**Mojave Desert Ecological Forecasting**

*Monitoring Bighorn Sheep Habitat by Assessing Vegetation, Topography, and Soil Moisture*

**VPS Title:** Sheepishly Picky: Vegetation Habits of the Mojave Desert Bighorn Sheep

**Project Team**

***Project Team*:**

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***Advisors & Mentors*:**

Dr. Kenton Ross (NASA Langley Research Center)

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***Past or Other Contributors*:**

Jacob Ramthun

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**Project Overview**

***Project Synopsis*:**

The spring 2018 NASA DEVELOP team in Wise County, Virginia, partnered with the National Park Service, the California Department of Fish and Wildlife, Oregon State University, and the Sierra Nevada Bighorn Sheep Foundation to investigate bighorn sheep (BHS) (*Ovis canadensis*) populations in the Mojave Desert, California. They identified trends in precipitation and vegetation related to BHS presence and habitat in order to produce Normalized Difference Vegetation Index (NDVI) and precipitation products. This project will use these products and additional NASA satellite products to further evaluate how BHS presence may be related to vegetation, soil types, and elevation to aid partners with their habitat modeling efforts.

***Abstract*:**

Bighorn sheep are a charismatic desert species that have enormous ecological and cultural significance to the Mojave Desert region in California. After overcoming large population losses in the late 1900s, further habitat degradation and fragmentation has continued to affect the livelihood of remaining bighorn sheep (BHS) herds. Past studies have shown that the habitat selection of remaining BHS metapopulations is extremely selective, requiring very specific forage and topographic conditions. A previous DEVELOP project used remotely sensed precipitation data to characterize vegetation greenness within known BHS habitat and found that additional parameters were needed to more accurately assess and predict herd placement. In partnership with the National Park Service, the California Department of Fish and Wildlife, Oregon State University, and the Sierra Nevada Bighorn Sheep Foundation, the fall 2018 NASA DEVELOP Alaska Ecological Forecasting team utilized data from various NASA Earth observations, including Soil Moisture Active Passive (SMAP), Terra Moderate Resolution Imaging Spectroradiometer (MODIS), Terra Advanced Spaceborne Thermal Emission and Reflection Global Digital Elevation Map (ASTER GDEM), along with National Agriculture Imagery Program (NAIP) aerial imagery to further evaluate spatiotemporal vegetation characteristics in relation to BHS habitat.

**Keywords:** Remote sensing, bighorn sheep (*Ovis canadensis*), Mojave Desert, Landsat, MODIS, SMAP, Terra ASTER GDEM V2, habitat modeling, Software for Assisted Habitat Modeling (SAHM)

***National Application Area Addressed:*** Ecological Forecasting

***Study Location:*** Mojave Desert, CA

***Study Period:*** January 2015 – June 2018; Forecasting to 2025

***Community Concern:***

* BHS are an integral species in the Mojave Desert whose presence is valued by tourists, game hunters, and native peoples alike.
* The preferred habitat range of BHS is extremely selective, requiring specific topography, water availability, and forage quantity and quality for populations to thrive. Over the years, suitable BHS habitat has become increasingly fragmented due to anthropogenic threats such as the construction of highways, groundwater pumping, and loss of food from livestock grazing.
* This habitat variation contributes to the challenges that local wildlife units face when attempting to monitor and manage existing BHS herds.

***Project Objectives:***

* Utilize Mojave Desert vegetation and topography maps to investigate the relationship between spatiotemporal vegetation and BHS preferred habitat
* Identify focal BHS forage areas for priority management and monitoring
* Provide project partners with tools and methods to assist them in continuing the use of NASA Earth observations to aid their management plans

***Previous Term:*** 2018 Spring (VA) – Mojave Desert Water Resources

**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 | End User | No |
| **California Department of Fish and Wildlife, Wildlife Branch, Game Management** | 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** | Clinton Epps, Associate Professor | Collaborator | No |
| **Sierra Nevada Bighorn Sheep Foundation** | John Wehausen, Bighorn Sheep Biologist | Collaborator | No |

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

In the 1960s, desert BHS populations in North America declined to less than 10,000 individuals due to disease, resource competition from livestock, over hunting, and habitat degradation by humans. Fortunately, this number has increased dramatically over the last few decades due to widespread reintroduction and relocation efforts. BHS in the Mojave Desert are currently monitored by the CA Department of Fish and Wildlife using GPS tracking collars to directly monitor foraging locations and habitat selections. Several partners have previously utilized NASA Earth observations such as Terra and Aqua MODIS and Landsat for both land cover analysis and BHS resource selection models. In addition to remote sensing, all partners have utilized i*n situ* monitoring to assess vegetation and BHS habitat ranges.

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

The end products produced by this project will support future BHS management by providing high resolution vegetation maps and habitat modeling tools that were not previously available to the project partners. These higher quality products produced with NASA earth observations can better highlight areas of concern that might benefit from more intensive management strategies in the face of additional habitat degradation and extreme changes in climate. Additionally, a more in-depth analysis of BHS habitat selection coupled with precipitation, vegetation, and topography data can provide additional insights into the population dynamics of future BHS herds.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Terra MODIS** | Surface reflectance, spectral vegetation indices | Terra MODIS data were used to create a vegetation classification map. |
| **Terra ASTER** | Digital elevation model | Terra ASTER data were used to model elevation and topography. |
| **SMAP** | Soil moisture | This was used to model soil moisture. |

***Ancillary Datasets:***

California Department of Fish and Wildlife BHS point locations – locations of BHS from GPS collars will be

used to generate resource selection functions

Oregon State University identified BHS ranges – previously identified locations of BHS habitat will be used

for comparisons to satellite-derived habitat ranges

USDA National Agriculture Imagery Program (NAIP) – create a verification layer for vegetation classifications

***Modeling:***

Software for Assisted Habitat Modeling (SAHM) (POC: Colin Talbert, USGS Fort Collins Science Center) –

provided a modeling framework for projecting future BHS population ranges

***Software & Scripting:***

Esri ArcMap – data analysis and map production

QGIS – data processing and analysis

Exelis ENVI – raster analysis and raster manipulation

Git – data management and bulk downloading

RStudio – data processing and analysis

Python – data processing and analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observation Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Vegetation Classification Map** | Terra MODIS | This map will assist the partners in locating the areas with vegetation that the BHS forage in order to better monitor and manage BHS populations. | I |
| **16-Day NDVI Maps** | Terra MODIS | This will demonstrate the rate of green up events occurring over a year and allow partners to better understand the temporal aspect of different vegetation species. | I |
| **Soil Moisture Map** | SMAP | This map will help partners identify vegetation by highlighting the amount of moisture in the soil. | I |
| **Bighorn Sheep Predicted Habitat Map** | Terra MODIS  Terra ASTER  SMAP | This shows partners future BHS habitat distribution patterns based on their preferred vegetation and elevation. | I |
| **Topography Maps** | Terra ASTER | This will be used to show the topography of preferred BHS habitat. | I |

**Project Handoff Package**

**Transition Plan:**

The Mojave Desert Ecological Forecasting team hosted a virtual hand off webinar the last week of the term. All final products and deliverables were emailed through NASA Large File Transfer (LFT) to the POC from each partner organization.

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**Handoff Package:**

* Final deliverables
* Vegetation Classification Map
* 16-Day NDVI Maps
* Soil Moisture Map
* Big Horn Sheep Predicted Habitat Map
* Topography Maps

**References:**

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