**NASA DEVELOP National Program**

**2017 Fall Project Proposal**

**Colorado – Fort Collins**

**Intermountain West Ecological Forecasting**

*Utilizing a Landsat Time Series to Forecast Forest Vulnerability to Bark Beetle Attack in Support of a Forest Bioenergy Feasibility Assessment*

**Project Overview**

***Project Synopsis*:** This project will use Landsat 4 &5 (TM), Landsat 7 (ETM+), Landsat 8 (OLI) and the Shuttle Radar Topography Mission DEM v3.0 to provide partners at the Bioenergy Alliance Network of the Rockies (BANR) with bark beetle outbreak vulnerability maps and short term forecasts of future potential outbreak activity for spruce beetle (*Dendroctonus rufipennis*) and mountain pine beetle (*Dendroctonus ponderosae*). Partners at BANR will apply the end products produced through this project to conduct preemptive forest monitoring and management efforts and to determine the feasibility of extracting beetle killed biomass for use as a biofuel.

***Community Concern:*** In the past decade, forests of the Intermountain West have experienced some of the worst bark beetle attacks of the century. Attacks by Douglas-fir beetle, mountain pine beetle, and spruce beetle have resulted in millions of acres of conifer mortality throughout the region. While recent attacks by mountain pine beetle have largely subsided, the cyclical nature of bark beetle attacks leaves resource managers concerned that the next large scale outbreak could be imminent. Current mapping and monitoring programs do not provide resource managers or land owners with information on forest vulnerability to future attack, making preemptive management and monitoring efforts that could reduce the severity of bark beetle attack difficult to carry out.

***Source of Project Idea:*** Dr. Bill Romme was introduced to the DEVELOP Program by another Bioenergy Alliance Network of the Rockies staff member who had worked with the program successfully in the past. Recognizing that the geospatial capacity necessary to complete a portion of one his current BANR projects was not currently available in his laboratory, Dr. Romme approached DEVELOP FC staff to learn more about the application of NASA Earth observations and to discuss project feasibility.

***National Application Area Addressed:*** Ecological Forecasting

***Study Location:*** CO, MT, ID

***Study Period:*** June 2000 - August 2017; Forecasting to 2020, 2040

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

**Partner Overview**

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

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Bioenergy Alliance Network of the Rockies, Feedstock Supply  | Dr. Bill Romme, Senior Research Scientist | End-User | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The Bioenergy Alliance Network of the Rockies (BANR) Feedstock Supply Team is responsible for quantifying and locating live and dead forest biomass and for developing short-term predictions of bark beetle outbreaks. Knowledge of the feedstock supply will be used to assess the economic, social, and environmental feasibility of using beetle-killed wood as a feedstock for biofuel production.

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

*Bioenergy Alliance Network of the Rockies, Feedstock Supply* – This organization is a diverse network of academic researchers, federal agencies, industry leaders, and policy makers. Our specific point of contact does not have experience using NASA Earth observations in research. This project will build capacity for both our specific point of contact as well as the BANR organization as a whole by showcasing the use and application of NASA Earth observations across disciplines.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners at BANR on a biweekly basis. Since the partners of this project are based locally in Fort Collins, in-person meetings will be simple to plan and carry out. The Center Lead and Team 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** | **Parameter(s)** | **Use** |
| **Landsat 4/5 (TM)** | Surface reflectance, differenced normalized burn ratio, normalized burn ratio, tasseled cap brightness, greenness, wetness | This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for mapping live and dead canopy cover to determine suitable beetle hosts in year 2000.  |
| **Landsat 7 (ETM+)** | Surface reflectance, differenced normalized burn ratio, normalized burn ratio, tasseled cap brightness, greenness, wetness | This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for mapping live and dead canopy cover to determine suitable beetle hosts. Landsat 7 imagery will be used as an ancillary dataset to Landsat 5 when cloud free imagery is not available. |
| **Landsat 8 (OLI)** | Surface reflectance, differenced normalized burn ratio, normalized burn ratio, tasseled cap brightness, greenness, wetness | This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for mapping live and dead canopy cover to determine suitable beetle hosts. |
| **SRTM** | Elevation, slope, aspect, compound topographic index | This dataset will be used to derive topographic indices to be used as predictors that could represent important characteristics of future beetle attack. |

***Ancillary Datasets:***

Bioenergy Alliance Network of the Rockies – Forestry Field Measurements – Delineation of Live and Dead Vegetation

US Forest Service – Aerial Detection Surveys of Insect Outbreaks – Distance to Outbreak

***Modeling:***

LandsatLinkr (POC: Justin Braaten, Oregon State University)

bfast Statistical and Spatial Packages (POC: Darin Schulte, Colorado State University)

LandTrendr (POC: Dr. Robert Kennedy, Oregon State University)

Random Forests (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

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

***Software & Scripting:***

Esri ArcGIS – Image processing, end product generation

ENVI/IDL – Image calibration, LandTrendr coding

Program R – Statistical analyses, raster processing

Google Earth Engine – Large scale image analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product(s)** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Long Term (2040) Mountain Pine Beetle Risk Map | This product will help our partner determine the possible locations of future mountain pine beetle outbreaks throughout the Intermountain West. | This product will integrate data from Landsat, the USFS Aerial Detection Survey, and partner collected field data to determine the likely locations of future bark beetle outbreaks in the Intermountain West region. | N/A |
| Near Term (2020) Spruce Beetle Vulnerability Map  | This product will help our partner pinpoint areas that are most vulnerable to new spruce beetle outbreak events in the next 3 – 5 years. This will help locate potential areas that may have sufficient feedstock to locate a bioenergy facility. | This product will integrate data from Landsat, the USFS Aerial Detection Survey, SRTM DEM v3.0, and partner collected field data to forecast areas most vulnerable to new bark beetle attack by Year 2020. | N/A |

***End-User Benefit*:** This project will save BANR time and money over conducting similar forest health inventories in the field. The project also enables analysis across larger scales and new study sites that would not be possible without full utilization of NASA Earth observations. End products will be integrated in their decision making processes related to long term feasibility of extraction of beetle killed wood for use as a biofuel.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2017 Fall

***Related DEVELOP Work:***

Spring 20154 (CO) – Colorado Agriculture: Reconstructing Forest Harvest History Using Landsat Imagery for Enhanced Land Management

Summer 2015 (CO) – Colorado Agriculture II: Reconstructing Forest Harvest History in Northern Colorado and Southern Wyoming Using the Landsat Time Series