**Gila Water Resources**

*Using Earth Observations to Track Watershed Recovery After Wildfires in the Gila National Forest*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:*** In recent years, New Mexico has experienced an increased frequency of severe wildfires, including the Whitewater-Baldy Complex Fire in 2012 and the Silver Fire in 2013. These wildfires cause drastic changes in hydrological functions in the Gila National Forest (Gila NF), affecting a wide variety of ecosystem components, such as the biodiversity of the immediate area and water quality downstream. This study assessed watershed recovery within the Gila NF following the 2012 and 2013 wildfires. This study aims to provide Gila NF with tools that inform management practices and restoration efforts.

***Abstract:***

The largest fire in New Mexico’s recorded history, the Whitewater-Baldy Complex Fire, occurred in 2012 in the Gila National Forest (Gila NF). Then, in 2013, the Silver Fire broke historic records for destruction of private property. These disturbances have become more frequent, more severe, and are powerful forces of landscape change. Fire disturbances prompt serious concern over associated impacts, such as post-fire flooding, erosion, debris flows, and the ability of the Gila NF to provide essential goods and services, including safe drinking water and timber. Understanding the impacts of interrelated disturbances on watershed recovery dynamics is increasingly important to ensure future health and function of watershed ecosystems. This project partnered with the US Department of Agriculture (USDA) US Forest Service’s (USFS) Gila National Forest and Region 3 to explore watershed recovery trends following wildfires. The purpose of this project was to generate data-supported knowledge to inform land management decisions and planning, including the prioritization of specific regions for restoration efforts. To evaluate the watershed recovery phenomena in the Gila NF, this project used a combination of local knowledge and Earth observations, including Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI). Normalized Burn Ratio (NBR) was the index used to evaluate recovery trends over time. Additionally, the team used USGS stream gauge data to evaluate the relationship between wildfires and flood events observed in the years following fire disturbances. Finally, potentially significant physical and environmental parameters were collected in a spatial database for use in subsequent studies.

***Keywords:*** wildfire, normalized burn ratio, watershed scale, Landsat, restoration ecology, flooding

***National Application Areas Addressed:*** Water Resources, Disasters

***Study Location:*** Gila National Forest, NM

***Study Period:*** May 1998 to September 2018

***Community Concerns:***

* Wildfire events are correlated with other ecological impacts, including vegetation loss, soil erosion, flooding, sedimentation, and debris flows.
* Disturbances drive change in the Gila NF and can negatively influence ecosystem function and provision of goods and services, such as access to clean water.
* Disturbances in upstream ecosystems affect communities downstream of the Gila NF watershed due to increased sedimentation and reduced water quality.
* Effective land management practices rely on understanding interrelated processes and their recovery repercussions. Without knowledge of the watershed-level wildfire impacts, forest managers are limited in their ability to plan effective restoration efforts.

***Project Objectives:***

* Utilize Earth observations and local data to determine watershed recovery trends and quantify these trends based on Normalized Burn Ratio (NBR) within Gila National Forest
* Conduct a relational study about recovery within discrete areas (i.e. riparian, forest, and severe burn areas), and create maps and tabular data displaying these relationships
* Determine whether streamflow is a viable metric for evaluating watershed recovery after fire disturbances and whether a correlation between flood and fire events can be identified
* Compile relevant environmental and physical data for future studies

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **USDA, US Forest Service, Gila**  **National Forest** | Carolyn Koury, Hydrologist; Mike  Natharius, Soil Scientist; Nessa  Natharius, Soil Scientist/Ecologist | End User | Yes |
| **USDA, US Forest Service,**  **Region 3** | Jack Triepke, Regional Ecologist; Bart  Matthews, Photogrammetry Program  Specialist; Anna Jaramillo, Regional Watershed Improvement Program and Burned Area Emergency Response Coordinator | End User | Yes |

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

The US Department of Agriculture (USDA) US Forest Service’s (USFS) Gila NF and Region 3 have used Landsat data provided by the regional office for vegetation mapping and for other purposes of natural resource analysis and inventory as well as US Geological Survey (USGS) data. More recently, the Region 3 office provided Gila NF with high-resolution aerial imagery. The Forest Service also has a host of analysts and cartographers mapping and cataloging fire disturbances. Otherwise, condition assessments and land management decision-making practices are site-specific and are informed largely by local knowledge, observational survey, and some *in situ* restoration monitoring and data collection. While the USFS Gila NF and Region 3 have several methods for documenting immediate landscape changes following wildfires, relatively few operational tools are in place to look at medium to long-term increments. USFS Gila NF also lacks a method for estimating recovery at the watershed scale.

