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Holocene spatio-temporal patterns of biomass burning in the Bohemian-Bavarian Forest Mountains (Central Europe)

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Long-term perspectives on disturbance dynamics are important for the conservation of protected areas, yet restoration and conservation strategies in the Bohemian-Bavarian Forest Mountains do not consider the long-term role and patterns of forest fire, which is still deemed a negligible ecosystem disturbance in Central Europe. The scarcity of macroscopic charcoal studies in this area has likely hampered a complete understanding of local fire regime dynamics and its legacies in the present forest structure and composition. Here we used macroscopic charcoal (number, area and morphology of charred particles) and pollen analysis to investigate high resolution spatial and temporal patterns in Holocene fire regimes in the Bavarian-Bohemian Forest. We explored the relationship between changing forest composition dynamics and the influence topography had on spatial patterns of biomass burning. For this, we selected three lacustrine sites (two new, one published), located along a 30 km longitudinal transect within the studied area, at similar elevations in the mixed forest belt, with opposite (north vs. south) aspects. Results showed similar changes in biomass burning, fire frequency and peak magnitude at all sites, with a maximum during the early Holocene when fire resistant taxa (*Pinus* and *Betula*) dominated. Fire frequency decreased by half with the expansion of more fire-sensitive taxa (e.g., *Picea* and *Fagus*) during the mid-Holocene and reached a second maximum in the late Holocene, parallel with sustained increases in anthropogenic pollen indicators. We found a close north-south correspondence in the succession of fire patterns, i.e., fine-scale changes in biomass burning in the Bavarian Forest site (south-facing catchment) occurred around the same time with those observed at the Bohemian Forest sites (predominantly north-facing catchments), and these changes mirrored the Holocene dynamics of the main forest taxa. For example, the lowest biomass burning and peak magnitude intervals marked the beginning of *Picea abies* expansion at ~ 9 ka BP, *Fagus sylvatica* expansion at ~6 ka and *Abies alba* expansion at ~5 ka BP. Furthermore, we found a direct relationship between the abundance of charred morphotypes of conifer needles and deciduous leaves and the

dominance of pine and birch in our pollen records, and a close correspondence between the abundance of non-woody charcoal morphotypes and pollen-derived landscape openness. Non-woody charcoal morphotypes dominated the charcoal records in the Early Holocene at the peak of biomass burning, whereas the abundance of woody morphotypes peaked around 6-8 ka BP and over the last millennium and their proportion in total charcoal influx increased starting 4 ka BP. Our study enables a better understanding of past and present fire regimes in the Bavarian-Bohemian Forest Mountains and highlights the need to consider the effects of fire as part of climate-change forest conservation strategies.