**NASA DEVELOP National Program**

**2019 Spring Project Proposal**

**Colorado – Fort Collins**

**Minnesota Agriculture & Food Security**

*Implementing NASA Earth Observations for the Validation of Spectral Detection Models for Northern Wild Rice*

**Project Overview**

***Project Synopsis*:** This project will use the Landsat and Sentinel series as well as SRTM to provide partners at the United States Department of Agriculture (USDA) Agricultural Research Service (ARS), University of Minnesota, and Minnesota Department of Natural Resources (MDNR) with improved distribution maps of northern wild rice (*Zizania palustris L.)* populations and a repeatable methodology to expand this process beyond a single state. Utilizing several approaches, this project will validate spectral detection models of the focal species with *in situ* data collected by the Colorado – Fort Collins node, partners, and collaborators. These novel methodologies present a particularly interesting opportunity to refine, validate, and compare collected field data with digital ocularly surveyed data, which is relevant to land and resource managers and other partners. The USDA ARS is responsible for conserving species’ genetic diversity, but currently lacks complete knowledge of the geographic distribution of northern wild rice populations. USDA ARS, University of Minnesota, and MDNR will apply the end products generated through this project to more effectively understand species distributions for eventual *ex situ* species genetic conservation.

***Community Concern:*** The USDA ARS National Laboratory for Genetic Resource Preservation (NLGRP), as part of the 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 limited geographic information about the crop wild relatives’ species distributions. Identifying crop wild relatives’ distributions by utilizing spectral detection models fit with data captured by NASA Earth observations can provide resource managers with additional information to pursue more targeted and effective species conservation strategies.

***Source of Project Idea:*** Dr. Colin Khoury was introduced to the DEVELOP National Program through a joint training opportunity with the Colorado – Fort Collins node, USGS, and USDA. Recognizing that the geospatial capacity necessary to complete a portion of one his current USDA projects was not currently available in his laboratory, Dr. Colin Khoury approached the Colorado – Fort Collins node staff to learn more about the application of NASA Earth observations and discuss project feasibility.

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

***Study Location:*** MN

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

***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?** |
| **USDA, Agricultural Research Service, National Plant Germplasm System** | Dr. Colin Khoury, Research Associate; Dr. Stephanie Greene, Supervisory Plant Physiologist | End User | No |
| **Minnesota Department of Natural Resources** | Paul Radomski, Research Scientist; Nicole Hansel-Welch, Shallow Lakes Program Supervisor; Donna Perleberg, Aquatic Plant Ecologist; Josh Knopik, Aquatic Ecologist; Dr. Annetta Drewes, Clean Water Legacy Specialist | Collaborator | Yes |
| **University of Minnesota** | Dr. Anthony Kern, Professor and Department Head of the Math, Science, and Technology Department; Dr. Jennifer Kimball, Cultivated Wild Rice Breeding Genetics | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The USDA ARS NPGS is responsible for collecting and conserving genetic diversity of useful flora and making that information available for research. Currently, USDA ARS NPGS has occurrence data for focal species in Minnesota but does not employ spectral detection model techniques. The USDA ARS NPGS conducts field surveys for species genetic sampling using historical records, personal field knowledge, and limited spatial modeling techniques. Further knowledge concerning the validated distribution of northern wild rice will enhance agency conservation strategies and potentially provide replicable methodologies for future work with other species.

***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 Americans every day. Our point of contact has limited experience using NASA Earth observations in research, specifically from work conducted with NASA DEVELOP in previous terms. This project will further build the partner’s capacity, and the USDA organization as a whole, by showcasing the use and application of NASA Earth observations.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Minnesota Department of Natural Resources* – This state agency actively conducts aquatic emergent vegetation surveys across the state to inventory and monitor species conservation. The agency will provide geospatial *in situ* field datasets and expert knowledge concerning the life history and ecology of the species in the region.

*University of Minnesota* – The affiliates at these state universities are species experts. They will provide knowledge concerning the life history and ecology of the focal species in the region as well as geospatial *in situ* field datasets.

