**New York Ecological Forecasting**

*Utilizing NASA Earth Observations to Map Ash Distribution and Inform Emerald Ash Borer Control*

**Project Team**

***Project Team:***

Liam Megraw (Project Lead)

Jesse Carlson

Samantha Kelly

Stefanie Mendoza

***Advisors & Mentors:***

Dr. Juan Torres-Pérez (NASA Ames Research Center)

Dr. Mark Friedl (Boston University)

Joseph Spruce (Science Systems & Applications, Inc.)

***Team Contact:*** Liam Megraw, lmegraw0405@gmail.com

***Partner Contact:*** Rebecca Bernacki, rebecca.bernacki@TNC.org

**Project Overview**

***Project Synopsis:***

The project focused on improving the ability to forecast future outbreaks of *Agrilus planipennis* (emerald ash borer) in New York’s Adirondack Park. In partnership with the Adirondack Park Invasive Plant Program (APIPP), the team derived ash tree distribution maps from multispectral and hyperspectral NASA Earth observations and modelled future EAB spread from 2022 to 2027 via insect flight scenarios. The final products enable end users to target biological control measures more efficiently with the potential for use with other invasive species within the park.

***Abstract:***

Since their first sightings in the U.S. in 2002, emerald ash borer beetles (Agrilus planipennis; EAB) have killed millions of native ash (Fraxinus spp.) trees across 35 states. Infected ash stands frequently exhibit complete mortality, with the predicted result being the functional extinction of native ash in U.S. forests. In August of 2020, EAB was discovered in the 6.1-million-acre Adirondack Park. The team’s partners at the Adirondack Park Invasive Plant Program (APIPP) desired ash tree distribution and EAB susceptibility information to help improve EAB bio-control efficiency and apply the methodology to future invasive programs. To assist, the team mapped ash tree distribution using NASA Earth observations from Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Shuttle Radar Topography Mission (SRTM), plus hyperspectral imagery from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS). Field data from the Monitoring and Managing Ash (MaMA) project, iMapInvasives and iNaturalist databases, and the New York State Department of Environmental Conservation (NYSDEC) provided ground truthing for mapping and modeling. Results indicate that for ash detection, the team’s Spectral Angle Mapping (SAM) hyperspectral classification is slightly more sensitive but less accurate than multispectral Random Forest (RF) classification, though neither method was above a ~20% detection rate. End products include maps of ash extent derived from both imagery types, a model forecasting future spread scenarios based on current EAB presence, and outreach materials. These products inform APIPP’s management decisions and facilitate public awareness of EAB’s threat to communities within the region.

***Key Terms:***

remote sensing, AVIRIS, Landsat, random forest, spectral angle mapping, spectral unmixing, hyperspectral, multispectral

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

***Study Location:*** Adirondack Park, NY

***Study Period:*** 2000–2022, Forecasting to 2027

***Community Concerns:***

* Ash tree mortality in urban areas necessitates replacement, which presents a costly problem for municipalities. As of 2009, a ten-year projection estimated the cost of replacement to be over $1 billion annually in the U.S.
* Numerous animals that rely on ash trees for food or reproduction are threatened, including amphibians and insects such as butterflies. Decline in these populations can disrupt food webs and limit plant growth.
* White ash makes up 15% of New York State’s timber production, which is jeopardized by the emerald ash borer.

***Project Objectives:***

* Assess ash tree distribution using multispectral and hyperspectral imagery
* Compare effectiveness of multispectral and hyperspectral ash identification methods utilizing field data
* Identify areas susceptible to future emerald ash borer outbreaks by using successive buffer and simplified SHIFT models to compare spread scenarios with ash stand locations

**Partner Overview**

***Partner Organization:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| The Nature Conservancy, Adirondack Chapter, Adirondack Park Invasive Plant Program | Rebecca Bernacki, Terrestrial Invasive Species Project Coordinator | End User |

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

The Adirondack Park Invasive Plant Program (APIPP) was established in 2005 to assist in the management of invasive species throughout the park and is responsible for overseeing both aquatic and terrestrial invasive species management. Most of the program’s data collection comes from field observations. With the park spanning over 6-million-acres, this method presents difficulty for covering the entire study area within a reasonable amount of time. The APIPP is familiar with remote sensing and GIS and would like to expand their usage of these technologies by using NASA Earth observations to identify the best locations for bio-control-based eradication efforts of both the EAB and other invasive species.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 7 ETM+** | Surface reflectance | Multispectral data were used to identify and map pre-infestation and current ash tree distribution. Results were compared to hyperspectral classification and in-situ data. |
| **ER-2 AVIRIS** | Surface reflectance | Historic hyperspectral data were used to identify and map pre-infestation ash tree distribution. Results were compared to Landsat classification and in-situ data. |
| **SRTM** | Elevation | Elevation data were used to create indices to identify and map pre-infestation and current ash tree distribution. |

***Ancillary Datasets:***

* iMapInvasives: Invasive Species Database – Identify EAB for spread model
* Monitoring and Managing Ash (MaMA) Ash/EAB Surveys: Ash & EAB presence/absence – Identify EAB for spread model
* iNaturalist: Biodiversity Database – Identify EAB for spread model
* DEC State Land Forest Stands 2021: Forest Database – Forest type ground truth data for classification training and validation
* Multi-Resolution Land Characteristics (MRLC) National Land Cover Database (NLCD) 2019: Land Cover Collection – Mapg forested areas
* DEC Campgrounds 2021: Public campground points and polygons – Evaluate human-mediated EAB spread potential
* US Census TIGER/Line® Shapefiles: States (and equivalent) 2021 – Define study area within New York State
* New York Natural Heritage Program PRISM Boundaries: Partnership for Regional Invasive Species Management jurisdictions – Display APIPP boundary within maps and reference when selecting AVIRIS flightlines

***Modeling:***

* L3 Harris ENVI (Contact: Mark Friedl, Boston University) – Species distribution modeling and spectral line unmixing

***Software & Scripting:***

* Google Earth Engine – Classifying ash tree distribution with multispectral imagery
* Harris Corporation ENVI v5.6.2 – Classifying ash tree distribution with hyperspectral imagery
* Esri ArcGIS Pro v3.0 and ArcGIS Notebooks – Managing shapefiles, creating layouts, and modeling EAB spread

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Ash Tree Distribution Maps** | Landsat 7 ETM+  ER-2 AVIRIS  SRTM | Maps visualizing the distribution and density of ash tree stands in the study area provided historical context to enable improved monitoring of ash tree stand extent over the study period. | N/A |
| **Emerald Ash Borer Susceptibility Maps** | N/A | Maps forecasting emerald ash borer susceptibility helped project partners with invasive species management practices and supported enhancement of their understanding of potential outcomes. | N/A |
| **Social Media Post Series** | N/A | Posts on social media platforms such as Facebook and Twitter were used to promote the combined research efforts of APIPP and the NASA DEVELOP team. | N/A |

***Product Benefit to End User:***

The DEVELOP New York Ecological Forecasting team’s work demonstrates that hyperspectral imagery can be useful for preliminary ash tree classification. The team’s work also demonstrates that multispectral imagery may not be sufficient for ash classification when using relatively shorter periods of imagery or single sensors. While these methods have some limitations, the team’s ash tree distribution maps and EAB forecasting model will still be practical tools that APIPP can utilize for identifying partial distribution of ash tree extent in 2009 within Adirondack Park. These products can inform EAB management practices such as biological control and trapping. Overall, these products can help APIPP as they strive to continue their efforts in reducing EAB presence within the park.

**References**

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