**NASA DEVELOP National Program**

**2018 Spring Project Proposal**

**Alabama – Mobile**

**Southeastern US Disasters**

*Assessing Bark Beetle Damaged Forest in the Southeastern United States Using MODIS, Landsat, and Sentinel-2 Data*

**Project Overview**

***Project Synopsis*:** The health of the southeastern United States forests is threatened due to infestation by multiple bark beetle species. The project will partner with the USDA US Forest Service’s Eastern Forest Environmental Threat Assessment Center (EFETAC) (Dr. Bill Hargrove, POC). Currently the US Forest Service is using *ForWarn* MODIS NDVI data to monitor evident forest disturbances throughout the region. However, the early phases of the insect outbreaks can be difficult to map with MODIS data due to its spatial resolution. The objectives of this project are to: (1) use Landsat and Sentinel-2 data to detect bark beetle induced forest mortality in pine forests of the southeast US, comparing results to *ForWarn* MODIS NDVI change products, aerial detection survey polygons, and *in situ* field surveys, (2) assess potential value-added by use of Sentinel-2 red edge bands for improving early detection of bark beetle damage, and (3) improve maps of conifer forests for pinpointing forests at greatest risk to damage from *Ips*, Southern Pine Beetle, and other bark beetle species. Due to the recent bark beetle outbreaks in the southeastern US, the study area will focus on coniferous forested areas in Alabama, Georgia, Mississippi, and Tennessee.

***Community Concern:*** *Ips* and Southern Pine bark beetles can be troublesome pests capable of causing extensive forest mortality in the southeastern United States, especially during prolonged drought conditions that cause water stress to coniferous trees. Not only can the bark beetles alter and impact forest ecosystems by killing overstory pine trees, the disturbed forests also are at higher risk for wildfires. The increased threat of wildfire is an additional factor that land managers in the southeast must be aware of when managing public and private lands.

***Source of Project Idea:*** This project arose from discussions with science advisor, Joe Spruce and Bill Hargrove from the USDA Forest Service. Dr. Hargrove supported the development of this proposal in response to information gaps in the *ForWarn* MODIS NDVI products.

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

***Study Location:*** Southeastern US; AL, GA, MS, TN

***Study Period:*** January 2010 – August 2017

***Advisors***: Joe Spruce (Science Systems & Applications, Inc), Dr. Kenton Ross (NASA Langley Research Center)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **USDA, US Forest Service, Eastern Forest Environmental Threat Assessment Center** | Bill Hargrove, Research Ecologist | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***

*ForWarn* MODIS NDVI change products are being used to highlight coniferous forest locations, with NDVI decline indicative of coniferous forest mortality. These change maps show visual correspondence with aerial detection and *in situ* field surveys. Currently, there are no maps of this disturbance event produced at the scale of Landsat and Sentinel-2 data. The latter is needed to help further corroborate and understand the MODIS NDVI change products for the study area. The project will address this information gap, helping *ForWarn* system developers and end users further understand the advantages and limitations of the MODIS NDVI change maps for this type of forest disturbance monitoring. The US Forest Service is interested in conducting or assisting forest management at the federal, state, and local levels in the region.

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

*USDA, US Forest Service,* *Eastern Forest Environmental Threat Assessment Center* –The end user is familiar with NASA Earth observations and has used them in the past, especially with respect to MODIS NDVI data. However, they have not attempted to use a combination of Landsat and Sentinel-2 data to corroborate *ForWarn* MODIS NDVI change maps of *Ips* bark beetle induced forest mortality in the southeast US.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organization:***

*USDA, US Forest Service, Eastern Forest Environmental Threat Assessment Center* – The EFETAC provides land managers with tools and disturbance mapping products generated from NASA MODIS data to help manage both public and private lands. They provide various organizations in the southeast with an increased knowledge of how to better predict and manage environmental threats. The end products created will be distributed within the EFETAC network to their partners, specifically those such as universities, NGOs, and state agricultural, environmental, and forestry extension services. The project will provide additional resources and methodologies using Landsat and Sentinel-2 data to address the partners disturbance monitoring needs. The information in terms of capacity building could be useful for compiling similar reports for future forest disturbance events due to insect outbreaks.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will schedule biweekly meetings with the USDA Forest Service EFETAC partner to update project status. Additionally, the team will meet with project partners as needed to discuss and compare project end products to the EFETAC’s map.

