**NASA DEVELOP National Program**

**Spring 2016 Project Proposal**

**USGS at Colorado State University, Fort Collins, CO**

**Laramie Mountains Ecological Forecasting**

Utilizing NASA Earth Observations to Evaluate Carrying Capacity of Mule Deer and Elk Habitat in the Laramie Range, Wyoming

**Project Overview**

***Objective:*** To use multi-temporal, multi-spectral indices and species distribution modeling to forecast aspen (*Populus tremuloides*)cover estimates across the Laramie Mountain Range, Wyoming, and compare areas that have been burned to unburned sites. To support state efforts in evaluating carrying capacities of mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) in the Laramie Mountain Range, and in planning habitat improvement efforts such as prescribed fire.

***Community Concern:*** Aspen stands provide critical habitat for wildlife and are one of the most species rich vegetation community types in Wyoming. Mixed age stands of aspen are associated with a high diversity of herbaceous understory species, and are important for ungulate fawning, fawn rearing, forage, and cover from predators. However, sudden aspen decline is a growing concern, in addition to declining mule deer populations throughout the Western US. As a result, land management agencies are planning habitat improvement efforts, such as prescribed burning, to stimulate aspen regeneration. The public values aspen communities for aesthetics, wildlife viewing, and recreation, among other landscape benefits.

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

***Study Location:*** Laramie Mountains, Wyoming

***Study Period:*** 1985 to 2015

***Advisor:*** Paul Evangelista (Natural Resource Ecology Laboratory, Colorado State University)

***Source of Project Idea:*** This project idea was motivated by ongoing interactions with one of our current DEVELOP project partners, Ryan Amundson, Statewide Habitat Biologist with Wyoming Game and Fish Department. Ryan inquired if we could use similar methods to those currently being employed by the Fall 2015 Wyoming Ecological Forecasting Team to map aspen cover in the Laramie Range. These maps will assist agency efforts in estimating the carrying capacities of ungulates in the area.

**Partner Overview**

***Partner Organizations:***

Wyoming Game and Fish Department (End User; POC: Ryan Amundson, Senior Wildlife Biologist)

Natural Resource Ecology Laboratory at Colorado State University (Collaborator and Boundary Organization, POC: Amanda West, Postdoctoral Fellow)

***End-User Current Decision Making Process:***

Currently, field surveys are the only tools being used to estimate aspen cover in the Laramie Mountain Range, and these surveys are limited by financial resources and accessibility (much of the area is inaccessible due to lack of roads and trails). The limited number of field surveys are extrapolated over the entire mountain range, therefore aspen cover estimates are incomplete. Furthermore, comparisons of aspen regeneration in burned vs. unburned sites in this region have not been conducted to date.

***NASA Earth Observations Capacity:***

Wyoming Game and Fish Department – The end-user is familiar with NASA Earth observations, however a lack of training and resources prevents the organization from adopting methods to utilize these resources. Wyoming Game and Fish is currently an end-user of the Fall 2015 Wyoming Ecological Forecasting Project, and the agency recognizes how maps created from remotely sensed data can strengthen their capacity to address wildlife habitat concerns across the state.

***Collaborator & Boundary Organization Support:***

Natural Resource Ecology Laboratory (NREL), Colorado State University – This collaborator and boundary organization was involved in the development of this project, has field data that will be used in this project, and will provide mentorship to the DEVELOP team. NREL has previously worked with the end-user on projects in the southern Medicine Bow Mountain Range, Wyoming, and will serve as the liaison with the end-user to maintain communication throughout the DEVELOP term and disseminate project results.

***Communication Plan & Transition Approach:***

The team will communicate with project partners on a weekly basis via email and meetings throughout the term. At the end of the term, the team will host a seminar to disseminate project results and hand off decision support tools. The end-user plans to begin using these products as soon as they are available to inventory all aspen stands in the region and begin planning habitat improvements, including prescribed burning.

***End-User Benefit:***

“This project will help my agency in identifying critical parturition habitats (i.e. fawning and calving) for ungulates in the Laramie Range and improve our current estimates of habitat carrying capacity. These estimates are important in deciding how to manage wildlife numbers to alleviate competition among ungulates and mitigate habitat conservation” (personal communication with end-user Ryan Amundson). Furthermore, this project will provide the organization with a better understanding of how fire history in the Laramie Range relates to aspen regeneration. Maps of aspen cover will save the organization time, money, and personnel hours that are currently depleted by conventional surveying efforts.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform** | **Sensor** | **Geophysical Parameter** |
| **Landsat 5** | Thematic Mapper (TM) | Surface reflectance, greenness, moisture, normalized difference burn ratio |
| **Landsat 7** | Enhanced Thematic Mapper Plus (ETM+) | Surface reflectance, greenness, moisture, normalized difference burn ratio |
| **Landsat 8** | Operational Land Imager (OLI) | Surface reflectance, greenness, moisture |
| **Landsat 8** | Thermal Infrared Sensor (TIRS) | Brightness temperature |
| **Aqua/Terra** | Moderate Resolution Imaging Spectroradiometer (MODIS) | Vegetation phenology |
| **Space Shuttle** | SRTM V2 | Elevation, slope, aspect, Compound Topographic Index |

***NASA Earth Observations Use:***

Landsat 5 TM – This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for mapping fire history in the Laramie Range, with images beginning in 1985. The normalized Difference Burn Ratio is used by the Monitoring Trends in Burn Severity (MTBS) project to develop fire perimeter and severity products and is derived from Landsat legacy data.

