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Impact of human activity and fire on vegetation, hydrology, and carbon accumulation in Mustjärve bog, Northwest Estonia (PEATFLAMES)

Harry Roberts[1], Luke Andrews[2], Leeli Amon[3], Atko Heinsalu[3], Piotr Kołaczek[2], Katarzyna Marcisz[2], Michał Słowiński[1], Normunds Stivrins[4], Siim Veski[3], and Mariusz Lamentowicz[2]

[1]Department of Past Landscape Dynamics, Institute of Geography and Spatial Organization, Polish Academy of Sciences, Warsaw, Poland

[2]Climate Change Ecology Research Unit, Adam Mickiewicz University, Poznań, Poland

[3]Department of Geology, Tallinn University of Technology, Tallinn, Estonia

[4]Department of Geography, Faculty of Geography and Earth sciences, University of Latvia

Peatlands are important ecosystems for carbon storage, storing an estimated 25-30% of global soil carbon despite covering just 3% of Earth's terrestrial surface. These ecosystems are under increasing pressure due to human activity and climate change, which threaten to turn peatlands from being carbon stores to sources. Human activities such as peat draining are extremely damaging to peatland hydrology, and fire was often used by people as a tool for land management clearance in the past. Fire is one of the foremost forces impacting peatlands, as it destroys surface peat and the subsequent release of stored carbon. Fire frequency is predicted to increase due to more frequent and severe droughts in some areas, and increasing human activity in areas where peat can form (particularly in the Northern Hemisphere). These trends, if realised, can accelerate climate warming as previously stored carbon is released into the atmosphere.

The focus of this study, Mustjärve bog, is an ombrotrophic peat bog located in northwest Estonia. Our project aims to assess changes in peatland fire regimes, vegetation dynamics, and hydrology to evaluate how the resilience of the site has changed over time within the context of relative changes in climate and human activity. A peat core was analysed using multiple palaeoecological proxies at high resolution (1 cm contiguous samples), to reconstruct past fire frequency, vegetation, and hydrological change over the past ~2500 years at the site. We also used historical data (population, past climate, and archaeological records) to better understand the drivers of changes uncovered in the palaeoecological record.

Our data reveals a distinct anthropogenic signal from ~700 CE onwards, coincident with increasing population and expanding land exploitation. Human activity from ~700 CE to ~1800 CE causes an increase in local fire events, culminating in lowered carbon accumulation rates, lowered water tables and higher peat bulk density. This trend continued until ~1950 CE, when there was a recovery in carbon accumulation and water table depth. Mustjärve's vegetation history was predominantly *Sphagnum*, with *Sphagnum* Sect. *Acutifolia* indicative of drier conditions

becoming much more prevalent from ca. 200 BC onwards, possibly owing to changes in water table depth. In the last 150 years, arboreal taxa such as *Pinus sylvestris* and *Betula nana* have encroached onto the bog, reflecting a decreasing water table and increased human activity that has impacted hydrological conditions, such as peat draining. We find little evidence for a significant climate influence on Mustjärve bog, as anthropogenic pressures on the site appear to dominate over the palaeoclimatic signal.