**NASA DEVELOP National Program**

**2018 Summer Project Proposal**

**Colorado – Fort Collins**

**Grand Canyon Water Resources**

*Employing Landsat to Model Availability of Ephemeral Water Sources and Vegetation Change in Support of a USGS Feasibility Assessment and Management Strategy of Bison*

**Project Overview**

***Project Synopsis*:** This project will use GRACE, Landsat 4 & 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Sentinel-2 MSI, and the Shuttle Radar Topography Mission to provide partners at the United States Geological Survey (USGS) with maps of available water resources and vegetation change analysis of habitat for populations of free-roaming bison (*Bison bison*) in Arizona. Partners at USGS will apply the end products generated through this project to more effectively enable targeted resource allocation and strategic ecological planning, as well as species management efforts.

***Community Concern:*** The USGS in accordance with the National Park Service (NPS) prepared an Initial Bison Herd Reduction Environmental Assessment (EA). Through this evaluation, the USGS and NPS will review management actions and impacts of reducing the Kaibab Plateau bison herd. The herd is currently comprised of 400 to 600 individuals, and will be potentially reduced to fewer than 200 over the next three to five years by lethal culling, non-lethal capture, and transfer to cooperating agencies and tribes. The USGS and NPS are concerned that the current distribution, abundance, density, and expected growth of the Kaibab Plateau herd will increase, and in turn, impact park resources such as water, vegetation, soils, and archaeological sites. The USGS and NPS are tasked with managing and maintaining appropriate population levels for these herds. Currently, there is limited information regarding available water resources for grazing bison. In addition, USGS and NPS seek to understand the vegetation changes that have occurred on the landscape from the time before bison were introduced to the area to the present. Subsequently, enacting informed and effective management decisions towards the completion of the initial Bison Herd Reduction EA has been challenging from this paucity of information regarding water resources and vegetation change analysis.

***Source of Project Idea:*** Dr. Kate Schoenecker worked with NASA DEVELOP on a previous project and was introduced to the DEVELOP program by another USGS staff member. Recognizing that the geospatial capacity necessary to complete a portion of one of her current USGS projects was not currently available in her laboratory, Dr. Kate Schoenecker approached DEVELOP’s CO team to learn more about the application of NASA Earth observations and to discuss project feasibility.

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

***Study Location:*** AZ

***Study Period:*** June 2000 – June 2018

***Advisors:*** Dr. Paul Evangelista (Natural Resource Ecology Laboratory), Nicholas Young (Natural Resource Ecology Laboratory), Tony Vorster (Natural Resource Ecology Laboratory), and Brian Woodward (Natural Resource Ecology Laboratory)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **USGS,****Fort Collins Science Center****Ecosystem Dynamics Branch** | Dr. Kate Schoenecker, Ecologist | End User | No |
| **National Park Service, Grand Canyon National Park** | Greg Holm, Wildlife Program Manager  | Collaborator | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***The USGS, in accordance with the NPS, are responsible for monitoring and managing the effects and potential degradation caused by free-roaming bison on public lands. Currently, the USGS and NPS are cooperating on studies investigating the management of bison in Arizona. To achieve the goals of the study, the USGS utilizes both radio telemetry and field observation data to monitor the movement and habitat use of focal species to accurately assess bison counts in the Kaibab Plateau region. Knowledge of the water resources and vegetation change will supply the USGS with a more informed prediction of potential ungulate movement, habitat use, and habitat selection. This information about water resources and vegetation change will aid the USGS in improving field monitoring tactics as well as creating more effective management strategies for bison.

***End User’s Capacity to Use NASA Earth Observations:***

*USGS, Fort Collins Science Center, Ecosystem Dynamics Branch* – This federal organization encompasses a diverse network of academic researchers, federal agencies, industry leaders, and policy makers and is designed to disseminate research-based information. Our specific point of contact has limited experience using NASA Earth observations in their research. This project will build capacity for both our specific point of contact as well as the USGS organization as a whole by showcasing the use and application of NASA Earth observations across disciplines.

***Collaborator & Boundary Organization Overview***

**Collaborator Support:**

*National Park Service, Grand Canyon National Park* – The NPS will provide bison movement datasets within the Kaibab Plateau region in support of the project.

