**Southern Wyoming Ecological Forecasting**

*Monitoring Cheatgrass in Southern Wyoming and Northern Colorado to Inform Management Efforts Post-Mullen Fire*

**Project Team**

***Project Team:***

Dahlia Shahin

Emily Snyder

Kyle Paulekas

Michael Segala

Sanju Khatri

***Advisors & Mentors:***

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

Dr. Catherine Jarnevich (USGS, Fort Collins Science Center)

Dr. Anthony Vorster (Colorado State University, Natural Resource Ecology Laboratory)

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

Peder Engelstad (Colorado State University, Natural Resource Ecology Laboratory)

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

***Team POC:*** Dahlia Shahin, dahliashahin@gmail.com

***Software Release POC:*** Dahlia Shahin, dahliashahin@gmail.com

***Partner POC:*** Janet Prevey, jprevey@usgs.gov

**Project Overview**

***Project Synopsis:***

The DEVELOP team partnered with the United States Forest Service (USFS), United States Geological Survey (USGS) Fort Collins Center, and Natural Resource Ecology Laboratory at Colorado State University (CSU) to monitor vegetation recovery and invasive cheatgrass after the Mullen Fire in southern Wyoming and northern Colorado. The team paired field data collected on cheatgrass cover and remote sensing data derived from Landsat 8 Operational Land Imager (OLI), Sentinel-2 MultiSpectral Instrument (MSI), and Shuttle Radar Topography Mission (SRTM) to create a cheatgrass detection model. End products include a cheatgrass extent map and analysis of recovery patterns across burn severity and vegetation types.

***Abstract:***

Cheatgrass (*Bromus tectorum*) is a prominent invasive species in the Intermountain West that has the potential to out-compete native plant species, reduce biodiversity, and reduce quality of habitat for ungulates. Furthermore, because cheatgrass readily establishes in disturbed landscapes, it can potentially increase fuel loads and exacerbate wildfire risk. In 2020, the Mullen Fire burned 176,878 acres in Carbon and Albany Counties, Wyoming and Jackson County, Colorado. Large fires such as this one raise concern for our partners, the United States Forest Service and the United States Geological Survey Fort Collins Science Center who are tasked with rapidly detecting and controlling invasive species in the post-fire environment. We developed a Random Forest model trained by in-situ field data and spectral indices such as Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index, and Enhanced Vegetation Index derived from Landsat 8 Operational Land Imager, Sentinel-2 MultiSpectral Instrument, and Shuttle Radar Topography Mission to detect and map cheatgrass presence during the 2021 growing season. Our team was able to successfully create a spectral cheatgrass detection map in the study area (RMSE = 13.71, R2 = 0.34). We also produced a NDVI time-series derived from Sentinel-2 MSI to analyze vegetation recovery patterns.

***Key Terms:***

remote sensing, post-wildfire, invasive species, cheatgrass presence, Landsat 8 OLI, Sentinel-2 MSI, Random

Forest

***National Application Areas Addressed:*** Ecological Forecasting, Disasters

***Study Location:*** Mullen Fire extent, WY & CO

***Study Period:*** June 2021 – October 2021

***Community Concerns:***

* Cheatgrass readily establishes in disturbed landscapes and can potentially increase fuel-loads and promote fire frequency and severity.
* Cheatgrass reduces biodiversity by out-competing native vegetation.
* Cheatgrass negatively impacts ungulate populations (i.e. mule deer and elk) that do not use cheatgrass as a food resource.

***Project Objectives:***

* Produce a cheatgrass detection map post-Mullen Fire
* Generate time-series for vegetation recovery
* Investigate relationship between cheatgrass cover and other variables (i.e. road cover, topography, burn severity, etc.)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Medicine Bow-Routt National Forest and Thunder Basin National Grasslands, USFS** | Katie Haynes, Botanist | End User | No |
| **USGS, Fort Collins Science Center** | Janet Prevey, Ecologist | Collaborator | No |

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

The USFS is an important stakeholder in managing recovery after the Mullen Fire. They have a goal of controlling invasive vegetation which will provide a quality habitat and encourage native vegetation recovery. Cheatgrass was sprayed with herbicide in targeted locations during the summer of 2021 and the USFS anticipate continuing this process over the next few years. The results of this project will assist in future targeted herbicide implementation and the continual monitoring of cheatgrass in the fire extent.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Spectral vegetation indices  | This dataset will provide the temporal (16 days) and spatial (30 m2) resolution used to Normalized Vegetation Index (NDVI), Soil-Adjusted Vegetation Index (SAVI), and Enhanced Vegetation Index (EVI) for mapping native and invasive species. |
| **Sentinel-2 MSI** | Spectral vegetation indices | This dataset will provide the temporal (5 days) and spatial (20 m2) resolution used to derive NDVI, SAVI, and EVI for mapping native and invasive species. |
| **SRTM** | Topography | This dataset will provide the spatial (30 m2) resolution used to derive topographic variables to identify areas within the suitable range of target species growth. |

***Ancillary Datasets:***

* USFS vegetation recovery field data – Field data collected during the summer of 2021 to characterize native and invasive plant cover in the Mullen Fire
* USFS Soil Burn Severity Maps – Static maps created to show burn severity in the Mullen Fire
* USGS time-lapse camera data – Time-lapse camera data during the summer of 2021 to characterize cheatgrass phenology in the Mullen Fire.

***Modeling:***

* Random Forest (POC: Anthony Vorster, Colorado State University) – Model used to map native and invasive plant species within the burned area

***Software & Scripting:***

* ESRI ArcGIS Pro 2.8.3 – Image processing and end product generation
* RStudio 4.0.3 – Statistical analyses, raster processing, and Random Forest modeling
* Google Earth Engine API v0.1.276 – Large-scale image analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Cheatgrass Extent Map**  | Landsat 8 OLISentinel-2 MSISRTM    | The GIS map product will locate where cheatgrass is established and where management may be needed.   | N/A  |
| **Analysis of Vegetation Recovery** | Sentinel-2 MSI   | Plotting NDVI values at game camera locations provided by the USGS from 2020-2021 will be used to explore vegetation recovery patterns. | N/A  |

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

The USFS will use the vegetation time series and cheatgrass detection map to strategize locations for future targeted herbicide spraying in ways that increase efficiency and stretch limited resources. They will also continue to work with the Natural Resource Ecology Laboratory at CSU as they monitor this area for years to come.

**References**

Bradley, B. A., Curtis, C. A., Fusco, E. J., Abatzoglou, J. T., Balch, J. K., Dadashi, S., & Tuanmu, M. N.

(2018). Cheatgrass (*Bromus tectorum*) distribution in the intermountain Western United States and its relationship to fire frequency, seasonality, and ignitions. *Biological Invasion*s, *20*(6), 1493-1506.

West, A. M., Evangelista, P. H., Jarnevich, C. S., Kumar, S., Swallow, A., Luizza, M. W., & Chignell, S. M. (2017). Using multi-date satellite imagery to monitor invasive grass species distribution in post- wildfire landscapes: An iterative, adaptable approach that employs open-source data and software. *International Journal of Applied Earth Observation and Geoinformation, 59,* 135-146.

<https://doi.org/10.1016/j.jag.2017.03.009>