**Colorado Front Range Disasters**

*Understanding the Impact of Forest Management on the Cameron Peak Fire and CalWood Fire*

**Project Team**

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**Project Overview**

***Project Synopsis:***

Recent intense fires in Colorado have emphasized the importance of forest treatments to reduce burn severity. This project evaluated the effect of forest treatments on the Cameron Peak Fire and the CalWood Fire in the summer and fall of 2020. We used Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multispectral Imager (MSI) data to map burn severity, evaluate burn severity in treatment areas, and determine correlations between burn severity and treatment characteristics. The project findings will inform partners and community stakeholders of trends between treatments and burn severity to improve future management efforts, improve community support, and foster more resilient forests.

***Abstract:***

Along the Colorado Front Range, the importance of forest management has gained significant attention due to uncharacteristically intense fires that burned late in 2020. The Cameron Peak Fire, the largest in Colorado’s recorded history, and the CalWood Fire collectively burned an estimated 219,019 acres from August through December of 2020. The partners (Coalition for the Poudre River Watershed, Colorado State Forest Service, the Ben Delatour Scout Ranch, The Nature Conversancy, the Colorado Forest Restoration Institute, and Colorado State University) are interested in understanding the effectiveness of previous forest treatments in reducing fire risk within the Cameron Peak Fire and the CalWood Fire. Firstly, a forest treatment dataset was collated from pre-existing datasets by reclassifying over 29,000 treatments, which occurred across the Colorado Front Range between 1970-2020. Secondly, using Earth observations from Landsat 8 Operational Land Imager (OLI) and Sentinel-2 MultiSpectral Instrument (MSI), burn severity was mapped using three burn indices for each of the two fires and compared to field-derived soil burn severity plots. Thirdly, a total of 35 topographic, disturbance, forest structure, and treatment predictor variables were generated across the fire regions. Finally, random forest algorithms were utilized to assess relationships between predictor variables, treatment categories, and burn severity. Model results indicate that elevation and distance to treatment edge were the primary drivers of burn severity for the Cameron Peak Fire. In contrast, model results indicate that fire area and forest canopy cover were the primary drivers of burn severity for the CalWood Fire. Further analysis of these variables paired with field data is necessary to understand the relationship between burn severity and treatments to guide future restoration efforts, improve forest resiliency, and mitigate fire risks.

***Key Terms:***

Remote sensing, Landsat, Sentinel, SRTM, fire, burn severity, forest treatment, fuel reduction, random forest algorithm

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

***Study Location:*** Northern Front Range, Colorado

***Study Period:***  August 2020 to December 2020

***Community Concerns:***

* Increasing temperatures and fire suppression throughout the 20th century have resulted in large amounts of forest fuels in forests along the Colorado Front Range that put local communities at risk of future fires.
* Colorado experienced the largest fires in Colorado’s history during the 2020 fire season. These fires severely impacted local communities with widespread evacuations, damaged residencies and businesses, dramatically impacted local air quality, and large financial costs for fighting the fires.
* Communities along the Colorado Front Range rely on forests for many ecosystem services, including clean drinking water, recreation, and carbon storage, and these services were severely impacted by the recent fires.
* Increased understanding of forest treatment methods and burn severity needed to assess recent and future fires.

***Project Objectives:***

* Map burn severity of the Cameron Peak Fire and the CalWood Fire utilizing Landsat 8 OLI and Sentinel-2 MSI
* Create a database of forest treatments
* Model the relationship between forest fuel reduction treatments, burn severity, climatic, and topographic variables to determine treatment effectiveness
* Communicate the impacts of wildfire and fuel reduction management across the Colorado Front Range via a StoryMap

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Colorado State Forest Service** | Daniel Beveridge, Wildfire Mitigation Specialist | End User | No |
| **Coalition for the Poudre River Watershed** | Daniel Bowker, Forest and Fire Project Manager | End User | No |
| **The Nature Conservancy, Colorado Chapter** | Rob Addington, Research Scientist | End User | No |
| **Ben Delatour Scout Ranch** | Robert Sturtevant, Conservation Chair | End User | No |
| **Colorado Forest Restoration Institute** | Michael Caggiano, Research Associate | End User | No |
| **Colorado State University, Department of Forest and Rangeland Stewardship** | Wade Tinkham, Assistant Professor | Collaborator | No |

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

Forest restoration work along the Front Range is based on extensive forest ecology research to identify the historic range of variability, fire regimes, and best practices for reducing fire risk. The partners, such as the Coalition for the Poudre River Watershed (CPRW), The Nature Conservancy (TNC), and the Colorado State Forest Service (CSFS), work with landowners, such as the Ben Delatour Scout Ranch (BDSR), to adapt these forest treatments to work within each landowner’s social and economic context. The partners collectively target priority treatment areas, build collaboration networks, and work with landowners and stakeholders to implement best management practices across the region. There have been few opportunities to evaluate the effectiveness of these treatments in slowing the spread of wildfire and reducing burn severity. These fires occurred recently, so partners have not yet had the opportunity and do not have the capacity to formally study the interactions of wildfire and treatments using remote sensing. Lessons learned from the effectiveness of past treatments can be used as these organizations move forward to communicate the importance of their work to stakeholders, adapt forest restoration best practices, and understand areas on the landscape to prioritize for future work.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Burn severity, land disturbance | Landsat 8 OLI was used to produce topographic and land disturbance variables for modelling. |
| **Sentinel-2 MSI** | Burn severity | Sentinel-2 MSI was used to map burn severity using multiple burn indices to be compared to field observations. |
| **Shuttle Radar Topography Mission (SRTM)** | Elevation, topographic position index, slope, aspect | SRTM topographic indices were utilized for analyses of burn severity and in comparisons of treated and untreated areas. |

