Evaluating Fuel Loading at a Landscape Scale in High Elevation Alpine Forests of Lassen Volcanic National Park

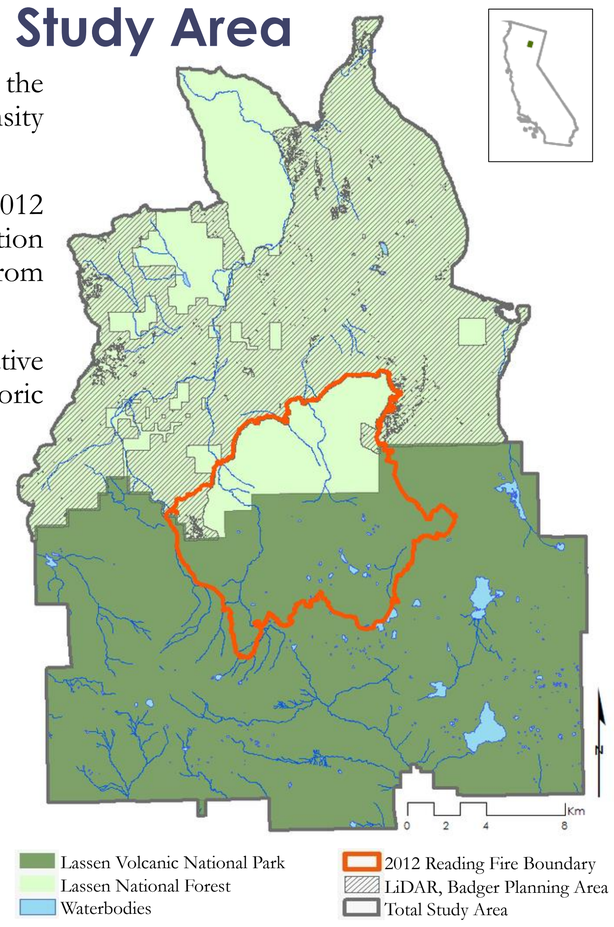
Abstract

The disruption of natural fire regimes caused by fire suppression policies, coupled with drought and changing climate conditions, allow fuel loads to grow in the absence of naturally occurring, low intensity surface fires. Within the mixed conifer forests of the Cascades, catastrophic wildfires challenge forest resilience in Lassen Volcanic National Park (LVNP) and Lassen National Forest (LNF). Land managers within these forested areas can benefit from integrating landscape-scale fuel load density and ecosystem recovery assessments derived from high-resolution, remotely sensed data into their wildfire mitigation and management projects. To provide a landscape-scale assessment, we calculated density estimates of stems per acre and canopy understory fuel loads for the Badger Planning Area with LiDAR, studied ecosystem recovery from the 2012 Reading Fire by calculating pre- and post-fire land cover using high spatial resolution imagery from the USDA National Agriculture Imagery Program (NAIP), and provided land managers an integrated web tool for spatiotemporal analysis of historical tree mortality and regional fire history using multispectral data from the Landsat series accessed in Google Earth Engine API. Examining fuels with this methodology for historic mortality trends, present conditions, and future planning, will improve wildfire management strategies across administrative boundaries in the Lassen area.

Objectives

- **Identify** continuous fuel structures using LiDAR in the Badger Planning Area by producing per acre stem density and high-risk canopy data
- **Analyze** how land cover has changed within the 2012 Reading Fire perimeter and assess the state of restoration interventions using NAIP imagery and planting data from LNF
- **Expand** the capabilities of the Simple Analysis of Vegetative Trends in Earth Engine (SAVeTrEE) tool to map historic tree mortality

