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Research Brief for Resource Managers

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Fire, Spatial Structure, and Heterogeneity in Sierra Nevada Forests

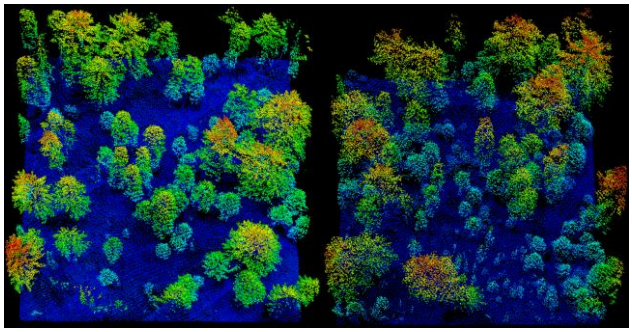
Kane,Van R., Malcolm P. North, James A. Lutz, Derek J. Churchill, Susan L. Roberts, Douglas F. Smith, Robert J. McGaughey, Jonathan T. Kane, and Matthew L. Brooks. 2013. Assessing fire effects on forest spatial structure using a fusion of Landsat and airborne LiDAR data in Yosemite National Park. Remote Sensing of Environment 151: 89–101.
http://dx.doi.org/10.1016/j.rse.2013.07.041

Structural variation and heterogeneity are essential features of resilient and functional forests, especially those characterized by a frequent fire regime. However, decades of fire exclusion in frequent-fire forests of the Sierra Nevada have greatly reduced their structural diversity, which has negative implications for wildlife habitat, biodiversity, and forest resilience. A 2013 study by Kane and others demonstrates that structural variation is significantly enhanced in these forests with the use of predominantly low- to moderate-severity fires.

The authors used a combination of two remote sensing technologies (Landsat and LiDAR) to evaluate the effects of a range of fire severity classes on structural variation in ponderosa pine, mixed conifer, and red fir forests of Yosemite National Park. Their novel approach permitted a three-dimensional analysis of the structure of forests and other vegetation. In addition, the authors analyzed structure across a wide range of spatial scales, from individual forest stands to entire landscapes, covering over 27,600 acres of forestlands.

Management Implications

- Low- to moderate-severity fires best replicated the historic patterns of heterogeneity and structural diversity that were common in low- to mid-elevation forests of the Sierra Nevada.
- In contrast, increasing proportions of unburned patches or high-severity fire resulted in greater degrees of structural homogeneity across the forest landscape.
- Forest restoration treatments may increase heterogeneity by: (1) breaking up large contiguous canopy areas into variable-sized tree clumps, (2) retaining scattered large individual trees, (3) creating a range of canopy opening sizes and shapes, and (4) promoting both multi-story and single-story canopy layers in tree clumps.



Structural diversity in Sierra Nevada forests is enhanced with the application of predominantly low- to moderate-severity fires, which creates of mosaic of canopy patch types. *Image Credit: Van Kane, University of Washington*.

The study showed that fire created a patchwork of openings and multistory tree clumps that were promoted under a low- to moderate fire regime, depending on the forest type (Figure 11). In contrast, large unburned or high-severity burned patches resulted in relatively lower levels of structural heterogeneity; forest fragmentation also increased with increasing fire severity. In addition, the presence of openings exceeding 0.75 acre in size, which generally favors shade-intolerant pine regeneration, increased rapidly with loss of canopy area.

The authors conclude that forest restoration seeking to enhance structural heterogeneity may want to consider the following recommendations: (1) reduce total canopy cover by breaking up large contiguous areas into variable-sized tree clumps and scattered large individual trees; (2) create a range of canopy opening sizes and shapes, including about 50% of the open area in gaps exceeding approximately 0.75 acre in size; (3) create multistory clumps in addition to single story clumps; (4) retain historic densities of large trees; and (5) vary treatments to include closed canopy, "mixed" clump–open, and open canopy mosaics across project areas to foster landscape variation in canopy patch types.

Additional references for this topic:

Kane, V. R., Lutz, J. A., Roberts, S. L., Smith, D. F., McGaughey, R. J., Povak, N. A., et al. (2013). Landscape-scale effects of fire severity on mixed-conifer and red fir forest structure in Yosemite National Park. Forest Ecology and Management, 287:17–31.

Larson, A. J., and D. Churchill. 2012. Tree spatial patterns in fire-frequent forests of western North America, including mechanisms of pattern formation and implications for designing fuel reduction and restoration treatments. Forest Ecology and Management 267:74–92.

North, M. 2012. editor. 2012. Managing Sierra Nevada forests. General Technical Report PSW-GTR-237. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

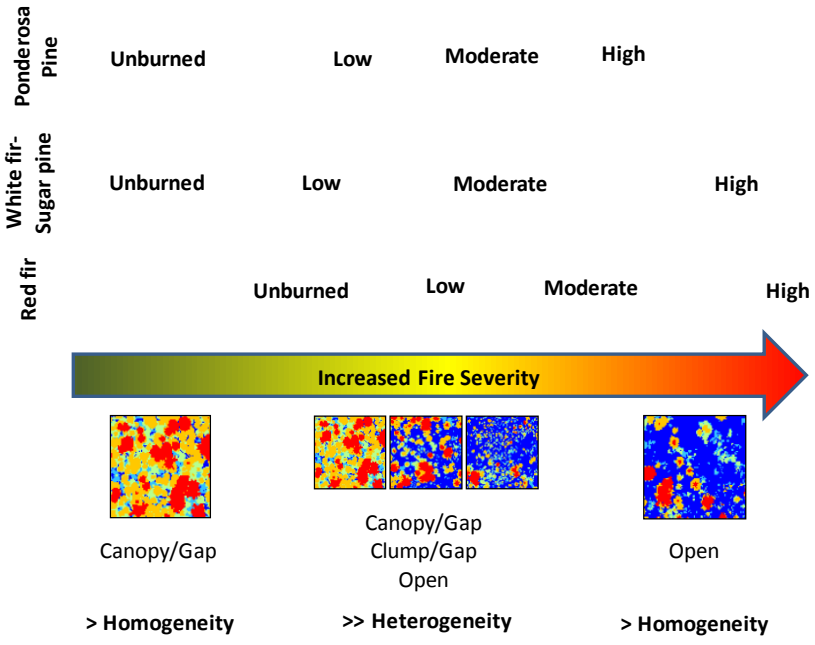


Figure 11. The relationship between fire severity and structural heterogeneity in ponderosa pine (top row), mixed conifer (middle), and red fir (bottom) forests of Yosemite National Park based on a combination of Landsat and LiDAR data. Structural heterogeneity is predominantly enhanced by low- to moderate-severity fires in ponderosa pine and mixed-conifer forests, and low-severity fire in red fir forests.