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

Abstract
Since 2015, bark beetle infestations have increased in the southeastern United States, increasing the potential for devastating wildfires. Bark beetle 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. Project results suggest that Sentinel-2 MSI and Landsat 8 OLI data were useful for assessing co-occurring bark beetle outbreaks and drought impacts to pine forests.

Study Area
- Mixed oak-pine-hickory forest surrounded by pine plantations
- Pine forests vulnerable to bark beetle attacks include:
  - Lobolly pine (Pinus taeda)
  - Shortleaf pine (Pinus echinata)
- Study period: 2016-2017

Earth Observations
- Landsat 8 OLI
  - NASA/USGS Mission
  - 16 day temporal resolution
  - 30 m spatial resolution
- Sentinel-2 MSI
  - European Space Agency Mission
  - 5 day temporal resolution
  - 10 m spatial resolution

Conclusions
- Negative NDVI, NDMI, and IREC changes are correlated with known bark beetle activity and drought impacts.
- Landsat 8 OLI and Sentinel-2 MSI data products offer a higher spatial resolution view of bark beetle activity than ForWarn.
- Sentinel-2 IREC index change maps showed greater potential for identifying early indications of disturbance by bark beetles compared to non-red edge NDVI and NDMI change maps.

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