**NASA DEVELOP National Program**

**Fort Collins – Colorado**

*Project Summary – Spring 2018*

**Utah Water Resources**

*Utilizing Landsat to Detect Ephemeral Water Sources in Support of a USGS Feasibility Assessment and Management Strategy of Equids*

**VPS Title:** Desert Riches

 *Mapping Ephemeral Surface Water: the Desert’s most Precious Resource*

**Project Team**

***Project Team*:**

Kristen Dennis (Project Lead), dennisk.kristen@gmail.com

Anson Call

Timothy Mayer

Gary Olds

***Advisors & Mentors*:**

Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory)

Nicholas Young (Colorado State University, Natural Resource Ecology Laboratory)

Tony Vorster (Colorado State University, Natural Resource Ecology Laboratory)

Brian Woodward (Colorado State University, Natural Resource Ecology Laboratory)

**Project Overview**

***Project Synopsis*:** This project utilized NASA and ESA Earth observations to locate perennial and ephemeral surface water within the Sinbad Herd Management Area (HMA) in central Utah. This region provides rangeland for wild burros, so understanding habitat selection in the area will aid burro conservation efforts. Working with United States Geological Survey (USGS), the team combined pre-existing data of water occurrence with Earth observations to map ecologically-relevant water sources across seasons. These maps and methodologies will aid researchers in developing habitat selection models for burros (*Equus asinus*) within the Sinbad HMA as well as for wild horses (SSP) across other HMA.

***Abstract*:** Since 1971, federal agencies have been tasked with managing burros in federally-designated herd management areas (HMAs). Because these areas are often large and remote, obtaining sufficient data on horse and burro populations and habitat preference can be difficult and expensive. In recent years, the United States Geological Survey (USGS) has partnered with the Bureau of Land Management (BLM) to study the population dynamics and habitat preferences of wild horse and burro populations on the Sinbad HMA in central Utah. Researchers at the USGS and BLM hypothesize that surface water is potentially an important factor in wild horse and burro habitat selection, thus these agencies are interested in determining how water availability affects species’ movement in both time and space. NASA DEVELOP leveraged NASA Earth observations and pre-existing water availability data to determine the spatial and temporal distribution of water on the landscape. Maps were developed to help researchers create habitat selection models for wild horses and burros on the Sinbad HMA and elsewhere.

**Keywords:** Google Earth Engine, surface water, random forest classification model, burro, Landsat, SRTM, Sentinel-1 C-SAR

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

***Study Location:*** UT

***Study Period:*** March 2013 – November 2017

***Community Concern:***

* The BLM and USGS support healthy populations of free-roaming burros on the rangelands across the west as a part of a multiple-use mission.
* The Sinbad HMA is home to over 100 burros.
* Water in semi-arid regions is a critically limiting factor for burro distribution, and information regarding water resources for equids in these ecosystems is limited.
* Information regarding the locations of ephemeral water sources is needed for the BLM and USGS to enact informed and effective management decisions.

***Project Objectives:***

* Test the feasibility of using NASA Earth observations to detect surface water at small scales
* Determine the seasonality of available surface water
* Up-scale the methods by creating a toolset and tutorial for use in other regions and by other organizations

**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 | Yes |
| **Bureau of Land Management,****Utah State Office** | Gus Warr, Program Manager | Collaborator | Yes |

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

In accordance with the Wild Free-Roaming Horse and Burro Act of 1971, the BLM is responsible for managing populations of free-roaming burros on public lands. The agency has partnered with the USGS to study habitat selection of burros on the Sinbad HMA. Currently, the USGS utilizes both radio telemetry and field observation data to monitor the movement and habitat use of focal species as a means to more accurately assess herd counts in designated HMAs. Water availability is assessed through sporadic field surveys. These surveys are limited in scope and are insufficient to develop reliable habitat selection models. Remote sensing techniques and NASA Earth observations are currently not utilized.

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

This project will save the USGS and BLM time and money by further refining monitoring and field survey efforts. Specifically, accurate assessments of available surface water will enable the USGS to create better models of burro habitat selection. The project also enabled 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 BLM decision-making and management processes to more effectively manage herd populations in semiarid ecosystems.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **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 m) resolution needed for mapping water available to equids. |
| **Sentinel-1 C-SAR** | 4 C-band radar polarization levels, water surface, and topography roughness | This dataset provides medium to high temporal (6 days) and spatial resolution (5 m) imagery in all weather conditions.  |
| **SRTM** | Elevation, slope, aspect, and compound topographic index | This dataset was used to derive topographic indices used as predictors representing important characteristics of hydrologic networks and water collection depressions. |

