**NASA DEVELOP National Program**

**2018 Spring Project Proposal**

**Virginia – Wise**

**Mojave Desert Water Resources**

*Assessing Vegetation and Precipitation Indices to Aid Bighorn Sheep Habitat Monitoring and Management*

**Project Overview**

***Project Synopsis*:** This project will utilize MODIS, CHIRPS, SMAP, SRTM, Landsat, Sentinel 2, and PRISM data products to characterize and assess spatio-temporal vegetation and precipitation patterns related to bighorn sheep (*Ovis canadensis*) habitat selection in the Mojave Desert region from 2005-2017. The project will connect remotely-sensed vegetation response and precipitation data to *in situ* measurements of nutrient content, population demographics, and resource availability to support models and other efforts that track habitat selection and utilization. Project partners including the National Park Service, California Department of Fish and Wildlife, Oregon State University, and Sierra Nevada Bighorn Sheep Foundation will use this research to make management and monitoring decisions regarding water availability, especially during drought conditions. In addition, the time series and trend analyses from the project will assist in other research at regional universities on nutrient availability and disease survival rates among bighorn sheep populations.

***Community Concern:*** Bighorn sheep (BHS) populations in California and Nevada are affected by a combination of habitat resource availability and quality in conjunction with mortality due to predation and disease. The complex, interacting effects of these factors can make monitoring, assessment, and managing BHS populations difficult, though decades of research have focused on understanding these impacts, and how they might be affected by environmental changes with respect to water availability and vegetative conditions. Given that BHS play a key ecological role in the mountainous regions of the Mojave Desert, in-depth studies and multi-organizational collaborations are essential for managing such wildlife. To aid effective widespread planning and management decisions to be made, a more synoptic, holistic view of resource availability across the region is needed in regard to BHS habitat selection. The use of NASA Earth observation data is of interest to the BHS management community as a means to provide critical synoptic, spatio-temporal information on water and vegetation.

***Source of Project Idea:*** This project idea originated during conversations with the National Park Service Mojave Inventory & Monitoring Network, which then expanded to include a larger regional, multi-organizational BHS research group.

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

***Study Location:*** Bighorn sheep ranges in the Mojave Desert region, CA, NV

***Study Period:*** January 2005 – August 2017

***Advisors:*** Joseph Spruce (Consultant to Science Systems & Applications, Inc.); Dr. L. DeWayne Cecil (NOAA National Center for Environmental Information, Global Science & Technology, Inc.), Bob VanGundy (The University of Virginia’s College at Wise) Dr. Kenton Ross (NASA Langley Research Center),

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **National Park Service, Mojave National Preserve** | Debra Hughson, Chief of Science and Resource Stewardship | End User | No |
| **National Park Service, Biological Resources Division, Wildlife Health Branch** | Nathan Galloway, Disease Ecologist; Jenny Powers, Wildlife Veterinarian | End User | No |
| **California Department of Fish and Wildlife, Wildlife Branch, Game Management** | Regina Abella, Desert Bighorn Sheep Program Coordinator;  Dave German, Research Analyst;  Paige Prentice, Desert Bighorn Sheep Biologist;  Jeff Villepique, Wildlife Biologist | End User | No |
| **Oregon State University, Department of Fisheries and Wildlife** | Daniella Dekelaita, PhD student; Clinton Epps, Associate Professor | Collaborator | No |
| **Sierra Nevada Bighorn Sheep Foundation** | John Wehausen, Bighorn Sheep Biologist | Collaborator | No |

***End User Overview***

***End User’s Current Decision-Making Process:***State and federal managers in the Mojave Desert region monitor BHS populations in part to assess population health trends and measure the impacts of disease and anthropogenic disturbances, in addition to resource availability and habitat utilization in observed wildlands. In response to these population dynamics, the end users are responsible for reallocating resources, making habitat conservation decisions, and determining areas needing more intensive management. Remote sensing is currently used along with *in situ* monitoring efforts to provide additional information about BHS habitat quality and usage.

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

*National Park Service, Mojave National Preserve* – Mojave National Preserve has used the MODIS Gross Primary Productivity products (MOD17A2 8-day composite at 1 km spatial resolution) to estimate forage production for a cattle grazing allotment to guide management decisions regarding protection of a listed species. This DEVELOP project will build upon that effort by providing higher spatial resolution MODIS NDVI data on vegetation canopy greenness phenology that will be used to aid park BHS management.

