**NASA DEVELOP National Program**

**USGS at Colorado State University**

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*Project Summary – Fall 2017*

**Colorado River Basin Water Resources II**

*Utilizing NASA Earth Observations to Evaluate the Distribution of Russian Olive and its Impact on Evapotranspiration in the Upper Colorado River Basin*

**VPS Title:** Olive and Thriving: Mapping Russian Olive Distribution in the Colorado River Basin

**Project Team**

***Project Team*:**

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

Kristin Davis

Dan Carver

Kevin Gallagher

Caroline Martin

***Advisors & Mentors*:**

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

Catherine Jarnevich (USGS, Fort Collins Science Center)

Gabriel Senay (USGS, North Central Climate Science Center)

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

Amanda West (Colorado State University, Natural Resource Ecology Laboratory)

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

***Past or Other Contributors*:**

Megan Vahsen

Emily Campbell

Julia Sullivan

Chanin Tilakamonkul

**Project Overview**

***Project Synopsis*:** Russian olive (*Elaeagnus angustifolia* L.) is an invasive riparian species that has displaced native communities and has altered rivers’ hydrological cycles. In this term, the team 1) mapped the distribution of Russian olive in the San Juan River with multiple classification algorithms in Software Assisted Habitat Modeling (SAHM), 2) compared distribution maps produced utilizing various Landsat satellites to those produced using Sentinel-2, and 3) determined evapotranspiration rates for Russian olive. The Walton Family Foundation will use these products to determine the feasibility of management for Russian olive and to prioritize future ecological restoration efforts.

***Abstract*:**

Riparian plant communities are vital to water quality, erosion control, biodiversity, and functionality of river ecosystems. The invasion of nonnative Russian olive (*Elaeagnus angustifolia* L.) poses a risk to these fragile ecosystems, as it outcompetes native riparian species such as cottonwoods (*Populus* spp.) and willows (*Salix* spp.) in semiarid environments throughout the western United States. Russian olive is well-established in the Colorado River Basin, which supplies water to 40 million people. Studies show that Russian olive alters riparian evapotranspiration rates, streamflow, and sediment regimes. Quantifying the effect of this species on the Colorado River Basin is vital for managing water quality and quantity. In this study, the team 1) mapped the distribution of Russian olive in the San Juan River (a tributary of the Colorado River) using Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), and Sentinel-2 MultiSpectral Instrument (MSI) imagery, 2) compared the accuracy of Landsat 5 and 8 presence maps to those of Sentinel-2, and 3) determined relative evapotranspiration (ET) rates for Russian olive. We identified predictor variables and utilized Software for Assisted Habitat Modeling (SAHM) to generate multiple classification algorithms, including Boosted Regression Trees (BRT), General Linear Model (GLM), Multivariate Adaptive Regression Splines (MARS), and Random Forest (RF). These algorithms were used to produce presence maps and evaluate modeling approaches. The Walton Family Foundation will use our products to assess previous restoration efforts of Russian olive and to prioritize future management plans and restoration efforts.

**Keywords:**

Russian olive, invasive species, remote sensing, SAHM, evapotranspiration

***National Application Area Addressed:*** Water Resources

***Study Location:*** Colorado River Basin, CO, NM

***Study Period:*** 2006 – 2017 (April – November)

***Community Concern:***

* The Colorado River is the primary water supply for over 40 million people in the U.S.
* Russian olive can alter soil water availability, evapotranspiration rates, streamflow, and sediment regimes, thereby changing ecosystem function and native species habitats.
* Although many field datasets on Russian olive presence are available, quantitative estimates of Russian olive distribution in riparian zones along the Colorado River are currently unavailable.
* Current projections of Russian olive extent are hindered by a lack of data and research on their distribution.

***Project Objectives:***

* Create presence-absence distribution maps of Russian olive along the Colorado River using remotely sensed data
* Compare the accuracy of Landsat and Sentinel-2 satellites in mapping Russian olive distribution
* Create a difference map, or change detection map, to quantify differences in Russian olive cover between 2005 and 2017
* Calculate ET of the study area and determine mean ET rates for known Russian olive presence points during the 2017 growth season

***Previous Term:*** 2017 Summer (Colorado - Fort Collins) – Colorado River Basin Water Resources

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Walton Family Foundation** | Peter Skidmore, Program Officer | End User | No |
| **USGS, Fort Collins Science Center** | Dr. Catherine Jarnevich, Research Ecologist | Collaborator | No |
| **USGS, North Central Climate Center** | Dr. Gabriel Senay, Research Physical Scientist | Collaborator | No |

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

The Walton Family Foundation helps promote a healthy environment for future generations by supporting the sustainable management of invasive species in the Colorado River Basin. The foundation currently uses publicly-sourced invasive species’ presence datasets, which are collected by multiple independent organizations with differing objectives and missions. These datasets were used to direct management efforts on the Colorado River in 2007 (Salt Cedar and Russian Olive Control Demolition Act), but the effectiveness of these efforts has not been extensively evaluated. The effects of Russian olive on ET are not well studied, but could inform how invasive species affect ecosystem function and services in the region. To date, the Walton Family Foundation has not investigated the impact of Russian olive on ET in the Colorado River Basin.

