**NASA DEVELOP National Program**

**Colorado – Fort Collins**

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*Project Summary – Fall 2017*

**Intermountain West Ecological Forecasting**

*Utilizing NASA Earth Observations to Forecast Forest Risk to Bark Beetle Attack in Support of a Forest Bioenergy Feasibility Assessment*

**VPS Title:** Under Attack: Mapping Forest Risk to Bark Beetle Outbreak

**Project Team**

***Project Team*:**

Julia Sullivan (Project Lead), jrpsullivan@gmail.com

Jillian LaRoe

Timothy Mayer

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Gary Olds

***Advisors & Mentors*:**

Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Lab)

Anthony Vorster (Colorado State University, Natural Resource Ecology Lab)

Brian Woodward (Colorado State University, Natural Resource Ecology Lab)

**Project Overview**

***Project Synopsis*:** This project will provide partners at the Bioenergy Alliance Network of the Rockies (BANR) with maps showing lodgepole pine (*Pinus contorta*) forests at risk to future mountain pine beetle (*Dendroctonus ponderosae*) outbreaks. Products were created using Landsat 5 TM, Landsat 8 OLI and TIRS, and the Shuttle Radar Topography Mission (SRTM) digital elevation model. Partners at BANR can apply this project’s end products to conduct forest monitoring and to assess feasibility of management efforts to extract beetle-killed biomass for use as biofuel.

***Abstract*:**

The mountain pine beetle (*Dendroctonus ponderosae*) is an endemic species and a natural driver of forest ecosystems. This beetle has impacted millions of acres of coniferous forest in the western United States since the early 2000s. Forest ecosystems provide critical habitat for wildlife, filter air, improve water quality, offer erosion control, and sequester carbon. In addition to their ecological importance, pine forests provide economic services; they are sources of timber production and serve as a backdrop for recreation. Drought, coupled with warming temperatures, has increased the vulnerability of forests, specifically lodgepole pine (*Pinus contorta*), to bark beetle epidemics. Though recent attacks have largely subsided, major outbreaks in the future are likely due to the cyclical nature of bark beetle attacks. The forests at greatest risk to future mountain pine beetle outbreaks are those with higher proportions of live lodgepole pine host trees. This project identified these vulnerable forests by mapping existing live lodgepole pine. The team utilized Google Earth Engine to map forest structure across Colorado, Idaho, Montana, and Wyoming using topographic data from NASA’s Shuttle Radar Topography Mission (SRTM) in conjunction with spectral imagery from Landsat 5 Thematic Mapper (TM), and Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). These resulting lodgepole pine map products will inform forest monitoring efforts and assessment of the feasibility of using beetle-killed wood as a biofuel for end users at the Bioenergy Alliance Network of the Rockies (BANR).

**Keywords:** Google Earth Engine, lodgepole pine, mountain pine beetle, Random Forests classification model, Remote sensing,

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

***Study Location:*** Intermountain West – CO, ID, MT, WY

***Study Period:*** 2000 – 2013 (June – September)

***Community Concern:***

* Since the early 2000s, forests of western North America have experienced the most severe bark beetle outbreaks on record, resulting in millions of acres of conifer mortality throughout the region.
* While recent mountain pine beetle outbreaks have largely subsided, resource managers are left to handle the large numbers of dead trees on the landscape and are looking to prepare for the next large-scale outbreak due to the cyclical nature of bark beetle attacks.
* Current mapping and monitoring programs do not provide resource managers with enough information on forest risk to future attacks, which is valuable information for planning current and future forest management.

***Project Objectives:***

* Identify lodgepole pine stands in Colorado, Idaho, Montana, and Wyoming
* Map live lodgepole pine stands to identify areas at risk to future bark beetle outbreaks

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **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 |

***Decision Making Practices & Policies***:

The Bioenergy Alliance Network of the Rockies, a network of academic researchers, federal agencies, industry leaders, and policymakers, has a Feedstock Supply Team that quantifies and locates live versus dead forest biomass to develop short-term predictions of bark beetle outbreaks. Their methods include costly and time-consuming field plot data collection, fragmented remote sensing data, and an assortment of modeling techniques. This information guides decision-making and assessment of economic, social, and environmental feasibility of using beetle-killed wood as a feedstock for biofuel production. Currently, NASA Earth observations are not used in evaluating risk of future bark beetle outbreaks.

***Project Benefit to End User***:

Using NASA Earth observations will save BANR time and money by providing similar forest health inventories to those currently conducted in the field. This project will also broaden the scope of BANR’s work by enabling a larger scale analysis and opening access to new study sites that would not be possible with field assessments alone. The methodology in this project can be integrated into decision making processes by improving understanding where future outbreaks may occur. Analyses over a greater geographic area will allow BANR to create a more comprehensive analysis of the feasibility of harvesting beetle-killed wood for biofuel.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface reflectance, NDMI, NDVI, tasseled cap greenness, wetness, brightness | This dataset provides the temporal (16 days) and spatial (30 m) resolution needed for mapping live and dead canopy cover to determine suitable beetle hosts in year 2000. |
| **Landsat 8 OLI** | Surface reflectance, NDMI, NDVI, tasseled cap greenness, wetness, brightness | This dataset provides the temporal (16 days) and spatial (30 m) resolution needed for mapping live and dead canopy cover to determine suitable beetle hosts in year 2012-2013. |
| **Landsat 8 TIRS** | Thermal bands | This dataset will be used to map 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 and the US Department of the Interior LANDFIRE – lodgepole pine forest extent

US Department of Agriculture NAIP – high resolution imagery used for sampling and image interpretation

***Modeling:***

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

***Software & Scripting:***

ESRI ArcGIS – Image processing, end product generation

R – Statistical analyses, raster processing

Google Earth Engine – Large scale image analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Mountain Pine Beetle Risk Map** | Landsat 5 TM, Landsat 8 OLI & TIRS, SRTM | This product will help our partner pinpoint areas that are most vulnerable to future mountain pine beetle outbreaks. This will allow them to assess current biofuel feedstock characteristics and potential future feedstock density.  | N/A |

**Project Handoff Package**

**Transition Plan:**

Project materials will be handed off to the BANR organization during the final week of the term. Products to be handed off will include a Mountain pine beetle risk map, written reports of project methods and results, and tutorials of methodology for BANR’s use. This transaction will occur in-person and through online data sharing.

**Team POC:** Julia Sullivan, jrpsullivan@gmail.com

**Partner POC**: Dr. Bill Romme, william.romme@colostate.edu

**Handoff Package:**

* In-person final presentation
* Final project deliverables
* Mountain pine beetle risk map
* Shapefiles and raw data associated with the end products
* Tutorials on the project methodology

**References:**

Chapman, T.B., Veblen, T.T., & Schoennagel, T. (2012). Spatiotemporal patterns of mountain pine beetle activity in the southern Rocky Mountains. *Ecology*, *93*(10), 2175-2185.

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