**NASA DEVELOP National Program**

**Alabama – Mobile**

*Project Summary – Spring 2018*

**Southeastern US Disasters**

*Early Detection of Bark Beetle Outbreaks in the Southeastern United States Using Earth Observations*

**VPS Title:** Barking Up the Wrong Tree: Early Detection of Bark Beetle Activity in the Southeastern US

**Project Team**

***Project Team*:**

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***Advisors & Mentors*:**

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Joe Spruce (Science Systems & Applications, Inc.)

Dr. Kenton Ross (NASA Langley Research Center)

**Project Overview**

***Project Synopsis*:** The health of the southeastern United States pine forests is threatened by multiple bark beetle species, including *Ips* and the southern pine beetle (*Dendroctonus frontalis*). Partnering with the United States Department of Agriculture (USDA) US Forest Service’s Eastern Forest Environmental Threat Assessment Center (EFETAC), the NASA DEVELOP team used data from Landsat 8 Operational Land Imager (OLI) and Sentinel-2 MultiSpectral Instrument (MSI) to improve early detection of bark beetle outbreaks. The team focused on outbreaks in the Oconee National Forest, in Georgia, between 2015 and 2017 to determine the feasibility of using these observations to aid more timely deployment of forest management intervention practices.

***Abstract*:**

Since 2015, bark beetle infestations have increased in the southeastern United States, increasing the potential for devastating wildfires. Bark beetles infestations begin in small spots, usually by attacking a weakened or stressed focal tree. Beetles then use aggregation pheromones to increase the breeding population in the area, boring into the trees and disrupting the flow of water and nutrients to reproduce and develop under the bark. This disrupting activity causes detectable canopy color changes, with needles fading and eventually turning red before falling off. The USDA US Forest Service currently uses *ForWarn* Moderate Resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) to identify locations of bark beetle outbreaks; however, the spatial resolution of MODIS can only detect infestation once a sufficiently large swath of trees have dying foliage, lost needles, or have been harvested via sanitation logging. This detection of widespread disturbance can be too late for effective intervention to reduce beetle populations using forest management practices. In response, the NASA DEVELOP team assessed the potential of higher resolution remotely sensed imagery from Landsat 8 Operational Land Imager (OLI) and Sentinel-2 MultiSpectral Instrument (MSI) to detect early stages of bark beetle outbreaks occurring in the Oconee National Forest from January 2015 – July 2017. The project assessed the possibility of enhanced early detection of bark beetle activity via remote sensing, which could improve the US Forest Service’s ability to mitigate beetle damage in forests of the southeastern United States.

**Keywords:** Landsat, Sentinel-2, MODIS, vegetation indices, forest health, forest disturbance, bark beetles, disaster management

***National Application Area Addressed:*** Disasters

***Study Location:*** Oconee National Forest, GA

***Study Period:*** 2015 – 2017

***Community Concern:***

* *Ips* and southern pine beetle can cause extensive forest mortality in the southeastern United States, especially during prolonged drought conditions that cause water stress to coniferous trees.
* Bark beetle-induced mortality of overstory pine trees has economic and ecological impacts to forest resources in the southeast.
* The accumulation of dead trees can increase the risk and intensity of wildfire.
* Due to a multitude of risks posed by unchecked bark beetle infestations, including widespread forest mortality, economic losses, and increased fuel for wildfires, it is important for managers to be able to detect outbreak activity early.
* Higher spatial resolution forest disturbance products enable the US Forest Service to execute forestry management techniques in a more cost efficient way.

***Project Objectives:***

* Assess algorithms using remotely sensed data from Landsat 8 OLI and Sentinel-2 MSI data to detect early stages of bark beetle infestation in the Oconee National Forest, GA
* Compare Landsat 8 OLI and Sentinel-2 MSI data for improving detection of forest damage from bark beetles
* Validate the methodology with aerial, satellite, and *in situ* survey data
* Provide options to EFETAC for improving utility of the *ForWarn* monitoring system for bark beetle outbreaks

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **USDA, US Forest Service, Eastern Forest Environmental Threat Assessment Center** | Dr. William Hargrove, Research Ecologist;  Dr. Steve Norman, Research Ecologist;  Bill Christie, Biological Scientist | End User | Yes |

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

The EFETAC currently uses *ForWarn* MODIS NDVI products to locate areas with changes in NDVI values indicative of forest mortality. These change maps, using visual correspondence with aerial detection and *in situ* data, are used to detect parcels of damaged forests with high beetle activity. Currently, *ForWarn* cannot detect these changes at the spatial scale of Landsat and Sentinel-2 data. As a result, detection is limited to after tree mortality is widespread. The application of data with finer spatial resolution may assist with early detection and more effective bark beetle management solutions.

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

*ForWarn* MODIS NDVI data are used to monitor disturbances at MODIS-based regional scale. This project provides the partner with Landsat 8 OLI and Sentinel-2 MSI high resolution data to examine vegetation change and coniferous forest types. This project will address the partner’s need to identify areas stressed by drought and damaged by *Ips* and southern pine bark beetles at a more local, site-specific scale. The end results will enhance the partner’s ability to conduct forest health assessments and implement timely bark beetle damage mitigation practices. Such mitigation could reduce the risk of wildfire in heavily forested areas near human population centers. In addition, the project methodologies might be applicable for agricultural use, such as forest plantations grown as crops harvested approximately every 25 years.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Surface reflectance, vegetation indices | Landsat 8 OLI data were used to identify changes in vegetation greenness to identify forest disturbance and mortality. |
| **Sentinel-2 MSI** | Surface reflectance, vegetation indices | Sentinel-2 MSI data were used to identify changes in vegetation greenness to identify forest disturbance and mortality. |

***Ancillary Datasets:***

US Forest Service EFETAC *ForWarn* NDVI-based phenology and vegetation change data - compare end products 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 beetle outbreak events

Georgia Forestry Commission 2017 Beetle Spot Locations - validate methodology

US Forest Service Forest Health and Protection 2017 Beetle Spot Locations - validate methodology

US Forest Service Southern Research Station 2016 Oconee National Forest Aerial Oblique Photography - validate methodology

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Forest Disturbance Map Products** | Landsat 8 OLI  Sentinel-2 MSI | The product will be used to assess the feasibility of Landsat for future USDA regional forest disturbance products. | N/A |

**Project Handoff Package**

**Transition Plan:**

During the week of March 26, 2018, the team teleconferenced with the partner to provide technical explanations of the methodology and the results. All deliverables prepared by the team were available to the partner throughout the term in a shared Google Drive folder.

**Team POC:** Haley Ritger, hmwritger@gmail.com

**Partner POC**: Dr. William Hargrove, whargrove@fs.fed.us

**Handoff Package:**

* Poster
* Presentation
* Technical Paper
* Project Video
* Forest Disturbance Map Products

**References:**

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