**Boundary Organization Dissemination:**

*National Park Service, Grand Canyon National Park* *–* This boundary organization is involved in the development of this project through close ties with the USGS. The NPS, along with the USGS, will provide focal species and first-hand ecological field knowledge that will be utilized by the DEVELOP team. The NPS seeks to expand their stakeholder’s knowledge of current and potential future impacts of bison The NPS will share the results of this project widely through their program network, which looks to provide data and resources to land and resource management organizations throughout Arizona through their website, workshops, and presentations.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners at USGS on a biweekly basis. Since the partners of this project are based locally in Fort Collins, in-person meetings will be simple to plan and carry out. The Center Lead and Project Lead of this project will be the primary points of contact with both 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 tutorial will follow the seminar.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **GRACE** | Groundwater and soil moisture drought indicators  | This dataset provides baseline groundwater and soil moisture data needed for deriving maps of water availability and vegetation change for ungulates. |
| **Landsat 4 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 m2) resolution needed for mapping water availability and vegetation change for ungulates.  |
| **Landsat 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 m2) resolution needed for mapping water availability and vegetation change for ungulates. |
| **Landsat 7 ETM+** | 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 m2) resolution needed for mapping water availability and vegetation change for ungulates. Landsat 7 imagery will be used as an ancillary dataset to Landsat 5 when cloud free imagery is not available. |
| **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 m2) resolution needed for mapping water availability and vegetation change for ungulates. |
| **Sentinel-2 MSI** | Surface reflectance, normalized difference vegetation index, normalized difference moisture index, tasseled cap brightness, greenness, and wetness | This dataset provides the temporal and spatial 10, 20, and 60 m2) resolution needed for mapping water availability and vegetation change for ungulates.  |
| **SRTM** | Elevation, slope, aspect, and compound topographic index | This dataset will be used to derive topographic indices to be used as predictors in modeling various approaches. |

***Ancillary Datasets:***

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

Environmental Predictor Variables Data

USGS National Elevation Dataset (NED) – Digital Elevation Model

USGS and NPS Ungulate Field Measurements – Species habitat usage

***Modeling:***

Random Forest (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, end product generation

ENVI/IDL – Image calibration, LandTrendr coding

R – Statistical analyses, raster processing

Google Earth Engine API – Large scale image analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Water Availability Map**  | This product will help our partner pinpoint predicted areas of available water sources in remote semiarid conditions. | This product will integrate data from Landsat, Sentinel, SRTM, Grace, and partner collected field data to determine the water availability in the Kaibab Plateau region. | N/A |
| **Vegetation Change Analysis Map**  | This product will provide our partners with information regarding the effect of bison graving and movement, specifically analyzing changes in vegetation.  | This product will integrate data from Landsat, Sentinel, SRTM, Grace, and partner collected field data to determine the vegetation change in the Kaibab Plateau region. | N/A |
| **Modeling Tutorial** | Enable end users to replicate this study in future years and for additional study locations. | The tutorial will cover data processing, fitting statistical models to the data, and interpretation of model output. | N/A |

***End-User Benefit*:** This project will save USGS and NPS time and money by further refining monitoring and field survey efforts. The project will also enable analysis across larger scales and new study sites that would not be possible without full utilization of NASA Earth observations. End products will be integrated in the USGS and NPS decision making and management processes to more effectively manage bison populations in semiarid ecosystems.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Summer

***Related DEVELOP Work:***

2018 Spring (CO) – Colorado Water Resources: Utilizing Landsat to Model Availability of Ephemeral Water Sources in Support of a USGS Feasibility Assessment and Management Strategy of Equids.

2014 Spring (CO) – Colorado Water Resources: Utilizing Landsat 8 and MODIS for Mapping Extent, River Stage, and Impacts of the 2013 Colorado Floods

2014 Spring (MSFC) – Southeast U.S. Water Resources: Development of an Alternative Drought Monitoring System using NASA Earth Observation-Derived Drought Indices and Groundwater Storage Estimates for Improved Water Resource Monitoring in the Southeastern United State