**NASA DEVELOP National Program**

**2020 Spring Project Proposal**

**Idaho – Pocatello**

**Great Basin Ecological Forecasting II**

*Assessing and Forecasting Live Fuel Moisture Content of Wildfire Fuels for the Eastern Great Basin to Improve Wildfire Timing and Severity Predictions*

**Project Overview**

***Project Synopsis*:** This project will use the Landsat satellite series, along with MODIS, SMAP, and VIIRS as inputs to accurately model live fuel moisture (LFM) to allow partners to make better informed decisions regarding preemptive wildfire risk planning and resource allocation throughout the eastern Great Basin (EGB). The team will use remotely sensed vegetation, soil moisture, and topographic variables in a machine learning technique to create predictive models of LFM. Additionally, they will analyze fuel moisture trends throughout high fire risk months and forecast bi-weekly the LFM of the entire EGB. The improved estimates of LFM, along with forecasts, will increase the efficiency of land managers deciding resource allocation to prevent wildfires, as well as combat active fires.

***Community Concern:*** Wildfires caused by natural or human ignition have increased in severity, size, and frequency across the U.S. in recent years. Because of these increases, wildfires cause billions of dollars in damages, suppression, and rehabilitation of the burned areas. A major component of fire management is monitoring LFM, or the water content in biomass fuels in wildfire hotspots. There are currently only 155 measurement sites across the entire EGB. A more complete map of changing LFM during the fire season for this large area will allow land managers to make more accurate risk assessments and determine where to allocate resources to preemptively combat fires on a timescale of two week increments during the summer months.

***Source of Project Idea:*** The Idaho – Pocatello DEVELOP team has a seasonal meeting with the Idaho BLM. Keith Weber saw this project idea as a common concern among the partners and this project tied many issues from various agencies into one neat project monitoring LFM to combat wildfires.

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

***Study Location:*** Eastern Great Basin, UT, ID, CO, AZ, WY, NV

***Study Period:*** 2001 – 2019 (May – October); Forecasting to 2021

***Advisor:*** Keith Weber (Idaho State University, GIS TReC)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Idaho Department of Fish and Game, Southeast Regional Office** | Scott Bergen, Senior Wildlife Research Biologist | End User | No |
| **Bureau of Land Management, Upper Snake Field Office** | Ben Dyer, Fire Ecologist; Michelle Mavor, Fire Ecologist | End User | No |
| **NOAA, National Weather Service**  | Mike Huston, Meteorologist, Science and Operations | End User | No |
| **Great Basin Coordination Center** | Nanette Hosenfeld, Meteorologist | Collaborator | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***Land managers in the Eastern Great Basin currently rely on 155 *in situ* data collection sites to estimate LFM for the entire 260,000 mi² area. There are some gaps of over 600 mi between collection sites. The size of the area and variability in weather, topography, and vegetation in the EGB make accurate estimations difficult. There is currently no LFM remote sensing involved in the decision making process for the EGB regarding fire warning, suppression, and prediction.

***End User’s Capacity to Use NASA Earth Observations:***

*Idaho Department of Fish and Game, Southeast Regional Office* – The Idaho Department of Fish and Game has research and management groups that currently use satellite-derived imagery (e.g. MODIS, Landsat) for natural resource management throughout the state of Idaho. Satellite data are used to meet specific informational needs, such as annual vegetation production, invasive species detection, and fire recovery estimation.

*Bureau of Land Management, Upper Snake Field Office* – The Upper Snake Field Office has worked in close collaboration with the GIS TReC at Idaho State University since 1999 on a variety of rangeland research projects that use NASA Earth observations, with many focusing on the effect of wildfire on rangeland health. Beginning with DEVELOP’s Idaho Disasters project in the fall term of 2014, the understanding and use of remotely sensed data for specific applications have continued to grow.

