**NASA DEVELOP National Program**

**2017 Spring Project Proposal**

**NASA Goddard Space Flight Center**

**New York Ecological Forecasting**

*Utilizing NASA Earth Observations to Map Eastern Hemlock for Hemlock Woolly Adelgid Management in Adirondack Park*

**Project Overview**

***Project Synopsis*:** The hemlock woolly adelgid, *Adelges tsugae*, is an insect native to East Asia; however, it has been invasive in eastern North America since the 1920’s. The adelgid has only recently invaded southern New England and is expanding its range northward, posing a considerable threat to New York state forests. Partnering with Adirondack Research LLC and the Adirondack Park Invasive Plant program, this project proposes to map eastern hemlock distributions in the Adirondack Park for the purpose of identifying and prioritizing forest stands for hemlock woolly adelgid early detection surveys. Data will also be used to forecast a risk map of hemlock stands most susceptible to infestation for the year 2025. Mapping will rely on NASA Earth observations, including the Landsat series, Suomi NPP, Terra, Aqua, and Sentinel-2. Imagery collected will contribute to the production of a detailed hemlock map that will be used to generate forecast scenarios of susceptibility and spread.

***Community Concern:*** The hemlock woolly adelgid (HWA) has not yet invaded Adirondack Park. Detecting new HWA infestations at the leading edge of the insects’ range is critically important for slowing the spread of this invasive species and increasing opportunities for eradication. As HWA is difficult to detect at low population levels, detailed hemlock distribution data is an important asset that will help land managers prioritize areas for ground surveys. Quickly identifying new infestations will increase the likelihood for successful management and help preserve the ecological and cultural values provided by the hemlocks. The Adirondack Park Invasive Plant Program (APIPP) in partnership with the New York State Hemlock Initiative at Cornell University has identified mapping known hemlock resources as a top priority.

***Source of Project Idea:*** Adirondack Research searches for innovative projects that give local land managers access to state-of-the-science tools. Mapping of hemlocks and susceptibility risk maps have been piloted in the research community in other regions (e.g. Massachusetts, Kentucky) and regionally by the US Forest Service. The APIPP has approached Adirondack Research to help find ways to map the current hemlock distribution across Adirondack Park. Dr. Ezra Schwartzberg (Adirondack Research) reached out to Dr. Amy McNally (GSFC) to inquire if NASA could be brought into help with this work. Dr. McNally then reached out to the Sean McCartney, DEVELOP Center Lead at Goddard Space Flight Center, for collaboration.

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

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

***Study Period:*** January2016 to January 2017; Forecasting to 2025

***Advisor:*** Amy McNally (NASA GSFC and UMD ESSIC)

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Adirondack Park Invasive Plant Program (APIPP) | Brendan Qurion, Program Coordinator | End-User | No |
| New York Invasive Species Research Institute at Cornell University | Dr. Mark Whitmore, Entomologist | Collaborator | No |
| Adirondack Research LLC | Dr. Ezra Schwartzberg, Entomologist | Collaborator | Yes |

***End-User Overview***

***End-User’s Current Decision-Making Process:***The Adirondack Park Invasive Plant Program (APIPP) (housed by the Adirondack Chapter of The Nature Conservancy) and New York State (NYS) Hemlock Initiative (housed at Cornell University) are aimed at preemptively organizing early detection, rapid response, and remote sensing options for the region with the sole purpose of mitigating the impending invasion of HWA to areas of the state that are currently un-infected. APIPP has no way of mapping hemlock stands in the Adirondack Park that are necessary for informing their prioritization models. APIPP has access to iMapInvasives, New York's Online Invasive Species Database and Mapping System, but needs a more accurate and descriptive remote sensing analyses.

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

Adirondack Park Invasive Plant Program – The end-user has used GIS, but not remote sensing data, as part of their invasive species management techniques. For example, iMapInvasives is a sophisticated GIS and citizen science platform that collects, distributes, and analyzes invasive species observation, survey, assessment, and treatment data. iMapInvasives also aids in the coordination of early detection and rapid response efforts though email alerts, and can perform analyses in GIS and modeling programs. APIPP’s strategic plans include the desire to investigate applicability and develop research regarding remote sensing for early detection/mapping inventories. However, the organization has not had sufficient capacity to initiate these efforts.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

New York Invasive Species Research Institute at Cornell University– This organization coordinates invasive species research to help prevent and manage the impact of invasive species in New York State. As part of this institute, the NYS Hemlock Initiative’s main role is to coordinate researchers and experts in advising APIPP’s prioritization of early detection and rapid response tactics aimed at mitigating the spread of HWA in New York State. They will provide the team with literature and data from their ongoing research of currently infested forests outside of our study area.

Adirondack Research LLC – This organization is collaborating with APIPP to build the prioritization model for early detection and long-term monitoring of HWA in parts of NY that are not currently infested with this invasive species, including the Adirondack Park. They will provide the team with literature and data from their ongoing research.

***Dissemination by Boundary Organizations*:**Adirondack Research engages with public and private organizations through their work addressing climate change, invasive species control, agriculture, and land use. Methodologies and results from this project will be shared with local stakeholders such as the Lake Placid Conservancy, Wildlife Conservation Society, The Nature Conservancy, and the NY Department of Environmental Conservation.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Dr. Ezra Schwartzberg will serve as POC among DEVELOP, Cornell University, and APIPP. Specifically, Ezra will meet monthly in-person with APIPP and will hold phone calls with Cornell. Ezra is attending the annual Cornell Cooperative Extension In-Service invasive species conference in Ithaca, NY on November 1, 2016 and has ongoing working relationships with both APIPP and Cornell University. The DEVELOP team will hold a telecon once a month with Dr. Schwartzberg for specific technical issues as needed through email.