*National Park Service, Biological Resources Division, Wildlife Health Branch* – The Wildlife Health Branch is familiar with NASA Earth observations, and currently utilizes studies based on NASA data that are attempting to identify relationships between BHS and their ecosystems. These results will be used to develop more holistic monitoring programs.

*California Department of Fish and Wildlife, Wildlife Branch, Game Management* – The end user has used NASA Earth observation data (Landsat, MODIS) to quantify snow cover (via NDSI), vegetation indices (NDVI) that were incorporated into models of resource selection by montane BHS, and to quantify plant species distribution. Application of the project’s NASA EO data will enhance spatio-temporal resolution of water and vegetation data that will be useful for siting of artificial water sources, plus aiding in predictions of movement and concomitant disease risk.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Oregon State University, Department of Fisheries and Wildlife* – Oregon State University (Clint Epps PI, Daniella Dekelaita, graduate student) is examining how BHS survival, reproduction, and movement are influenced by spatial and temporal environmental variation and presence of respiratory disease. BHS location data will be used by D. Dekelaita to examine movement and space use within the Mojave National Preserve and nearby areas, and is potentially available for project use.

*Sierra Nevada Bighorn Sheep Foundation* – The Sierra Nevada Bighorn Sheep Foundation will contribute subject-matter expertise about BHS and the Mojave Desert ecosystem to this project, in addition to ground-truth data to help validate and assess remotely sensed observations.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The Center Lead and the Project Lead will be the main POCs for the project. Weekly emails and biweekly telephone calls will be used to discuss project progress and receive feedback from the partners.

***Transition Plan*:** A handoff at the end of the term will be conducted virtually via WebEx. All end products and project deliverables will be emailed to the partner before this handoff meeting, allowing time for feedback.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 5 TM** | Surface reflectance, spectral vegetation indices | Landsat 5 will be used to derive vegetation indices to assess long-term trends in availability and quality. |
| **Landsat 8 OLI** | Surface reflectance, spectral vegetation indices | Landsat 8 will be used to derive vegetation indices to assess long-term trends in availability and quality. |
| **Terra MODIS** | Surface reflectance, spectral vegetation indices | Terra MODIS will be used to derive vegetation indices to assess long-term trends in availability and quality. |
| **Aqua MODIS** | Surface reflectance, spectral vegetation indices | Aqua MODIS will be used to derive vegetation indices to assess long-term trends in availability and quality. |
| **SMAP** | Soil moisture | SMAP will be used to assess the interactions between soil moisture and vegetation indices. |
| **Sentinel-2 MSI** | Surface reflectance | Sentinel-2 will be used to identify current vegetation distributions and compare to Landsat- and MODIS-based results. |

***Ancillary Datasets:***

California Department of Fish and Wildlife – provide locations from GPS collars used to generate resource selection functions

Climate Hazards Group CHIRPS data – assess precipitation trends

Oregon State University identified Bighorn Sheep ranges – identify locations of Bighorn Sheep habitat for analysis

PRISM Climate Data – assess precipitation trends

USGS National Land Cover Database (NLCD) –determine and assess general land cover types

LANDFIRE Database existing vegetation type – determine and assess more specific vegetation types of interest

USGS National GAP Analysis Program – determine land cover types of interest

USDA Forest Service *ForWarn* NDVI – This quarter kilometer 8-day NDVI data set was temporally processed from MODIS MOD13 and MYD13 data. It will be used to construct annual and multiyear NDVI time series needed for comparison to precipitation time series data.