*NOAA, National Weather Service –* The National Weather Service (NWS) is interested in outputs from this project and can assist in providing integrated weather and climate data for the project. They routinely use LFM as input in their forecasting and a factor when issuing fire weather warnings due to predicted incoming thunderstorm events. Our contact at the NWS has some familiarity with GIS but has not used remote sensing for wildfire applications.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Great Basin Coordination Center* – The Great Basin Coordination Center provides insight into how LFM is measured and what assumptions can be made about *in situ* sampling techniques, as well as providing this *in situ* data to the team. This center also gives constant feedback on model refining to let the DEVELOP team know what will be helpful to land managers in the field.

***Dissemination by Boundary Organizations*:**

*Great Basin Coordination Center* – The Great Basin Coordination Center maintains partnerships with agencies that oversee the Great Basin eco-region. The center currently manages a database of all LFM measurements taken by partner agencies and makes use of Earth observation data for other decision-making such as pre-emptively staging fire suppression resources if LFM and fire weather reports indicate the potential for numerous fire starts in the near term. This agency will enable coordination and collaboration between various other local and federal partners, both for distribution of data and decision-making.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The Idaho – Pocatello DEVELOP team will communicate with partners on a bi-weekly meeting schedule over teleconference. The Fellow and Project Lead will be the main POCs of the partner organizations during the project.

***Transition Plan*:** At the end of the term, the partners will receive all deliverables over email and attend a presentation both in person and via a web-hosted seminar presented by the DEVELOP team. The handoff will include LFM maps and forecasts, the DEVELOP team’s technical report, and a written tutorial on steps taken in prediction and analysis so that the partners can recreate these results at other high-risk sites across the US. No software release will be required for this project.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Terra MODIS** | Land Surface Temperature (LST), Evapotranspiration (ET), NDVI | MOD16 evapotranspiration (ET) products will be used to approximate land surface ET and assist in estimates of water/energy fluxes in the study area. Terra MODIS NDVI data will be used for correlation analysis. |
| **Aqua MODIS** | LST, ET | LST and ET from Aqua MODIS will be used as an input in the classification schema. |
| **NOAA-20 VIIRS** | LST, NDVI | VIIRS derived GIS products will be fed into the machine learning model to determine best-fit parameters for the model. |
| **Landsat 8 OLI**  | Surface Albedo, NDVI | Landsat 8 OLI data will be used to monitor vegetation health that will be used in applied models. |

***Ancillary Datasets:***

* Great Basin Coordination Center LFM *in situ* Database – historical LFM data to validate model outputs from our LFM prediction
* National Land Cover Database 2016 – used for calibrating vegetation land cover and as well as identifying and masking out impervious surfaces
* Landfire Land Cover datasets 2018– used to define existing vegetation type (EVT) and existing vegetation cover (EVC) to potentially improve LFM modeling by clustering vegetation types and modeling within each type.

***Modeling:***

* Classification Tree Analysis (POC: Keith Weber, GIS TReC)
* Support Vector Machines (POC: Keith Weber, GIS TReC)
* Land Change Modeler (POC: Keith Weber, GIS TReC)

***Software & Scripting:***

* Esri ArcGIS Pro – raster manipulation and analysis, map creation
* TerrSet – Raster processing and spectral classification and land cover change modeling
* Google Earth Engine Application Programming Interface – time series data sampling and automation
* Python – ArcPy scripting, raster analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Live Fuel Moisture and Forecasting Model** | LFM models will allow partners to make better informed decisions regarding impending fire events and streamline resource allocation in advance of wildfires.  | This ArcGIS Pro Model Builder model will integrate elevation, aspect, soil moisture, evapotranspiration, vegetation type, and vegetation indices along with *in situ* LFM measurements to model LFM across the EGB.Forecasting future LFM can be accomplished by forward projecting near term (1-2 weeks) using past trends.  | I |
| **Predictive LFM Forecast maps, biweekly April - September** | These maps will be used by partners to better allocate resources to high risk areas in the EGB. | These are output maps enerated using the Live Fuel Moisture and Forecasting Model. | I |
| **Developing Reliable Live Fuel Moisture Datasets: A Tutorial** | The tutorial will enable end users to replicate this predictive model set-up in the future. | This tutorial will describe the steps to generate the Live Fuel Moisture and Forecasting model described above. | I |