***Transition Plan*:** Upon successful completion of the project, all decision support tools will be exchanged through email or large file transfer. Virtual presentation of the results will be executed over video or teleconference with the project partners. A software release will not be required. APIPP will use this information to continue to develop its HWA early detection and rapid response prioritization plan.

***Letters of Support*:** Attached.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Terra, ASTER** | Spectral vegetation indices | NDVI for winter-time delineation of evergreen vegetation classification. |
| **Landsat 7 ETM+,**  **Landsat 8 OLI** | Spectral vegetation indices | NDVI for summer time imagery, and input to classification and regression tree models. |
| **Aqua and Terra, MODIS** | Spectral vegetation indices | MODIS can be used to scale-up Landsat analysis, and provide more routine observations. Cross reference with the ForWarn Forest Change monitoring tool. |
| **Suomi NPP, VIIRS** | Spectral vegetation indices | VIIRS can be used to scale-up Landsat analysis, provide more routine observations, and continuity to methods using MODIS. |
| **Sentinel-2, MSI** | Spectral vegetation indices | Complimentary to Landsat 8 for filling in data gaps or cross validation. |
| **SRTM** | DEM Version 3 | Input for classification and regression tree |
| **AVIRIS** | Hyperspectral optical imagery | Input for classification and regression tree |

***Ancillary Datasets:***

iMapinvasive – Invasive Species Distribution Data – ground observations of woolly adelgid

US Forest Service Forest Inventory and Analysis (FIA) – tree species distribution information

USDA – dSSURGO Soils – input for classification and regression tree

WorldClim – annual mean temperature, annual total precipitation

OpenStreetMap – roads and rivers

USDA Cropland Data Layer (CDL) – Land cover

***Modeling:***

TerrSet Land Change Modeler (POC: Dr. James Toledano, Clark Labs)

Maximum Entropy [Maxent] (POC: Steven J. Phillips, AT&T Research)

***Software & Scripting:***

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

ERDAS IMAGINE – land classification of Landsat imagery

TerrSet – species distribution modeling

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product(s)** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Early Detection and Rapid Response Prioritization Maps | APIPP will use early detection and rapid response prioritization maps to monitor wooly adelgid reports, and to alert nearby regions to be ‘on-watch’. These maps will also help respond to reports by targeting the most vulnerable perimeter (as defined by Hemlock species presence, density, connectivity to other stands, susceptibility to human-facilitated spread. | Susceptibility mapping with the suite of sensors (Landsat 8 OLI, Terra and Aqua MODIS, Terra ASTER, Suomi NPP VIIRS, Sentinel-2 MSI) will be used to compute vegetation indices combined with ancillary data via classification and regression trees. | I |
| Risk Map for Hemlock Wooly Adelgid | APIPP will use risk maps for targeted field campaigns for likely presence of HWA going forward. | Susceptibility mapping with the suite of sensors (Landsat 8 OLI, Terra and Aqua MODIS, Terra ASTER, Suomi NPP VIIRS, Sentinel-2 MSI) will be used to compute vegetation indices combined with ancillary data via classification and regression trees. | I |

***End-User Benefit*:** The end-user, Adirondack Park Invasive Plant Program, in coordination with the NYS Invasive Species Institute’s Hemlock Initiative, aims to protect hemlock stands from the invasive HWA. Accurate hemlock distribution data is critical for early detection, to prioritize ground survey efforts and increase the potential for successful, cost effective management of this invasive species. Currently, APIPP does not have funding to support necessary remote sensing data analysis needed to inform their program. Secondly, forecasted risk maps will contribute to targeted field campaigns for HWA in Adirondack Park in the future, saving APIPP time, money, and other resources.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2017 Spring

***Related DEVELOP Work:***

2013 Summer (MSFC) – Great Smoky Mountains Ecological Forecasting: Utilizing NASA Earth Observations to Monitor Loss of Hemlock Forest and Advance Mitigation Practices Against the Invasive Hemlock Woolly Adelgid

2014 Spring (UGA) – Smoky Mountains Ecological Forecasting: Utilizing NASA Earth Observations to Monitor Long Term Hemlock Decline Caused by Invasive Hemlock Woolly Adelgid in Great Smoky Mountains National Park

2014 Summer (WC) – Appalachian Energy: NASA Earth Observation Detection of Burned and Blighted Areas for Creation of an Unhealthy Forest Index to Prioritize Forest Harvest for Biofuel Production

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

**Notes & References:**

***References:***

ForWarn forest change monitoring (2016). *ForWarn Satellite-Based Change Recognition and Tracking* [Website]. Retrieved from <http://forwarn.forestthreats.org/>

Kong, N., Fei, S., Rieske-Kinney, L., & Obrycki, J. (2008). In Proceedings of the 6th Southern Forestry and Natural Resources GIS Conference: *Mapping Hemlock Forests in Harlan County, Kentucky*.

New York iMapInvasives (2016). *iMapinvasives* [Website]. Retrieved from <https://sites.google.com/site/nyimapinvasives/>

New York Invasive Species Information (2016). *Hemlock Wolly Adelgid (Adelges tsugae).* [Website]. Retrieved from <http://www.nyis.info/index.php?action=invasive_detail&id=24>

Schwert, B. & Rogan, J. (2010). *Using classification trees with Landsat imagery, ancillary variables, and FIA data to map tree species in Massachusetts, USA* [Poster]. Retrieved from: <https://www2.clarku.edu/departments/hero/pdfs/FIA_poster_bschwert_2010.pdf>

US Forest Service (2016). *Forest Inventory and Analysis National Program* [Website]. Retrieved from: <http://www.fia.fs.fed.us/tools-data/>