**Southern Colorado Disasters**

*Using NASA Observations to Map Aspen Extent and Recovery Due to Wildfire*

**Project Team**

***Project Team:***

Scott Cunningham (Project Lead)

Camille Blose

Audrey Colley

David Keyes

***Advisors & Mentors:***

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

Dr. Catherine Jarnevich (United States Geological Survey, Fort Collins Science Center)

Dr. Anthony Vorster (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:*** Scott Cunningham, scottcunningham321@gmail.com

***Partner POC:*** Aaron Swallow, aaron.swallow@trincheraranch.com

**Project Overview**

***Project Synopsis:***

The 2018 Spring Creek Fire burned 108,000 acres in southern Colorado, including thousands of acres of quaking aspen (*Populus tremuloides*) forest. To understand post-fire aspen response, the team employed Landsat 8 OLI, Sentinel-2 MSI, SRTM, and National Agriculture Imagery Program (NAIP) data to 1) produce maps of aspen extent before and after the fire, (2) identify changes in aspen extent due to the fire, and 3) model and map areas most suitable for aspen regeneration. Findings will help project partners at Trinchera Ranch and the Colorado State Forest Service to understand aspen’s role in forest recovery after fire and aid current forest management techniques.

***Abstract:***

Quaking aspen (*Populus tremuloides*) is an important species for wildlife, watershed health, and ecosystem resilience across its range. Heavy ungulate browsing and factors influenced by a changing climate including seasonal temperature changes and moisture deficit have led to reduced post-fire aspen regeneration rates in southern Colorado. This project partnered with Trinchera Ranch and the Colorado State Forest Service to estimate aspen recovery after the Spring Creek Fire, which ignited in June of 2018. The Southern Colorado Disasters team utilized field measurements and satellite imagery from Landsat Operational Land Imager (OLI), Sentinel-2 MultiSpectral Instrument (MSI), and the Shuttle Radar Topography Mission (SRTM) to train and run several random forest models that detect pre- and post-fire aspen extent. Ocular sampling of over 500 points on high-resolution pre-fire and post-fire images identified percentage aspen cover in 30 x 30-meter grid cells. This process provided training data for regression models, which were able to detect aspen across the landscape for both time periods using multiple remote sensing vegetation health indices. In addition, landscape suitability for aspen regeneration was modeled to provide a guide for managers on where to monitor for aspen regeneration post-fire.

***Key Terms:***

Aspen recovery, wildfire, remote sensing, Landsat 8 OLI, Sentinel-2 MSI, SRTM, Random Forest

***National Application Area Addressed:*** Disasters

***Study Location:*** Southern Colorado (between Fort Garland and La Veta, CO)

***Study Period:*** June – October (2017 – 2020)

***Community Concerns:***

* The western United States is facing a future with more frequent and severe wildfire. Communities are concerned about the impacts this will have on forests and the associated services they provide for water quality, wildlife, recreation, carbon storage, and economies.
* Aspen resprouts following a disturbance can be one of the first species to recover after fire. The quick re-establishment of aspen can help stabilize watersheds and serve as important wildlife habitat. Partners at Trinchera Ranch actively manage for aspen and are interested in how their past management and the Spring Creek Fire are shaping forests and aspen in particular.
* The Colorado State Forest Service works with landowners in burned landscapes across the state and is interested in understanding forest resiliency to fire in order to communicate knowledge from past fires to the landowners that they serve.

