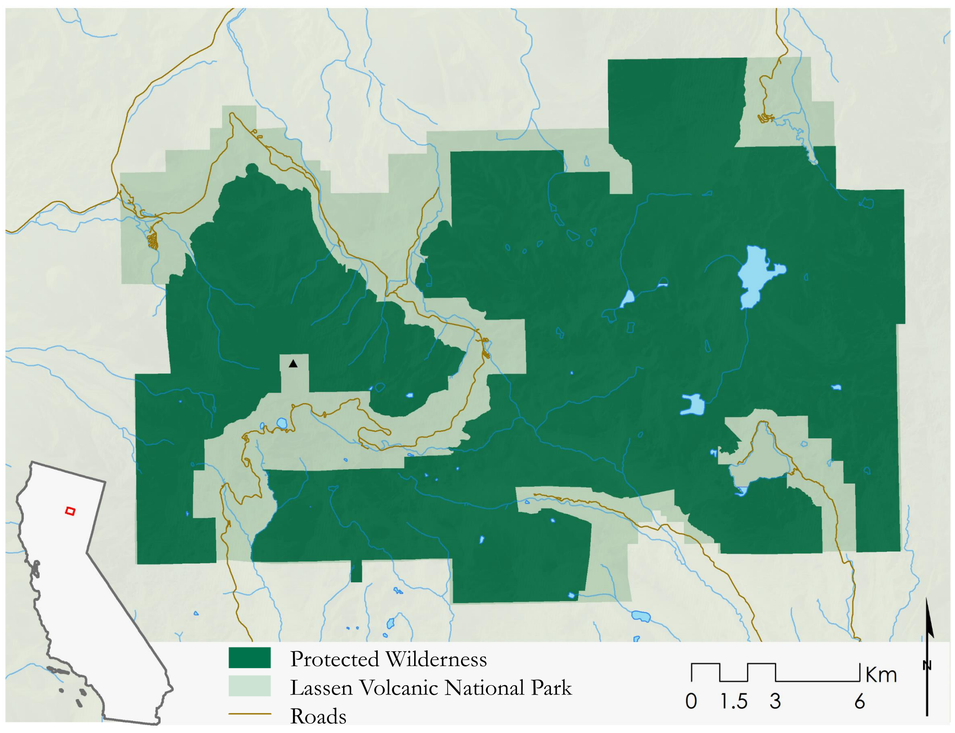
Understanding Fuel Loading in Lassen Volcanic National Park Through Earth Observation to Manage Wildland Fire Risk

Lassen Volcanic National Park Disasters

Abstract

Nearly three quarters of Lassen Volcanic National Park (LVNP) is designated as Wilderness under the Wilderness Act of 1964, meaning it is to be managed "to preserve its natural conditions […] with the imprint of man's work substantially unnoticeable." This prevents land managers from clearing excess vegetative fuels that have accumulated due to fire suppression policy. Therefore, LVNP must rely on fire to restore healthy levels of vegetation. Devastation following the 2012 Reading Fire demonstrated the strength of accumulated fuel loads. Detailed cataloguing of fuel loads is necessary to predict the behavior and severity of any fire allowed to burn in LVNP. To provide these estimates, NASA Earth observations were used to generate maps of historical and present-day tree mortality, and to evaluate advantages in using LiDAR data to obtain detailed fuel load measurements. We estimated tree mortality using a linear trend regression analysis implemented in Google Earth Engine (GEE), to process time series of multispectral data from Sentinel-2 and the Landsat series (TM, ETM+, OLI). LiDAR data were related to spatial layers of species coverage and other environmental factors to estimate fuel loads. These products will help partners at LVNP to periodically update their mortality maps and fuel loading estimates in their ongoing efforts to maintain a healthy and safe Wilderness.

