Research Brief for Resource Managers

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Where are the Sierra Nevada's large trees and can they persist?

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Identification and conservation of mature and old-growth forests has become a federal government priority. In California's Sierra Nevada's most of the remaining large trees are concentrated on Forest Service and National Park Service lands. We used airborne lidar data to census large (≥30" diameter at breast height (DBH)) and very large (≥40") trees across three large Sierra landscapes. We found that large trees are either locally absent to rare or are aggregated in stands with 8-20 large trees per acre.

Protecting large trees from future wildfires and drought will require local treatments to reduce stand densities. Treatments will also be needed across landscapes because many stands of large trees are interspersed with stands of shorter, highly flammable trees.

Management Implications

- Large (≥30" DBH) and very large (≥40") trees are not rare in the Sierra Nevada, but they are primarily aggregated in patches with 8-20 large trees per acre
- Most large trees are in stands likely to be at risk to wildfire and drought because of overly dense stocking (60%+ canopy cover)
- Most large trees are in complex networks of patches
- Management strategies to protect large trees likely will require both local thinning to reduce stocking and landscape-scale strategies
- Effective protection strategies likely will require a mix of mechanical thinning, prescribed fire, and leveraging wildfires as treatments

A common belief, implicit in Forest Service practices that prohibit cutting trees with 30-inch or larger diameters, is that remaining large trees are rare. Depending on the location examined, we found that large trees are often rare, but in some locations can be locally abundant. However, today's large trees (many of which established within the last century), exist in historically unprecedented stand conditions Fire suppression has allowed infilling to create high stocking levels. Forests in 1911 averaged 12% - 28% canopy cover compared to the common 60% - 80% canopy cover we found for current locations with large trees. These high tree densities increase competition for scarce resources, particularly soil moisture, which can reduce tree vigor and increase susceptibility to drought, bark beetles, and other stressors.

Under climate change, droughts such as the 2012-2016 one in the Sierra Nevada, which killed more than 100 million trees, are likely to become more common. Uncharacteristically severe wildfires represent another growing threat to contemporary large trees. In a recent analysis, change in large tree cover from 2011 to 2020 in the southern Sierra killed almost 50% of the identified mature and old-growth large trees and stands with higher canopy cover were at greater risk of loss.

The high canopy cover observed around most large trees suggests that protecting these trees will require treatments both within the stands that contain them and across the landscapes in which they are imbedded. Management options for thinning density and reducing fuels within overly dense stands could use a landscape-scale strategy such as pyrosilviculture. This approach uses a combination of mechanical treatments and prescribed fire and/or managed wildfire to modify future wildfires at larger spatial scales.

Methods: In this study, we conducted a census of large (≥30"/76.2 cm) and very large (≥40"/101.6 cm) DBH trees using airborne lidar across public lands in the Tahoe region (2013/4 lidar data), in and around Yosemite National Park (2019 data), and portions of the Sierra National Forest (2020 data). Within our study areas, we analyzed the lower montane zone dominated by ponderosa pine; the mixed conifer zone composed of ponderosa pine, sugar pine, white fir, and Jeffrey pine; and the upper montane zone dominated by red fir.

We used local FIA plot data to develop height-to-diameter regression models specific to local climate classes within each study area. Preliminary analysis showed that substantial portions of our study area had low densities (<8) of large trees per acre that contributed only a small portion of the total count of large trees. We therefore focused on patches of forests with ≥ 8 large trees per acre.

Results: We identified 8,092,251 large trees (modeled DBH ≥ 30") and 2,777,423 very large trees (DBH ≥ 40"). Forest patches with ≥ 8 (typical range, 8-20) large trees per acre represented approximately one-half to one-quarter of our different study areas and contained the vast majority of large trees. We found similar trends for patches of trees ≥ 40", but the portion of area with very large tree patches ranged from approximately a fifth to a twentieth of the area depending on the study area and forest zone.

We found many small, isolated patches of large trees 1-4 ac in size, but this cumulatively represented a small portion of the large tree population. The majority of large trees were in patches of >125 ac with most in patches 1250-2500 + ac. However, these large patches are rarely simple large blocks. Instead, they form complex matrices interspersed with patches of forests with shorter trees, requiring landscape planning and treatments needed to protect these networks of large tree patches (see figure for examples).

Management implications: In this first census of large trees over large areas of the Sierra Nevada, we found that the distribution of large trees was spatially aggregated with most in patches containing 8 to 20+ large trees per acre. However, large portions of our study area had either no or low densities (<8) of large trees per acre.