***Project Objectives:***

* Produce models to recognize and map aspen extent before and after the Spring Creek Fire
* Identify the amount and locations of aspen lost due to the fire
* Model and map areas most suitable for aspen regeneration

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Trinchera Ranch** | Aaron Swallow, Environment and Forest Manager | End User | No |
| **Colorado State Forest Service**  | Dr. Amanda Fordham West, Manager of Science Information  | Collaborator | Yes |

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

Trinchera Ranch and the Colorado State Forest Service have been working to improve forest health and land management in southern Colorado. To track progress towards these management goals, the ranch has utilized costly field observations to monitor fuel loads and forest composition and structure. In addition, these field surveys are spatially limited due to inaccessible, remote terrain. The ranch has implemented a variety of silvicultural treatments to spur aspen regeneration and to protect the aspen from elk browsing. Knowledge of how aspen extent has been impacted by the Spring Creek Fire has supplied the managers and cooperating agencies with information to assist with improving management strategies.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Spectral vegetation indices | Landsat 8 OLI imagery was used to detect aspen before and after the Spring Creek Fire. Seasonally differenced Landsat images will distinguish aspen using its distinct phenology. |
| **Sentinel-2 MSI** | Spectral vegetation indices | Sentinel-2-MSI provided a layer to differentiate between deciduous and coniferous trees if the seasonal difference was unrecognizable. |
| **SRTM** | Elevation, topographic position index, slope, aspect | SRTM topographic indices were utilized in the analysis of aspen recovery patterns. |

***Ancillary Datasets:***

* National Agriculture Imagery Program (NAIP) – aerial 1m imagery was used as a visual reference of past and current forest condition
* Natural Resource Ecology Laboratory Spring Creek fire shapefile – shapefile was used to delineate fire extent in analysis
* NASA DEVELOP burn severity raster created by Fall 2018 Colorado & New Mexico Disasters team – severity raster was used to evaluate changes in aspen extent by burn severity
* Natural Resource Ecology Laboratory forest inventory field data – collected during the summer of 2020 in the Spring Fire Extent, field data were used to train aspen detection models
* U.S. Department of Agriculture Forest Service and U.S. Department of the Interior Landscape Fire and Resource Management Planning Tools (LANDFIRE), Existing Vegetation Cover – vegetation dataset was used to locate pre-fire forest types likely to have an aspen component
* Trinchera Ranch forest management shapefiles – used for validation of aspen regeneration in open areas

***Modeling:***

* Random Forest (RF) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center) – machine learning algorithm used for aspen detection model generation

***Software & Scripting:***

* Esri ArcGIS Pro 2.6.1– image processing and end product generation
* Rstudio 1.2.5 – statistical analyses and raster processing
* Google Earth Engine API – large-scale image analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Pre- and Post-Fire Aspen Extent Maps** | Landsat OLISentinel-2 MSISRTM | These maps of aspen extent just before the fire and two years after will give partners more complete information about aspen extent on the property and how it has changed to guide management and monitoring efforts. | N/A |
| **Aspen Distribution Change Maps** | Landsat OLISentinel-2 MSISRTM | Understanding how the Spring Fire impacted aspen distribution will inform the Trinchera Ranch’s approach to aspen management moving forward. This will provide information about spatial trends in the aspen population. | N/A |
| **Analysis of Aspen Recovery Patterns** | Landsat OLISentinel-2 MSISRTM | This analysis will inform partners about existing topographic and climatic factors that influence aspen occurrence, and allow them to adapt existing management strategies for a changing future climate. | N/A |

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

This project provides valuable data to project partners to characterize post-fire forest recovery, impacts of the Spring Creek Fire on aspen distribution, and potential drivers of these changes. The partners recognize the utility of remote sensing to inform their management and are looking to this partnership with DEVELOP to increase their capacity for incorporating NASA Earth observations into their decision-making processes. The products included comprehensive maps across this difficult-to-access terrain and harness the temporal power of remote sensing to identify pre-fire aspen distribution. This will help end users evaluate the impact of their forest management before and after the fire to promote aspen growth, which is one of their primary objectives. They will also be able to better target forest management moving forward.

**References**

Binkley, D. & Romme, B. (2020). Aspen Next Generation: Conversations from Southern Colorado and Northern New Mexico. *Western Landowners Alliance, https://westernlandowners.org/publication/aspen-next-generation/*