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Rocky Mountain Research Station

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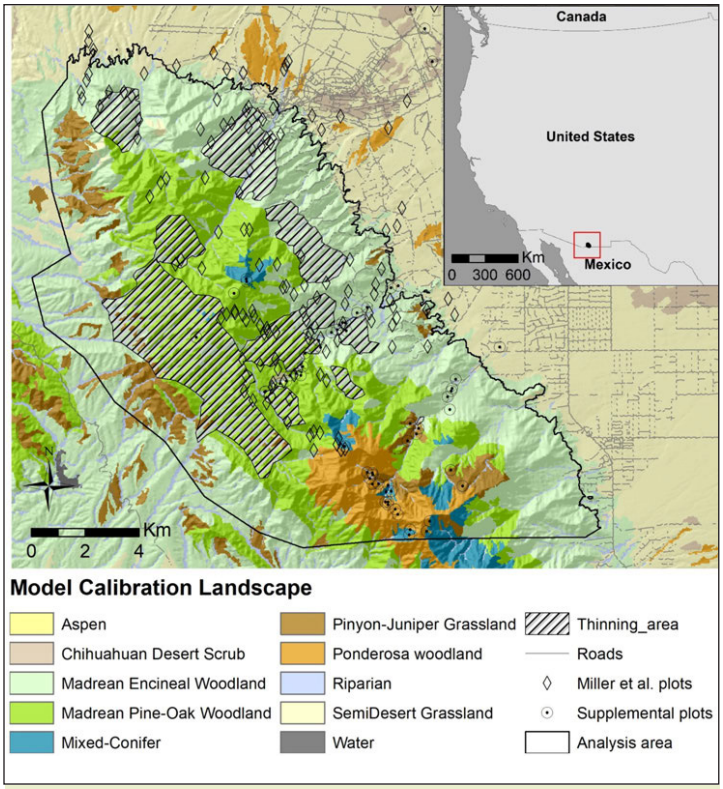
Harbingers of Change: Arizona Sky Islands Offer Unique Opportunities to Understand Climate Change, Carbon, Fire, and Ecological Transition

Climate stressors on forests of the American West are shifting species' distributions across spatial and vertical scales, lengthening fire seasons, and increasing the incidence of drought and insect-related die-off. Yet, little is known about the specific mechanisms driving vegetation transitions and what, if any, mitigations can be taken to slow these changes. Reducing stand densities and surface fuel loads is a means of moderating fire behavior, but this may not be enough to yield resilient ecosystems in the face of a changing climate.

Just north of the United States–Mexico border, the Huachuca Mountains of Arizona are situated near the center of the Madrean Sky Island archipelago. This ecosystem is incredibly biodiverse. Vegetation transitions are shaped by gradients of elevation and aspect; grasslands cover the base of slopes while the peaks are topped with stands of pure aspen, ponderosa pine, and mixed conifer forests. These unique islands provide scientists the opportunity to study ecology, fire, and climate change in isolated areas.

Rocky Mountain Research Station research ecologist Kit O'Connor and colleagues used an ecosystem process model to examine the potential for prescribed fuel treatments to mitigate the effects of climate and fire in the Huachuca Mountains. On the simulated landscape, forests are projected to undergo significant shifts in biomass, species distributions, and patterns of fire over the next 50 years. These rapid yet lasting changes, caused by climate change and fire interactions, suggest that the forests of the Huachuca Mountains may transition from a carbon-neutral system to a significant carbon source over the coming decades.

The research team found that initial fuel treatments reduced the extent and relative mortality of high-severity patches for the first two decades, and



In the incredibly diverse ecosystems of the Huachuca Mountains of the Madrean Sky Island mountain range, vegetation transitions are shaped by gradients of elevation and aspect. RMRS scientists' models demonstrated that these landscapes will shift as a result of changing climate. USDA Forest Service map by Kit O'Connor et al.

secondary treatments at simulation year 20 extended these effects for the remaining 30 years of simulation. Immediate and future fuel treatments showed potential to mitigate the severity of fire effects under projected conditions and slow the transition from forest to shrubland in some vegetation types. However, a reduction in basal area and spatial extent of some forest species occurred regardless of management actions.

O'Connor says, "Many of the forest types and species of this region are situated at the edge of their range distributions, so the rapid changes we project in our study may be a harbinger of what is to come in similar vegetation types farther north at longer time scales and assuming similar climatic conditions. While fuel treatments helped to moderate fire-induced mortality, warming temperature appears to be the most significant driver of tree mortality and forest to shrubland transition in the Huachuca Mountains." Local land managers and partners in the Southwest are using these findings to anticipate landscape changes resulting from climate-fire interactions and to coordinate active management of fuels across ownerships.

This RMRS research is being used to inform local land managers and partners of potential landscape changes resulting from climate alone and from climate–fire interactions and to coordinate active management of fuels across ownerships. USDA photo.

KEY MANAGEMENT CONSIDERATIONS

- Landscapes are shifting in response to climate change and wildfire. Forests of the Huachuca Mountains are projected to undergo significant shifts in biomass, species distributions, and patterns of fire over 50 years of projected future climate.
- By midcentury, the expansive mid-elevation forests, historically dominated by a multilayered canopy of pine and understory oak, are projected to convert to shrublands even in the absence of fire, and upper-elevation pine and mixed conifer forests are expected to lose more than a third of their basal area and species diversity.
- Changes to fire dynamics, either through fire exclusion or fuel reduction treatments, did not slow the rate of landscape scale biomass loss or changes to species distributions, which were still driven inexorably by climate.
- These rapid and lasting changes suggest that forests of the Huachuca Mountains may transition from a carbon-neutral system to a significant carbon source over the coming decades.

PROJECT LEAD

Kit O'Connor is a Research Ecologist with the USDA Forest Service Rocky Mountain Research Station Human Dimensions Program. His research is focused on integrating fire, insect disturbance, and changing climate into landscape planning and incident response.

FURTHER READING

O'Connor, Christopher D.; Falk, Donald A.; Garfin, Gregg M. 2020. Projected climate-fire interactions drive forest to shrubland transition on an Arizona Sky Island. Frontiers in Environmental Science. 8: Article 137.

The Rocky Mountain Research Station is one of seven units within USDA Forest Service Research & Development. RMRS maintains 14 field laboratories throughout a 12-state geography encompassing parts of the Great Basin, Southwest, Rocky Mountains, and the Great Plains. While anchored in the geography of the West, our research is global in scale. RMRS also administers and conducts research on 14 experimental forests, ranges and watersheds and maintains long-term research databases for these areas. Our science improves lives and landscapes. More information about Forest Service research in the Rocky Mountain Region can be found here: https://www.fs.usda.gov/rmrs/.

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