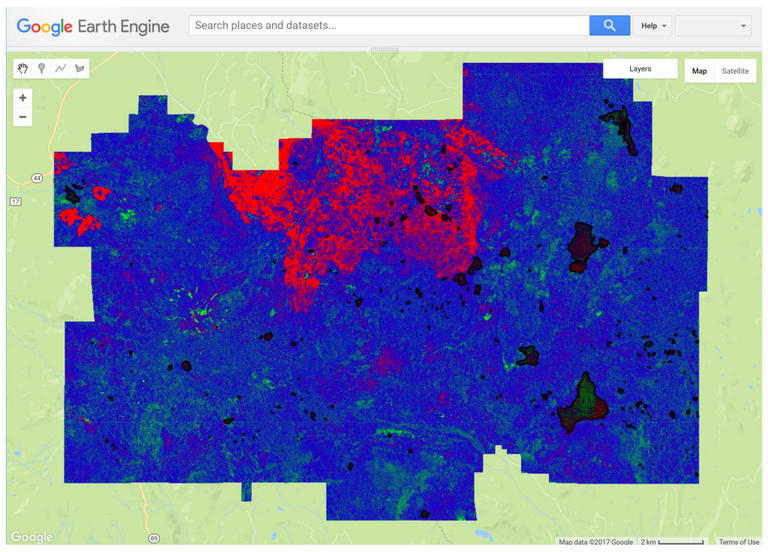
Study Area



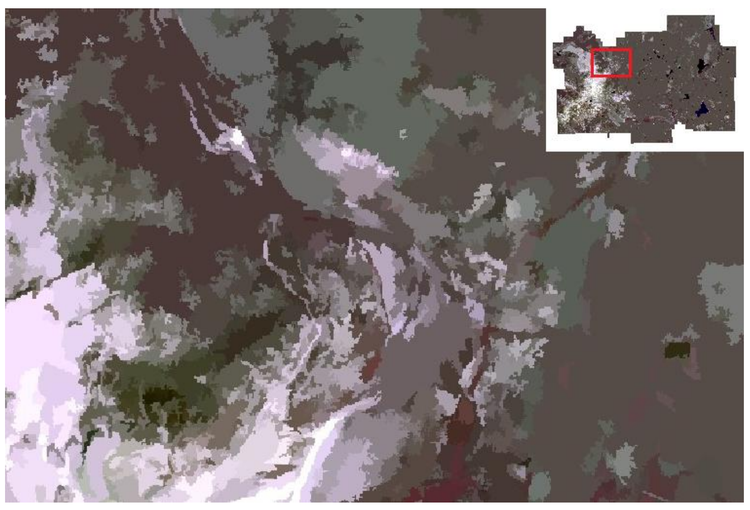
Objectives

- **Create** a tool for quickly classifying vegetation condition (growing, stable, declining) from satellite imagery time series based on user-input year
- **Analyze** the utility of LiDAR for mapping fuel loads within LVNP

Results



Earth Engine 5-year time series linear regression trend product for NDMI values 2012-2016

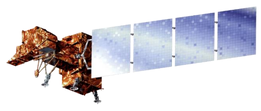


Mean Shift Segmentation of Sentinel-2 Multispectral Data, for use in a Support Vector Machine Classifier

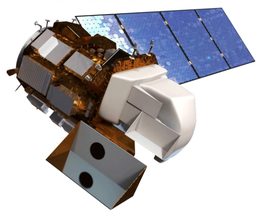
Earth Observations

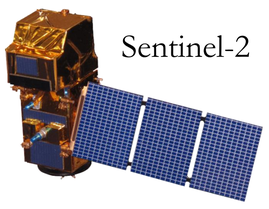
Landsat 5 TM

Landsat 7 ETM+

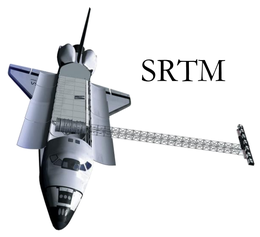


Landsat 8 OLI





Sentinel-2

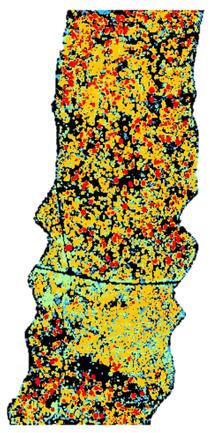


SRTM

G-LiHT (Airborne LiDAR)

LANDFIRE 2012 Canopy Height Model

- Non-Forested
- 1m < CH < 5m
- 5m <= CH < 10m
- 10m <= CH < 25m
- 25M <= CH < 50m



NASA G-LiHT Airborne Imager

Methodology

Historical Tree Mapping

Filter GEE Cloud Repository
- Year
- Growing Season (Mid-May → Mid-Aug)
- Study Area

Create Growing Season Composite
- Highest NDVI per pixel across Growing Season
- Removes clouds, phenological variation

Calculate Linear Trend
- $\varrho = \beta_0 + \beta_1 t + e_t$
- Best fit line of spectral value over time period

Generate Spectral Indices
- NDVI
- NDMI

Repeat for each year in 5-year period

Generate Mortality Classification
- $+\beta_1$ = Growth
- $-\beta_1$ = Mortality
- $\beta_1 \approx 0$ = Stable

Present Day Tree Mapping

Preprocess Sentinel-2
- Acquire growing season scene
- Processing in STEP: Terrain & Atmospheric Correction

Train Classification
- Support Vector Machine
- Train on recent tree mortality classification
- Environmental factors input

Generate Mortality
- Fit classification on Sentinel-2 high resolution imagery

Lidar Feasibility

Acquire Data
- Goddard's LiDAR, Hyperspectral & Thermal Imager
- Download in LAS format

Process Models
- Canopy Height
- Bare Earth
- Canopy Closure
- Understory Binning

Generate Areas Of Interest
- Combine with environmental parameters
- Calculate weighted fuel loadings

Conclusions

- Cloud-based computing with Google Earth Engine enables rapid mapping of tree mortality over a 30+ year time series of Landsat imagery. This provides Park managers insight to historic forest conditions impacting fuel build up.
- Classification of present-day tree mortality from 10 meter resolution Sentinel-2 imagery is possible using vegetation and environmental data as inputs to a Support Vector Machine. This gives an up-to-date detail of tree health throughout the entire forest.
- LiDAR provides finer spatial resolution and information about vertical structure of a forest that is missing from satellite multispectral imagery. This finer level of detail allows for more accurate understanding of fuel loads.

Project Partners

National Park Service,
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