Post-fire subalpine forest regeneration varies with climate in patches of stand-replacing wildfire

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Warming and drying climate conditions in western North America have increased wildfire activity and created more stressful growing conditions for trees. These changes may be particularly important for subalpine forests of the Northern Rocky Mountains (USA) where most tree species must regenerate from seed following infrequent severe (i.e., stand-replacing) fire. If recent severe fires are followed by conditions that are inhospitable for post-fire tree seedling establishment, successional trajectories may be altered or forest reestablishment substantially delayed. Such changes would have important consequences for forest-associated ecosystem services (e.g., carbon storage, wildlife habitat, recreation). In subalpine forests of the Greater Yellowstone Ecosystem (hereafter Yellowstone) and Glacier National Park (hereafter Glacier), we asked whether patterns of natural post-fire tree regeneration differed in recent fires that were followed by contrasting climate conditions. We were also interested in how establishment varied spatially (i.e., with increasing distance from edge of burn patch) and among tree species.

Using field-calibrated satellite indices of burn severity, we identified patches of stand-replacing fire that occurred in years followed by periods of anomalously warm/dry or cool/wet climate conditions. We sampled post-fire tree seedling densities in 184 plots situated along 32 transects extending from the edge to the middle of severe burn patches, distributed across different topographic and directional (i.e., direction from nearest seed source) contexts.

Post-fire forest regeneration was abundant, with nearly all plots in both regions exhibiting post-fire seedling densities greater than pre-fire tree density, and densities were greater in Glacier than in Yellowstone. However, post-fire seedling densities were substantially lower in fires followed by warm/dry vs. cool/wet conditions in both study regions (74% lower in Yellowstone; 88% lower in Glacier). Sensitivity of tree seedling establishment to distance from burned edge varied among species, with wind-dispersed conifers exhibiting the strongest distance-to-edge effects, followed by seedbanking conifers and re-sprouting trees; distance-to-edge effects also were stronger in Yellowstone. These results suggest that post-fire forest recovery in subalpine forests of the Northern Rockies may be very sensitive to climate during the tree establishment phase, and that effects of fire size may be most pronounced in fires followed by drought conditions. We illustrate a wide range of early resilience to severe fire, but important questions remain about how variability in post-fire forest recovery rates interact with the provision of ecosystem services, human perceptions of post-fire forest resilience, and potential management response in the Northern Rockies.