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Research Brief for Resource Managers

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Spatial predictions of conifer regeneration after wildfire may help managers prioritize reforestation efforts

Shive, K. L., Preisler, H. K., Welch, K. R., Safford, H. D., Butz, R. J., O'Hara, K. and Stephens, S. L. 2018. From the stand scale to the landscape scale: predicting the spatial patterns of forest regeneration after disturbance. Ecological Applications 28: 1626-1639. https://doi.org/10.1002/eap.1756

Management Implications

- This predictive model combines seed availability with climatic, topographic, and burn severity data to forecast the spatial patterns of post-fire conifer regeneration.
- GIS-based prediction maps, developed immediately post-fire, can help managers identify and prioritize areas for reforestation.
- Burn severity, seed availability, and 30-year average annual precipitation were the strongest drivers of post-fire regeneration patterns.

In the yellow pine and mixed conifer forests of California, large patches of stand-replacing wildfire are increasingly more common. In these forest types, which are dominated by conifer species that lack adaptations to quickly regenerate after disturbance, alterations in fire severity patterns can significantly impact post-fire conifer regeneration and increase the risk of conversion to non-forested vegetation types. These largescale shifts in disturbance patterns can create a significant challenge for land managers tasked with reestablishing forests in large post-fire landscapes.

Recent work by researchers from U.C. Berkeley and the U.S. Forest Service may help managers meet this challenge. Drawing from both remotely-sensed and field-derived datasets, Shive et al. combined metrics of seed availability with broadly available climatic, topographic, and fire severity data, to produce a spatially-explicit predictive model that can be used to forecast where regeneration of (non-serotinous) conifers is most likely to occur after wildfire. Specifically, the model was designed to predict the probability of observing at least one regenerating conifer of the common species in these forest types (Douglas-fir, incense-cedar, Jeffrey pine, ponderosa pine, sugar pine, and white fir).

To make these predictions across a large landscape, and to be able to run the model quickly after a future wildfire, the researchers focused on predictive variables that were broadly available and easily accessible to managers. For example, they developed a novel approach for predicting spatial patterns of seed availability by estimating annual seed production from existing basal area and burn severity maps. They used data from >1,800 field plots to develop and assess their model and found good agreement between their final predictions and observed regeneration.

The final model included annual precipitation, climatic water deficit, actual evapotranspiration, snowpack, aspect, slope, time since fire, burn severity, and the seed availability proxy (SAP) with a 150-m neighborhood. Of these, the primary drivers were burn severity, seed availability, and average annual precipitation. Sites that burned at very high severity had regeneration probabilities that were about 60% less than sites that burned at low-to-moderate severity. Not surprisingly, this was correlated with seed availability, with higher regeneration in areas closer to lower-severity edges. They also found evidence of the key role that moisture plays; the odds of regeneration were roughly seven times greater in sites that were wetter (precipitation > 2,000 mm) than average (~1,200 mm).

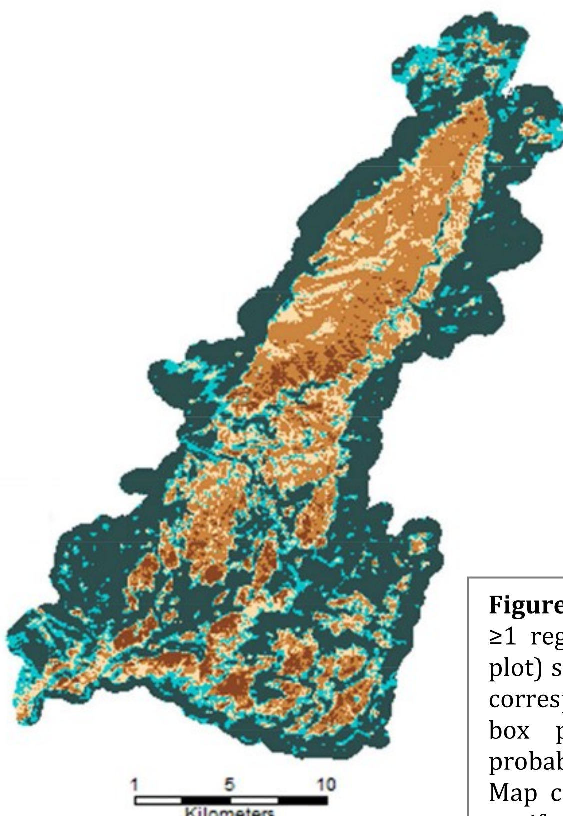
A real world example

To demonstrate how managers can use this model to create predictive maps to support postfire restoration planning, the authors created a prediction map for the 2014 King Fire on the Eldorado National Forest. This map shows the probability of observing at least one regenerating conifer at the 60-m^2 scale (the size of the field plots used to build the model), at five years post-fire. To assess the goodness-of-fit of the model, the authors used the "leave-one-out" approach, where they left out each of the 24 wildfires, and predicted regeneration on that fire using the other 23 wildfires. This approach allowed them to quantify the range of variation in predicted probabilities that may be observed on the landscape, as shown in the boxplot.

In their analysis of the King Fire, the model predicted that roughly one-third of the burned area (12,975 ha) was in the two lowest classes, corresponding to a large patch of contiguous high severity where seed sources were limited. Interestingly, the model also predicted the lowest class in smaller high severity patches at the southern end of the fire; these areas were less seed limited, but had low annual precipitation. This highlights the importance of considering overall site suitability, particularly under a warming climate.

In addition to the predicted probabilities, the authors also provide the range of observed seedling densities from the data used to build the model. For example, in the lowest category, observed seedling densities ranged from 0 to 14,666 seedlings/ha, with a mean of 144 (+/-86) seedlings/ha. While the range and mean of observed densities are useful values to refer to, the median values may prove most useful for assessing current USFS seedling stocking guidelines (e.g. at least 50% of an area needs to exhibit regeneration). In the table below, the median in the two lowest regeneration categories is 0 seedlings/ha, suggesting low densities of conifer regeneration in the short-term.

Predicted probability class	Observed densities (seedlings/ha) Min	95th percentile	Median	Mean (SE)
Low	0	333	0	144 (86)
Low-Mod	0	16,658	0	317 (55)
Moderate	0	2,500	166	672 (101)
Mod-High	0	12,000	333	3,665 (985)
High	0	27,216	1,333	6,301 (755)



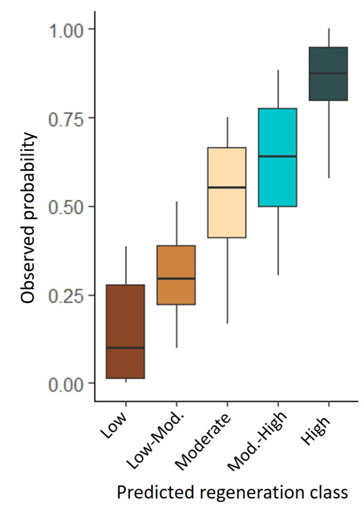


Figure 1. Map of the probability of observing ≥1 regenerating conifer at the 60-m^2 (field plot) scale for the 2014 King Fire. Map colors correspond to the classes on the x-axis of the box plot, with the range of expected probabilities within each class on the y-axis. Map colors also correspond to the table of conifer seedlings/ha observed in the 24 fires used to build the model.