Two factors will make protecting large trees challenging. First, these trees are usually found in locations with high canopy cover (≥60%), suggesting many are in overstocked stands. Second, while large trees are typically found in high density patches of large trees > 2500 ac, these patches were not compact but instead appeared to be highly interspersed with dense patches of small trees that are highly flammable Managers will need to improve the resilience of large-tree patches against future wildfires, droughts, and the stress of changing climate conditions and disturbance events.

Suggestions for further reading:

- GIS maps of large trees from study: https://arcg.is/8LfW9

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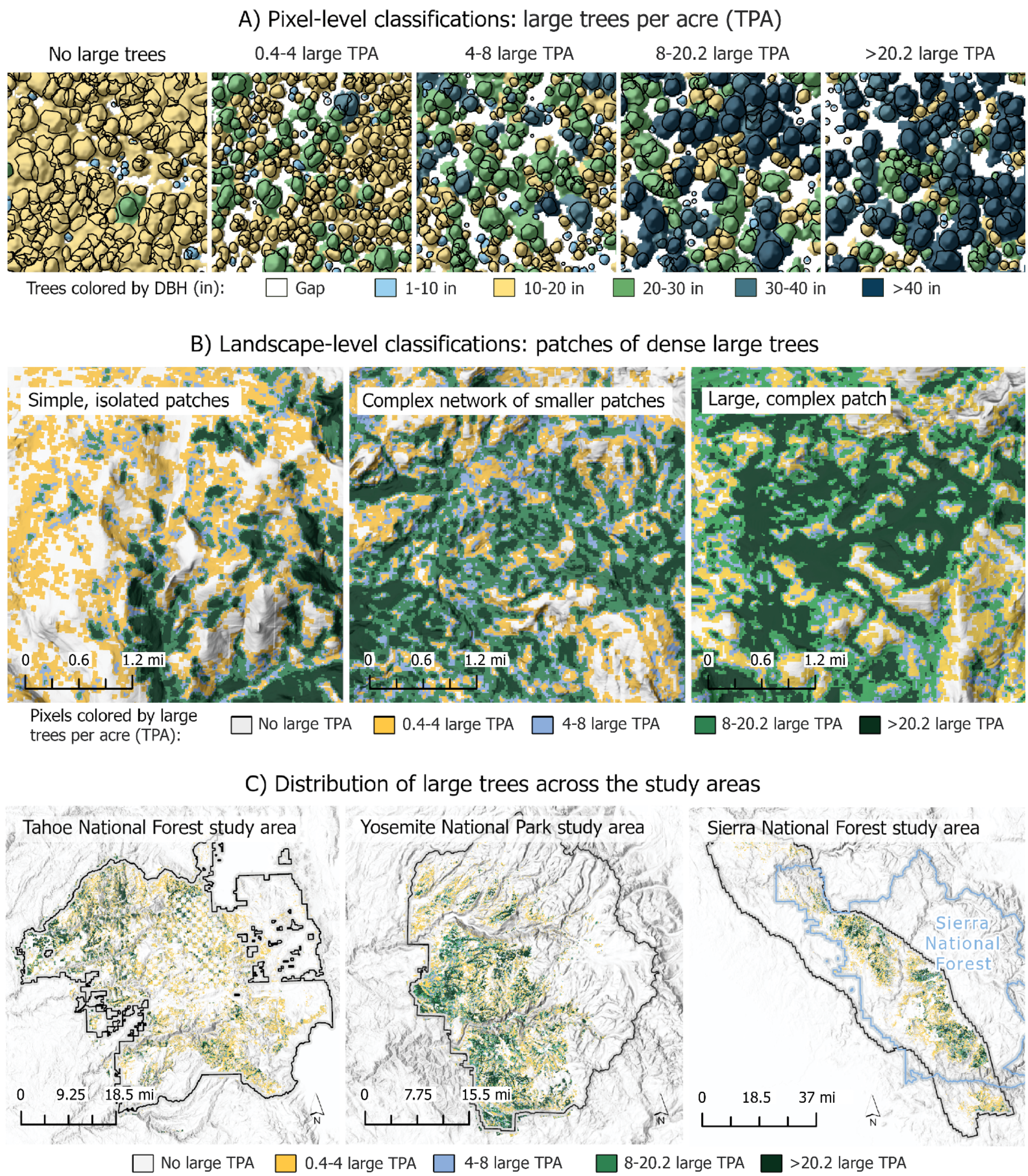

Visualizations of the data used in this study. A) Individual trees identified from the airborne lidar data for different densities of large (≥76.2 cm) trees per hectare with ranges of modeled diameters at breast height. Areas shown are 90 × 90 m. (Breaks correspond to 1–10, 20–30, 30–40, and > 40 in.) B) Examples of the typical complexity of networks of large tree patches found in our study areas. C) Distributions of large tree patches with different densities of large trees across our study areas. Interactive maps of large trees available at https://arcg.is/8LfW9