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Hydrogeological controls on post-fire moss recovery in peatlands

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Wildfire is the largest disturbance affecting peatlands, however, little is known about the spatiotemporal variability of post-fire recovery in these ecosystems. High water table (WT) positions after wildfire are critical to limit atmospheric carbon losses and enable the re-establishment of keystone peatland mosses (i.e. Sphagnum). While small-scale variation in burn severity can reduce capillary flow from the WT and lead to a dry surface after fire, steep WT declines can also limit post-fire moss water availability. As such, post-fire moss water availability is also a function of large-scale controls on peatland WT dynamics, specifically, connectivity to groundwater flow systems (i.e. hydrogeological setting). For this reason, we assessed the interacting controls of hydrogeological setting and burn severity on post-fire moss water availability by measuring peatland WTs, soil tension (Ψ) and surface volumetric moisture content (θ) in three burned, Sphagnum-dominated peatlands located in different hydrogeological settings for three years following wildfire. The effect of burn severity on post-fire moss water availability did not vary with hydrogeological setting, however, the spatial coverage of high and low burn severity did vary between peatlands located in different hydrogeological settings due to its influence on pre-fire fuel loads and species cover. Locations covered by S. fuscum prior to fire exhibited decreasing post-fire water availability with increasing burn severity. In contrast, the lowest water availability ($\Psi > 400$ cm, $\theta < 0.02$) was observed in feather mosses that underwent low burn severity (residual branches identifiable). Where depth of burn was > 0.05 m (high burn severity) and pre-fire species were not identifiable, water availability was highest ($\Psi < 90$ cm). Where burn severity did not limit water availability through a reduction of capillary flow, depth to WT (and therefore hydrogeological setting) played a large role in affecting post-fire moss water availability. A peatland located in a groundwater flow-through system exhibited high post-fire moss water availability (surface $\theta > 0.15$, $\Psi < 60$ cm) and shallow WTs that were less variable and exhibited lagged responses to climatic variability. In contrast, peatlands in hydrogeological settings that were not connected or ephemerally connected to groundwater flow systems exhibited deeper and more dynamic WTs that led to lower post-fire moss water availability (surface $\theta < 0.15$, $\Psi > 60$ cm), especially during dry periods. As such, we argue that the post-fire recovery of keystone peatland mosses is strongly linked to a peatland's hydrogeological setting. These results suggest that post-fire moss re-establishment in peatlands located in dry hydrogeological settings may be particularly vulnerable to post-fire droughts and future climate change.