***Ancillary Datasets:***

* Colorado Forest Restoration Institute Dataset (CFRI) – a compilation of treatments of interest to the forest management community provided by Mike Caggiano at the Colorado Forest Restoration Institute. Used for producing a collated forest treatment dataset.
* Canyon Lakes Ranger District Rx Burns – Shapefile showing location, method, year, and other information about forest treatments. Used for producing a collated forest treatment dataset.
* Colorado State Forest Service Forest (CSFS) Treatment Polygons – Shapefiles showing location, method, year, and other information about forest treatments. Used for producing a collated forest treatment dataset.
* Colorado State University (CSU) Burn Severity Plots – Field plots measuring burn severity in the Cameron Peak Fire. Used to compare and validate burn severity maps produced from remotely sensed data.
* Hazardous Fuel Treatment Reduction – Shapefile showing location, method, year, and other information about forest treatments. Used for producing a collated forest treatment dataset.
* InciWeb Fire Progression Map – Maps showing the daily spread of each fire to understand conditions under which each area burned. Used to create a fire progression variable for modelling burn severity.
* LANDFIRE – Dataset with vegetation, fuel, disturbance, and fire regimes geospatial data. Used to create variables for modelling burn severity.
* LANDFIRE Remap Public Events Geodatabase (Model Ready Events) – Shapefile showing location, method, year, and other information about forest treatments. Used for producing a collated forest treatment dataset.
* Stewardship Mapping and Reporting Tool (SMART) – Shapefile showing location, method, year, and other information about forest treatments. Used for producing a collated forest treatment dataset.
* Sarah Osbourne Dataset – Forest fuel treatment administered by Boulder County, Colorado digitized from paper maps. Used for producing a collated forest treatment dataset.
* United Stated National Elevation Dataset (NED) Topographic Diversity Layer (Conservation Science Partners) – Topographic diversity variable representing the variety of temperature and moisture conditions available to species as local habitats. Used as a predictor layer for modeling burn severity.

***Modeling:***

* Non-parametric machine learning algorithm (POC: Anthony Vorster, Colorado State University) – This algorithm was used to run a regression model to correlate burn severity and forest treatment type across the landscape.

***Software & Scripting:***

* Google Earth Engine – This software was used to map burn severity indices, view, filter, derive and export Landsat 8 OLI, Sentinel-2 MSI, and SRTM imagery.
* RStudio v.1.4.1106 – This software was used to organize and filter data to run non-parametric regression models and general statistical analyses.
* Esri ArcGIS Pro v2.4.0 – This software was used to extract spectral information, visualize model results, and generate map products.

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Use** | **Software Release Category** |
| **Cameron Peak, East Troublesome, and CalWood Fire Burn Severity Maps** | Landsat 8 OLI, Sentinel-2 MSI | Partners will be able to better evaluate the burn severity of the fires with maps that are field-validated. Burn severity maps can be used to inform targeted restoration activities and to inform areas for future research. | N/A |
| **Analysis of Treatment Impact on Burn Severity** | Landsat 8 OLI, Sentinel-2 MSI, SRTM | Partners will gain a better understanding of the efficacy of forest treatments for the studied fires, in addition to the scenarios including weather conditions and topographic positions where treatments can be expected (or not expected) to reduce burn impacts regarding potential future fires. | N/A |
| **ArcGIS Online StoryMap** | N/A | The StoryMap will enable partners to share the team's findings about these fires and about treatment effectiveness with local communities. These visuals will help improve partner communication with a diversity of stakeholders interested in forest management and will help engage the public with ongoing treatment methods. | N/A |

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

The project partners will be mitigating the impacts of these fires through restoration efforts aimed at reducing erosion and facilitating vegetation recovery in critically burned areas. Updated burn severity maps are key for these efforts due to the large spatial footprint of the fires that occurred. Additionally, these end users are working with landowners and stakeholders who were alarmed by these recent fires and will be eager to accelerate forest restoration work to prepare for future fires and improve forest resiliency and recovery. The findings from this project will help inform the type of treatments that should be completed, where they should be targeted, and under what conditions they can be expected to be effective.

**References**

Addington, R. N., Aplet, G. H., Battaglia, M. A., Briggs, J. S., Brown, P. M., Cheng, A. S., Dickinson, Y., Feinstein, J. A., Pelz, K. A., Regan, C. M., Thinnes, J., Truex, R., Fornwalt, P. J., Gannon, B., Julian, C. W., Underhill, J. L., & Wolk, B. (2018). Principles and practices for the restoration of ponderosa pine and dry mixed-conifer forests of the Colorado Front Range. *RMRS-GTR-373. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 121 p.*, *373*.<https://www.fs.usda.gov/treesearch/pubs/55638>

Parks, S. A., Holsinger, L. M., Koontz, M. J., Collins, L., Whitman, E., Parisien, M.-A., Loehman, R. A., Barnes, J. L., Bourdon, J.-F., Boucher, J., Boucher, Y., Caprio, A. C., Collingwood, A., Hall, R. J., Park, J., Saperstein, L. B., Smetanka, C., Smith, R. J., & Soverel, N. (2019). Giving Ecological Meaning to Satellite-Derived Fire Severity Metrics across North American Forests. *Remote Sensing*, *11*(14), 1735.<https://doi.org/10.3390/rs11141735>

Westerling, A. L. (2016). Increasing western US forest wildfire activity: Sensitivity to changes in the timing of spring. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1696), 20150178.<https://doi.org/10.1098/rstb.2015.0178>