**NASA DEVELOP National Program**

**2017 Fall Project Proposal**

**California - Ames**

**Lassen Volcanic National Park Disasters II**

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

**Project Overview**

***Project Synopsis*:** In recent years, Lassen Volcanic National Park (LVNP) has experienced increased tree mortality rates due to fire suppression policies, prolonged drought, and climatic change, resulting in heavy fuel loading and raising concerns regarding wildfire occurrence. Partnering with the National Park Service and the Lassen National Forest (LNF) the second term of this project will have three main objectives. First, to investigate how LiDAR and Earth observations can expand the ability of interagency teams to make landscape scale restoration treatments by preforming a case study of the Badger Planning area. The second is to look at pre-fire biophysical conditions of the footprint of the 2012 Reading fire to help the LVNP and the LNF understand potential outcomes of future fire events if similar conditions are present. Lastly, the third objective is to continue the analysis of mortality events using the SAVeTrEE tool created in the first term will help park managers better understand different types of mortality events occurring in the park and on adjacent national forest lands. All of this work will aid the LVNP and the LNF when making decisions about different types of land treatments in relation to potential fire events.

***Community Concern:*** LVNP is host to numerous vegetation communities but is dominated by coniferous forests. These communities have changed dramatically in the past 100 years, driven largely by fire suppression policies and most recently by drought trends exacerbated by climate change that have increased large tree mortality throughout the park. As a result, there is significant fuel loading in the forests, leading to a reticence on the part of park managers to allow fire to burn in the park when naturally ignited. LVNP is currently in the midst of a wilderness stewardship planning process for the nearly 80,000 acres of designated Wilderness. Because of the parks’ Wilderness designation, managers are unable to mechanically thin in these areas to reduce fuel loads. The limitations imposed by not being able to mechanically thin leaves the management of fire as the most important tool to reduce fuel load. Additional community conerns from the LNF along the northern boundary of the LVNP include how to develop restoration treatments to address high fuel loads, improve stand structure in previously planted areas, and develop strategies to reintroduce low to moderate severity fire to the landscape.

***Source of Project Idea:*** This project originated from Steve Buckley, an ecologist at LVNP. Steve was a partner on the Southwest Eco Forecasting project conducted at LaRC during the summer 2016 term. Interested in continuing the collaboration with DEVELOP, Steve reached out to the LaRC Center Lead and began working on ideas for future projects. ARC was brought in due to its proximity to LVNP. The expansion of the project to include LNF lands to the north of the park is designed to support Collaborative Forest Landscape Restoration projects in the Hat Creek watershed. This interagency effort has regional implications for forest health that have significant bearing on the LVNP and adjacent USFS lands.

***National Application Area Addressed:*** Disasters

***Study Location:*** Lassen Volcanic National Park, California (CA)

***Study Period:*** 1984 – 2016 (June – October)

***Advisors:*** Dr. Juan Torres-Perez (Bay Area Environmental Research Institute), Keith Weber (GIS Training and Research Center), Cindy Schmidt (Bay Area Environmental Research Institute), Vince Ambrosia (California State University – Monterey Bay and NASA Applied Science Wildfire Program)

**Partner Overview**

***Partner Organization(s):***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| National Park Service, Lassen Volcanic National Park | Steve Buckley, Ecologist; Elizabeth Hale, GIS Specialist | End User | No |
| USDA, US Forest Service, Lassen National Forest | Amber Wittner, District GIS Coordinator, Hat Creek Ranger District | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***There is a large body of wildland fire research and many tools have been developed to assist land managers with decision making for wildland fire (LANDFIRE, FlamMap, Wildland Fire Decision Support System (WFDSS)). The park and surrounding forest both have a long history of local fire science research. In the LVNP, naturally occurring wildfires are evaluated for their potential to accomplish resource objectives through the Wildland Fire Decision Report process. Preference is given for managing natural ignition to meet the role of fire as an ecological process when under favorable environmental and spatial conditions. Current and expected fire behavior and fire weather is one of the main factors that influence a fire manager’s decision on the appropriate action to take for each new ignition. Fuel loading arrangement, availability, and moisture have a large impact on a fire manager’s decision to suppress or manage a fire for resource benefit.

***End User’s Capacity to Use NASA Earth Observations:***

*National Park Service, Lassen Volcanic National Park* – Academic researchers working in LVNP have used Landsat 5 imagery to develop models to map forest canopy fuels to better understand and model fire behavior. Landsat, MODIS, and PRISM products have all been used for climate and other vegetation related research, including the park vegetation map. LiDAR has been used at Crater Lake National Park to investigate forest structure and fuels mapping. The US Forest Service also has LiDAR available for areas adjacent to the park. The use of NASA Earth observations is limited by technical capacity at the park. The LNF has technical capacity on the Hat Creek Ranger District to assist.

