**NASA DEVELOP National Program**

**2019 Spring Project Proposal**

**Colorado – Fort Collins**

**Nevada & Oregon Ecological Forecasting**

*Employing NASA Earth Observations to Create Species-specific Environmental Variables for Invasive Species Risk Distribution Modeling*

**Project Overview**

***Project Synopsis*:** This project willusedata from Landsat 5 TM, Landsat 8 OLI, Sentinel-1 C-SAR, Sentinel-2 MSI, Aqua MODIS, Terra MODIS, and SRTM to provide the National Park Service (NPS) North Rocky Mountain Exotic Plant Management Team (EPMT) with derived species-specific geospatial environmental layers at improved management and ecologically significant spatial resolutions. These derived layers will be tested within a species distribution modeling (SDM) approach to generate predictive ecological forecasting risk maps for environmental scenarios in 2018, 2038, and 2068. Several invasive species of concern will be investigated, including orange hawkweed (*Hieracium aurantiacum*), meadow hawkweed (*Hieracium caespitosum*),scotch broom *(Cytisus scoparius),* and medusahead (*Taeniatherum caput-medusae*). The team will provide the NPS North Rocky Mountain EPMT with useful insights and methodology for expanding these processes from a regional state level to a national scale.

***Community Concern***: All of the regional NPS EPMTs are tasked with providing approximately 290 national park units with professional expertise on invasive species. Specifically, the North Rocky Mountain EPMT provides expert knowledge towards preventing the introduction of new species, reducing existing infestations, and restoring native plant communities and ecosystem functions across a wide diversity of landscapes. The invasive species orange hawkweed, meadow hawkweed,scotch broom*,* and medusahead are prevalent throughout the west and of major concern to NPS management. Researchers at the US Geological Survey (USGS) Fort Collins Science Center (FORT) have partnered with the North Rocky Mountain EPMT to create habitat suitability models of species of concern to guide management. However, these approaches are limited by the availability of species-specific geospatial environmental layers to derive informed model outputs. Creating management level and ecologically significant environmental layers, using data captured by NASA Earth observations along with testing these layers in an SDM forecasting framework, can provide the North Rocky Mountain EPMT with improved and additional information for future management activities.

***Source of Project Idea:*** Terri Hogan from the NPS is collaborating with the USGS FORT on national level invasive species projects aimed at assisting the North Rocky Mountain EPMT. From close work with FORT, Terri has worked directly with Dr. Catherine Jarnevich, who introduced Terri to the NASA DEVELOP National Program. Recognizing that a larger geospatial capacity was necessary to complete a portion of her current project, Terri approached the Colorado – Fort Collins node to learn more about the application of NASA Earth observations and discuss project feasibility.

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

***Study Location:*** NV; OR

***Study Period:*** May2000 – May 2018; Forecasting to 2038 & 2068

***Advisors:*** Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory), Dr. Catherine Jarnevich (USGS, Fort Collins Science Center), Nicholas Young (Colorado State University, Natural Resource Ecology Laboratory), Tony Vorster (Colorado State University, Natural Resource Ecology Laboratory), and Brian Woodward (Colorado State University, Natural Resource Ecology Laboratory)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **National Park Service, Biological Resource Division, Landscape Restoration and Adaptive Branch, North Rocky Mountain Exotic Plant Management Team** | Terri Hogan, NPS Invasive Plant Program Manager | End User | Yes |
| **USGS, Fort Collins Science Center** | Catherine Jarnevich, USGS Research Ecologist | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The NPS regional EPMTs are responsible for providing expertise regarding invasive species prevention and control for an array of plant species for park units across America. Currently, the USGS and North Rocky Mountain EPMTs have gathered occurrence data for focal species, but these organizations do not have NASA Earth observation-derived environmental layers at management-relevant resolution, which can help to strengthen predictive models.

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

*National Park Service, Biological Resource Division, Landscape Restoration and Adaptive Branch, North Rocky Mountain Exotic Plant Management Team* – This regionally supported team, as part of the Biological Resources Division of the NPS, encompasses a broad array of managers and policy makers tasked with providing park units with tactics and methodologies to stem the encroachment and establishment of invasive species while also providing expertise in restoring plant communities and ecosystem functions. Our specific point of contact has limited experience using NASA Earth observations in her work. This project will further build the capacity of the North Rocky Mountain EPMT as a whole by displaying the use and application of NASA Earth observations.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*USGS, Fort Collins Science Center* – The USGS FORT is currently working in collaboration with the North Rocky Mountain EPMT. Specifically, FORT has developed a variety of presence and background species datasets along with environmental variables previously used in species distribution modeling approaches. FORT will be providing both expertise and crucial datasets utilized for ecological forecasting modeling work to the Colorado – Fort Collins project team.

***Dissemination by Boundary Organizations*:**

*National Park Service, Biological Resource Division, Landscape Restoration and Adaptive Branch, North Rocky Mountain Exotic Plant Management Team* – The North Rocky Mountain EPMT will utilize the end products, specifically the tutorial, to employ the methodologies utilized in the project to other regions with a variety of species of concern. The North Rocky Mountain EPMT will communicate the results, findings, and approaches to fellow EPMTs, such as the North Coast/Cascades EPMT and the California EPMT, to grow their capacity to use NASA Earth observations in their future SDM and management efforts.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners and collaborators at the NPS North Rocky Mountain EPMT and USGS FORT on a biweekly basis. Since the partners of this project are based locally in Fort Collins, in-person meetings will be simple to plan and carry out. The Center Lead and Project Lead will be the primary points of contact with the partner organization.

