CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Fire severity impacts on winter snowpack

Stevens, Jens T. 2017. Scale-dependent effects of post-fire canopy cover on snowpack depth in montane coniferous forests. Ecological Applications in press.
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Coniferous forest structure influences how much snow accumulates on the ground during winter, and how quickly that snowpack disappears. Evergreen tree canopies intercept falling snow, so areas with greater tree cover often have less snow reaching the ground. However, tree canopies also increase shading from solar radiation and reduce wind speeds, so areas with greater tree cover can also extend the duration of snowpack. These counteracting effects of forest canopy create uncertainty in forecasting how snowpack will respond to future changes in forest structure.

Fire is a strong driver of changes in montane forest structure in California's Sierra Nevada and southern Cascade mountain ranges, which provide much of the snowpack and associated water storage for the state of California. A recent study by Stevens presented one of the first direct investigations in California of how fire can influence snowpack depth. Field crews sampled snowpack depth at three different fires (Reading, Showers and Angora) a total of 11 times during winter of 2013-14. At each fire, they sampled four different levels of burn severity, as well as unburned forest. The categories of burn severity were mapped as very low severity (0% canopy cover loss), low severity (1-20% canopy loss), moderate severity (20-90% canopy loss) and high severity (> 90% canopy loss). At each sampling point, they also recorded overhead canopy cover, as either open, edge, or under canopy.

Management Implications

- Spring snowpack depth was highest in areas of unburned forest and low severity fire effects. Within unburned and low severity areas, canopy gaps had the deepest snowpack
- Fine-scale forest variability with < 1ha gaps that are created or maintained by fire may have benefits for water storage in snow.
- Weather is the primary control over snowpack, and may influence how fire affects snow.

The effect of canopy cover on snow depth depended on the spatial scale of canopy measurement. Snow depth was greater at lower burn severities on average, but snow depth was also greater in canopy gaps than directly under canopy (controlling for burn severity; Fig. 1).

The size of post-fire canopy gaps therefore appears to influence the depth of spring snowpack. Although more snow may initially hit the ground in larger gaps associated with more severely burned stands, the increase in snowmelt in these larger openings appears to control snowpack duration. However, smaller openings at the scale of one to several tree crowns surrounded by live forest, commonly observed in unburned and low severity stands (where canopy cover in this study was 57% and 42%, respectively) appear to act as important reservoirs for snowpack water storage (Fig. 2).

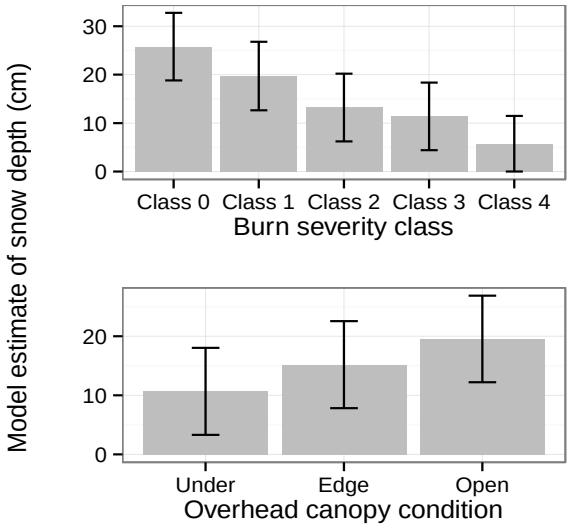

Figure 1: *Estimate of snow depth across all site visits as a function of burn severity and overhead canopy. Class 0 is unburned forest, and Class 4 is high-severity.*

Specifically, canopy gaps in the unburned and very low-severity areas were only 34% of the total sampled area, but contributed 78% of the total snowpack water storage (Fig. 2). In contrast, large canopy gaps in high-severity stands (ranging from ~0.5 to 16 ha) accounted for 20% of the sampled area but only 2% of total water storage.

