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Rates and drivers of postfire tree regeneration through 2100 in Greater Yellowstone

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Background/Questions: Novel climatic conditions and increased disturbance are eroding resilience (the ability to recover after disturbance) in many forests. Tree regeneration is key to forest resilience, yet sparse postfire tree establishment has been reported recently in parts of Greater Yellowstone. Because recovery pathways often lock in soon after wildfires, the early postfire years can shape stand development for decades to centuries. However, it is difficult to know where and why postfire tree regeneration may succeed or fail. Here, we used a spatially explicit process-based model, iLand, to simulate subalpine forests of Greater Yellowstone (Wyoming, USA) in five representative landscapes. Fire and forest dynamics were simulated through 2100 under four contrasting climate scenarios that varied in aridity and temperature. We asked (1) How do rates of postfire tree regeneration change throughout the 21st century across species and climate scenarios? (2) What drives regeneration within fire patches?

Methods: Within simulated burned areas, we quantified the mean density of seedlings that established 5-years postfire by species and fit generalized linear models (GLMs) to estimate the rate of change in postfire regeneration to 2100 for each species and landscape x climate scenario. We then fit GLMs to assess potential drivers of regeneration, including distance to seed source, species prefire basal area, proportion of young forest, patch size, and proportion high-severity fire.

Results/Conclusion: Rates of tree regeneration varied among species and scenarios. For example, postfire regeneration density of Engelmann spruce *(Picea engelmannii*), a cold-tolerant species, declined by over 80% in all scenarios, dropping to < 50 seedlings/ha by 2100 in some landscapes. Serotinous lodgepole pine (*Pinus contorta* var. *latifolia*) regeneration decreased by >50% in dry climate scenarios in plateaus of Yellowstone where it now dominates. In contrast, regeneration rates of Douglas-fir (*Pseudotsuga menziesii*), a thick-barked fire resister, always increased, with seedling densities increasing >200% in dry scenarios. Across all species, prefire basal area and distance to seed source were strong drivers of postfire tree regeneration, highlighting the importance of mature trees on the landscape for postfire establishment. The proportion of high-severity fire in a burn patch was negatively related to postfire regeneration of non-serotinous lodgepole pine and Douglas-fir in most landscapes. Overall, postfire tree regeneration was greater in topographically complex landscapes, including

northern Yellowstone and the Greys River district on the Bridger-Teton National Forest, that included all dominant tree species, suggesting that proximity of species with different environmental tolerances and a variety of environmental niches could enhance 21st-century forest resilience.