***Collaborator Organization Overview***

***Collaborator Support:***

*USDA, US Forest Service, Lassen Nation Forest* – Lassen National Forest is the main provider of LiDAR data as well as other geospatial dataset that pertain to fires, vegetation type, and vector datasets for the forest and Lassen Volcanic National Park.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** During the term, the team will have bi-weekly teleconferences with project partners. The DEVELOP Ames Center Lead will be the liaison between the project partners and DEVELOP team at Ames Research Center (ARC). ARC management will coordinate an in-person site visit with LVNP and LNF where participants and partners can meet and give a presentation with preliminary results and collect VPS footage.

***Transition Plan*:** A formal end-user handoff will take place at the end of the research term in the form of a WebEx teleconference. Results will be sent via NASA’s Large File Transfer (LFT). This project will not require a software release as it was already started during the first term.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Spectral vegetation indices; historical vegetation analysis | Landsat 8 will be used to identify vegetation and create vegetation layers by preforming Classification Tree Analysis (CTA). These layers will be used to determine fuel loading (tons per acre of biomass) historically in the park. They will also be analyzed in 5 year increments to see if there has been any forest die-off between years. |
| **Landsat 4 TM** | Spectral vegetation indices; historical vegetation analysis | Landsat 4 will be used to identify vegetation and create vegetation layers by preforming Classification Tree Analysis (CTA). These layers will be used to determine fuel loading (tons per acre of biomass) historically in the park. They will also be analyzed in 5 year increments to see if there has been any forest die-off between years. |
| **LiDAR** | Present day understory vegetation density | LiDAR from the LNF will be combined with Sentinel-2’s present day forest density landscape analysis to gain a more robust understand of overall vegetation density in applicable areas. Development of this case study is intended to add additional support for expanding LiDAR coverage for the LVNP and adjacent areas of the LNF. |
| **SRTM – V3** | Digital Elevation Model (DEM) | SRTM will be used to derive 30 m digital elevation model to be incorporated into the CTA. |
| **Sentinel-2 MSI** | Spectral vegetation indices; present day vegetation analysis; tree mortality | Sentinel-2 will be used to identify vegetation and create vegetation layers by preforming CTA analysis. These layers will be used to determine current fuel loading throughout the project area, both inside the LVNP and in the Badger planning area. These data will be used to look at vegetation recovery post Reading fire and compared with UAVSAR data as well as the LiDAR product to gain a robust understanding of vegetation density from the understory to tree tops. |
| **RAPIDEYE** | Reading pre-fire vegetation analysis | This imagery will be used in the case study of the Reading fire. This is Planet imagery that is provided for free in California at 5m pixels and will enhance the understanding of the types of vegetation make-up and see how it relates to the burn severity post fire.  |
| **UAVSAR** | Reading pre-fire vegetation density; species and biomass composition | A case study of Reading fire can look at the pre-fire vegetation make-up and look at how this relates to the burn severity post fire. Burn severity of this fire has been well documented allowing for the potential to extrapolate vegetation regrowth to the greater study area. |

***Ancillary Datasets:***

LVNP – Fuels Data – *in situ* plot data that has been collected in the past 10 years to add to the training data set for vegetation identification

LVNP – Vegetation Database – park vegetation database to help classify vegetation points and compare Classification Tree Analysis (CTA) results

LVNP – Fire Polygons – polygons of any fires that have occurred in the past will be used to remove training points

LVNP – Reading Fire Polygon – used for analysis of UAVSAR burn severity

LNF – Base raster – aspect, slope, hillside, and elevation layers for Lassen National Forest

MTBS – Monitoring Trends in Burn Severity: <http://www.mtbs.gov/> – used for assessing pre-fire vegetation type and how it is related to post fire burn severity

USGS – National Elevation Dataset (NED) – 10 m DEM to be incorporated into CTA

USDA National Agriculture Imagery Program (NAIP) – NAIP Digital CIR 2015 – source for point classification of observable water sources.

RECOVER Geodatabase - Historic Fire polygons – compiled database of all fire polygons in the West including CA

University of Maryland Oakridge DAAC – North American Land Cover Disturbance Product – land disturbance in CA

CAL FIRE – California Statewide Fire Map – use map archive to assess general location of major fires in California history from 2011 to present

Region 5 – 2002 and 2009 Strata Raster: Timber Volume, Value, & Live Tree Biomass – bring into forest health analysis for Landsat historical analysis

National Land Cover Database (NLCD) – Percent Tree Canopy – compare tree canopy results

***Modeling:***

Imager/Object Based Classification (POC: Jenna Williams, NASA DEVELOP)

***Software & Scripting:***

Google Earth Engine API – This platform will be used to analyze the historical time series using Landsat to look at tree mortality throughout the park.