***Software & Scripting:***

Google Earth Engine API – raster analysis and data visualization

Esri ArcGIS 10.4 – raster analysis and map creation

QGIS – raster and vector data visualization, analysis, and map product development

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Annual, Seasonal, and 8-day NDVI Maps** | Partners will use NDVI maps to assess historic trends in vegetation availability to determine areas of increased priority for monitoring and management. | ForWarn Aqua/Terra MODIS NDVI data will be used to derive time series for 2000-2015. Landsat and Sentinel-2 data will be used to generate NDVI products in a supplemental capacity. | N/A |
| **Precipitation Event and Seasonal Precipitation Maps** | Partners will use precipitation maps to assess historic trends in precipitation across the Mojave Desert to determine areas of increased priority for monitoring and management. | CHIRPS and PRISM data will be used to create precipitation aggregates between 2005 and 2017. | N/A |
| **NDVI Change Analysis** | Partners will use change analysis of NDVI to identify areas of persistent and ephemeral vegetation resources to understand locations where BHS populations have steadily-available resources. | ForWarn-based Aqua/Terra MODIS 8-day NDVI imagery will be used to compute change products. | N/A |
| **Precipitation Change Analysis** | Partners will use change analysis of precipitation to identify areas of persistent or boom-or-bust precipitation patterns. | CHIRPS and PRISM aggregates will be used to assess trends in precipitation over the study period. | N/A |
| **Assessment Tutorial and Guide** | Partners will use the write-up of the project methodology to continue using NASA Earth observations in the future to inform their management decisions. | N/A | N/A |

***End User Benefit*:** The vegetation greenness (NDVI) and precipitation trend analyses and maps produced by this project will support the management of BHS and their habitat by providing additional datasets to inform resource availability, disease mitigation, and plans for managing habitat connectivity in the Mojave Desert region. This research will complement other studies on nutrient availability and population dynamics that are being conducted by collaborating organizations, and would allow for better resource planning and efficiency among management staff through a more improved understanding of the BHS habitat vegetation and precipitation dynamics of the region. Ultimately, this information will be combined into models to describe habitat selection and utilization in relation to water availability.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2018 Spring to 2018 Summer

***Multi-Term Objectives:***

* **Term 1 (Proposed Term):** 2018 Spring (VA) – Mojave Desert Water Resources
  + Term one will focus on creating a time series of vegetation and precipitation indices for the study period and then assessing relationships between the two parameters. This initial term of the project will choose between pursuing trend analyses in ArcGIS, Google Earth Engine API, and/or QGIS. The initial trend analyses will be focused on identifying pulses in precipitation that then correspond with pulses in vegetation. The project team will assess these time series data sets with *in situ* datasets available from the project partners. Depending on the relationships that are present between the vegetation and precipitation parameters, the project will be re-evaluated at the end of this term.
* **Term 2:** 2018 Summer (VA) – Mojave Desert Water Resources II
  + The second term of this project will include refining the methodology and analyses that compare time series data sets with *in situ* datasets from project partners. It will expand upon results from the first term. Statistical analyses will be conducted on results of comparing precipitation and vegetation data sets. Information and products from the second term will be provided to the end-user organizations for aiding various BHS monitoring activities. A second objective of this term will be to do a multi-webinar partner handoff, packaging up all materials, end products, and deliverables to provide a holistic package to the partners.

***Related DEVELOP Work:***

2016 Summer (CO) – Laramie Mountains Ecological Forecasting: Modeling Aspen Distribution Utilizing NASA Earth Observations to Identify Critical Habitat for Mule Deer and Elk in the Laramie Range, Wyoming

2016 Spring (LaRC) – Southern Rockies Ecological Forecasting: Tracking Mule Deer for Wildlife Corridors between Seasonal Habitats in the Southern Rockies

**Notes & References:**

***Notes*:**

CDFW has artificial drinker systems that have rain gauges that transmit via satellite. Also, they might be able to contribute some personnel time if on-the-ground validation is needed.

Research questions:

How are vegetation responding to precipitation events across mountain ranges and elevational gradients?

What are the long-term trends in vegetation and precipitation in the region? Can these trends then be used to separate annual growth events from long-term hydrologic cycle responses?

Can plant productivity be deduced by calculating the difference between late winter and early spring greenness and late spring to mid-late summer greenness?

Habitat utilization is also affected by topography, including slope, insolation, and ruggedness, and must be taken into account in resource selection models.

* Human supplied water is a management alternative and practice. Investigating how spatio-temporal variations in forage quality and quantity relate to resource selection could yield valuable insights into predicting where provisional water might achieve the greatest benefit.

***References:***

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Wehausen, J. D. (1995). Fecal measures of diet quality in wild and domestic ruminants. *Journal of Wildlife Management*, *59*(4), 816-823.

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