***Ancillary Datasets:***

USGS and BLM Equid Field Measurements – Species habitat usage

USDA National Agriculture Imagery Program (NAIP) – High-resolution aerial imagery for identification of surface water features

***Modeling:***

Random Forests (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center) – Classification algorithm used to select variables to be used as model inputs

***Software & Scripting:***

Google Earth Engine API – Large scale image analysis

Esri ArcGIS – Image processing, end product generation

R – Statistical analyses, raster processing

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Water Detection Map** | Landsat 8 OLI, SRTM, Sentinel-1 C-SAR | This product utilizes Google Earth Engine and random forest modeling techniques to integrate NASA Earth observations, remote sensing data, and partner collected herd field data. These data will be employed to detect water in Utah herd management areas.  | N/A |
| **Modeling Tutorial** | Landsat 8 OLI, SRTM, Sentinel-1 C-SAR | The tutorial covers data processing, fitting statistical models to the data, and interpretation as well as mapping of model output. The tutorial will enable end users to replicate this study in future years and for additional study locations. | N/A |

**Project Handoff Package**

**Transition Plan:**

Project materials and final products will be handed off to the USGS and BLM during the final week of the term. The team will host a seminar at the National Resource and Ecology Lab to disseminate project results to the Geospatial centroid at CSU. A short training workshop on the use of the data and tutorial will follow the seminar.

**Team POC:** Kristen Dennis, dennisk.kristen@gmail.com

**Partner POC**: Kate Schoenecker, schoeneckerk@usgs.gov

**Handoff Package:**

* Final project deliverables
* Water Detection Map
* Modeling Tutorial
* Seminar to communicate project results
* Training workshop on use of data and tutorial
* Shapefiles and raw data associated with the end products

**References:**

Breiman, L. (2001). Random forests. *Machine Learning, 45*(1), 5-32. doi:10.1023/a:1010933404324

Crane, K. K., Smith, M. A., & Reynolds, D. (1997). Habitat selection patterns of feral horses in south central Wyoming. *Journal of Range Management, 50*(4), 374-380. doi:10.2307/4003303

Du, Y., Zhang, Y., Ling, F., Wang, Q., Li, W., & Li, X. (2016). Water bodies' mapping from Sentinel-2 imagery with modified Normalized Difference Water Index at 10-m spatial resolution produced by sharpening the SWIR Band. *Remote Sensing, 8*(4). doi:10.3390/rs8040354

Elith, J., Phillips, S. J., Hastie, T., Dudik, M., Chee, Y. E., & Yates, C. J. (2011). A statistical explanation of MaxEnt for ecologists. *Diversity and Distributions, 17*(1), 43-57. doi:10.1111/j.1472-4642.2010.00725.x

Feyisa, G. L., Meilby, H., Fensholt, R., & Proud, S. R. (2014). Automated Water Extraction Index: A new technique for surface water mapping using Landsat imagery. *Remote Sensing of Environment,* *140*, 23-35. doi:10.1016/j.rse.2013.08.029

Ganskopp, D., & Vavra, M. (1986). Habitat use by feral horses in the northern sagebrush steppe. *Journal of Range Management*, *39*(3), 207-212. doi:10.2307/3899050

Girard, T. L., Bork, E. W., Neilsen, S. E., & Alexander, M. J. (2013). Landscape-scale factors affecting feral horse habitat use during summer within the Rocky Mountain foothills. *Environmental Management,* *51*(2), 435-447. doi:10.1007/s00267-012-9987-2

Miller, R. (1983). Habitat use of feral horses and cattle in Wyoming red desert. *Journal of Range Management, 36*(2), 195-199. doi:10.2307/3898161

Pekel, J.-F., Cottam, A., Gorelick, N., & Belward, A. S. (2016). High-resolution mapping of global surface water and its long-term changes. *Nature, 540*(7633), 418-+. doi:10.1038/nature20584

Westerhoff, R. S., Kleuskens, M. P. H., Winsemius, H. C., Huizinga, H. J., Brakenridge, G. R., & Bishop, C. (2013). Automated global water mapping based on wide-swath orbital synthetic-aperture radar. *Hydrology and Earth System Sciences, 17*(2), 651-663. doi:10.5194/hess-17-651-2013

Young, N. E., Anderson, R. S., Chignell, S. M., Vorster, A. G., Lawrence, R., & Evangelista, P. H. (2017). A survival guide to Landsat preprocessing. *Ecology, 98*(4), 920-932.

Zhou, Y., Dong, J., Xiao, X., Xiao, T., Yang, Z., Zhao, G., Zou, Z., & Qin, Y. (2017). Open surface water mapping algorithms: A comparison of water-related spectral indices and sensors. *Water, 9*(4). doi:10.3390/w9040256