**Grand Valley Ecological Forecasting II**

*Forecasting Trends in Pinyon-Juniper and Sagebrush Habitat Relative to Wildfire, Drought, Beetle Disturbance, and Treatment Impact for Management Planning*

**Project Team**

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**Project Overview**

***Project Synopsis:***

Colorado’s Grand Valley region is comprised of pinyon-juniper woodlands (PJW) and sagebrush ecosystems, which provide habitat and ecosystem services to the area. These ecosystems are under threat from wildfires, climate change, and bark beetle infestations. The vegetative habitats of the area are represented across much of the Western United States and the region is part of a broader area under threat of landcover change. This project used NASA Earth observation data to forecast potential trajectories of the ecology of the region and to assess the effectiveness of past management solutions.

***Abstract:***

Disturbances and landcover change in pinyon-juniper and sagebrush ecosystems are enhanced by environmental conditions such as variability in climate characteristics. Our DEVELOP team partnered with the National Park Service (NPS) in Colorado National Monument and the Bureau of Land Management (BLM) in McInnis Canyons and Dominguez-Escalante National Conservation Areas to investigate these disturbances. NPS partners were interested in identifying areas at risk of pinyon-juniper die-off or encroachment by invasive species. The BLM partners prioritized identifying areas suitable for fire prevention treatment. To address these concerns, we forecasted landcover change in the Grand Valley region of Colorado. We used NASA Earth observation data, from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper (ETM+), Landsat 8 Operational Land Imager (OLI) and Moderate Resolution Imaging Spectroradiometer (MODIS) aboard Terra and Aqua, collected and analyzed in conjunction with Term I of this project. We found that the primary driver variables for forecasted landcover change in the study area were aspect and elevation. Our forecasted landcover change maps, created using the Idrisi TerrSet Land Change Modeler, addressed the needs of both partner organizations by showing potential habitat suitability trends, which will inform management planning. Forecasted land cover maps indicated that by 2040, ecosystems within partner management perimeters will likely see tree encroachment on shrublands.

***Key Terms:***

ecology, land cover change, remote sensing, TerrSet LCM, Ips beetle, MODIS, Landsat, pinyon-juniper woodlands, sagebrush, satellite imagery

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

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

***Study Period:*** 1985-2021, Forecasting to 2040

***Community Concerns:***

* Loss of PJW and sagebrush habitats present in Grand Valley will lead to loss of native fauna, which are critical for the function of the ecosystem as a whole, and could lead to the encroachment of invasive plant species. These habitats also play a critical role in stabilizing soil and regulating soil water content, providing habitat for the various fauna of the region and facilitating living conditions for perennials and forbs.
* PJW and sagebrush provide rural communities with protection from erosion, stabilization of water content, and heat abatement, which assist in maintaining their ways of life. The loss of this habitat due to beetle infestation or fire would impact community infrastructure and damage homes.
* Due to the wide distribution of PJW and sagebrush habitat in conjunction with climate change, increased threat of wildfires and bark beetle infestation are expected across the American West, which also threaten native wildlife and community infrastructure.

***Project Objectives:***

* Forecast landcover changes in pinyon-juniper woodlands and sagebrush habitat and map forecasted land cover change of pinyon-juniper and sagebrush habitats that include historical fire impact, fuels treatment impact, and potential beetle kill
* Verify possible beetle infestation locations identified in Term I using partner field surveys and high spatial resolution aerial and satellite imagery
* Evaluate threats of bark beetle infestation and wildfire based on environmental variables such as temperature, precipitation, and solar radiation

***Previous Term:***

2022 Spring (ID) – Grand Valley Ecological Forecasting I

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Boundary Org** |
| **National Park Service, Colorado National Monument** | Molly Murphy, Natural Resource Specialist; Jessica Resnik, Chief of Resource Stewardship and Science; Arlene Jackson, Chief of Interpretation, Education and Community Outreach; Eric Shaver, Lead Biological Science Technician | End User | No |
| **Bureau of Land Management, McInnis Canyons and Domingues-Escalante National Conservation Areas** | Nikki Grant Hoffman, Ecologist and Science Coordinator; Marlin Deras, Natural Resource Specialist; Emily Latta, Ecologist | End User | No |

