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Interaction between peatland moisture and plant functional types drives fire dynamics in forested peatlands in central-western Siberia

Angelica Feurdean[1,2], Andrei-Cosmin Diaconu[3], Geanina Butiseaca[2], Mariusz Galka[4], Simon M. Hutchinson[5], Sergey Kirpotin[6], Mirjam Pfeiffer[2], and Spassimir Tonkov[7]

[1]Goethe University, Physical Geography, Frankfurt, Germany (angelica.feurdean@gmail.com)
[2]Senckenberg Biodiversity and Climate Research Centre (BiK-F), Senckenberganlage, 25, 60325, Frankfurt am Main, Germany
[3]Department of Geology, Babeş-Bolyai University, Kogălniceanu 1, 400084, Cluj-Napoca, Romania
[4]Department of Geobotany and Plant Ecology, Faculty of Biology and Environmental Protection, University of Lodz, Banacha 12/16, Lodz, Poland
[5]School of Science, Engineering and Environment, University of Salford, Salford, Greater Manchester M5 4WT, UK
[6]Bio-Clim-Land Center of Excellence, National Research, 634050, Tomsk State University, Tomks, Russia
[7]Laboratory of Palynology, Faculty of Biology, Sofia University St. Kliment Ohridski, Dragan Tsankov 8, 1164 Sofia, Bulgaria

Boreal forests are among the ecosystems most significantly impacted by wildfires as a consequence of climate warming. A large proportion of the global boreal forest area is located in Siberia, however, its vast extent and restricted access limit datasets recording changes in wildfire activity, especially from a longer-term perspective. Such long-term records of wildfire activity are vital to understanding how fire regimes vary with changes in climate, vegetation composition and human-vegetation interaction, as well as the impacts of wildfires on boreal forests.

Here, we explore how patterns in fire regime (biomass burned, fire frequency, fire type) have changed over the Holocene. We focus on the relationship between fire regime, forest density and the fire-related traits of the main tree species, and peatland hydrology. We used charcoal-morphologies based reconstructions of fire regimes, along with pollen-based assessments of vegetation composition and testate amoebae-based hydro-climate reconstructions in Pinus-Betula dominated peatlands from central-western Siberia, Tomsk Oblast, Russia.

The occurrence of more severe fires (i.e., higher biomass burning per fire episode and abundant woody morphotypes) were recorded between 7500 and 5000 cal yr BP. Higher temperatures during that time, likely enhanced peatland dryness and fuel flammability creating conditions conducive to peat and forest fires. Drier peatland conditions also affected forest composition and density by favouring the expansion of a mix of light taiga and fire resisters (e.g., Pinus sylvestris, P. sibirica, Larix) with denser taiga and fire avoiders (Picea obovata and Abies sibirica) on the peatland. A shift to the lowest biomass burning and fire types affecting mostly litter and understorey vegetation, was registered between 4000 and 1500 cal yr BP. Temporally, it coincides with an increase in peatland surface moisture and a change in forest composition characterised by

a decline in fire resisters, while fire avoiders remained abundant. An almost synchronous intensification in fires frequency and severity from ca. 2000 cal yr BP to the present at all sites, was concurrent with the rise to dominance of fire-invader species (Betula), as well as a more abundant biomass in the understory layer (shrubs, herbs, ferns, moss), while fire resisters and avoiders declined substantially. We found that Picea obovata to be highly vulnerable tree taxa to frequent, severe fires.

This long-term perspective demonstratesthat peatland hydrology is connected to, and feedbacks on peatland and forest composition and fuel dryness and ultimately fire regime. It also shows that more frequent fires of higher severity can lead to compositional or structural changes of forests, if trees cannot reach reproductive ages prior to the next burning events. Future predicted increases in temperatures are likely to enhance peatland drying, with cascading effects on forest and peat plant composition, subsequently exacerbating wildfire activity. This study thus contributes to an understanding of disturbance regimes in boreal forests and considers their potential to adapt to new climate conditions and fire regimes.