**NASA DEVELOP National Program**

**2018 Fall Project Proposal**

**Colorado – Fort Collins**

**Wisconsin Agriculture & Food Security**

*Employing NASA Earth Observations to Model Distributions of Vaccinium Spp. Crop Wild Relatives, in Support of USDA ARS Genetic Resource Conservation Efforts*

**Project Overview**

***Project Synopsis*:** This project will use Landsat 5 TM, Landsat 8 OLI, Sentinel-2 MSI, Sentinel-1 C-SAR, and SRTM to provide partners at the United States Department of Agriculture’s (USDA) Agricultural Research Service (ARS) with distribution maps of common heath family (*Vaccinium L*.) populations. Utilizing a multitude of modeling approaches, this project will identify potential suitable habitat for focal species. The USDA ARS is responsible for conserving species genetic diversity, but this organization lacks insight to the geographic distribution of *Vaccinium L*. populations, specifically *Vaccinium corymbosum L, Vaccinium macrocarpon aiton*, and *Vaccinium oxycoccos L*. Partners at USDA ARS will apply the end products produced through this project to more effectively enable strategic ecological planning, as well as apply more targeted field collections for species conservation.

***Community Concern:*** The USDA ARS National Plant Germplasm System (NPGS) is tasked with collecting, preserving, and making available for research an array of crucial species as a means to conserve genetic diversity and to bolster both national and global food security as well as rural economic productivity. Currently, there is a need for improved spatial resolution along with field validation of crop wild relative species distributions. Identifying and improving these distributions by utilizing species distribution models, while incorporating NASA Earth observation spectral data, can provide resource managers with more targeted and effective species conservation strategies.

***Source of Project Idea:*** USDA Research Associate, Dr. Colin Khoury, previously worked with NASA DEVELOP as a partner in the spring 2018 term. This project’s concept of utilizing species distribution models in addition to spectral detection modeling methods grew from the spring 2018 term, wherein the team investigated Northern wild rice (*Zizania palustris L.)*, a cropwild relatives which grows in contiguous large patch on water a spectral distinct surface water. Dr. Colin Khoury reached out to NASA DEVELOP to further investigate a myriad of economically important crop wild relative species found in more diverse habitats. Recognizing that the additional geospatial methods necessary to complete a portion of one his ongoing USDA projects was not currently available in his laboratory, Dr. Colin Khoury approached NASA DEVELOP at Colorado – Fort Collins to learn more about the applications of NASA Earth observations and to discuss project feasibility.

***National Application Area Addressed:*** Agriculture & Food Security

***Study Location:*** WI

***Study Period:*** June 1984 – August 2018

***Advisors:*** Dr. Paul Evangelista (Natural Resource Ecology Laboratory), Nicholas Young (Natural Resource Ecology Laboratory), Tony Vorster (Natural Resource Ecology Laboratory), and Brian Woodward (Natural Resource Ecology Laboratory)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **USDA, Agricultural Research Service, National Plant Germplasm System** | Dr. Colin Khoury, Research Associate; Dr. Stephanie Greene, Supervisory Plant Physiologist | End User | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The NPGS is responsible for collecting and conserving genetic diversity of useful flora and making that information available for research. Currently, NPGS has occurrence data for focal species in Wisconsin. Further knowledge of historic and current distribution of suitable habit for *Vaccinium L,* specifically *Vaccinium corymbosum L, Vaccinium macrocarpon aiton*, and *Vaccinium oxycoccos L* will supply the agency with more informed conservation information, as well as potentially replicable methodologies for future work.

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

*USDA, Agricultural Research Service, National Plant Germplasm System* – This federal organization encompasses a broad array of academic researchers and policy makers tasked with searching for solutions to agricultural problems that affect the United Sates every day. Our specific point of contact has limited experience using NASA Earth observations in their research. This project will build capacity for the partner, as well as the USDA organization as a whole, by showcasing the use and application of NASA Earth observations.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners at USDA 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 of this project will be the primary points of contact with both partner organizations.

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

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **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 provides the temporal (16 days) and spatial (30 m2) resolution needed for environmental predictive variables employed via a species distribution modeling and/or detection modeling approach investigating crop wild relative’s presence. |
| **Landsat 7 ETM+** | Surface reflectance, normalized difference vegetation index, normalized difference moisture index, tasseled cap brightness, greenness, and wetness | This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for mapping and detecting species distribution of crop wild relatives. Landsat 7 ETM+ imagery will be used as an ancillary dataset to Landsat 5 TM when cloud free imagery is not available. |
| **Landsat 8 OLI** | Surface reflectance, normalized difference vegetation index, normalized difference moisture index, tasseled cap brightness, greenness, and wetness | This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for environmental predictive variables employed via a species distribution modeling and/or detection modeling approach investigating crop wild relatives presence. |
| **Sentinel-2 MSI** | Surface reflectance, normalized difference vegetation index, normalized difference moisture index, tasseled cap brightness, greenness, and wetness | This dataset provides the spatial (10-60 m2) resolution needed for environmental predictive variables employed via a species distribution modeling and/or detection modeling approach investigating crop wild relatives presence. |
| **Sentinel-1 C-SAR** | Synthetic Aperture Radar  Backscatter values, surface roughness | This dataset provides high temporal resolution (6 days) imagery used to refine the model of species distribution and/or detection modeling of crop wild relatives approach in tandem with spectral imagery. |
| **SRTM** | Elevation, slope, aspect,  compound topographic  index | This dataset will be used to derive topographic indices to be used as predictors that could represent important characteristics of crop wild relative presence. |

