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Disturbance at the edge: Douglas-fir beetle outbreaks and potential forest-grassland shifts near the lower tree line of Greater Yellowstone

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Background/Questions/Methods

Ongoing bark beetle outbreaks have caused widespread tree mortality in conifer forests across much of North America, prompting questions about the regeneration and future composition of affected landscapes. Effects of beetle outbreaks on forest regeneration are known to vary strongly depending on the structure, composition, and abiotic setting of the forest at the time of outbreak. Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* v.*glauca*) forests affected by the Douglas-fir beetle (*Dendroctonus pseudotsugae*) are a key example of such variation. Covering ~30% of the forested area of Greater Yellowstone (Wyoming, USA), Douglas-fir spans an exceptionally wide range of conditions, from mesic closed-canopy stands to drier open parklands that form the lower-elevation ecotone with non-forest vegetation. We examined how post-outbreak forest structure and composition as well as regeneration abundance, timing, and growth varied with post-outbreak time in these two settings (mesic forest, dry parkland). A specific question was whether dry parklands may revert toward non-forest condition after a beetle outbreak because of limited regeneration on marginal forest sites, especially under the generally warmer climate of the past two decades. To explore these questions we sampled overstory trees and sapling/seedlings in 0.25-hectare plots in 20 stands distributed across 28 years of post-outbreak time.

Results/Conclusions

Outbreak severity ranged from 38-85% of basal area, leaving a significant portion of canopy trees intact (mean of 718 and 237 surviving stems ha^{-1} in mesic forest and dry parkland, respectively). Douglas-fir remained the dominant canopy species in both settings, but in mesic forests, other species increased in relative importance by 5-25%, including *Picea engelmannii, Pinus contorta,*and *Abies lasiocarpa*. Limited new (post-outbreak) seedling regeneration was observed in either setting even 20+ years after disturbance, with >80% of seedlings having established prior to outbreaks. This advanced regeneration was abundant in mesic forest stands (median 1560 stems ha^{-1}) and sparse to absent in dry parklands (median 152 stems ha^{-1}). These data suggest successional trajectories following beetle outbreaks in Rocky Mountain Douglas-fir forests are determined largely by the extant understory, rather than new outbreak-stimulated regeneration. Thus, in mesic closed-canopy stands with abundant tree understories, succession is accelerated and forests are likely to persist. In dry parklands, however, lack of a well-developed tree understory means that beetle-induced mortality shifts the system toward non-forest vegetation. Such potential tree-line shifts are consistent with hypotheses regarding directional changes or century-scale fluctuations in forest cover associated with climatic conditions, with bark beetles as the immediate catalyst of change.