**NASA DEVELOP National Program**

NASA Goddard Space Flight Center

*Spring 2017*

**Short Title: New York Ecological Forecasting**

**Subtitle:** Utilizing NASA Earth Observations to Map Eastern Hemlock for Hemlock Woolly Adelgid Management in Adirondack Park and Tug Hill State Forest, New York

**VPS Title:** Woolly Bully: Monitoring the Impending Hemlock Woolly Adelgid Infestation

**Project Team & Partners**

**Project Team:**

Madeline Ruid (Project Lead), madeline.r.ruid@nasa.gov

Sara Lubkin

Sean McCartney

Rachel Soobitsky

Ariel Walcutt

**Advisors & Mentors:**

Dr. Amy McNally (University of Maryland, Earth System Science Interdisciplinary Center)

**Partner Organizations:**

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| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| New York State Department of Environmental Conservation, Partnership for Regional Invasive Species Management, Adirondack Park Invasive Plant Program | Brendan Quirion, Program Manager | End-User | No |
| Adirondack Research, LLC | Dr. Ezra Schwartzberg, Director/Entomologist | Collaborator | Yes |
| Cornell University, New York Invasive Species Research Institute | Dr. Mark Whitmore & Carri Marschner, Entomologist, Cornell University Department of Natural Resources | Collaborator | No |
| New York State Department of Environmental Conservation, Partnership for Regional Invasive Species Management, Saint Lawrence - Eastern Lake Ontario (SLELO PRISM) | Rob Williams & Megan Pistolese, Invasive Species Program Coordinator | Collaborator | No |
| New York State, Tug Hill Commission | Katie Malinowski, Executive Director | Collaborator | No |
| US Forest Service, State and Private Forestry, Northeastern Area | Ryan Hanavan, Entomologist | Collaborator | No |

**Project Details**

**Applied Sciences National Application Addressed:** Ecological Forecasting

**Study Area:** Adirondack Park and Tug Hill State Forest, NY

**Study Period:** January 2016 – January 2017; Forecasting to 2035

**Earth Observations & Parameters:**

Landsat 8, Operational Land Imager (OLI) – Spectral vegetation indices

Sentinel-2, MultiSpectral Instrument (MSI) – Spectral vegetation indices

Shuttle Radar Topography Mission (SRTM) Version 3 – Digital Elevation Model

Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) – Hyperspectral optical imagery

**Ancillary Datasets Utilized:**

* iMapinvasives Invasive Species Distribution Data – ground observations of hemlock woolly adelgid
* WWF HydroSHEDS – rivers
* U.S. Census Bureau TIGER – streets
* USDA SSURGO – soil input for classification and regression tree
* USDA Cropland Data Layer (CDL) – land cover
* NASA Earth Exchange NEX-DCP30 Downscaled Climate Model – climate scenarios
* Adirondack Park Invasive Plant Program (APIPP) – Conifer presence/absence data
* PRISM Climate Group – January average minimum temperature from 1981-2010

**Models Utilized:**

* TerrSet Habitat and Biodiversity Modeler (HBM)
* Maximum Entropy (MaxEnt)

**Software Utilized:**

* ESRI ArcGIS – image processing, classification, raster manipulation/analysis, map creation
* R – regression trees, data extraction and statistical analysis
* Google Earth Engine API – acquisition, mapping, classification of Landsat and MODIS data
* TerrSet – species distribution modeling
* Exelis ENVI – classification of Landsat and MODIS data

**Project Overview**

**80-100 Word Objectives Overview:**

Eastern hemlock is a keystone species that prevents soil erosion, provides critical habitat for surrounding wildlife, and affects soil chemistry, microclimate, and ecosystem dynamics. The hemlock woolly adelgid is an invasive insect that has caused significant damage to hemlock in over 20 states. While the pest has not yet been found in the Adirondack region of New York, the range of the HWA is slowly moving northward in response to a warming climate. Maps of existing hemlock stands and of infestation risk in 2035 will allow the Adirondack Park Invasive Plant Program to more accurately finalize prevention plans.

**Abstract:**

The hemlock woolly adelgid (HWA), *Adelges tsugae* Annand, is an invasive species first identified on the East Coast of the United States in Richmond, Virginia in 1951. The pest has spread rapidly and has devastated eastern hemlock, *Tsuga Canadensis* (L.) Carrière populations from Georgia to Maine. Hemlock populations in the Adirondack Mountains and Tug Hill region of New York have been spared because the HWA cannot survive temperatures lower than -30°C to -35°C (-22°F to -31°F). However, warming winter temperatures are placing these stands at risk. Eastern hemlock is a keystone species in eastern forests, as it is slow growing, long-lived, shade tolerant, and provides habitat for a variety of wildlife. Existing eastern hemlock stands in Adirondack Park were mapped using the spectral angle mapper classification and Airborne Visible InfraRed Imaging Spectrometer (AVIRIS) imagery. Ancillary datasets, such as HWA presence data, were used within the Maximum Entropy species distribution model to predict habitat suitability in this region of upstate New York, to forecast the risk of infestation in 2035. The Adirondack Park Invasive Plant Program (APIPP) can use the present-day eastern hemlock stand maps and HWA risk models to better allocate resources for monitoring this invasive species.

**Keywords:**

AVIRIS, *Tsuga canadensis*, *Adelges tsugae,* invasive species, MaxEnt, Landsat, risk map, distribution map

**Community Concerns:**

* Eastern hemlock is a keystone species in many eastern forests. It provides food and habitat for birds, amphibians, fish, insects, mammals, and other plants, as well as having an important role in regulating stream flow.
* The HWAhas decimated populations of eastern hemlock in 20 eastern states. Carolina hemlock, *Tsuga caroliniana*, has been eradicated from the Smoky Mountains and other regions in the southeast of the United States. The HWA has not yet invaded Adirondack Park and the Tug Hill region of New York, but its range is currently spreading northward into Maine, New Hampshire, and Vermont.
* The New York State Threat Ranking Assessment Score of the HWA is high (76.00) based on the probability that the pest will spread into Northern New York by 2035.

**Current Management Practices & Policies**:

APIPP coordinates actions between its founding partners to protect the Adirondack region from widespread damage by invasive species. These initiatives include prevention education, surveillance, early detection, and rapid response efforts. APIPP also conducts data analysis for the region. They currently use GIS tools to maintain a spatiotemporal database for both aquatic and terrestrial invasive species found within the park. These data points are collected through on-the-ground efforts by the program, its partners, and volunteers. They do not currently use remote sensing techniques for mapping inventories or early detection. In addition, APIPP only collects data on invasive species and do not have detailed location data for eastern hemlock stands. HWA management and prevention efforts would greatly benefit from hemlock distribution maps, making this a top priority.

**Decision Support Tools & Benefits:**

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| **End-Product** | **Earth Observations Used** | **Benefit & Impact** | **Software** **Release** |
| Present-day Hemlock Stand Distribution Map  | Landsat 8 OLI, AVIRIS, Sentinel-2 | Highlights locations of hemlock stands and those most at risk to infection by HWA in order to help partners create monitoring and prevention plans. | I |
| Habitat Suitability and Infestation Risk Map for Hemlock Woolly Adelgid (HWA) | Landsat 8 OLI, AVIRIS, SRTM, Sentinel-2 | Enhances decision making by allowing partners to plan targeted response to HWA threat. | I |