

# NASA DEVELOP National Program

## 2017 Spring Project Proposal

### USGS at Colorado State University

#### Arizona Water Resources

*Utilizing NASA Earth Observations to Evaluate Invasive Species Cover and Evapotranspiration in Riparian Areas of the Colorado River Basin*

### Project Overview

**Project Synopsis:** Riparian areas of the Colorado River Basin are threatened by invasive species such as tamarisk (*Tamarix spp.*) and Russian olive (*Elaeagnus angustifolia*), which alter flow regime and evapotranspiration rates. The objective of this project is to map riparian areas and quantify the percentage of this area inhabited by invasive species in a tributary of the Colorado River in Arizona. The project will integrate data collected by Landsat 5, 7, and 8, Sentinel-2, and SRTM. Project partners with the Walton Family Foundation will use map products from this project to evaluate previous management treatments and locate areas where future ecological restoration should be prioritized.

**Community Concern:** The Colorado River is the primary water supply for more than 40 million people in the western US, irrigating 5.5 million acres of crops, and is a major recreational resource. Riparian areas along the Colorado River Basin are important to maintain the overall health of the river, and provide irreplaceable habitat for wildlife including migratory waterfowl. Quantifying riparian areas threatened by invasive species is a high concern for farmers, land managers, and the general public. Invasive species such as tamarisk and Russian olive affect ecosystem structure and function, alter flow regimes and sediment loads, and affect evapotranspiration rates.

**Source of Project Idea:** Recently, the Walton Family Foundation reached out to the lab of Dr. Paul Evangelista to discuss the use of remote sensing to evaluate riparian areas and effectiveness of tamarisk management efforts in the Colorado River Basin. One of the visions of the Walton Family Foundation is to promote a healthy environment for future generations; therefore, promoting effective and sustainable management of invasive species in the Colorado River Basin is a high priority. This project builds on existing research at the USGS-CSU DEVELOP node and will apply tested methodologies to a new riparian system. This will set the stage for a second term DEVELOP project which will develop a novel approach to compare evapotranspiration rates among invasive and native riparian species.

**National Application Area Addressed:** Water Resources

**Study Location:** Colorado River Basin, AZ

**Study Period:** January 2006 to December 2016

**Advisors:** Dr. Paul Evangelista (Colorado State University), Dr. Amanda West (Colorado State University)

### Partner Overview

#### Partner Organizations:

Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?
Walton Family Foundation	Peter Skidmore, Program Officer	End-User	No
US Geological Survey, Fort Collins Science Center	Dr. Catherine Jarnevich, Research Ecologist	Collaborator	No

US Geological Survey, North Central Climate Science Center	Dr. Gabriel Senay, Research Physical Scientist	Collaborator	No
--	--	--------------	----

### **End-User Overview**

**End-User's Current Decision-Making Process:** Currently, the Walton Family Foundation relies on a patchwork of publically available data and associated information regarding the locations of potential riparian areas and invasive species cover throughout the Colorado River Basin. In some tributaries, intensive management efforts began in 2007, including removal and release of the tamarisk leaf beetle (*Diorhabda carinulata*). The effectiveness of these treatments has been quantified on only a limited number of local study sites, but broader, tributary-wide analyses have not yet been conducted.

### **End-User's Capacity to Use NASA Earth Observations:**

*Walton Family Foundation* – This organization is familiar with NASA Earth observations; however, to date they have not used them to quantify riparian areas or invasive species cover. This project will create a robust, replicable methodology that will build their capacity to monitor future changes in riparian areas along the Colorado River Basin and evaluate efficiency and effectiveness of invasive species management efforts.

### **Collaborator & Boundary Organization Overview**

#### **Collaborator Support:**

*USGS Fort Collins Science Center* – Dr. Catherine Jarnevič will provide expert knowledge to the team in invasive species ecology and the use of the Software for Assisted Habitat Modeling.

*USGS North Central Climate Science Center* – Dr. Gabriel Senay will provide expert knowledge to the team in the use of Landsat.

### **Project Communication & Transition Overview**

**In-Term Communication Plan:** The team will communicate with the partners frequently throughout the term. Collaborators Dr. Jarnevič and Dr. Senay both have offices located on the Colorado State University campus. Dr. Evangelista and Dr. West have established a working relationship with the Walton Family Foundation, and can facilitate team and partner communication via e-mail and web conferences.

**Transition Plan:** At the end of this term, the team will hand-off map products and a tutorial describing replicable methodology to the end-users either in-person or via web-conferencing and online data sharing.

