Research Brief

WARNER COLLEGE OF NATURAL RESOURCES
COLORADO STATE UNIVERSITY

INTERMOUNTAIN WEST TRANSFORMATION NETWORK

# Piñon pine and juniper seedling regeneration persists at burned edges but remains limited two decades after large wildfires

*Jamie Woolet[a], Camille S. Stevens-Rumann[ab]*

*a. Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, CO, 80521, USA*
*b. Colorado Forest Restoration Institute, Colorado State University, Fort Collins, CO, 80521, USA*

## Key Points

- Natural tree regeneration was concentrated near unburned edges and mature seed sources.
- Gambel oak and downed logs are important nurse microsites for seedling establishment.
- Areas with non-native plant cover had less piñon regeneration.
- Large, high-severity burn patches may experience prolonged woodland recovery without intervention.

Piñon-juniper (PJ) woodlands are a widespread lower-elevation forest type found across Colorado, Arizona, Utah, New Mexico, and Nevada. These woodlands provide countless ecosystem services in the southwestern US, including wildlife habitat, carbon storage, watershed protection, and cultural resources. PJ woodlands are increasingly challenged with interacting stressors such as larger wildfire footprints, hotter and drier climate, and non-native species establishment. Together, these stressors may influence post-fire recovery and the long-term persistence of woodlands on the landscape.


Figure 1. 27-year-old burned woodlands at edge plots (near the unburned edge), interior plots (~100 m in the interior of the burn), and unburned woodlands.

While slow post-fire recovery is expected in PJ, assessing woodland recovery several decades after wildfires can help identify which factors promote or limit woodland tree regeneration. Here, we investigated two-needle piñon pine and Utah juniper seedling establishment in PJ woodlands in western Colorado that burned 25–27 years ago.

### Objectives:

1. Identify and compare vegetation cover in edge and interior burned plots and in unburned reference plots and compare native and non-native species establishment.
2. In the same plots, quantify piñon and juniper seedling regeneration and seedling microsite conditions and identify important biotic and abiotic variables that correlate with piñon and juniper seedling regeneration.

## Key Findings:

***Burned areas remain structurally different from unburned woodlands.*** 25–27 years post-fire, burned areas had greater shrub, grass, and forb cover than unburned woodlands. Burned areas also contained substantially higher cover of non-native herbaceous species. In contrast, unburned plots had greater exposed soil and maintained woodland structure.

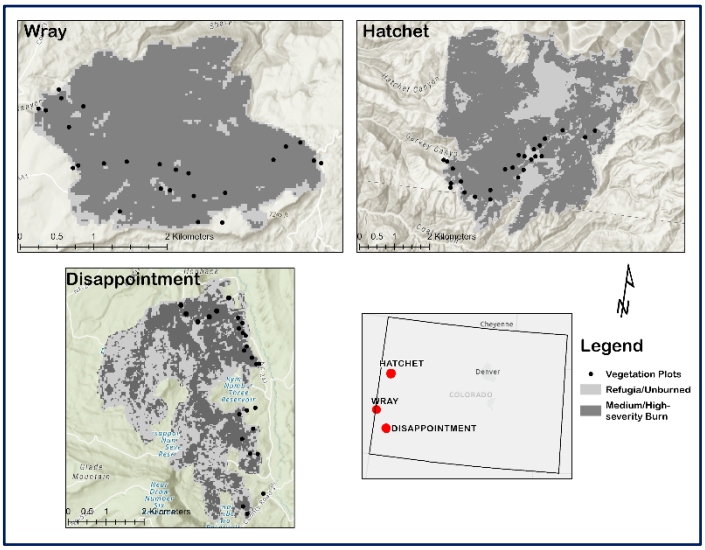


Figure 2. Locations of study fires and sampling plots in western Colorado.

***Tree regeneration is strongly limited by distance to seed sources***. Across all plots, piñon and juniper seedling densities were highest in unburned woodlands and substantially lower in burned areas (Figure 3). Within burned areas, regeneration was concentrated near unburned edges and existing seed sources, while interior portions of large burned patches contained very few seedlings. Models indicated that proximity to mature trees was one of the strongest predictors of seedling establishment. Piñon seedling density was positively associated with nearby mature piñon trees and negatively associated with non-native plant cover. Juniper seedling density was positively associated with nearby mature juniper trees and greater fine-fuel loading (1-hour and 10-hour fuels).

***Nurse objects facilitate seedling establishment.*** Most piñon and juniper seedlings occurred beneath nurse objects rather than in open microsites. Within burned areas, both species were most commonly found beneath Gambel oak and downed logs. These microsites may provide favorable growing conditions by moderating temperature extremes, retaining soil moisture, and reducing environmental stress on young seedlings.

## Conclusions:

Piñon-juniper woodlands recover slowly following wildfire. Nearly 30 years after fire, burned areas remained dominated by shrubs, grasses, and forbs and had less piñon and juniper seedlings than in unburned woodlands. Tree regeneration occurred more near unburned edges and mature seed sources, indicating that seed availability is a major constraint on post-fire recovery. In addition, higher non-native plant cover was associated with lower piñon seedling establishment, suggesting that invasive species may further inhibit woodland recovery. Together, these findings indicate *that large patches burned at high-severity may require hundreds of years to recover to woodland structure through natural regeneration alone*.

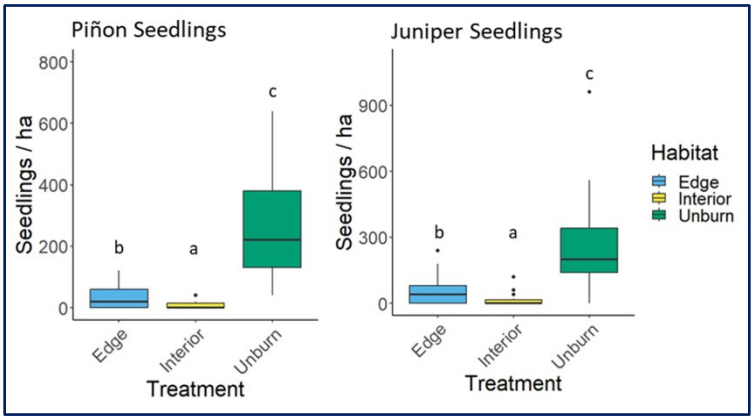


Figure 3. Box plots displaying piñon seedlings per ha and juniper seedlings per ha in edge, interior, and unburned plots.

Where tree recovery is a management objective, targeted planting in interior burned areas and management of non-native vegetation may help accelerate recovery. Long-term monitoring is essential for understanding recovery trajectories and identifying when management intervention may be needed to achieve desired future conditions.

## For Further Reading


Woolet, J., Stevens-Rumann, C.S. 2026. Piñon pine and juniper seedling regeneration persists at burned edges but remains limited two decades after large wildfires. *Fire Ecology*.