***Transition Plan*:** At the end of the term, the team will host a seminar to disseminate project results and hand off decision support tools. A short training workshop on the use of the data and a tutorial will follow the seminar.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface reflectance, Normalized Difference Vegetation Index, Normalized Difference Moisture Index, tasseled cap brightness, greenness, and wetness | This dataset will provide the temporal (16 days) and spatial (30 m2) resolution needed for environmental predictive variables employed via a species distribution modeling approach to investigate invasive species presence. |
| **Landsat 8 OLI** | Surface reflectance, Normalized Difference Vegetation Index, Normalized Difference Moisture Index, tasseled cap brightness, greenness, and wetness | This dataset will provide the temporal (16 days) and spatial (30 m2) resolution needed for environmental predictive variables employed via a species distribution modeling approach to investigate invasive species presence. |
| **Sentinel-1 C-SAR** | Synthetic aperture radar  backscatter values, surface roughness | This dataset will provide high temporal resolution (6 days) imagery used to refine the species distribution modeling approach investigating invasive species presence. |
| **Sentinel-2 MSI** | Surface reflectance, Normalized Difference Vegetation Index, Normalized Difference Moisture Index | This dataset will provide the spatial (10-60 m2) resolution needed for environmental predictive variables employed via a species distribution modeling approach investigating invasive species presence. |
| **SRTM** | Elevation, slope, aspect, Compound Topographic Index | This dataset will be used to derive topographic indices to use as predictors representing important characteristics of northern invasive species habitat. |
| **Aqua MODIS** | Normalized Difference Vegetation Index, Enhanced Vegetation Index, land cover | Aqua MODIS derived environmental predictive variables will be employed via a species distribution modeling approach to investigate invasive species presence. |
| **Terra MODIS** | Normalized Difference Vegetation Index, Enhanced Vegetation Index, land cover | Terra MODIS derived environmental predictive variables will be employed via a species distribution modeling approach to investigate invasive species presence. |

***Ancillary Datasets:***

Google Climate Engine – Habitat suitability prediction

NPS/USGS aggregated occurrence presence dataset – Generate species distribution models

North American Land Data Assimilation System (NLDAS-2) Mosaic Precipitation, Soils, Surface Water – Environmental predictor variables data

POLARIS 30-meter probabilistic soil series – Environmental predictor variables data

USGS Field datasets – Watershed Boundary Dataset (WBD); National Hydrography Dataset (NHDPlus);

Height Above Nearest Drainage (HAND)

USGS National Elevation Dataset (NED) – Digital elevation model

USGS National Land Cover Database (NLCD) – Environmental predictor variables data

***Modeling:***

Random forest classification model (RF) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Boosted regression trees (BRT) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Multivariate adaptive regression splines (MARS) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science

Center)

Generalized linear model (GLM) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Support vector machine (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

***Software & Scripting:***

Esri ArcGIS – Image processing and end product generation

ENVI/IDL – Image calibration, LandTrendr coding

R – Statistical analyses and raster processing

Google Earth Engine API – Large-scale image analysis

Software for Assisted Habitat Modeling (SAHM) – Suitability mapping

**Decision Support Tool & End Product Overview**

***End Products:***

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| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Species-specific Geospatial Environmental Layers** | These derived environmental layers will be employed in species distribution models as training data sets for predictive risk mapping of focal species. | Landsat 5 TM, Landsat 8 OLI, Sentinel-1 C-SAR, Sentinel-2 MSI, Aqua MODIS, Terra MODIS, and SRTM data will be used to generate environmental layers with a modeling approach. | I |
| **Current and Predictive/ Forecasting Invasive Risk Maps** | Current and predictive maps forecasted to 2018, 2038, and 2068, incorporating environmental scenarios, will be produced using derived species-specific geospatial environmental layers to elucidate the potential distribution of specific invasive species in Nevada and Oregon. | Random forest, MaxEnt,  multivariate adaptive  regression splines, generalized linear, and boosted regression tree models will be trained with field survey data and species-specific geospatial environmental layers  created from SRTM, Sentinel,  Landsat, and MODIS and other existing geospatial layers to create refined potential distribution maps of the focal invasive species. | I |
| **Species-specific Geospatial Environmental Layers Modeling Tutorial** | The tutorial will enable end users to replicate the methodology in diverse ecosystems with a multitude of focal species. | The tutorial will cover data collection and processing, fitting statistical models to the data, and interpretation of model output. | N/A |

***End-User Benefit*:** This project will save the NPS North Rocky Mountain EPMT significant time and money by further refining invasive species predictive mapping with the incorporation of newly derived geospatial layers. The project is designed to enable future analysis across larger scales and with new species. This would not be possible without full utilization of NASA Earth observations. End products will be potentially integrated into North Rocky Mountain EPMT decision-making processes.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Spring

***Related DEVELOP Work:***

2016 Summer (FC) – Laramie Mountains Ecological Forecasting: Modeling Aspen Distribution Utilizing NASA Earth Observations to Identify Critical Habitat for Mule Deer and Elk in the Laramie Range, Wyoming

2017 Summer (FC) – Alaska Climate: Utilizing NASA Earth Observations to Model Potential Suitable Habitat of Invasive Species Threatening Alaskan Wetlands

**Notes & References:**

***References:***

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