**NASA DEVELOP National Program**

**Fort Collins – Colorado**

*Project Summary – Spring 2018*

**Minnesota & Texas Agriculture**

*Employing NASA Earth Observations to Model Current and Historic Distribution of Crop Wild Relatives, in Support of USDA ARS Genetic Resource Conservation Efforts*

**VPS Title:** Kindred Crops: Remote Sensing of Wild Rice across Minnesota & Texas

**Project Team**

***Project Team*:**

Kaitlin Walker (Project Lead), katiewalker3791@gmail.com

Jillian LaRoe

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***Advisors & Mentors*:**

Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory)

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Tony Vorster (Colorado State University, Natural Resource Ecology Laboratory)

Brian Woodward (Colorado State University, Natural Resource Ecology Laboratory)

**Project Overview**

***Abstract:***

Northern wild rice (*Zizania palustris L.)* and Texas wild rice (*Zizania texana*) provide valuable ecosystem services, such as food sources, economic development, and cultural resources to local populations in Minnesota and Texas. Research on crop wild relatives, wild plants closely related to cultivated plants, is imperative to understanding gene flow and genetic diversity of harvested species. The United States Department of Agriculture (USDA) Agricultural Research Service (ARS) is responsible for conserving the genetic diversity of valuable species, such as wild rice. However, this organization lacks insight as to the geographic distribution of *Zizania* populations. NASA Earth observations, including Landsat 4 & 5 TM, Landsat 8 OLI, Sentinel-2 MSI, and the SRTM version 3, were used to create a multitude of models to detect wild rice presence. The team provided partners at the USDA ARS with potential distribution maps for northern wild rice and Texas wild rice populations in 2005 and 2015. Partners at USDA ARS will apply the end products produced through this project to effectively enable strategic ecological planning, and apply more targeted field collections for species conservation.

***Project Synopsis*:**

An understanding of the gene flow and distribution of agricultural crop wild relatives is essential to the United States Department of Agriculture (USDA) Agricultural Research Service’s (ARS) mission to conserve genetic diversity of valuable crops. The team used NASA Earth observations, including Landsat 4 & 5 TM, Landsat 8 OLI, Sentinel-1 SAR, and Sentinel-2 MSI to create historical and current models and potential distribution maps of wild rice presence in Minnesota and Texas. Our results test the feasibility of using remote sensing to detect agricultural crop wild relatives.

**Keywords:**

Landsat 8, Landsat 4/5, Synthetic Aperture Radar, wild rice, USDA, Minnesota, Texas, Random Forest algorithm.

***National Application Area Addressed:*** Agriculture

***Study Location:*** MN, TX

***Study Period:*** 1984 – 2017

***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 to conserve genetic diversity and to bolster both national and global food security as well as rural economic productivity.
* There is currently limited geographic information about crop wild relative species distribution.
* Maps of crop wild relative distribution can provide resource managers with additional information to pursue more targeted and effective species conservation strategies.

***Project Objectives:***

* Create presence maps of current wild rice distributions in Minnesota and Texas using NASA Earth observations
* Map the historical distribution of wild rice
* Scale methods for use in other regions and create a tool to transfer methodology

**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 |

***Decision Making Practices & Policies***:

The USDA ARS NPGS is responsible for collecting and conserving genetic diversity of agricultural flora, and making that information available for research. Currently, the USDA ARS NPGS has field-based occurrence data for focal wild rice species in both Minnesota and Texas, but does not utilize remote-sensing for wild rice detection.