### **Earth Observations Overview**

#### **Earth Observations:**

Platform & Sensor	Parameter(s)	Use
<b>Space Shuttle SRTM V2</b>	Elevation, slope, compound topographic index, integrated moisture index	This sensor will be used to develop topographic indices related to hydrology for potential riparian areas mapping.
<b>Landsat 8 OLI</b>	Surface reflectance, NDVI, EVI, SAVI, tasseled cap brightness, greenness,	This sensor will be used to map riparian vegetation and to distinguish tamarisk and Russian olive from native riparian species in 2016.

	and wetness	
<b>Landsat 8 TIRS</b>	Thermal bands	This sensor will be used to map riparian vegetation and to distinguish tamarisk and Russian olive from native riparian species in 2016.
<b>Landsat 7 ETM+</b>	Surface reflectance, NDVI, EVI, SAVI, tasseled cap brightness, greenness, and wetness	This sensor will be used to map riparian vegetation and to distinguish tamarisk and Russian olive from native riparian species in 2006 and 2016.
<b>Landsat 5 TM</b>	Surface reflectance, NDVI, EVI, SAVI, tasseled cap brightness, greenness, and wetness	This sensor will be used to map riparian vegetation and to distinguish tamarisk and Russian olive from native riparian species in 2006.
<b>Sentinel-2</b>	NDVI; red-edge bands	This satellite will be used to conduct a cross-platform analysis with Landsat of riparian areas and invasive species cover in 2016.

#### **Ancillary Datasets:**

USGS – Field Surveys of riparian areas and invasive species  
 GBIF – Field Surveys of invasive species and native riparian species  
 NREL (CSU) – Field Surveys of riparian areas and invasive species  
 USFWS – Field Surveys of riparian areas and invasive species  
 NRCS – Soils Classification – Aid in delineating areas predicted as riparian  
 USGS – National Landcover Database – Use for distinguishing agricultural (i.e. irrigated) lands from riparian areas

#### **Modeling:**

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

#### **Software & Scripting:**

Software for Assisted Habitat Modeling – Random Forests and Boosted Regression Tree Modeling  
 ESRI ArcGIS – Data processing and analysis; Map creation  
 Exelis ENVI – Processing imagery  
 R – Index Calculation

### **Decision Support Tool & End Product Overview**

#### **End Products:**

<b>End Products</b>	<b>Partner Use</b>	<b>Datasets &amp; Analyses</b>	<b>Software Release Category</b>
Potential Riparian Areas Map	Support in quantifying total current potential riparian area along a tributary of the Colorado River and provide a method that can be applied across the entire Colorado River Basin	Random Forests and Boosted Regression Tree models will be trained with field survey data and indices created from SRTM, Landsat 8, 7, and 5, and Sentinel-2 data to create maps of potential riparian areas. Ancillary data,	N/A

		including soils and land cover, will be used to further refine these maps.	
Invasive Species Cover Maps for 2006 and 2016	Will be used to evaluate total cover of invasive tamarisk and Russian olive as a percentage of riparian area in 2006 and 2016	Random Forests and Boosted Regression Tree models will be trained with field survey data and indices created from SRTM, Landsat 8, 7, and 5, and Sentinel-2 data to create maps of tamarisk and Russian olive cover	N/A
Species Cover Modelling Tutorial	Enable end-users to replicate this study in future years.	The tutorial will cover data collection and processing, fitting statistical models to the data, and interpretation of model output.	N/A

**End-User Benefit:** Remote sensing can be used to map invasive species cover and biomass, compare evapotranspiration rates among native and invasive species, and evaluate success of previous management efforts in the Colorado River Basin. Maps of total potential riparian area and the percentage of that area negatively impacted by invasive species will enhance Walton Family Foundation efforts in outreach and planning of environmental programs in the Colorado River Basin, including water resource management efforts. Tutorials produced from this project will provide the organization with robust, replicable methods for evaluating riparian areas, invasive species cover, and invasive species management effectiveness in future years.

### Project Timeline & Previous Related Work

**Project Timeline:** 2 Terms: 2017 Spring (Start) to 2017 Summer (Completion)

#### Multi-Term Objectives:

- **Term 1 (Proposed Term):** 2017 Spring (USGS-CSU) – Arizona Water Resources I
  - The objectives of this term are to develop a methodology for estimating total riparian area affected by invasive tamarisk and Russian olive in a tributary of the Colorado River Basin, and to compare the cover of these invasive species in 2006 to the cover in 2016. A tutorial will be created of these methodologies to share with project partners.
- **Term 2:** 2017 Summer (USGS-CSU) – Arizona Water Resources II
  - The objectives of this term are to apply methodologies developed in the first term to a broader area of the Colorado River Basin and use an independent field-collected dataset to validate these methods. Additionally, this proposed project will estimate and evaluate potential evapotranspiration differences between tamarisk, Russian olive, and native riparian vegetation using Landsat 8 TIRS, SRTM, MODIS, and ancillary climate data.

#### Related DEVELOP Work:

2014 Summer (USGS-CSU) – Ethiopia Water Resources: Application of Landsat 8 Imagery and Statistical Models for Mapping Critical Headwater Wetlands of Ethiopia

2014 Fall (USGS-CSU) – Arizona Ecological Forecasting I: Using Landsat 8 OLI and TIRS to Enhance Invasion Risk Assessment of Tamarisk (*Tamarix* spp.) in Topock Marsh, Havasu National Wildlife Refuge

2015 Spring (USGS-CSU) - Arizona Ecological Forecasting II: Comparing WorldView-2 with Landsat 8 Imagery: Refining and Evaluating Invasive Tamarisk Mapping in Havasu National Wildlife Refuge