Study Area



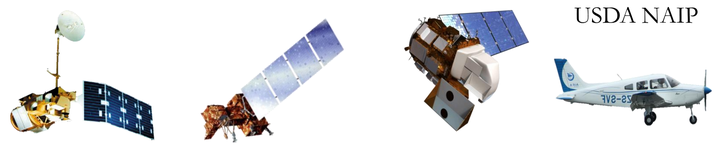
Project Partners

National Park Service, Lassen Volcanic National Park

USDA, US Forest Service Lassen National Forest

Earth Observations

Landsat 5 TM | Landsat 7 ETM+ | Landsat 8 OLI | LiDAR and USDA NAIP



Methodology

Badger Planning Area LiDAR Case Study

Acquire
- USFS 2015 Badger LiDAR

Process in ArcMap
- Canopy Height Model (CHM)
- Canopy Cover (CC)

Segment
- Thiessen polygons to segment individual canopies

Density
- Stems per acre

Process
- Canopy Base Height (CBH) for all trees

Reading Fire Recovery Map

Acquire
- NAIP 2012-2016
- LNF planting points

Process in ArcMap
- Mosaic quadrangles Calculate NDVI

Classify
- Supervised classification: bare earth, tree, grass

Mean NDVI
- At planting points in LNF
- At random points in LVNP

Change Analysis
- State of ecosystem recovery post-Reading Fire

Change Analysis
- Compare recovery across boundary

SAVeTrEE 2.0

Acquire
- LNF and Badger Planning Area boundaries
- CA fire history data
- Fuels treatment data

Google Earth Engine
- Enable user uploaded area of interest
- Drape documented fuel treatments and wildfires over mortality classification

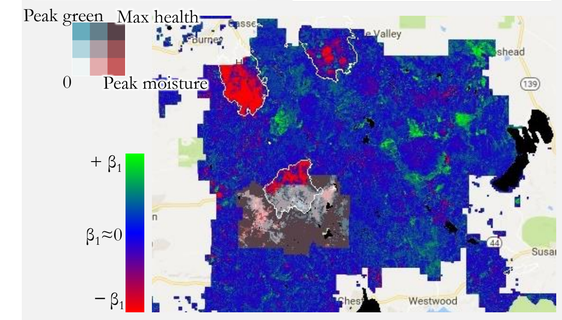


Figure 6. Time series map of vegetation health trend calculated with a linear regression over a user-specified spectral index, interval, area. Inner map is a bivariate plot of moisture and greenness for one year. Historic fire perimeters are overlaid over entire area.

Results

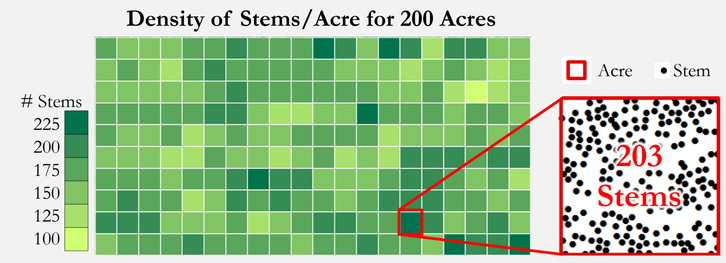


Figure 1. In this planted area of Lassen National Forest, the stem locations of dominant and co-dominant pine trees were determined using a tree segmentation algorithm. This algorithm uses Thiessen Polygons to interpolate the natural boundary between relative maximum heights.

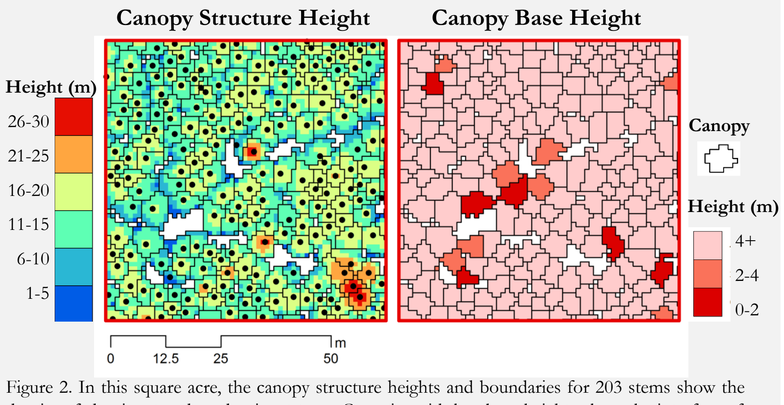


Figure 2. In this square acre, the canopy structure heights and boundaries for 203 stems show the density of dominant and co-dominant trees. Canopies with low base heights along the interface of forest and grass patches present a concern for continuous surface fuels that can lead to canopy fires.