***Transition Plan*:** As the partner is not local, a virtual handoff is anticipated. The team will email end products and deliverables to the partners and conduct a virtual closeout to share findings and results. The project partners will be briefed on the results of the project and given an opportunity to use project end products for follow-on work. The DEVELOP team working on the project will assist the USDA Forest Service in further sharing results as a boundary organization. In addition, project results will be presented in at least one professional meeting.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface reflectance, vegetation indices | Landsat 5 will be used to identify changes in vegetation greenness to identify forest disturbance and mortality. |
| **Landsat 7 ETM+** | Surface reflectance, vegetation indices | Landsat 7 will be used to identify changes in vegetation greenness to identify forest disturbance and mortality. |
| **Landsat 8 OLI** | Surface reflectance, vegetation indices | Landsat 8 will be used to identify changes in vegetation greenness to identify forest disturbance and mortality. |
| **Sentinel-2 MSI** | Surface reflectance, vegetation indices | Sentinel-2 will be used to identify changes in vegetation greenness to identify forest disturbance and mortality. |
| **Terra MODIS** | Vegetation indices | *ForWarn* NDVI data will be compared to final end products to assess feasibility of Landsat and Sentinel-2 data products. |
| **Aqua MODIS** | Vegetation indices | *ForWarn* NDVI data will be compared to final end products to assess feasibility of Landsat and Sentinel-2 data products. |

***Ancillary Datasets:***

US Forest Service *ForWarn –* The project end products will be compared to *ForWarn* MODIS NDVI change maps to help corroborate use of the *ForWarn* end products for detecting regional impacts from the *Ips* and Southern Pine bark beetle outbreak events.

***Software & Scripting:***

Esri ArcGIS Pro 2.0.0 – raster manipulation and map creation

Google Earth Engine API – raster data product generation and analysis

QGIS – raster manipulation and map creation

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Landsat Forest Disturbance Map Products** | The EFETAC will use project products to compare to their own ForWarn forest disturbance monitoring products. The product will be used to assess the feasibility of Landsat for future USDA regional forest disturbance products. | End products will utilize the Landsat suite to identify potential areas of forest disturbance from *Ips* bark beetle attacks. NDVI and additional vegetation indices will be used to identify impacted areas. Landsat spectral data will be used to help map coniferous forests most vulnerable to bark beetle attacks. | N/A |
| **Sentinel-2 Forest Disturbance Map Products** | The EFETAC will use this product to compare to their own forest disturbance products. The product will be used to assess the feasibility of Sentinel-2 for future USDA regional forest disturbance products. | This end product will utilize Sentinel-2 to identify potential areas of forest disturbance due to *Ips* bark beetle attacks. NDVI and additional vegetation indices will be used to identify impacted areas. | N/A |

***End-User Benefit*:** Currently, the USDA Forest Service and the EFETAC uses *ForWarn* MODISNDVI data to monitor disturbances at MODIS-based regional scale (250 m). The additional use of higher resolution data to examine vegetation change and coniferous forest type mapping products could help managers enhance forest health assessments and management practices conducted at a more local, site-specific scale. This project will address the partner’s need by providing higher-resolution data products for forests in the study area being stressed by drought and damaged by *Ips* and Southern Pine bark beetle attacks. The project end results may assist the partner to mitigate bark beetle damage in a more timely manner. In addition, the project methodologies might be applicable for agricultural use including forest plantations grown as crops harvested approximately every 25 years.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Spring

***Related DEVELOP Work:***

2016 Spring (MSFC) – Alabama Ecological Forecasting: Assessing Southern Pine Beetle Epidemics in the Bankhead Forest of Alabama Using NASA Earth Observations

2016 Spring (CO) – Gunnison National Forest Agriculture: Mapping Spruce Beetle Outbreak Severity and Distribution in Gunnison National Forest Using Landsat and Integrative Spatial Modeling

2014 Spring (SSC) – U.S. Disasters: Assessing the Potential to Use VIIRS Data for Detecting Forest Disturbance from Insects and Fire

**Notes & References:**

***References:***

Hargrove, W.W., J.P. Spruce, G.E. Gasser, & F.M. Hoffman. 2009. Toward a National Early Warning System for Forest Disturbances Using Remotely Sensed Phenology*,* *75*(10), 1150-1156.

Spruce, J.P., G.E. Gasser, & W.W. Hargrove. 2016. MODIS NDVI Data, Smoothed and Gap-filled, for the Conterminous US: 2000-2015. ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1299>

Spruce, J. P., Sader, S., Ryan, R. E., Smoot, J., Kuper, P., Ross, K., . . . Hargrove, W. (2011). Assessment of MODIS NDVI time series data products for detecting forest defoliation by gypsy moth outbreaks. *Remote Sensing of Environment, 115*, 427-437.

USDA Forest Service, 2017, ForWarn retrieved from https://forwarn.forestthreats.org/ (last accessed 11/28/2017)