It should be noted that the data in this paper come from winter 2013-14, when most of the Sierra Nevada and southern Cascades were in a historic multi-year drought. Given abnormally low winter snowfall totals, greater accumulation in larger canopy gaps may have mattered less to snowpack duration. The benefits of larger gaps for snowpack may therefore be greater in wetter years, and gaps may retain more summer soil moisture regardless of the snowpack environment if tree competition for water is reduced (Boisramé et al 2016 and unpublished data), raising further questions about how interactions between fire, forest structure and climate change will regulate California's critical winter snowpack.

Additional references for this topic:

Boisramé G *et al*. 2016 Managed Wildfire Effects on Forest Resilience and Water in the Sierra Nevada. Ecosystems, 20, 717–732.

Harpold AA *et al*. 2014 Changes in snow accumulation and ablation following the Las Conchas Forest Fire, NM, USA Ecohyd., 7, 440-452.

Varhola A *et al*. 2010 Forest canopy effects on snow accumulation and ablation: An integrative review of empirical results. Journal of Hydr., 392, 219-233.

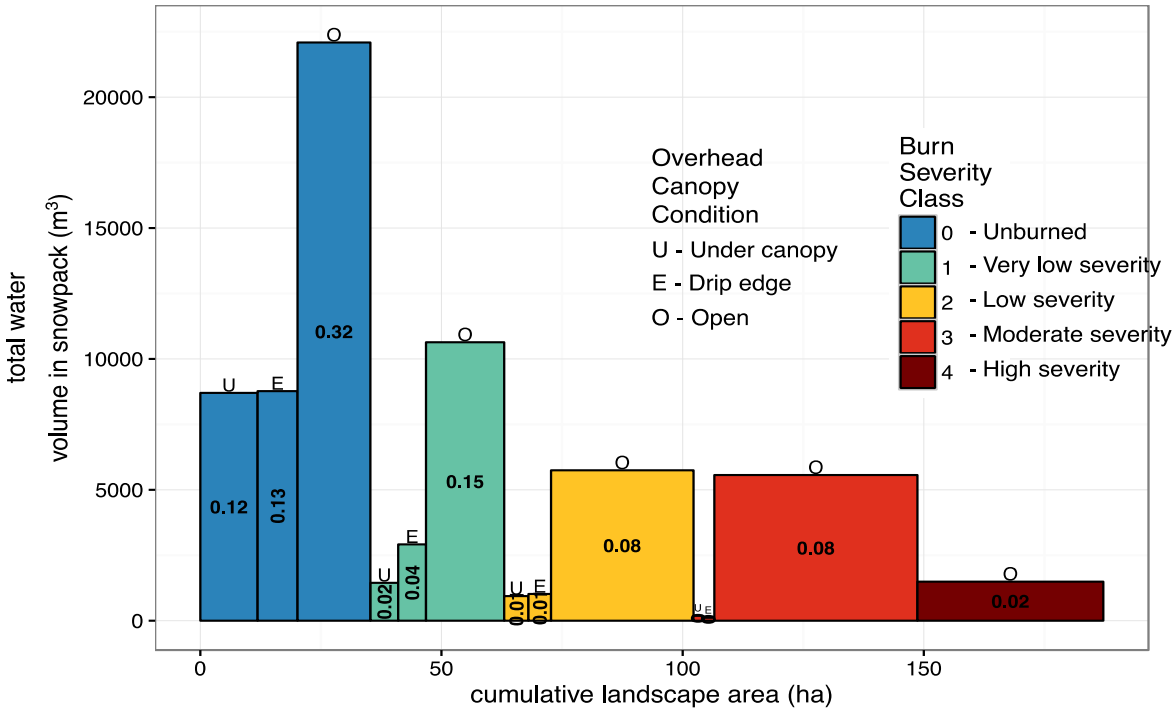

Figure 2: *Distribution of water in snowpack at the Reading Fire on April 14 2017 (bar height), by overhead canopy and burn severity combination. Bar widths reflect cumulative area in a given class.*