Land Cover Classification

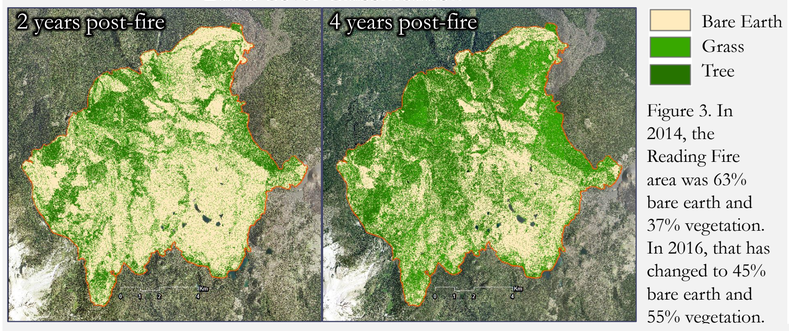


Figure 3. In 2014, the Reading Fire area was 63% bare earth and 37% vegetation. In 2016, that has changed to 45% bare earth and 55% vegetation.

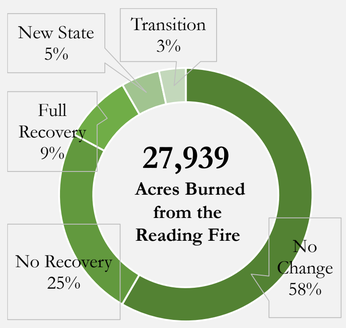


Figure 4. 2,460 acres (9%) grew from bare earth to grass or tree.

Distribution of vegetation health within the Reading Fire

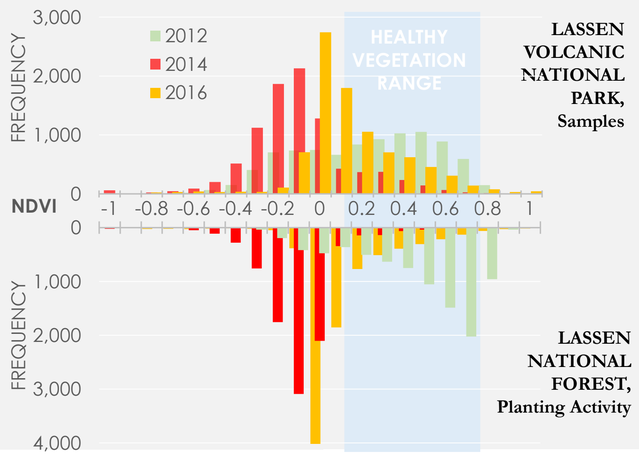


Figure 5: Before the fire, vegetation was evenly distributed within the healthy NDVI range from 0.2 to 0.8. However, the post-fire health varies due to different management practices at the U.S. Forest Service and National Park Service. In 2016, less than 10% of vegetation was healthy, whereas 75% and 50% were healthy in the Forest and Park. Four years after the fire, the distribution of vegetation health increased by approximately 0.2 towards the healthy range.

Conclusions

- The mean density of stems in the Badger Planning Area is 157 stems per acre.
- Canopies with low base heights along the forest-grassland interface are high-priority locations for fuel treatments.
- Within the Reading Fire perimeter: 9% of the vegetation has returned to near pre-fire state, 3% is in transition to its pre-fire state, and 25% show no signs of post-fire recovery.
- According to spectral data from NAIP imagery, planting restorations have not significantly accelerated vegetation recovery.
- SAVeTrEE tool now includes historical fire perimeters.

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Lassen Volcanic National Park Disasters II