**NASA DEVELOP National Program**

**2018 Fall Project Proposal**

**Colorado – Fort Collins**

**Colorado & New Mexico Disasters**

*Investigating Forest Mortality and Burn Severity Using NASA Earth Observations to Provide Forest Management Tools for Ranches and Open Lands*

**Project Overview**

***Project Synopsis*:** This project will use data from Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Sentinel-2 MSI, Sentinel-1 C-SAR, and the SRTM to provide partners in the Environment and Forest Management team at the Tercio and Trinchera Ranches with a change analysis of forest morality and burn severity to better elucidate potential wildfire risk. Partners will apply the end products to more effectively enable targeted resource allocation, improve strategic ecological and safety planning, as well as future forest restoration and management efforts.

***Community Concern:*** Recent wildfire such as the Spring Creek Fire, which was one of the most destructive in Colorado State history, has increased concerns for land managers throughout the region. Tercio and Trinchera Ranches and the Colorado State Forest Service are tasked with managing vast regions and preserving open lands and undisturbed wilderness to protect Colorado’s natural heritage, identity, and wildlife species. The forest composition and structure, especially in southern Colorado, has been altered due to a historically suppressed seasonal forest fires, large scale insect outbreaks, and extreme to exceptional drought conditions. This has left these forests at risk of a catastrophic wildfire. Our partners need more up-to-date geospatial analysis, specifically concerning spruce budworm impacts on forests, to effectively implement decision making and land management efforts.

***Source of Project Idea:*** Aaron Swallow, Environment and Forest Manager at the Tercio and Trinchera Ranches, reached out to the Colorado – Fort Collins node and science advising team for expertise and recommendations about the application of NASA Earth observations to answer land management questions.

***National Application Areas Addressed:*** Disasters

***Study Location:*** CO & NM; WRS-2 Path/Row: 33/34

***Study Period:*** April 2000 – October 2018

***Advisors:*** Dr. Paul Evangelista (Natural Resource Ecology Laboratory), Nicholas Young (Natural Resource Ecology Laboratory), Tony Vorster (Natural Resource Ecology Laboratory), and Brian Woodward (Natural Resource Ecology Laboratory)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Tercio and Trinchera Ranch** | Aaron Swallow, Environment and Forest Manager | End User | No |
| **Colorado State Forest Service** | Amanda West, Manager of Science Information | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***Currently, the ranches and the Colorado State Forest Service are cooperating to improve forest health and land management in southern Colorado. To ascertain these management goals, the two ranches utilize costly field observation to monitor fuel loads and forest composition and structure. In addition, these field surveys are spatially limited due to inaccessible remote terrain. Knowledge of the forest mortality and burn severity across the entire diverse forest ecosystems, and within the large ranches, will supply the managers and cooperating agencies with more informed strategies to assist with improving field monitoring and survey tactics.

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

*Tercio and Trinchera Ranches* – The Environment and Forest Management team of the ranches have limited experience using NASA Earth observations in their research. This project will build capacity for the end user by highlighting the use and application of NASA Earth observations.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Colorado State Forest Service* –This agency will provide expert knowledge of the landscape along with aerial detection surveys and spatial datasets consisting of forest and inventory plot data, which will be utilized to conduct mortality and burn severity mapping.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners at the Tercio and Trinchera Ranches on a biweekly basis. Since the partners of this project are based within Colorado, an in-person meeting will be simple to plan and carry out. The Center Lead and Project Lead of this project will be the primary points of contact with both partner organizations.

***Transition Plan*:** At the end of the term, the team will host a seminar to disseminate project results and hand off decision support tools. A short training workshop on the use of the data and tutorial will follow the seminar.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface reflectance, normalized difference vegetation index, normalized difference moisture index, tasseled cap brightness, greenness, and wetness | This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for modeling forest mortality and burn severity. |
| **Landsat 7 ETM+** | Surface reflectance, normalized difference vegetation index, normalized difference moisture index, tasseled cap brightness, greenness, and wetness | This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for mapping forest composition and structure. Landsat 7 ETM+ imagery will be used as an additional dataset to when cloud free Landsat 5 TM imagery is not available. |
| **Landsat 8 OLI** | Surface reflectance, normalized difference vegetation index, normalized difference moisture index, tasseled cap brightness, greenness, and wetness | This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for modeling forest mortality and burn severity. |
| **Sentinel-2 MSI** | Surface reflectance, normalized difference vegetation index, normalized difference moisture index, tasseled cap brightness, greenness, and wetness | This dataset provides the temporal and spatial (10, 20, and 60 m2) resolution needed for generating a high resolution burn severity map. |
| **Sentinel-1 C-SAR** | Synthetic Aperture Radar  backscatter values, surface roughness | This dataset provides high temporal resolution (6 days) imagery used to refine the forest mortality and burn severity modeling approach in tandem with spectral imagery. |
| **SRTM** | Elevation, slope, aspect, compound topographic index | This dataset will be used to derive topographic indices to use as predictors representing important characteristics of forest mortality and burn severity. |

