**NASA DEVELOP National Program**

**2017 Summer Project Proposal**

**NASA Ames Research Center**

**Lassen Volcanic National Park Disasters**

*Utilizing NASA Earth Observations to Enhance Fuel Load Mapping in High Elevation Alpine Forest to Support Wildfire Recovery and Mitigation*

**Project Overview**

***Project Synopsis*:**

Lassen Volcanic National Park (LVNP), located in northeastern California, is currently in the midst of a wilderness stewardship planning process for nearly 80,000 acres designated as Wilderness, meaning it is protected from human manipulation. Past fire suppression policies, climatic change, and recent spikes in tree mortality have resulted in heavy fuel loading and is a primary concern when planning where to reintroduce fire in the Wilderness. Careful reintroduction of fire is essential to reducing fuel load and restoring ecosystem processes, but the park currently lacks integrated models and assessment tools to quantify and evaluate wildfire risk. This project will leverage Landsat, Sentinel-2, LiDAR, and UAVSAR to remotely sense biophysical parameters to analyze park-wide spatial data on various aspects of fuel loading and forest structure. These results will help park managers understand potential outcomes and prioritize areas for treatment and restoration.

***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.

***Source of Project Idea:*** This project originated from Steve Buckley, an ecologist at LVNP. Steve had been a part of the Southwest Eco Forecasting project conducted at LaRC during the summer 2016 term. Wanting to continue collaboration with the program Steve reached out to Emily, the LaRC center lead and began working on ideas for future projects. ARC was brought in due to its proximity to LVNP.

***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 (BAERI), Vince Ambrosia (NASA Applied Science Wildfire Program)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| National Park Service, Lassen Volcanic National Park | Steve Buckley, Ecologist | End-User | 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)) and the park has a long history of local fire science research. All naturally occurring wildfires are evaluated for their potential to accomplish resource objective through the Wildland Fire Decision Report process. Preference will be given for natural ignition to be managed in meeting 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. Specific community concerns include historical and cultural resources scattered throughout the areas of potential impact, as well as high use visitation areas. Rare species factor into our decision making only peripherally and concern is limited to only a few areas of the park. Improved ecosystem function as a consequence of the reintroduction of moderate and low severity fire improves conditions for most of our rare species.

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

*National Park Service, Lassen Volcanic National Park -* Academic researchers working at Lassen Volcanic NP 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 NP 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.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** During the term, the team will have bi-weekly teleconferences with project partners. Brittany Zajic will be the liaison between the project partners and research team at Ames Research Center (ARC). ARC management will coordinate an in-person site visit with LVNP where participants and partners can meet.

***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.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **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. |
| **UAVSAR** | Reading pre-fire vegetation density, health, and species 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 severity to the greater park. |
| **LiDAR** | Present day understory vegetation density | LiDAR 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. This will serve as a case study to add additional impetus to getting LiDAR for LVNP. |
| **Sentinel-2** | Spectral vegetation indices, Present day vegetation analysis | 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 park. This 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. |
| **SRTM** | DEM | SRTM will be used to derive a 30 m digital elevation model to be incorporated into the CTA. |

***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

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 meter 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** |
| **Historic Forest Health and Tree Mortality (model/methods)** | This product will act as a historical catalog of forest health and die-off so park managers can identify areas of high fuel loading. The methods developed for this product will be done in such a way that managers can periodically reproduce this product to understand changes in fuel loading and forest structure. They will be implementing these methods every 3 to 5 years, or as needed under drought conditions. This also provides managers a way to assess resistance and resilience at the landscape/patch level.  | Utilizing the Landsat’s deep catalog to produce a historical time series of the health of the parks vegetation over time. Analyzing areas of tree die off and/or burned areas and the rate of recovery over time by measuring greenness or biomass or repeated RdNBR values.  | II |
| **Present day Tree Mortality** | This will assist in the classification of current tree mortality across the park. It will aid park officials in planning for careful introduction of fire in Wilderness areas and give them a good understand of total biomass (tons per acre). This product will also be combined with LiDAR data. (see LiDAR Case Study End-Product) | Utilizing Sentinel-2 to create present day fuel loading layers by preforming machine learning Classification Tree Analysis. This analysis will be used to determine the levels of fuel loading the park is currently experiencing. | I |
| **LiDAR Case study** | Combing LiDAR of the park with the present day tree mortality product park managers will be able to gain a better understanding of what the vegetation structure is from the understory to the tree tops. This product will serve as a case study to evaluate if it is beneficial to fly LiDAR through the rest of the park. | Using LiDAR from the US Forest Service in combination with the Sentinel-2 tree mortality product areas that have a large number of returns and areas with high tree mortality will be analyzed to gain a better understanding of potential fire severity and long-term impacts (areas where the forest floor is likely to be consumed). | I |
| **Reading Recovery Map** | Develop a case study to determine how site conditions and pre-fire biophysical parameters that might predict fire spread and severity using both airborne and satellite imagery. | Using UAVSAR and Sentinel-2 data a pre-fire and post-fire analysis of vegetation and burn severity of the Reading fire will be analyzed. UAVSAR will target pre and post vegetation biomass structures, and Sentinel-2A will complement this analysis temporally.  | I |

***End-User Benefit*:** This project is focused on pre-fire analysis and planning in LVNP and will benefit park managers by providing new tools and/or updated information derived from remotely sensed imagery along with tools and methods to repeat models and decision tools in successive years. The products produced will help assess aspects of risk associated specifically those related to increasing tree mortality, such that it will be related to wildland fire when planning for prescribed-burns and provide park managers with a better understand characteristics of overall canopy density so they can work to determine potential fire behavior and add to their pre-fire predictions of severity/effects of the fire. Additionally, a major benefit to the end-users will be a package of scripts, tools, or methodology that will allow park staff to continue generating these products annually so they will depict current conditions.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2017 Summer

***Related DEVELOP Work:***

2015 Summer (NASA Jet Propulsion Laboratory) – 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 (NASA Jet Propulsion Laboratory) – 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 (BLM Idaho State University) – Eastern Idaho Disasters: Developing Fire Susceptibility Models Using Remote Sensing to Identify Wildlife Habitats in the Sagebrush-Steppe Ecosystem Threatened by Wildfires

**Notes & References:**

***References:***

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

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

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