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

Staff at Colorado National Monument (CNM) generally follow the NPS philosophy of “letting nature take its course” when making land management decisions. This includes minimal human intervention to mitigate future disturbances such as beetle infestation and fires. Though the NPS has a large number of seasonal workers and volunteers, managers are generally restricted in what actions they can take. The NPS is more interested in knowing what changes they can expect over time and not necessarily what action they can take to prevent it. However, they may consider monitoring and treating disturbances such as invasive plants to mitigate fire risk. Staff at both McInnis Canyons and Dominguez-Escalante National Conservation Areas MCNCA/DENCA follow the BLM philosophy of “multiple use and sustained yield” to ensure that the land is used in such a way that its resources remain viable for future use. The BLM allows use access to the public with proper permitting. The large amount of acreage managed by the BLM makes mitigation and treatment of fires more difficult. The CNM and NCAs frequently employ GIS data and are currently seeking to incorporate GIS layers that include NASA satellite data alongside other datasets already in use to update their wildland resource and fire management practices.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | NDVI,  NDMI,  NDWI  MASAVI2 | Spectral vegetation indices including Normalized Differenced Vegetation Index (NDVI)were used to train a model for forecasted land cover maps. |
| **Landsat 7 ETM** | NDVI,  NDMI,  NDWI  MASAVI2 | Spectral vegetation indices including NDVI were used to train a model for forecasted land cover maps. |
| **Landsat 8 OLI** | NDVI,  NDMI,  NDWI  MASAVI2 | Spectral vegetation indices including NDVI were used to train a model for forecasted land cover maps. |
| **Terra MODIS** | NDVI | NDVI was used to train models for forecasting landcover change. |
| **Aqua MODIS** | NDVI | NDVI was used to train models for forecasting landcover change. |
| **SRTM** | Aspect | Aspect was used to train models for forecasting landcover change. |

***Ancillary Datasets:***

* The National Solar Radiation Database; Global Horizontal Irradiance, Direct Normal Irradiance –Raster data of solar radiation levels in 4km resolution | for training landcover forecasting models to produce landcover change maps
* United States Department of Agriculture Landscape Change Monitoring System – Raster data of landcover types | for training landcover forecasting models to produce landcover change maps
* National Centers for Environmental Information NOAA; NOAA Monthly U.S. climate Divisional Database – Historical temperature and precipitation raster data in 5km resolution | for training landcover forecasting models to produce landcover change maps
* National Park Service, Colorado National Monument; Vegetation Type Presence data – Park-provided vegetation data | for training landcover forecasting models to produce landcover change maps
* BLM National NLCS National Monuments, National Conservation Areas and Similar Designations Polygons – Geodatabase of National Conservation Area boundaries | for training landcover forecasting models to produce landcover change maps

***Modeling:***

* Idrisi TerrSet Land Change Modeler (Contact: Keith Weber, ISU GIS TreC) – Model land cover change and pinyon-juniper habitat suitability
* Random Forest Regressor – Provide supplementary forecasts and determine the drivers of ecological change in the pinyon juniper habitat. The R package CARET was used to implement Random Forest Regressor.

***Software & Scripting:***

* Esri ArcGIS Pro 2.9.3 - Data preprocessing and forecast visualization
* R 4.2.0 - Data preprocessing and machine learning model application
* Idrisi TerrSet- Land cover change modeling and pinyon-juniper habitat suitability

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Forecasted Pinyon-Juniper & Sagebrush Habitat Maps** | Landsat 5 TM  Landsat 7 ETM  Landsat 8 OLI  Terra MODIS  Aqua MODIS | These maps show partners forecasted land cover change for up to 20 years following disturbances. Forecasted land cover change maps will help inform management decisions at CNM and MCNCA/DECNA in regard to mitigating wildfire and beetle infestation risk. | N/A |
| **Forecasted Land Cover Change & Habitat Suitability Layers** | Landsat 5 TM  Landsat 7 ETM  Landsat 8 OLI | These layers can assist partners at CNM and MCNA/DECNA in interacting with the data in ArcGIS and can be reused in future projects to perform ongoing analysis of environmental trends. Layers will be packaged together by agency-specific needs and requests. | N/A |
| **Land Cover Change & Habitat Suitability Forecasting Tutorial** | N/A | This written tutorial provides partners with instructions on how to create forecasted land-cover change maps for continued use in management following the conclusion of the term. | N/A |

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

Our results will assist the NPS and BLM in managing their respective parcels within Grand Valley, CO. This benefits both CNM and MCNCA/DENCA by allowing them to visualize historical and forecasted changes in the extent of pinyon-juniper woodlands and sagebrush stands as well as general landcover changes. The NPS, in line with their more hands-off strategy, can utilize the geodatabase provided and interact with or update the GIS layers in combination with their own Earth observation data and field surveys to inform management.

**References**

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