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

This project created a robust, replicable methodology that will build the capacity of the Walton Family Foundation to monitor future changes in riparian areas along the Colorado River Basin and evaluate the effectiveness of previous invasive species management efforts. It introduces the end user to the uses of remotely sensed data for ecological monitoring efforts and provides an alternate method of field data validation.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **SRTM** | Elevation, slope, compound topographic index, integrated moisture index | This sensor was used to develop topographic indices related to hydrology for potential riparian area mapping.  |
| **Landsat 5 TM** | Surface reflectance, NDVI, EVI, SAVI, tasseled cap brightness, greenness, wetness | This sensor was used to map riparian vegetation and to distinguish Russian olive from native riparian species in 2006.  |
| **Landsat 7 ETM+** | Surface reflectance, NDVI, EVI, SAVI, tasseled cap brightness, greenness, wetness | This sensor was used to map riparian vegetation and to distinguish Russian olive from native riparian species in 2006 and 2016.  |
| **Landsat 8 OLI** | Surface reflectance, NDVI, EVI, SAVI, tasseled cap brightness, greenness, wetness | This sensor was used to map riparian vegetation and to distinguish Russian olive from native riparian species in 2016.  |
| **Landsat 8 TIRS** | Thermal bands | This sensor was used to calculate evapotranspiration rates, map riparian vegetation, and distinguish Russian olive from native riparian species in 2016.  |
| **Sentinel-2 MSI** | NDVI, red-edge bands | Satellite data was used to conduct a cross-platform analysis with Landsat of riparian areas and invasive species cover in 2016.  |

***Ancillary Datasets:***

USGS – partner *in situ* field surveys of riparian areas and Russian olive presence

Global Biodiversity Information Facility (GBIF) Open Access Biodiversity Data – georeferenced presence data of Russian olive

Colorado State University, Natural Resource Ecology Laboratory (NREL) partner *in situ* data – georeferenced presence data of Russian olive

National Institute of Invasive Species (NISS) Invasive Species Database – georeferenced presence data of Russian olive

Tamarisk Coalition partner *in situ* data – Russian olive cover

International Biological Information System (IBIS) Non-Native Species Datasets – georeferenced presence data of Russian olive

US Fish and Wildlife Service (USFWS) field surveys riparian areas and Russian olive

NRCS Soils Classification – soils

USGS National Land Cover Database (NLCD) – agricultural and riparian land cover

USDA National Agriculture Imagery Program (NAIP) – high resolution imagery

USGS National Hydrography Dataset (NHD) – flowlines and waterbodies

***Modeling:***

Random Forest Classification Model (Dr. Catherine Jarnevich, USGS; Ryan Anderson, CSU)

Boosted Regression Trees (Dr. Catherine Jarnevich, USGS; Ryan Anderson, CSU)

Multivariate Adaptive Regression Splines (MARS) (Dr. Catherine Jarnevich, USGS; Ryan Anderson, CSU)

Generalized Linear Model (GLM) (Dr. Catherine Jarnevich, USGS; Ryan Anderson, CSU)

***Software & Scripting:***

Software for Assisted Habitat Modeling (SAHM) – spatial distribution modeling

R – index calculation and model variable selection

Esri ArcGIS – data processing and analysis, map creation

Google Earth Engine – data validation and training data generation

Python – calculation of evapotranspiration rates

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **2005 - 2006, 2016 -2017 Russian Olive Distribution Map and Land Cover Change Map** | Landsat 5 TM, Landsat 8 OLI, Landsat 7 ETM+, and Sentinel-2 MSI | A detailed Russian olive map can be used by our partners to locate and prioritize areas for riparian habitat restoration and invasive species management activities. A change map will provide information on the success of previous restoration efforts of Russian olive. | N/A |
| **Evapotranspiration Rates by Vegetation Type Map (2006 and 2017 growing season)** | Landsat 5 TM and Landsat 8 TIRS | Maps of evapotranspiration rates of Russian olive will increase understanding of spatial patterns of water use and will be utilized by partners to determine prioritization of restoration efforts.  | N/A |

**Project Handoff Package**

**Transition Plan:**

At the end of this project, the team will handoff maps and data products and a tutorial describing replicable methodology to the end users either in-person or via web-conferencing.

**Team POC:** Katie Walker, katiewalker3791@gmail.com

**Partner POC**: Peter Skidmore, peter@peterskidmore.com

**Handoff Package:**

* 2006-2017 Russian olive cover maps
* 2006-2017 Russian olive cover change maps
* Evapotranspiration rates by vegetation type map (2006 and 2017 growing season)

**References:**

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