** NASA DEVELOP National Program**

**North Carolina – NCEI**

*Project Summary – Summer 2018*

**South Dakota Ecological Forecasting**

*Monitoring the Spread of Invasive Grasses and the Impacts on Grassland Management Practices in the Great Plains Using NASA Earth Observations and NOAA Climate Data Records*

**VPS Title:** Into the Weeds: Utilizing NASA and NOAA Earth Observations for Remote Detection of Invasive Grasses in South Dakota

**Project Team**

***Project Team*:**

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***Advisors & Mentors*:**

Dr. Jessica Matthews (North Carolina Institute for Climate Studies)

**Project Overview**

***Project Synopsis*:**  Invasive grass species that are typically found in the Great Basin, such as *Bromus japonicus* (Japanese brome), *Bromus tectorum* (cheatgrass), and *Melilotus* (sweet clover), are expanding east into the Great Plains. Regional planners are interested in determining the spread of invasive grass, as its prevalence will create repercussions extending from increased wildfire risk, changes in cattle grazing patterns, and decreased biodiversity. This project used NASA Earth observations, National Oceanic and Atmospheric Administration (NOAA) climate data records, and *in situ* data to create a historical land cover classification of South Dakota as a case study for the Great Plains region. Partner organizations will use the results of this project to guide in situ data collection and invasive species mitigation and management efforts over the region.

***Abstract*:** Invasive grass species, specifically *B. tectorum* (cheatgrass), *B. japonicus* (japanese brome), and *Melilotus* (sweet clover), have expanded out of the Great Basin and into the western Great Plains of the United States. Increased development and land use in western South Dakota have provided a gateway for these species to invade and dominate formerly native grasslands. This project evaluated the historic distribution of invasive species, by creating invasive species distribution maps on a county level of South Dakota for 1997-2018.  Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) were used to classify regions of grassland and non-grassland in South Dakota. Invasive and native grasses were identified within the grassland regions using Earth Observations and phenological climate data records. Phenology variables from the NOAA Advanced Very High-Resolution Radiometer (AVHRR) climate data record included Normalized Difference Vegetation Index (NDVI), Leaf Area Index (LAI), and Fraction of Absorbed Photosynthetically Active Radiation (FAPAR). Forwarn Phenology Parameter Products derived from MODIS also provided additional NDVI data. These phenology variables from AVHRR and Forwarn were studied to determine a method to distinguish between native and invasive grasses. The team validated the classification of native and invasive grasses using *in situ* data to cross reference and compare to the remote sensed data. This comparison also provided insight into the spatial and temporal completeness of the *in situ* data reporting in the area. Finally, the team used regression modeling to make future projections of land cover classification by county. The methods applied to our case study region of South Dakota will serve as a guide for historical and future invasive grass identification over the Great Plains region. The results will be used to inform local management practices and combat ecosystem threats, such as an increased risk of wildfire and an altered biomass of the region that impact cattle grazing patterns.

**Keywords:**

Remote sensing, MODIS ForWarn, Landsat, AVHRR, invasive grasses, phenology, ranching

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

***Study Location:*** SD

***Study Period:*** 1997- 2018 (March- September); Forecasting to 2022

***Community Concern:***

* Invasive brome grasses often survive routine fire regimes and drought, altering the biomass of the region which affects ranching and wildlife.
* Brome grasses can act as a catalyst to stronger, longer, wildfires in the region.
* Cattle grazing is deeply impacted by the phenological differences of invasive annual bromes due to the displacement of native grasses, which complicates standard and routine livestock practices.
* The current understanding of invasive species distribution and spread relies on sparse *in situ* data in the region.

***Project Objectives:***

* Identify regions of invasive and native grasses in South Dakota from 1997-2018 using Earth Observations and Climate Data Records
* Produce land cover classification maps to determine the spread of invasive grasses during the historical period
* Forecast invasive grass species distribution to 2022 using a regression model

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **DOI, National Invasive Species Council Secretariat** | Dr. Jeff Morisette, Chief Scientist | End User | Yes |
| **NOAA Regional Climate Services, Central Region** | Doug Kluck, Director | Collaborator | Yes |
| **USDA Agricultural Research Service, High Plains Grasslands Research Station** | Justin Derner, Research Leader | Collaborator | No |

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

Currently, the National Invasive Species Council (NISC) Secretariat provides guidance to federal policy makers within the council as well as local and regional planners. This council is composed of representatives from thirteen federal agencies and three White House offices, enabling all of the agencies to effectively manage and work on the conservation of the nation. These agencies follow base guidelines of early detection practices and rapid response techniques, which include land surveys, emergency containment and quarantine, and immediate eradication of the species. Eradication methods vary from chemical use with herbicides to fire regimes, as well as wildlife foraging prior to the blooming season.

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

Dr. Jeff Morisette, the chief scientist for NISC Secretariat, will be provided maps of the historical distribution of invasive grasses in South Dakota and projection maps of invasive grass distribution on the county level. The use of NASA Earth observation and NOAA climate data records will not only provide a spatial and temporal distribution of invasive grasses in the region, but it will expose gaps in the regional *in situ* data of invasive species. User benefits will include an increased awareness of *in situ* data quality and quality, contributing to planning for improved field campaigns in the future, and a better-informed decision-making process to control and eradicate invasive grass species.

**Earth observations & End Products Overview**

***Earth observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Spectral Radiance | False Color Composite images were used to classify the land cover of the region. The images were also used as a visualization tool. |
| **Landsat 8 OLI** | Spectral Radiance | False Color Composite images were used to classify the land cover of the region. The images were also used as a visualization tool.  |
| **AVHRR** | NDVI, LAI, FAPAR | NDVI, LAI, and FAPAR were used to estimate the regional phenology and identify a method of differentiation between invasive and native grasses.  |

***Ancillary Datasets:***

ForWarn phenology dataset – Created by the US Forest Service in collaboration with NASA. ForWarn uses MODIS derived phenology parameters (NDVI) to estimate regional phenology

Biological Information to Serve Our Nation (BISON)- *In situ* data of invasive and native species in South Dakota used to verify the classification made from remote sensing data

Northern Great Plains Fire Effects Program (NG-FEP) - *In situ* data of invasive species in South Dakota used to verify the classification made from remote sensing data

***Software & Scripting:***

Esri ArcGIS – Spatial analysis and map creation

Python– Data analysis of phenology variables

NetCDF Operators – Data processing

Exelis ENVI – Land cover classification, data processing

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **County level maps of invasive to native grassland percentage in South Dakota** | NOAA AVHRR, Landsat 5 TM, Landsat 8 OLI | These analyses will be incorporated into current land management practices and will provide partners with a methodology that can be used to access invasive species spread across South Dakota and the Great Plains, and alert regional land managers to encroaching invasive species. | N/A |
| **Forecast maps of invasive grass distribution in South Dakota** | NOAA AVHRR, Landsat 5 TM, Landsat 8 OLI | This product will inform decision-makers on the spatial evolution of invasive grasses in South Dakota in the near future, given that they continue growing at the historical rate. The product will be on the county level and will project to year 2022.  | N/A |

**Project Handoff Package**

**Transition Plan:**

Handoff of the end product maps and discussion of results was transferred to partners via NASA Teleconference during week 10 of the term (August 6). The documents were sent via email and NASA’s Large File Transfer system.

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**Handoff Package:**

* Poster
* Presentation
* Technical Paper
* Land classification for South Dakota- historical classification and forecasting
	+ Tutorial of methods and explanation of results

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