**Grand Valley Ecological Forecasting**

*Assessing Trends in Pinyon-Juniper Habitat Relative to Drought, Beetle Infestation, Wildland Fires, And Treatment to Plan Future Management Strategies*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

Drought, beetle infestation, and more frequent fires are causing changes to the landscape of Grand Valley, Colorado. DEVELOP partnered with public land managers in the Grand Valley region to monitor these landscape changes over time. The team used Earth observation data to create time-series maps of pinyon-juniper woodland and sagebrush habitats, along with the location and severity of disturbance events from wildfire and beetle infestation. The team also assessed the impact of management practices implemented by land managers on vegetation recovery after fires.

***Abstract:***

Drought, beetle infestation, and more frequent wildfires are changing the composition and distribution of the pinyon-juniper woodland and sagebrush ecosystems of the Grand Valley in western Colorado. Land managers must consider short- and long-term goals for restoration as well as budgetary and personnel limitations after such disturbances. Satellite remote sensing can provide long-term and continuous vegetation monitoring to assess where restoration is needed most and where treatment practices are most likely to succeed. Harnessing Earth observation data, our team set out to observe trends in disturbances and the distribution of pinyon-juniper woodlands and sagebrush communities of National Park Service (NPS) and Bureau of Land Management (BLM) lands within the Grand Valley. We used imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the Aqua and Terra satellites, and Landsat sensors to map landcover change within these ecosystems from 1984–2021. Additionally, we analyzed disturbed areas and treatment sites to understand their effect on long-term vegetation health and recovery. Results showed that pinyon-juniper woodland has expanded in extent more than other landcover types, indicating woody encroachment into sagebrush ecosystems. We also found that wildfire disturbances had lasting impacts up to 20 years post-disturbance. Pre-fire treatment practices showed mixed results regarding their effectiveness at stopping fires and promoting post-fire recovery. These results will provide context to public land managers in the Grand Valley when developing management plans, ecological monitoring locations, and implementing treatment practices for future disturbances.

***Key Terms:***

land cover change, fire management, pinyon-juniper woodlands, Ips beetle, sagebrush, satellite imagery

***National Application Areas Addressed:*** Ecological Forecasting, Wildfires

***Study Location:*** Grand Valley, CO

***Study Period:*** January 1984 – September 2021

***Community Concerns:***

* Pinyon-juniper woodlands provide wildlife habitat and act as a seasonal foraging area for livestock and large game animals. They also aid with water absorption and erosion control. These valuable ecosystem services are threatened by increasingly severe disturbances in the form of wildfire, beetle infestation, and drought.
* These severe disturbances also threaten the ecosystem services and biodiversity provided by sagebrush habitats, which wildlife like the greater sage-grouse depend on.
* The changing conditions of these habitats aren’t fully understood which poses a challenge for preparing effective management practices that will protect the study area and the surrounding communities.
* Drier and standing dead plants, due to beetle infestation, create higher severity fires, which can top-kill vegetation, leaving burned areas susceptible to invasive plant species like cheatgrass, as well as endangering people and structures within the wildland urban interface.

***Project Objectives:***

* Monitor changes to the geographic extent of pinyon-juniper woodland and sagebrush habitat within the Grand Valley region using Earth observations from 1984 to 2021
* Determine the impact of wildfires and pinyon engraver beetle (*Ips confusus)* infestation on the landscape of the Grand Valley using Earth observations from 1984 to 2021
* Measure the response of pinyon-juniper and sagebrush habitat to fire treatments within the Grand Valley in order to guide future management practices

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Bureau of Land Management, Grand Junction Field Office, McInnis Canyons National Conservation Area** | Nikki Grant Hoffman, Ecologist and Science Coordinator; Emily Latta, Ecologist; Douglas Paul, Fuels Specialist; Marlin Deras, Natural Resource Specialist | End User | No |
| **National Park Service, Colorado National Monument** | Jessica Resnik, Resource Stewardship and Science Division Chief; Arlene Jackson, Chief of Interpretation, Communication and Community Outreach; Robert E. Shaver, Lead Biological Science Technician; Molly Murphy, Natural Resource Specialist | End User | No |

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

Our partners are the Colorado National Monument (COLM), which operates under the National Park Service (NPS), and McInnis Canyons National Conservation Area (MCNCA), which operates under the Bureau of Land Management (BLM). COLM prefers to have as minimal impact on the land as possible, and thus has a “let nature take its course” mindset regarding the environmental issues of wildfire and beetle infestation. Although they prefer minimal landscape interference COLM will consider fuel-reduction and other treatments if they have strong scientific backing. MCNCA do not share this minimalist mindset. All three organizations, however, regularly use Geographic Information Systems (GIS) applications in their decision-making processes, but do not regularly use NASA Earth observations. Our partners operate under the Department of the Interior (DOI), a US government agency, whose policies dictate management regulations of and funding to these areas. Thus, the decision-making process of our partners is influenced by the policies of their mother agency, the DOI, their current resource management philosophies, and the current GIS layers they use, which do not include NASA Earth observations.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Visible and near infrared imagery bands | Bands were used to generate vegetation indices to detect possible beetle-induced disturbance and assess fire impacts. |
| **Landsat 7 ETM+** | Visible and near infrared imagery bands | Bands were used to generate vegetation indices to detect possible beetle-induced disturbance and assess fire impacts. |
| **Landsat 8 OLI** | Visible and near infrared imagery bands | Bands were used to generate vegetation indices to detect possible beetle-induced disturbance and assess fire impacts. |
| **Terra MODIS** | Vegetation indices | Index data were used to measure vegetation response to treatment over time. |
| **Aqua MODIS** | Vegetation indices | Index data were used to measure vegetation response to treatment over time. |

