**NASA DEVELOP National Program**

**2017 Fall Project Proposal**

**Colorado – Fort Collins**

**Colorado River Basin Water Resources II**

*Evaluating Invasive Species Cover Influence on Water Yield and Availability in the Colorado River Basin using NASA Earth Observations*

**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 objectives of this multi-term project are to 1) map riparian areas and quantify the percentage of this area inhabited by invasive species, and 2) to evaluate the influence these species may have on water yield and availability in tributaries of the Colorado River in Arizona. The project will integrate data collected by Landsat 5, Landsat 7, Landsat 8, Sentinel-2, and SRTM. Project partners at the Walton Family Foundation will use map products from this project to assess the outcome of previous management treatments and to locate areas to prioritize future ecological restoration efforts.

***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 maintaining the overall health of the river and providing irreplaceable habitat for wildlife including migratory waterfowl. Invasive species such as tamarisk and Russian olive affect riparian ecosystem structure and function, alter flow regimes and sediment loads, and affect evapotranspiration rates. Quantifying the riparian areas threatened by invasive species is a major concern for farmers, land managers, and the general public.

***Source of Project Idea:*** 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. This project builds on existing research at the USGS-CSU DEVELOP node and will apply tested methodologies to a new riparian system.

***National Application Areas Addressed:*** Water Resources, Ecological Forecasting

***Study Location:*** AZ

***Study Period:*** January 2006 – July 2017

***Advisors:*** Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory (NREL)), Dr. Amanda West (Colorado State University, NREL)

**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 Science Center | Dr. Gabriel Senay, Research Physical Scientist | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***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. Currently, the Foundation relies on a patchwork of publicly 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, and the effectiveness of these treatments has been quantified on only a limited number of local study sites. Additionally, attempts have not been made to quantify the influence of invasive species on water yield at the tributary scale, which can inform both the foundation and local communities of the threat invasive species pose to ecosystem services in the region.

***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, invasive species cover, or the influence of invasive species cover on water yield. 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 Jarnevich 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 data products.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with the partners biweekly throughout the term. Collaborators Dr. Jarnevich 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 project, the team will hand-off map products and a tutorial describing replicable methodology to the end users either in-person or via web-conferencing. Data products will also be shared.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **SRTM V3** | 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. |
| **Landsat 8 OLI** | 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 2016. |
| **Landsat 8 TIRS** | Thermal bands | This sensor will be used to map riparian vegetation and to distinguish tamarisk and Russian olive from native riparian species in 2016. |
| **Landsat 7 ETM+** | 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. |
| **Landsat 5 TM** | 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. |
| **Sentinel-2** | 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 – used for riparian vegetation delineation

Global Biodiversity Information Facility (GBIF) – Field Surveys of invasive species and native riparian species – used for invasive vegetation delineation

NREL (CSU) – Field Surveys of riparian areas and invasive species – used for riparian vegetation delineation

USFWS – Field Surveys of riparian areas and invasive species – used for riparian vegetation delineation

NRCS – Soils Classification – aid in delineating areas predicted as riparian

USGS – National Landcover Database – used for distinguishing agricultural (i.e. irrigated) lands from riparian areas

***Modeling:***

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

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

Integrated Valuation of Ecosystem Services and Tradeoffs Model (InVEST) (Dr. Darin Schulte, CSU)

***Software & Scripting:***

Software for Assisted Habitat Modeling (SAHM) – spatial modelling

TerrSet – ecosystem services modeling, water yield modeling

Esri ArcGIS – data processing and analysis; map creation

Exelis ENVI – processing imagery

R – index calculation

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| 2017 Land Use Land Cover Map | A detailed LULC map providing information on the extent and cover of invasive species (tamarisk and Russian olive) relative to other land cover types will be used by our partners to locate and prioritize areas for riparian habitat restoration and invasive species management activities throughout the watershed. | Random Forests models will be trained with field survey data and indices created from SRTM, Landsat 8, Landsat 7, Landsat 5 to produce a land use land cover map for input into our water yield models. | N/A |
| Evapotranspiration Rates by Vegetation Type Map (2006 and 2017 growing season) | Maps of ET rates by vegetation type will increase understanding of spatial patterns of water balance and water use, and will be utilized by partners as a reference map for planning and prioritization of areas for water resource and riparian habitat management actions. | Evapotranspiration estimates will be generated using Landsat 8 TIRS & OLI, SRTM, and climate data produced following the methodology employed by Senay *et al.,* 2016. ET rasters will be used as an input into our water yield models. | N/A |
| Water Yield by Vegetation Type Map | Modeled average annual runoff (Water Yield) by vegetation type will provide partners with the distribution of water availability and an understanding of the potential impacts of invasive species on water availability. These data will be used by our partners for planning and prioritization of areas for water resource and invasive species management actions. | Water Yield estimates at three spatial scales (watershed, sub-watershed, and pixel level) will be generated utilizing the TerrSet Ecosystem Services Water Yield Modeler with ET rates, land cover, and ancillary soils and climate data as inputs to the model. | 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, and the potential effects of invasive species on water availability will enhance Walton Family Foundation efforts in outreach and planning of environmental programs in the Colorado River Basin, with a focus on water resource management efforts. Tutorials produced from this project will provide the organization with methods for evaluating riparian areas, invasive species cover, and water availability, increasing the effectiveness of invasive species management in future years.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2017 Summer to 2017 Fall

***Multi-Term Objectives:***

* **Term 1 :** 2017 Summer (CO) – Colorado River Basin Water Resources I
  + The objectives of this term were to apply methodologies developed during the spring 2017 Arizona Water Resources project to a broader area of the Colorado River Basin and use an independent field-collected dataset to validate these methods. Additionally, this project estimated and evaluated potential evapotranspiration differences between tamarisk, Russian olive, and native riparian vegetation using Landsat 8 TIRS, SRTM, and ancillary climate data.
* **Term 2 (Proposed Term):** 2017 Fall (CO) – Colorado River Basin Water Resources II
  + The objectives of this term are to build upon the analyses of the previous term to model Water Yield by vegetation type and evaluate the impacts of invasive species on water use and water availability. In addition, the tamarisk and Russian olive mapping methods developed in the second term will be applied to a broader area of the Colorado River Basin. This term will culminate with an in-person handoff of all data, end-products, and a comprehensive tutorial detailing methods to enable partners to replicate these methods for future years.

***Previous Terms:***

2017 Spring (CO) – Arizona Water Resources

2017 Summer (CO) – Colordao River Basin Water Resources I

***Related DEVELOP Work:***

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

2014 Fall (CO) – 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 (CO) – Arizona Ecological Forecasting II: Comparing WorldView-2 with Landsat 8 Imagery: Refining and Evaluating Invasive Tamarisk Mapping in Havasu National Wildlife Refuge

**References:**

Senay, G. B., Friedrichs, M., Singh, R. K., & Velpuri, N. M. (2016). Evaluating Landsat 8 evapotranspiration for water use mapping in the Colorado River Basin. *Remote Sensing of Environment, 185*, 171-185.