**Southern Rockies Western Slope Agriculture**

*Identifying Drivers of Rangeland Production for Drought Planning on the Western Slope of the Southern Rockies*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

The team partnered with the Bureau of Land Management, United States Forest Service, Colorado State University Extension, and National Drought Mitigation Center to support drought planning across the western slope of the southern Rocky Mountains, covering parts of Wyoming, Utah, Colorado, and New Mexico. The goal was to provide data-driven recommendations for ranchers for improved adaptive management during drought. Remotely sensed observations of rangeland production allowed for characterizations across space and time by evaluating spatial and temporal patterns of rangeland production and identifying “early warning” indicators that correlate with peak forage volume (e.g., precipitation, temperature, snowpack, streamflow, etc.).

***Abstract:***

Over the last decade, the southern Rocky Mountains of the United States experienced severe and variable drought. Local ranchers and landowners have reported strain on their operations, citing decreasing forage for their cattle and a need to adjust their business models. This study identified Major Land Resource Area-48 (MLRA-48) and northwestern Colorado as the key region for analysis. NASA DEVELOP partnered with the BLM Colorado River Field Office, Colorado State University Extension, USDA Forest Service, and the National Drought Mitigation Center to address concerns regarding the efficacy of remotely sensed rangeland production platforms and identify early warning climatic indicators of drought. The study identified two key platforms, The Rangeland Productivity Monitoring Service (RPMS) and Rangeland Analysis Platform (RAP), which use NASA Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI to estimate rangeland biomass. We regressed these with in situ biomass data to validate their efficacy and found that RAP was more effective than RPMS in estimating rangeland biomass, though it presents a tendency to overestimate. Our study performed a random forest analysis, comparing monthly RAP biomass estimates to a variety of climate variables, including mean precipitation, temperature, Palmer Drought Severity Index, snow water equivalent, wind speed and direction, and vapor pressure deficit. We determined that vapor pressure deficit and precipitation are key indicators in predicting forage production in MLRA-48. Our climate analysis provided our partners with greater understanding of the influence of various climate variables in determining rangeland production and allows them to assist land managers in drought mitigation.

***Key Terms:***

remote sensing, rangeland production, drought, Landsat, MODIS, RAP, RPMS, early-warning climate indicators

***National Application Area Addressed:*** Agriculture

***Study Location:*** Western Slope of southern Rocky Mountains (Major Land Resource Area 48A & B), WY, UT, CO, NM

***Study Period:*** 1984 – 2022

***Community Concerns:***

* Drought conditions impact rangeland production, which affects national food security, the livelihood of land managers, and is associated with concerns surrounding ecosystem degradation.
* Overgrazing has negative effects on rangeland ecosystems; overgrazing can lead to soil degradation and erosion.
* Moreover, lower rangeland production can result in negative financial outcomes for ranchers and landowners.
* Lower production can result in ranchers having to sell off livestock and can create more labor for ranchers.
* When there is less forage available, livestock must be moved more frequently and alternative food sources may have to be implemented, taking time and money away from ranchers and land managers.

***Project Objectives:***

* Produce ground truth rangeland models that quantify the reliability of the RAP and RPMS remote sensing products
* Create a forage production analysis of the relationship between production and multiple meteorological factors in the region

***Previous Term:***

Fall 2022 (CO) – Colorado Eastern Plains Agriculture

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Colorado State University Extension** | Retta Bruegger, Regional Specialist, Range Management | End User |
| **USDA, US Forest Service** | Lydia Labelle de Rios, Rangeland Management Specialist | End User |
| **Bureau of Land Management, Colorado River Valley Field Office** | Kristy Wallner, Rangeland Management Specialist | End User |
| **University of Nebraska, National Drought Mitigation Center** | Tonya Haigh, Research Assistant Professor and Social Science Coordinator; Grace Campbell, Master’s Student | End User |

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

The end user organizations work with livestock producers on the western slope of the southern Rocky Mountains. These end users and producers face large uncertainty about the amount of rangeland production and forage that will be available for their livestock each year. This uncertainty makes it difficult to make adaptive management decisions, such as how many livestock to keep in a drought year. These decisions have important economic, social, and environmental consequences. Early warning indicators have been developed in other areas to help producers better predict how much forage may grow in each season. However, an analysis by the National Drought Mitigation Center found the western slope of the Southern Rocky Mountains to have weak relationships between climate and range production.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Spectral bands and indices | This dataset provided the temporal (16 days) and spatial (30m2) resolution needed to track rangeland production. |
| **Landsat 7 ETM+** | Spectral bands and indices | This dataset provided the temporal (16 days) and spatial (30m2) resolution needed to track rangeland production. |
| **Landsat 8 OLI** | Spectral bands and indices | This dataset provided the temporal (16 days) and spatial (30m2) resolution needed to track rangeland production. |
| **Landsat 9 OLI-2** | Spectral bands and indices | This dataset provided the temporal (16 days) and spatial (30m2) resolution needed to track rangeland production. |
| **MODIS** | Spectral bands and indices | 500m2 resolution Contiguous US Snow Persistence and Trends Data were used to delineate the snow zones within the region of interest |

***Ancillary Datasets:***

* CSU Extension rangeland production field data – in situ data for validating RAP and RPMS biomass predictions for MLRA 48A & B
* RAP annual aboveground biomass – rangeland aboveground biomass production data
* RPMS annual aboveground biomass – rangeland aboveground biomass production data
* Global snow zone data – data from MODIS were used for delineating snow zones within MLRA 48A & B
* GRIDMET surface meteorological data – palmer drought severity index and wind data
* DAYMET gridded estimates of daily weather and climatology variables – snow water equivalent data
* PRISM climate observations – precipitation, temperature, and vapor pressure deficit data

***Modeling:***

* Random forest (POC: Tony Vorster, Colorado State University) – model used to characterize the relationship between production and climatic variables.

***Software & Scripting:***

* Google Earth Engine – gather, manipulate, and download satellite data
* ArcGIS Pro – create snow zones and map area of interest
* QGIS – create snow zones and map area of interest
* R Studio – develop linear regression and random forest models

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Ground Truth Rangeland Production Models** | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Landsat 9 OLI-2, MODIS | Quantify the accuracy of rangeland production maps for this region to inform producers about the level of confidence they can have in these remotely sensed products. | Options:  N/A  I  II  III  IV  V  III |
| **Forage Production Analysis** | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Landsat 9 OLI-2, MODIS | To identify and share forage production early warning signals as a tool with producers for improved adaptive management during drought. | III |
| **2 Page Project Summary** | N/A | Summary of project results, knowns and unknowns for predicting forage growth, improved forage growth curves, and “early warning” indicators. | N/A |

***Product Benefit to End User:***

The end products of this project will provide end-users with information on how accurate RAP and RPMS data sources are in predicting production for the western slopes of the southern Rocky Mountains that will inform rangeland managers about how confident they can be in the use of these products. End users will also be able to identify potential early warning indicators of forage production as a tool to aid in adaptive management during drought conditions. This project will help producers make decisions about the size of the herd based off of production and become better prepared for a drought. These products will help to limit the need to completely destock or other drastic negative impacts on business.

**References**

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