Wanner et al., 2008; Marcott et al., 2013). Despite these advances, additional efforts are still critically needed, at the regional scale, to document past climatic variability and ecosystem dynamics from paleoenvironmental archives. In this regard, peatland regions from the Southeast Baltics – located at the interface between the temperate and boreal vegetation zones (BACC Author Team, 2014; Edvardsson et al., 2016a) and influenced by both western oceanic and eastern continental air masses (Gałka et al., 2017) – offer a substantial, yet underexploited potential for the documentation of Late-Holocene hydroclimatic variability.

To date, climatic variations during the Holocene have been documented mostly with pollen-based studies in the Northern Baltic region (Seppä and Poska, 2004; Heikkilä and Seppä, 2010). Late-glacial climatic reversals have been assessed from pollen and chironomid records in the Eastern Baltics and Belarus (Veski et al.,

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2015) and from plant macrofossils and testate amoebae in NE Poland (Gałka et al., 2017). In these regions, the climatic and anthropogenic signals related to e.g. drainage, fires, deforestation, and deposition of nitrogen in peatlands or adjacent regions (Hughes et al., 2008; Gałka et al., 2017) remain, however, difficult to disentangle. In Lithuania, previous studies covering the Late-Holocene remain scarce and have been developed mostly locally and in the framework of archaeological investigations (Stančikaitė et al., 2006, 2009, 2013).

In this study, we combine newly-developed peat stratigraphic records and tree-ring series from subfossil peatland trees to document the vegetation history, climatic dynamics, and land-use changes in Lithuania over the Common Era (CE). In the framework of this multiproxy approach, (i) pollen records with (multi) decadal resolution are used to derive information on local to regional vegetation changes (Huntley and Birks, 1983; Lindbladh et al., 2013). They are complemented by (ii) plant macrofossil analyses that reflect primarily local vegetation dynamics and thereby offer higher taxonomic precision (Dudová et al., 2013). In addition, (iii) tree-ring width and tree replication series from subfossil peatland trees were used to compute annually-resolved information on (hydro)climatic variability (Edvardsson et al., 2016b).

2. Material and methods

2.1. Site descriptions

Peat stratigraphic sequences were extracted from the Čepkeliai wetland complex (54°00′N; 24°30′E; Figs. 1 and 2a, 5858 ha of raised bogs), the largest wetland complex in Lithuania. By contrast to many areas where the natural dynamics of wetland and peatland ecosystems have been profoundly modified by anthropogenic activities, the Čepkeliai wetland has remained a well-preserved, natural complex which makes it of particular interest for research. The wetland complex is located along the marginal zone reached by the Late Weichselian ice sheet (Bitinas, 2012). The entire area is thus underlain by glaciolimnic layers of silty and clayey sands deposited during the onset of the last deglaciation when meltwater was drained along the ice sheet and when outwash plains were developed (Blažauskas et al., 2007). The landscape is therefore composed of water-filled depressions in which deposition of limnic, biogenic, and minerogenic material has occurred during the Holocene (Stančikaitė et al., 2002; Blažauskas et al., 2007). At present, the wetland complex consists of lowland sedge bogs, black alder swamps, dry *Cladinoso-callunosa* forests, bog islands and lakes. The surface of the wetland is slightly undulating (128.5–134.4 m a.s.l.) and average depth of the organic layers is about 2.3 m, but can locally reach 16.5 m in depth. The region north of the wetland complex is dominated by Lateglacial sand dunes which are mostly forested with pines (Molodkov and Bitinas, 2006).

Subfossil trees were sampled at the Rieznyčia raised-bog complex located about 53 km northwards from Čepkeliai (54°29′N; 24°32′E, 137 m a.s.l., 229 ha, Figs. 1 and 2b). Due to extensive peat mining activities, numerous tree stumps and trunks can be found in deposits adjacent to the Rieznyčia bog and at the present day peat surface.

The region surrounding the study sites belongs to the boreo-nemoral vegetation zone, which is dominated by Scots pine (*Pinus sylvestris* L.), spruce (*Picea abies* (L.) Karst.), and birch (*Betula pubescens* Ehrh. and *Betula pendula* Roth.) (Natkevičaitė-Ivanauskienė, 1983). According to data series from the Varėna weather station, located about 27 km north of the Čepkeliai wetland complex and managed by the Lithuanian Hydrometeorological Survey, the average annual air temperature in southern Lithuania is 6.2 °C, with mean January temperatures of −5.4 °C, and mean July temperatures at approximately 17.7 °C. The mean summer temperature is thereby about 0.5–1.0 °C above the average of Lithuania. Average precipitation is 673 mm yr^{-1}. Moreover, the largest variations of daily temperature are usually recorded for this region in Lithuania and the snow cover often lasts for about 75–80 days yr^{-1}.

2.2. Collection and preparation of peat sequences

For the palaeobotanical analysis, stratigraphic sequences were extracted from the Čepkeliai peatland complex. The coring site is

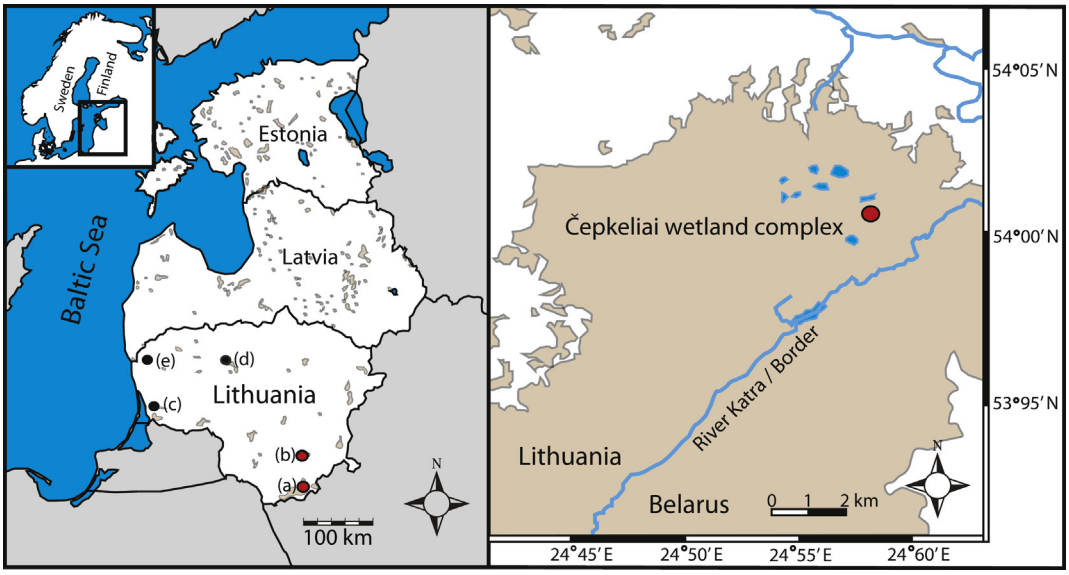

Fig. 1. (a) Overview of the sites described in this study: Red dots show locations of the study sites used: (a) Čepkeliai and (b) Rieznyčia. Black dots show peatlands discussed in the paper, namely (c) Aukštumala, (d) Rekyva, and (e) Užpelkių Tyrelis bog (Pukienė, 1997). Large peatland complexes are shown in brown. (b) The Čepkeliai wetland complex. Wetland and peatland areas are highlighted in brown whereas forested mineral soil areas are shown in white. The red dot shows the coring point. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)