**Great Basin Ecological Forecasting**

*Integrating NASA Earth Observations into Live Fuel Moisture Models to Improve Wildfire Timing and Severity Forecasting in the Eastern Great Basin*

**Project Team**

***Project Team:***

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Keith Weber (Idaho State University, GIS Training and Research Center)

**Project Overview**

***Project Synopsis:*** In the eastern Great Basin, land managers derive live fuel moisture from *in situ* measurements, which aids in estimating wildfire timing, issuing safety warnings, and allocating response resources. This project partnered with the Bureau of Land Management, the National Weather Service, the Idaho Department of Fish and Game, and the Great Basin Coordination Center to improve the efficiency and decision-making process behind wildfire resource deployment. Using NASA Earth observations, the project team evaluated the correlation strength between remotely sensed live fuel moisture and *in situ* measurements in order to create a predictive model for live fuel moisture.

***Abstract:***

The eastern Great Basin (EGB) covers approximately 411,000 km2 within the states of Arizona, Colorado, Idaho, Utah, and Wyoming. Since the 1950s, wildfires have increased in both frequency and size within the EGB and neighboring states. Partners at the Bureau of Land Management (BLM), the Idaho Department of Fish and Game, the National Weather Service, and the Great Basin Coordination Center (GBCC) are particularly concerned with Live Fuel Moisture (LFM). Living vegetation that fuels wildfires, referred to as live fuel, requires greater energy input to combust when wet and less energy input to combust when dry, making LFM a vital measurement for predicting wildfire risk and severity. To increase spatial coverage for the EGB from the 155 *in situ* observation sites, the NASA DEVELOP team modeled LFM using satellite data from Aqua and Terra Moderate Resolution Imaging Spectroradiometer (MODIS) and Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS). The team incorporated remotely sensed data into machine learning modeling techniques, such as the Random Trees Classifier through ArcGIS Pro, to develop a predictive model of LFM. The remotely sensed data included vegetation indices, land surface temperature, evapotranspiration, and topographic variables. Model accuracy was evaluated by testing generated values against historical data obtained from partners at the BLM and the GBCC. The LFM model benefitted partners by improving the spatiotemporal resolution for wildfire forecasts. While model accuracy averaged at 8.2%, the LFM trend developed from model classification was useful for resource allocation and improved emergency response to wildfires within the EGB.

***Keywords:***

remote sensing, wildfire, live fuel moisture, NDVI, evapotranspiration, soil moisture, MODIS, VIIRS

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

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

***Study Period:*** 2016 to 2017 (April to September), Forecasting to 2020

***Community Concerns:***

* Wildfires cost billions of dollars in suppression and recovery.
* Wildfires can impact water quality and watershed susceptibility to erosion and flooding for months, even years, after a burn period ends.
* Untimely response to wildfires can waste resources and risk the loss of human and ecological life.

***Project Objectives:***

* Evaluate the feasibility of using existing spatial datasets to determine Live Fuel Moisture (LFM)
* Determine which data inputs have the highest correlation strength with *in situ* datasets from the Bureau of Land Management (BLM) and the Great Basin Coordination Center (GBCC)
* Generate a predictive LFM model to forecast wildfire risk and severity
* Produce a tutorial describing the model, allowing partners to replicate the process

**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** | Kurt Buffalo, Science and Operations Officer; Mike Huston, Meteorologist | End User | No |
| **Great Basin Coordination Center** | Nanette Hosenfeld, Meteorologist | Collaborator | Yes |

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

Land managers with the Idaho Department of Fish and Game (IDFG), BLM, National Oceanic and Atmospheric Administration (NOAA), and the Great Basin Coordination Center (GBCC) currently rely on 155 field collection sites to estimate LFM levels for the eastern Great Basin (EGB) region. The area equates to approximately one observation site per 2,600 km2. Due to the size of the study area, it exists in four watershed regions and includes large variabilities in topography, soil associations, and vegetation type. Informed decisions on resource allocation are made using *in situ* measurements of LFM. However, these decisions are subject to the ecological variability of the region.

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

Prior to wildfire events, resource allocation by land management agencies is influenced by LFM derived from