***Dissemination by Boundary Organizations*:**

*Minnesota Department of Natural Resources* – This state agency is particularly interested in utilizing the results and products of the project to further refine field conservation methods as well employ a potential monitoring process which directly connects with stakeholders and community members in the region.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners and collaborators on a biweekly basis. Since the partners are based locally in Fort Collins, in-person meetings will be simple to plan and carry out. Teleconference meetings will be established with collaborators outside of Colorado. The Center Lead and Project Lead will be the primary points of contact with the partner organizations.

***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.

***Letters of Support:*** Dr. Colin Khoury, Research Associate; USDA Agricultural Research Service.

**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 will provide the temporal (16 days) and spatial (30 m2) resolution needed for environmental predictive variables employed via a spectral detection modeling approach investigating/validating crop wild relative’s 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 spectral detection modeling approach investigating/validating crop wild relative’s 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 detection modeling of crop wild relatives.  |
| **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 spectral detection modeling approach investigating/validating crop wild relatives’ 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 wild rice suitable habitat. |

***Ancillary Datasets:***

Colorado – Fort Collins NASA DEVELOP Focal species presence dataset collected in August 2018 while meeting partners in Minnesota – Field validation dataset

Minnesota Department of Natural Resources Biota Floating Leaf Stage Emergent Vegetation – Field validation dataset

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

 Environmental predictor variables data

University of Minnesota Focal species presence dataset – Field validation dataset

USDA ARS NPGS GRIN Global Focal species presence dataset – Field validation dataset

Global Biodiversity Information Facility Occurrence data for crop wild relatives – Generate species

 distribution models

USGS Biodiversity Information Serving Our Nation Occurrence data for crop wild relatives – Generate

 species distribution models

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

***Modeling:***

Random forest (RF) classification model (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 and LandTrendr coding

R – Statistical analyses and raster processing

Google Earth Engine API – Large-scale image analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Field Validated Northern Wild Rice Distribution Map | Maps produced will elucidate the distribution of northern wild rice in Minnesota to 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 data to create field validated distribution maps of northern wild rice.  | I |
| 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 rapidly allow the USDA to refine 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 into the USDA decision making and conservation processes.

**Project Timeline & Previous Related Work**

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

***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

2018 Spring (LaRC & JPL) – North Dakota & Georgia Agriculture & Food Security: Using NASA Earth Observations and SAR to Enhance Crop Classification Accuracy from Ground Surveys to Larger Scales in the Long Term Agroecosystem Research (LTAR) Network

**Notes & References:**

***Notes*:** The team will work to produce a manuscript for a scientific journal. The article produced will compare modeling techniques employing presence data derived from digital ocular sampling methods versus *in situ* field data. This crucial comparison addresses a paucity in the literature as well as highlights a novel methodology employing radar.

***References:***

Drotts, G. (2008). *Wild rice distribution and abundance in Minnesota* (Appendix B in a Wild Rice Study document submitted to the Minnesota Legislature by the Minnesota Department of Natural Resources). Retrieved from http://files.dnr.state.mn.us/fish\_wildlife/wildlife/shallowlakes/statewide-inventory-wild-rice-waters.pdf

Frescino, T. S., & Moisen, G. G. (2012). Comparing alternative tree canopy cover estimates derived from digital aerial photography and field-based assessments. In W. McWilliams & F. A. Roesch (Eds), *Monitoring Across Borders: 2010 Joint Meeting of the Forest Inventory and Analysis (FIA) Symposium and the Southern Mensurationists* (e-Gen. Tech. Rep. SRS-157, pp. 237-244). Asheville, NC: US Department of Agriculture Forest Service, Southern Research Station. Retrieved from https://www.srs.fs.fed.us/pubs/gtr/gtr\_srs157/gtr\_srs157\_237.pdf

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Price, M. W. (2012). *Spectral identification of wild rice (Zizania palustris L.) using indigenous knowledge and Landsat multispectral data* (Master’s Thesis). Retrieved from the ScholarWorks at University of Montana Graduate Student Theses, Dissertations, & Professional Papers database. https://scholarworks.umt.edu/etd/910

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