***Ancillary Datasets:***

* Bureau of Land Management, Vegetation Treatments Completed – Perform time series analysis of fuels and vegetation treatment impacts
* Bureau of Land Management, Wildfire Data – Perform time series analysis of fire occurrence and impact and fuels and vegetation treatment impacts
* Bureau of Land Management, National Conservation Areas Boundary Files – Delineate areas of interest within the study area
* Bureau of Land Management, Fuels Reduction Projects – Perform time series analysis of fuels and vegetation treatment impacts
* United States Department of Agriculture (USDA) Landscape Change Monitoring System (LCMS) – Perform time series analysis of landcover change over time and analyze differences in fire response by land cover class
* Rangeland Analysis Platform (RAP) – Perform time series analysis of fractional vegetation cover after fires
* United States Geological Survey, The National Map Download (TNM) v2.0 – Use Digital Elevation Models to create hill-shade of the study area for visualizing terrain
* United States Geological Survey (USGS) Monitoring Trends in Burn Severity (MTBS) Dataset – Create an updated wildfire perimeter map and perform analysis with burn severity information

***Modeling:***

* IDRISI TerrSet Land Change Modeler (POC: Keith Weber, Idaho State University, GIS Training and Research Center) – Model land cover change and pinyon-juniper habitat suitability

***Software & Scripting:***

* Esri ArcGIS Pro 2.9.1 – Digital image processing, geospatial data analysis, and cartography
* IDRISI TerrSet 19.0.5 – Digital image processing and land cover change detection
* R version 4.1.2 – Tabular data manipulation and plotting
* Microsoft Excel 2019 – Tabular data manipulation and plotting

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partners Benefit & Use** | **Software Release Category** |
| **Pinyon-Juniper and Sagebrush Habitat Time-Series Maps** | N/A | These maps will show partners how land cover and habitat suitability changed over time and aid partners in performing their own analyses to inform management decisions at COLM and MCNCA/DENCA. | N/A |
| **Beetle Infestation Time-series Map** | Landsat 5 TM  Landsat 7 ETM+  Landsat 8 OLI | This map will show partners areas where vegetation productivity has declined over time and serve as proxies for possible beetle disturbance locations. Overall, this map will help inform beetle outbreak management. | N/A |
| **Fire Occurrence and Impact Time Series Map** | Landsat 5 TM  Landsat 7 ETM+  Landsat 8 OLI | This map will show partners how fire occurrences have changed vegetation cover over time and help inform fire management decisions. | N/A |
| **Fire Treatment Impact Layers and Maps** | Terra MODIS  Aqua MODIS | These maps will help partners identify which treatment types were more successful in stopping fires, as well as their impacts on post-fire vegetation recovery. These maps will help to inform fuel-management decisions and can be used for future research. | N/A |

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

Our project will benefit end users by adding valuable geospatial data to their GIS projects, which will help to inform management planning. These layers will provide historical evidence of what the landscape looked like and how it has changed in response to disturbances over time, aiding our partners’ natural resource management decisions. These products will also allow partners to see the effectiveness of previous fire treatment. Additionally, partners will be able to use our data for a range of applications, such as forecast modelling or using it as a base map for future analysis. Finally, this research will serve as evidence for future funding proposals to protect and apply pre and post fire treatments in the Grand Valley.

***Project Continuation Plan:***

The second term of the project will build upon the time series analysis performed on pinyon-juniper and sagebrush habitat, beetle infestation, fire occurrence and impact, and fire treatment and impact. We will coordinate a handoff of data that the team in term II of the project can use as training data for forecast modelling. This will be done through ISU’s Z drive and the data will be compatible with IDRISI TerrSet and ArcGIS Pro. If there are no returning team members next term, we will designate a current team member to communicate with the new team for concerns or questions.

**References**

Brewer, K. C., Winne, J. C., Redmond, R. L., Opitz, D. W., & Mangrich, M. V. (2005). Classifying and Mapping Wildfire Severity. *Photogrammetric Engineering & Remote Sensing*, 11, 1311–1320. https://www.asprs.org/wp-content/uploads/pers/2005journal/nov/2005\_nov\_1311-1320.pdf

Colorado Natural Heritage Program. (2018). *Pinyon-juniper: Impacts and adaptation strategies in a changing climate.* 17 pp.

Grant-Hoffman, M. N., Lincoln, A., & Dollerschell, J. (2018). Post-fire native seed use in western Colorado: a look at burned and unburned vegetation communities. *Natural Areas Journal,* 38(4), 286-297. https://doi.org/10.3375/043.038.0409

Grant-Hoffman, M. N., & Dollerschell, J. (2019). Post-fire vegetation communities in western Colorado. *Native Plants Journal*, *20*(3), 226–238. https://doi.org/10.3368/npj.20.3.226

Grant-Hoffman, M. N., & Plank, H. L. (2021). Practical postfire sagebrush shrub restoration techniques. *Rangeland Ecology & Management*, 74, 1-8. <https://doi.org/10.1016/j.rama.2020.10.007>

Miller, R. F., Chambers, J. C., Evers, L., Williams, C. J., Snyder, K. A., Roundy, B. A., & Pierson, F. B. (2019). *The ecology, history, ecohydrology, and management of pinyon and juniper woodlands in the Great Basin and Northern Colorado Plateau of the western United States.* General Technical Report RMRS-GTR-403. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 284 p., 403. https://doi.org/10.2737/RMRS-GTR-403

Roundy, B. A., & Vernon, J. L. (1997). Watershed Values and Conditions Associated with Pinyon-Juniper Communities. *Proceedings: Ecology and Management of Pinyon-Juniper Communities within the Interior West*.