***Project Benefit to End User***:

Further knowledge of historic and current distribution of northern wild rice and Texas wild rice will supply the USDA with potentially replicable methodologies for future work, and will help the agency carry out more efficient conservation and management strategies. Specifically, our products will help refine monitoring and field survey collection efforts. Our methodology can enable future analysis across large scales, with the intent of creating a decision support tool that may also aid in the detection of other important species. End products will be integrated into the USDA’s decision making and conservation processes.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 4 & 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 m) resolution needed for environmental predictive variables employed via a species distribution modeling approach investigating 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 provides the temporal (16 days) and spatial (30 m) resolution needed for environmental predictive variables employed via a species distribution modeling approach investigating crop wild relative presence. |
| **Sentinel-2 MSI** | 13 spectral bands including Near Infrared and Narrow Near Infrared  | This dataset provides the spatial (10-60 m) resolution needed for environmental predictive variables employed via a species distribution modeling approach investigating crop wild relative presence. |
| **Sentinel-1 SAR** | Synthetic Aperture Radar (SAR) band | This dataset provides high temporal resolution (6 days) imagery and will be used to refine the species modeling approach in tandem with spectral imagery. |
| **SRTM** | Elevation, slope, aspect,compound topographicindex | 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:***

USDA presence field measurements – Generate species distribution models.

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, Minnesota 2011 Land Cover, Texas 2011 Land Cover – Guide and mask Google Earth Engine sample collection.

Minnesota Department of Natural Resources: Lake Bathymetric Outlines, Contours, Vegetation, and Digital Elevation Model – Guide and mask Google Earth Engine sample collection.

USGS and Environmental Protection Agency (EPA): Texas National Hydrology Dataset – Identify water bodies within Hays County, TX.

***Modeling:***

Random Forest (POC: Dr. Amanda West, Colorado State University, Natural Resource Ecology Laboratory) – Modeling wild rice distribution in Minnesota and Texas.

Boosted Regression Tree (POC: Dr. Amanda West, Natural Resource Ecology Laboratory) – Modeling wild rice distribution in Minnesota and Texas.

Generalized Linear Model (POC: Dr. Amanda West, Natural Resource Ecology Laboratory) – Modeling wild rice distribution in Minnesota and Texas.

Multivariate Adaptive Regression Splines (POC: Dr. Amanda West, Natural Resource Ecology Laboratory) – Modeling wild rice distribution in Minnesota and Texas.

***Software & Scripting:***

Esri ArcGIS – Image processing, data analysis, map creation, end product generation

R – Index calculation.

VSURF package in R – Model variable selection.

Google Earth Engine API – Large scale image analysis and data acquisition.

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **2017 Great Lakes Region Northern Wild Rice Distribution Map** | Landsat 8 OLI, Sentinel-1 SAR, SRTM  | Maps will be used to evaluate the distribution for northern wild rice in the Great Lakes region and guide future monitoring and conservation efforts.  | N/A |
| **Historic Great Lakes Region Northern Wild Rice Distribution Map**  | Landsat 5 TM, Sentinel-1 SAR, SRTM  | Maps will be used to evaluate the historic distribution for northern wild rice in the Great Lakes region.  | N/A |
| **2017 Texas Wild Rice Distribution Map** | Landsat 8 OLI, Sentinel-1 SAR< SRTM  | Maps will be used to evaluate the current distribution for Texas wild rice, as well as compare to the Minnesota study area to test modeling methodology within a new geographic location. | N/A |
| **Historic Texas Wild Rice Distribution Map**  | Landsat 5 TM, Sentinel-1 SAR, SRTM  | Maps will be used to evaluate the historic distribution for Texas wild rice, as well as compare to the Minnesota study area to test modeling methodology within a new geographic location. | N/A |
| **Distribution Modeling and Mapping Tutorial**  | None  | The tutorial will cover data collection and processing, fitting statistical models to the data, and interpretation of model output. This will enable end users to replicate this study in future years and for additional crop wild relatives. | N/A |

**Project Handoff Package**

**Transition Plan:**

The team will host a close out seminar at the end of the term to disseminate project results and hand off decision support tools to project partners. A short training workshop on the use of the data and tutorial will follow the seminar.

**Team POC:** Kaitlin Walker

**Partner POC**: Colin Khoury, Colin.Khoury@ars.usda.

**Handoff Package:**

* 2017 Great Lakes Region Northern Wild Rice Distribution Map
* Historic Great Lakes Region Northern Wild Rice Distribution Map
* 2017 Texas Wild Rice Distribution Map
* Historic Texas Wild Rice Distribution Map
* Distribution Modeling and Mapping Tutorial
* DEVELOP Technical Paper

**References:**

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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).