

Connected SCIENCE

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Fire Refugia: Predicting locations of forest resistance and recruitment in a fire prone world

Wildfire size and severity have increased in recent decades prompting scientists to take a closer look at where fire refugia—forested locations that are burned less frequently or severely than their surroundings—occur on a given landscape. Recently published research to identify potential refugia across upland conifer forests sheds light on the factors that influence where tree survival and recruitment are likely.

“For me, a big motivation behind this study is that it can feed into planning and prioritization of restoration efforts, both before and after fire” says Kyle Rodman, research scientist at the Ecological Restoration Institute in Flagstaff, Arizona.

The information can help inform management strategies for forest restoration and climate adaptation planning, fire suppression that could protect ecological resources, and reforestation planning after severe fires occur.

“Our previous research indicates that seedling establishment and survival is more likely in close proximity to trees that survive fire,” says Kimberley Davis,

research ecologist at the Missoula Fire Sciences Lab with the Rocky Mountain Research Station. “Working with Kyle on this recent project was a great opportunity to look at where that’s likely to occur, and how that matches up with climate that is suitable for seedling establishment and survival.”

Mapping fire severity and tree recruitment

Rodman and Davis, together with RMRS research ecologists Jose Iniguez and Sean Parks and nine other scientists, looked at patterns of fire severity from 1,180 recent (2002–2020) fire events to identify factors (fuels, weather, topography, and prior fire) that were associated with refugia in large fires. Then they used these factors to predict the locations of potential refugia across all upland conifer forests in the Southwest and southern Rocky Mountains. Finally, they overlaid these predictions with data from an earlier study, led by Davis, of seedling establishment and survival to identify refugia that would be most likely to promote post-fire tree regeneration into nearby areas. Several key findings may help inform management decisions.

- Fire refugia were most commonly associated with low pre-fire forest cover (< 40 %), flat slopes or valley bottoms, moderate fire weather conditions, and spring-season burning.
- Areas that had burned once in the previous 15 years burned at roughly half the severity of places that had not burned recently.
- Even under extreme fire weather conditions, low- to moderate-severity fires within the previous 15 years substantially increased the likelihood of tree survival in subsequent fires. Potential refugia were 36% (moderate fire weather conditions) and 31% (extreme fire weather conditions) more common across forests that experienced recent fires.
- Overall, 23% (when burning under moderate fire weather) and 6% (extreme fire weather) of forests were classified as refugia with a high potential to support post-fire recruitment in the surrounding landscape. Recruitment potential was highest at the wetter end of species ranges, varied based on the tree species composition of existing communities, and was greatest in northern states (Colorado, Utah).

Landscape-scale thinking

While much planning is done at the stand level, Rodman hopes this study will help managers think about how what happens in a stand is related to the surrounding landscape. For example, wildlife species move around in a landscape based on needs for food or nesting resources. Fire is also a landscape scale process.

“Fire is contagious,” he says. “The areas around a stand matter a lot in terms of whether a fire is going to burn into that stand and how it will affect the stand when it gets there.”

When funding and time are limited, Davis says using the landscape as a guide is a helpful way to apply different treatments most effectively, for example, using topography to determine where lower and higher density forests are warranted.

To allow land managers and researchers to explore maps of the study areas at regional and landscape scales under different weather and fire severity conditions, the scientists created [a web application](#).

Rodman is currently working with RMRS scientists in the Southwest to compare fire refugia locations with high-quality habitat for the Mexican Spotted Owl.

Contributors

Kimberley Davis is a research ecologist at the Missoula Fire Sciences Lab, Rocky Mountain Research Station in Montana.

Jose M. Iniguez is a research ecologist with Rocky Mountain Research Station based in Flagstaff, Arizona.

Sean Parks is a research ecologist with the Aldo Leopold Wilderness Research Institute at the Rocky Mountain Research Station in Missoula, Montana.

Kyle Rodman is a research scientist with the Ecological Restoration Institute at Northern Arizona University in Flagstaff, Arizona.

Sylvia Kantor is the author of this Science You Can Use in 5 min.

MANAGEMENT IMPLICATIONS

- Predictions of fire refugia may inform prioritization of fuels reduction treatments to enhance or expand fire refugia.
- Because areas with previous fire are associated with refugia, the use of burning under moderate fire weather conditions is a critical management tool to promote more fire-resistant landscapes.
- Fire refugia may also be important for providing habitat for fire-sensitive species and maintaining forest persistence in an increasingly fire-prone world.
- Combining fire refugia with recruitment potential can inform broad-scale climate adaptation planning and incorporate a key ecological disturbance into such plans.

FURTHER READING

Rodman, K.C., K.T. Davis, S.A. Parks, T.B. Chapman, J.D. Coop, J.M. Iniguez, J.P. Roccaforte, A.J. Sánchez Meador, J.D. Springer, C.S. Stevens-Rumann, M.T. Stoddard, A.E.M. Waltz, and T.N. Wasserman. 2023. [Refuge-yeah Or Refuge-nah? Predicting Locations of Forest Resistance and Recruitment in a Fiery World](#). Global Change Biology.

Davis, K. et al. 2023. [Reduced fire severity offers near-term buffer to climate-driven declines in conifer resilience across the western United States](#). PNAS. 120(11): e2208120120.

Stevens, J. et al. 2021. [Tamm Review: Postfire landscape management in frequent-fire conifer forests of the southwestern United States](#). Forest Ecology and Management. 502: 119678.

Rocky Mountain Research Station researchers work at the forefront of science to improve the health and use of our Nation's forests and grasslands. More information about Forest Service research in the Rocky Mountain Region can be found [here](#).

The Ecological Restoration Institute (ERI) is nationally recognized for mobilizing the unique assets of a university to help solve the problem of unnaturally severe wildfire and degraded forest health throughout the American West.



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