***Ancillary Datasets:***

Global Biodiversity Information Facility occurrence data for crop wild relatives – Generate species distribution models

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

Environmental Predictor Variables Data

USDA presence field measurements – Generate species distribution models

USDA National Agricultural Imagery Program (NAIP) – high resolution imagery used for sampling and image interpretation

USGS Biodiversity Information Serving Our Nation occurrence data for crop wild relatives – Generate species distribution models

USGS and Environmental Protection Agency (EPA): Wisconsin National Hydrology Dataset – Identify water bodies

USGS Landfire Existing Vegetation Type (EVT) – Land Cover Classification

USGS National Elevation Dataset (NED) – Digital Elevation Model

USGS National Land Cover Database (NLCD) Wisconsin 2011– Guide and mask Google Earth Engine sample collection

Wisconsin Department of Natural Resources: lake bathymetric outlines, contours, vegetation, and digital elevation model – Guide and mask Google Earth Engine sample collection

***Modeling:***

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

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

Maximum Entropy (MaxEnt) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Multivariate Adaptive Regression Splines (MARS) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Random Forest Classification Model (RF) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

Support Vector Machine (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

***Software & Scripting:***

Software for Assisted Habitat Modeling (SAHM) – suitability mapping

Esri ArcGIS – Image processing and end product generation

R – Statistical analyses and raster processing

Google Earth Engine API – Large scale image analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Wisconsin *Vaccinium L*. Distribution Map** | Maps will be used to evaluate the distribution for *Vaccinium L*. in the Great Lakes region and guide future monitoring and conservation efforts. | Random Forest, MaxEnt, Multivariate Adaptive Regression Splines, Generalized Linear Model, and Boosted Regression Tree models will be trained with field survey data and indices created from SRTM, Sentinel, and Landsat to create potential distribution maps of *Vaccinium L*. | N/A |
| **Distribution Modeling and Mapping Tutorial** | The tutorial will enable end users to replicate this study in future years and for additional crop wild relatives. | 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 USDA time and money by further refining monitoring and field survey collection efforts. The project also enables future analysis across larger scales and new species and study sites that would not be possible without full utilization of NASA Earth observations. End products will be integrated in the USDA decision making and conservation processes.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Fall

***Related DEVELOP Work:***

2018 Spring (CO) – Minnesota & Texas Agriculture & Food Security: Employing NASA Earth Observations to Model Current and Historic Distribution of Crop Wild Relatives, in Support of USDA ARS Genetic Resource Conservation Efforts

2014 Spring (CO) – Colorado Agriculture: Reconstructing Forest Harvest History Using Landsat Imagery for Enhanced Land Management

2015 Summer (CO) – Colorado Agriculture II: Reconstructing Forest Harvest History in Northern Colorado and Southern Wyoming Using the Landsat Time Series

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

**Notes & References:**

***References:***

Bruederle, L. P., Hugan, M. S., Dignan, J. M., & Vorsa, N. (1996). Genetic variation in natural populations of the large cranberry, *Vaccinium macrocarpon Ait.(Ericaceae*). *Bulletin of the Torrey Botanical Club*, 41-47.

Christofferson, J. M. (1992). *Enhancement of cranberry management by quantitative remote sensing techniques* (Doctoral dissertation, University of British Columbia).

Nordberg, M. L., & Evertson, J. (2003). Monitoring change in mountainous dry-heath vegetation at a regional scale csing multitemporal Landsat TM data. *AMBIO: A Journal of the Human Environment*, *32*(8), 502-509.

Miller, Richard, Colin Khoury. (November 7, 2017). The Gene Pool Concept Applied to Crop Wild Relatives: An Evolutionary Perspective. Retrieved from: <https://www.ars.usda.gov/research/publications/publication/?seqNo115=348333>

Meilleur, B. A., & Hodgkin, T. (2004). In situ conservation of crop wild relatives: Status and trends. *Biodiversity & Conservation, 13*(4), 663-684

Nelson, A. (2014). Towards an operational SAR-based rice monitoring system in Asia: Examples from 13 demonstration sites across Asia in the RIICE Project. *Remote Sensing*, *6*(11), 10773-10812.

Panda, S. S., Hoogenboom, G., & Paz, J. (2009). Distinguishing blueberry bushes from mixed vegetation land use using high resolution satellite imagery and geospatial techniques. *Computers and Electronics in Agriculture*, *67*(1-2), 51-58.