TerrSet – This software will be used to derive spectral indices as well as run classification tree analysis.

Esri ArcGIS – This software package will be used for all vector-based analysis.

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product(s)** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Badger Creek LiDAR Case Study | Partners at LVNP are working with other agencies to develop landscape scale restoration projects in the Badger planning unit that is part of Collaborative Forest Landscape Restoration (CFLR) program of the USFS. This case study will help land managers understand how LiDAR and EO increases the ability of interagency teams to design landscape scale restoration treatments. It will also provide justification as NPS seeks additional funding for future LiDAR flights to fill gaps in regional coverage. | Using LiDAR from the US Forest Service and corresponding plot data in combination with the Sentinel-2 derived tree mortality product, those areas with a large number of returns and high tree mortality will be analyzed to identify areas of potential fire severity and long-term impacts (areas where the forest floor is likely to be consumed). The analyses will assist land managers to better understand regional fuel loadings. | I |
| Reading Recovery Map | Develop a case study to determine how site conditions and pre-fire biophysical parameters might help predict fire spread and severity of future fires that have similar conditions using both airborne and satellite imagery. | Using UAVSAR, the SAVeTrEE tool, Sentinel-2, and RAPIDEYE imagery a pre- and post-fire analysis of vegetation types and recovery of the Reading fire will be analyzed. UAVSAR and Rapid Eye imagery will target pre- and post-fire vegetation biomass structures, and Sentinel-2 and SAVeTrEE will complement this analysis temporally.  | I |
| Mortality Event Type analysis using SAVeTrEE  | This analysis will further leverage the temporal and spatial extent of the Landsat archive by applying geospatial statistical analysis methods to study spatial and temporal autocorrelations of mortality events. The exportable raster layers will help park managers understand what type of mortality event occurred and if long-term mortality events influence other mortality occurrences.  | Incorporating the park Fire History dataset and vegetation type data into SAVeTrEE for quantitative and qualitative analysis of mortality events and analyzing SAVeTrEE outputs on a per pixel basis using principle component and cross-correlation on a pixel basis to help determine types of mortality event e.g. fire vs. beetle kill vs. drought stress. | I – Already in SR process |

***End-User Benefit*:** Results from this project will provide park managers in the LVNP and LNF with tools and updated information derived from remotely sensed imagery. These products will help them better understand park conditions so they can make decisions about land treatments as well as better inform them of potential fire behavior by analyzing pre-fire variables and comparing these with known post-fire outcomes. These analyses will be used as a kind of predictive surface for better understanding how fire interacts with the LVNP and LNF landscape and how Earth observations can be intergraded into current decision-making frameworks.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2017 Summer to 2017 Fall

***Multi-Term Objectives:***

* **Term 1:** 2017 Summer (ARC) – Lassen National Park Disasters I
	+ The first term of this project leveraged Landsat, Sentinel-2, and LiDAR to remotely sense biophysical parameters to analyze park-wide spatial data on various aspects of fuel loading and forest structure. Using Google Earth Engine, an open source cloud-based computing platform, the team built a tree mortality tool that allows this analysis to be reproduced on a 5-year period to help park managers understand potential fire outcomes and prioritize areas for treatment and restoration.
* **Term 2 (Proposed Term):** 2017 Fall (ARC) – Lassen National Park Disasters II
	+ The term will look to enhance the understanding of how LiDAR and Earth observations can expand the ability of interagency teams to make landscape scale decisions about restoration treatments. Analysis of the Reading fire will help park managers understand how site conditions and other biophysical parameters affect fire severity. The continuation of mortality analysis using the SAVeTrEE tool will provide greater understand of the different types of mortality events occurring in the park. This term will involve participation from Amber Wittner at Lassen National Forest. A handoff using large file transfer will occur after a product demonstration in-depth WebEx presentation.

***Previous Terms:***

2017 Summer (ARC) – Lassen National Park Disasters I

***Related DEVELOP Work:***

2015 Summer (JPL) – US Disasters II: Using GRACE-Derived Water and Moisture Products as a Predictive Tool for Fire Response in the Western United States

2015 Spring & Summer (JPL) – California Disasters I & II: A New Method for Providing Near-Real-Time Active-Fire and Post-Burn Support to Fire Responders Using Data Products Derived from NASA’s Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR)

2016 Summer (ID) – Eastern Idaho Disasters: Developing Fire Susceptibility Models Using Remote Sensing to Identify Wildlife Habitats in the Sagebrush-Steppe Ecosystem Threatened by Wildfires

**References:**

FlamMap: <https://www.firelab.org/project/flammap>

WFDSS: <http://wfdss.usgs.gov/wfdss/WFDSS_Home.shtml>

LANDFIRE: <https://www.landfire.gov/>