155 *in situ* measurement sites. Creating a model that allows for partners to effectively forecast LFM at a greater spatial extent will improve resource allocation ahead of wildfire events. Additionally, a predictive LFM model that covers a larger spatial extent compared to current *in situ* measurements will streamline decision-making processes and, if feasible, will be applied to the remaining nine Geographic Area Coordination Centers (GACC), as well as the entire Great Basin. The GACCs mobilize resources and provide support to federal and state land management agencies for emergency incidents, such as wildfires. *In situ* measurements will not be eliminated, but rather will be used to effectively calibrate model parameters and improve spatial coverage of LFM data.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Suomi-NPP VIIRS** | Land surface temperature (LST), Normalized Difference Vegetation Index (NDVI) | VIIRS data were integrated into a machine learning algorithm that produced a best-fit parameter for the applied model. NDVI and LST were used as model inputs. |
| **Terra MODIS** | Evapotranspiration (ET) | MOD16 ET products were used for approximating land surface ET and estimating water fluxes in the eastern Great Basin and as inputs in applied models. |
| **Aqua MODIS** | ET | Aqua MODIS ET data were used as inputs in applied models. |
| **SRTM** | Aspect, slope, elevation | Shuttle Radar Topography Mission elevation data were used to map topographic data such as slope, aspect, and elevation. These data were used as inputs in the end product tool. |
| **Landsat 8 OLI** | NDVI, surface albedo, Normalized Difference Water Index (NDWI) | Landsat 8 OLI data were used to create a vegetation index as well as energy parameter inputs that were used in the end product tool. |
| **Landsat 8 TIRS** | LST | LST from Landsat 8 TIRS was used as an energy parameter in the end product tool. |
| **Landsat 5 TM** | Surface reflectance, NDVI, NDWI | Landsat 5 TM data were used to create a vegetation index as well as energy parameter inputs that were used in the end product tool. |

***Ancillary Datasets:***

* Great Basin Coordination Center LFM *in situ* Dataset – Historical LFM data were used to validate model outputs
* Landfire Land Cover Datasets 2018 – Used to define existing vegetation type (EVT) and existing vegetation cover (EVC) to improve LFM by classifying vegetation types and modeling within each type
* Landfire 40 Scott and Burgan Fire Behavior Fuel Models 2005 – Used for fuel and vegetation classification
* National Elevation Dataset – Digital elevation model (DEM) was derived primarily from USGS 10- and 30-meter DEMs. Aspect, slope, elevation, and hillshade were created from this dataset

***Modeling:***

* Random Trees Classifier (POC: Keith Weber, GIS Training and Research Center) – Classification of LFM percentages using remotely sensed elevation, ET, LST, NDVI, and aspect. Training and validation was done using *in situ* LFM observations

***Software & Scripting:***

* Esri ArcGIS Pro 2.4.2 – Raster and vector manipulation and analysis, map creation
* Google Earth Engine API – Time series data sampling and automation
* Python 3.2 – Automation of raster analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Live Fuel Moisture Model** | Aqua MODIS  Terra MODIS  Suomi-NPP VIIRS | This model allowed partners to make more informed decisions regarding wildfire events. | N/A |
| **Developing Reliable Live Fuel Moisture Datasets: A Tutorial** | Aqua MODIS  Terra MODIS  Suomi-NPP VIIRS | This tutorial navigated partners through the necessary steps to recreate the LFM model described above and replicate our study. | N/A |
| **Developing Reliable Live Fuel Moisture Datasets: A Brochure** | Aqua MODIS  Terra MODIS  Suomi-NPP VIIRS | This brochure illustrated to partners the steps and reasoning behind the model building process. | N/A |
| **Great Basin Analysis Tool (GreBAT)** | SRTM  Landsat 8 OLI  Landsat 8 TIRS  Landsat 5 TM | This tool provided verification of the LFM inputs for the LFM model to allow for higher accuracy during the partners’ decision making process. | III |

**Project Handoff Package**

***Transition Plan:*** The Great Basin Ecological Forecasting team presented project results to partners via teleconference during week 10 of the term. The team sent the remotely sensed data, technical paper, tutorial, and brochure to partners using NASA’s Large File Transfer.

***Software Release Plan:*** The Great Basin Ecological Forecasting team informed the partners of the software release and communicated that the software would be released at a later date. The partners were informed that the software package for GreBAT would be digitally delivered to them. This package includes the code, tutorial, and documentation on how to execute the code.

***Project Continuation Plan:*** In the second term of this project, there is interest for future inquiry into creating a forecasting model for wildfire severity and timing, specifically for the 2020 fire season. Outputs from the LFM model developed during Term I will be incorporated into the forecasting model. The final products of the second term will include data, a technical report, a forecasting model, a tutorial, and a project video.

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***Software Release POC:*** Gavin Pirrie, pirrie13@gmail.com

***Partner POC:*** Nanette Hosenfeld, nhosenfeld@blm.gov

***Handoff Package:***

* Live Fuel Moisture Model
* Developing Reliable Live Fuel Moisture Datasets: A Tutorial
* Developing Reliable Live Fuel Moisture Datasets: A Brochure
* Technical Paper
* Presentation
* Poster
* Study Area Shapefiles

**References**

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USGS. (2018, March 6). Water Quality after a Wildfire. Retrieved October 1, 2019, from https://ca.water.usgs.gov/wildfires/wildfires-water-quality.html