***End-User Benefit*:** LFM is used to allocate resources and plan for fires more efficiently by land managers. Estimates of LFM can predict fire intensity, severity, and size without having to wait for the fire to combust. These models will allow the partners to use NASA EOs to gain a stronger estimate of LFM across this wide geographical area, making it easier to decide what resources need to be where, and when. *In situ* measurements will still be needed to verify the model in future fire seasons, but these models will make a more spatially complete understanding of the LFM in the EGB for the partners, saving on the cost of fire prevention, mitigation, and human loss.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2019 Fall to 2020 Spring

***Multi-Term Objectives:***

* **Term 1:** 2019 Fall (Idaho – Pocatello) – Great Basin Ecological Forecasting
	+ The team gathered data and determined what data inputs best matched *in situ* datasets. The team also created a Google Earth Engine tool to monitor vegetation indices on the fly without needing a more robust toolset. The research done for this study area focused on the Eastern section of the Great Basin, but can eventually be applied to the entire Great Basin and potentially other GACC’s across the nation. End products from this term were validated using the LFM observations database using Random Trees Classifiers in ArcPro.
* **Term 2 (Proposed Term):** 2020 Spring (Idaho – Pocatello) – Great Basin Ecological Forecasting II
	+ This will focus on refining the LFM forecast model and generating forecast outputs from these LFM models which will be ready for use by land managers during the 2020 fire season in the EGB. The final handoff will occur in person at closeout, with methods outlined in tutorials, and export approved technical report turned over to the partner. Since this will be a culmination, a project video will be required which will outline the needs of the partner and tell the story of the project.

***Previous Terms:***

2019 Fall (ID) – Great Basin Ecological Forecasting

***Related DEVELOP Work:***

2019 Spring (ID) – Argentina Water Resources: Evaluating Evapotranspiration in Humid Subtropical and Semi-Arid Climates with NASA Earth Observations to Understand Water Balance in Paraná and the Patagonian Steppe of Argentina

2018 Fall (ID) – Idaho Water Resources II: Evaluating Evapotranspiration and Water Budget Components in Semi-Arid Sagebrush Steppe

2018 Summer (ID) – Idaho Water Resources: Estimating Soil Moisture in Semiarid Sagebrush Steppe utilizing NASA Satellite Imagery

**References:**

Chuvieco, E., Cocero, D., Riano, D., Martin, P., Martınez-Vega, J., de la Riva, J., & Perez, F. (2004). Combining NDVI and surface temperature for the estimation of live fuel moisture content in forest fire danger rating. *Remote Sensing of Environment*, *92*(3), 322-331.

Davis, J., Weber, K. T. (2018). Spatio-Temporal Relationships of Historic Wildfires: Using the NASA RECOVER Historic Fires Geodatabase to Perform Long-term Analysis of Wildfire Occurrences in the Western United States. Retrieved from <http://giscenter.isu.edu/research/Techpg/nasa_RECOVER/pdf/Davis_SpatioTemporalRelationshipsHistoricWildfires_final.pdf>

Nghiem, S. V., et al. (2014). Enhancing Wildland Fire Decision Support and Warning Systems. *Enhancing Wildland Fire Decision Support and Warning Systems*. Jet Propulsion Laboratory News Room, 1–59.

Toombs, W. A., Weber, K. T., Stegner, T., Schnase, J. L., Lindquist E., & Lippitt, F. (2018). Use and benefits of NASA’s RECOVER for post-fire decision support. Intl Journal of Wildland Fire. *27*(7), 441-446. Retrieved from http://www.publish.csiro.au/WF/WF18010

Westerling, A. L., Hidalgo, H. G., Cayan, D. R., & Swetnam, T. W. (2006). Warming and earlier spring increase western US forest wildfire activity. *Science*, *313*(5789), 940-943.