***Ancillary Datasets:***

Colorado State Forest Service – Aerial Detection Surveys, Forest and Inventory Plot Data – Environmental Predictor Variable Data

North American Land Data Assimilation System (NLDAS-2) Mosaic Precipitation, Soils, Surface Water –

Environmental Predictor Variables Data

USDA NAIP – High resolution imagery used for sampling and image interpretation

USGS National Elevation Dataset (NED) – Digital Elevation Model

USGS Landfire Existing Vegetation Type (EVT) – Land Cover Classification

***Modeling:***

Random Forest Classification Model (RF) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Boosted Regression Trees (BRT) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Multivariate Adaptive Regression Splines (MARS) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Generalized Linear Model (GLM) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Support Vector Machine (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

***Software & Scripting:***

Esri ArcGIS – Image processing and end product generation

ENVI/IDL – Image calibration and LandTrendr coding

R – Statistical analyses and raster processing

Google Earth Engine API – Large scale image analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Forest Mortality Map** | This product will help our partner pinpoint predicted insect outbreaks areas and resulting forest mortality locations. | Random Forest, Multivariate Adaptive Regression Splines, Generalized Linear Model, and Boosted Regression Tree models will be trained with field survey data and indices created from SRTM, Sentinel, and Landsat to create forest mortality maps in southern Colorado. | N/A |
| **Burn Severity Forest Map** | This product will provide our partners with information regarding burn severity at varied resolution for future management efforts. | This product will integrate data from Landsat, Sentinel, SRTM, and partner collected field data to determine the potential wildfire risk in Southern Colorado. | N/A |
| **Modeling Tutorial** | Enable end users to replicate this study in future years and for additional study locations. | The tutorial will cover data processing, fitting statistical models to the data, and interpretation of model output. | N/A |

***End-User Benefit*:** This project will help inform the management of the contiguous forest while enabling a refined monitoring and field survey effort. The project will also enable analysis across larger scales and new study sites that would not be possible without full utilization of Earth observations. End products will be integrated in the Tercio and Trinchera Ranches’ decision making and management processes to more effectively manage insect outbreak affected forests to mitigate wildfire potential.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Fall

***Related DEVELOP Work:***

2017 Fall (CO) – Intermountain West Ecological Forecasting: Utilizing NASA Earth Observations to Forecast Forest Risk to Bark Beetle Attack in Support of a Forest Bioenergy Feasibility Assessment

2018 Spring (AL) – Southeastern US Disasters: Early Detection of Bark Beetle Outbreaks in the Southeastern United States Using Earth Observations

**Notes & References:**

***References:***

Deo, R. K. K., Domke, G. M., Russell, M., Woodall, C. W., & Andersen, H. E. (2018). Evaluating the influence of spatial resolution of Landsat predictors on the accuracy of biomass models for large-area estimation across the eastern USA. *Environmental Research Letters*, *13,* 055004.

Hargrove, W.W., Spruce, J.P., Gasser, G.E., & Hoffman, F.M. (2009). Toward a national early warning system for forest disturbances using remotely sensed phenology. *Photogrammetric Engineering & Remote Sensing, 75*(10*),* 1150-1156.

Humagain, K., Portillo-Quintero, C., Cox, R. D., & Cain, J. W. (2017). Mapping tree density in forests of the southwestern USA using Landsat 8 Data. *Forests, 8*(8), 287.

Quintano, C., Fernández-Manso, A., & Fernández-Manso, O. (2018). Combination of Landsat and Sentinel-2 MSI data for initial assessing of burn severity. *International Journal of Applied Earth Observation and Geoinformation, 64*, 221-225.

Shrum, T., Travis, W., Williams, T., & Lih, E. (2018). Managing climate risks on the ranch with limited drought information. *Climate Risk Management*, *20*, 11-26.

Sidder, A. M., Kumar, S., Laituri, M., and Sibold, J. S. (2016). Using spatiotemporal correlative niche models for evaluating the effects of climate change on mountain pine beetle. *Ecosphere, 7*(7), e01396.

Vorster, A. G., Evangelista, P. H., Stohlgren, T. J., Kumar, S., Rhoades, C. C., Hubbard, R. M., … Elder, K. (2017). Severity of a mountain pine beetle outbreak across a range of stand conditions in Fraser Experimental Forest, Colorado, United States. *Forest Ecology and Management, 389*, 116-126.

Wolter, P. T., Hilgemann, L. A., & White, M. A. (2017). Quantifying downed coarse woody material and residual forest basal area following retention harvesting in northeastern Minnesota using Landsat sensor data. *Canadian Journal of Forest Research, 47*(10), 1325-1338.