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Mega-Disturbances and forest decline in the Sierra Nevada of California, USA: Insights for managing disturbance dynamics

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Mature forests characterized by high cover of tall trees and complex understories are important habitat for native plant and wildlife species and support critical ecosystem functions globally. In California's Sierra Nevada a combination of a century of fire exclusion and worsening climate change has led to increasingly severe wildfires and extreme drought that threaten habitats of sensitive species. Using spatially explicit datasets of forest structure and the Ecosystem Disturbance and Recovery Tracker, we quantified the loss of conifer forest cover in the southern Sierra Nevada between 2011 and 2020, a decade and region characterized by unprecedented mega-disturbances. Due to the combination of wildfires, drought, and drought-associated beetle kill, 30% of conifer forest extent was lost (fell below 25% canopy cover) during this period. Of the spatially limited mature forest habitats, 56% of moderate density (40-60% canopy cover) and 84% of high density (>60% canopy cover) forests were degraded. Drought and beetle-kill caused greater cumulative degradation than areas where wildfire mortality overlapped with the other disturbances. However, burned areas resulted in larger patches of forest loss and greater forest fragmentation on average. These results highlight that current conservation approaches are failing to protect mature forest habitats within disturbance-prone ecosystems like the conifer forests of California. We emphasize the need to switch from a static approach to conservation toward one focused on managing healthy disturbance dynamics, especially using frequent low-severity fire to increase forest resilience to future mega-disturbances. Without rapid management interventions, remaining mature forest habitat in the Sierra Nevada may be susceptible to complete loss in the coming decades.