Landsat 7 ETM+ – This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for mapping fire history in the Laramie Range, with images beginning in 1999. The normalized Difference Burn Ratio is used by the Monitoring Trends in Burn Severity (MTBS) project to develop fire perimeter and severity products and is derived from Landsat legacy data.

Landsat 8 OLI – This dataset provides the temporal (16 days) and spatial (30 m2) resolution needed for mapping current aspen cover and fire history in the Laramie Range, with images beginning in 2013. Spectral indices from Landsat 8 OLI have been used in prior species distribution modeling projects at the Fort Collins DEVELOP node.

Landsat 8 TIRS – This dataset will be used to derive additional covariates for species distribution modeling. For example, the team could explore using this dataset to examine correlations between surface temperature or soil moisture with aspen cover.

Aqua/Terra MODIS – This dataset will be used to derive vegetation phenology, which is important in distinguishing aspen stands from surrounding vegetation.

Space Shuttle SRTM V2 – This dataset will be used to derive topographic indices to be used as covariates in species distribution modeling for aspen.

***Ancillary Datasets:***

Administrative Boundaries – provided by USFS; Aspen Field data – provided by USFS and Natural Resource Ecology Laboratory

***Models:***

Generalized Linear Model (POC: Catherine Jarnevich: USGS)

Multivariate Adaptive Regression Spline (POC: Catherine Jarnevich: USGS)

Random Forests (POC: Catherine Jarnevich: USGS)

Boosted Regression Trees (POC: Catherine Jarnevich: USGS)

Maxent (POC: Catherine Jarnevich: USGS)

**Decision Support Tool & End-Product Overview**

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| --- | --- | --- |
| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Aspen Cover Map | Locations for evaluating critical mule deer habitat, estimating habitat carrying capacity | Field surveys |
| Aspen Cover in Burned vs. Unburned Areas Maps | Prescribed burn treatment | Estimation from local knowledge |
| Topographic indices | Assessing suitable aspen habitat | Field Surveys |

Aspen Cover Map – This product will be developed using spectral indices from the Landsat 8 OLI and TIRS sensors, topographic indices from SRTM V2, and phenological products derived from MODIS in combination with aspen field survey data in an ensemble of five species distribution models; Generalized Linear Model, Multivariate Adaptive Regression Spline, Random Forests, Boosted Regression Trees, and Maxent.

Aspen cover in Burned vs. Unburned Areas – This product will be developed using the normalized Difference Burn Ratio derived from Landsat 5TM, Landsat 7 ETM+, and Landsat 8 OLI sensors and the aspen cover forecast map product produced by this project. Linear regression will be used to evaluate current aspen cover to burned vs. unburned areas.

Topographic Indices – This product will be developed from a SRTM V2 digital elevation model, and will include slope, aspect, compound topographic index, topographic roughness, cosine and sine transformations of aspect and slope, heat load index, and topographic radiation index.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2016 Spring and 2016 Summer

* **Term 1 (Proposed Term)** –The goal of the first term will be to develop a detailed model of fire history for the Laramie Range for the years 1985 - 2015. This will be used to evaluate fire return interval for the study area, and will provide data to be used during the second term of the project. Project partners will be engaged on a weekly basis throughout the term, and a meeting will be scheduled at the end of the term to evaluate results.
* **Term 2**–The goals of the second term will be to develop an aspen cover map for the Laramie Range, and relate that back to the fire history map and fire return interval evaluation from the first term of the project. Project partners will be engaged on a weekly basis throughout the term, and a handoff will be scheduled at the end of the term to share project products.

***Previous Related DEVELOP Work:***

Fall 2015 (Fort Collins), Wyoming Ecological Forecasting – Using Landsat 8 and Aqua and Terra MODIS to Target Cheatgrass Mitigation in a Post-Wildfire Landscape in Wyoming’s Medicine Bow National Forest

Summer 2015 (Fort Collins), Ethiopia Ecological Forecasting – Mapping Fire History for Habitat Conservation in Ethiopia’s Bale Mountains Using a Time Series of Landsat Data

Fall 2014 and Spring 2015 (Fort Collins), Arizona Ecological Forecasting I and II – Comparing WorldView-2 with Landsat 8 Imagery: Refining and Evaluating Invasive Tamarisk Mapping in Havasu National Wildlife Refuge

Summer 2014 (Fort Collins), Alaska Ecological Forecasting – Modeling Current and Future Invasion Vulnerability for Critical Habitat in Interior Alaska: Applying Novel Modeling Techniques for Invasive Species Risk Assessment in the Yukon Flats National Wildlife Refuge

**Project Needs/Requests**

***Participants Requested:*** 4

***Software & Scripting:***

ENVI – Landsat imagery calibration and pre-processing

ArcGIS – Landsat imagery processing (study area designation, clipping, etc.), derivation of indices, map creation

Software for Assisted Habitat Modeling – Fit all modeling algorithms

**Notes & References:**

***References:***

Kirkpatrick, S and Abendroth D (2001). Aspen response to prescribed fire and wild ungulate herbivory. *In* Sustaining Aspen in Western Landscapes: Symposium Proceedings, USFS General Technical Report Rocky Mountain, 387 – 394.