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

Tools that enable more informed decision-making at the watershed scale will allow for more effective land management and planning, such as vegetation restoration within the Gila NF. These efforts benefit both the forest and downstream users. USFS Gila NF will use this project’s resultant recovery maps and spatial analysis to identify recovery trends at the forest or watershed (US Hydrologic Unit Code – 12) scale. With these results, inferences may be made about which areas would benefit from seeding, mulching, and other restoration practices. Additionally, understanding some of the factors that significantly impact recovery will allow managers to proactively manage or plan mitigation interventions.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 5 TM** | Spectral vegetation  indices | Landsat 5 TM data were used to identify change  in historical vegetation presence at the watershed scale. The NBR was calculated and used as a proxy for changes in vegetation and soil condition. |
| **Landsat 7 ETM+** | Spectral vegetation  indices | Landsat 7 ETM+ data were used to identify change in historical vegetation presence at the watershed scale. The NBR was calculated and used as a proxy for changes in vegetation and soil condition. |
| **Landsat 8 OLI** | Spectral vegetation  indices | Landsat 8 OLI data were used to identify change  in historical vegetation presence at the watershed scale. The NBR was calculated and used as a proxy for changes in vegetation and soil condition. |
| **SRTM V3** | Slope, elevation | SRTM V3 slope and elevation data were used to create a database of habitat parameters related to watershed recovery. |

***Ancillary Datasets:***

* USGS National Hydrography Dataset – Surface hydrology
* USGS National Land Cover Database Land Cover Collection – Land cover classifications
* USGS National Water Information System – Historical and current water data including in situ

streamflow

* USFS Riparian Delineation Dataset – Riparian areas
* USFS Terrestrial Ecological Unit Inventory – Description, classification mapping, and interpretation

of ecological types

* US Forest Service Monitoring Trends in Burn Severity Data – Burn severity and fire extent
* Natural Resources Conservation Service Soil Survey Geographic Database – Derived soil type
* World Wildlife Fund Hydrological Data and Maps Based on Shuttle Elevation Derivatives at

Multiple Scales - Stream flow accumulation

***Software & Scripting:***

* Google Earth Engine API – Large scale image processing and analysis, land cover classification, platform creation
* Esri ArcGIS Map 10.7.1 – Map creation and imagery analysis
* R – Statistical computing and graphics for dissemination of results

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Watershed Maps of Gila NF Landcover Baseline and Post-Fire Time Series (Using Normalized Burn Ratio Metric)** | Landsat 5 TM  Landsat 7 ETM+  Landsat 8 OLI | Partners will use this map to identify changes in the watershed pre- and post-fire. This will help determine the current watershed recovery trends. | N/A |
| **Map of Relative Watershed Recovery within Gila NF** | Landsat 7 ETM+  Landsat 8 OLI | Partners will use this map to identify regions with greater recovery potential based on historic recovery trends. This will allow the partner to focus restoration efforts throughout the watershed based on recovery potential. | N/A |
| **Database of Environmental Variables Influencing Recovery Dynamics** | Landsat 7 ETM+  Landsat 8 OLI  SRTM | Partners and subsequent DEVELOP team members will use this information to identify environmental factors, such as flooding events, which may be statistically significant to watershed recovery. This will help identify tools for mitigating fire damages in the future. | N/A |

**Project Handoff Package**

***Transition Plan:*** In week 9, our team presented the Gila Water Resources project at USDA USFS headquarters in Washington, D.C. and included the USFS Gila NF team in New Mexico via webinar. The team reviewed the project’s process, findings, and products. Team members presented map results illustrating recovery to date within the watershed and recovery potential. The team also presented the table of environmental variables related to recovery and plots illustrating streamflow dynamics following fire events. ArcGIS maps and map layers were organized into a database. Other data and deliverables were transferred to partners via online file sharing.

***Project Continuation Plan:*** A second term will focus on the completion of a watershed recovery interactive platform. The aim of the platform is to model recovery using the difference in NBR, condition maps, and the environmental variables database created in this term. High resolution imagery has been downloaded for the second term. The team will be able to use imagery to validate recovery assessments. Known recovered pixels can be used as data points to train predictive recovery models. The project will culminate in the creation of a user-friendly dashboard that will allow USDA USFS to identify changes in watershed condition before and after the recent wildfires and predict future recovery. All products will be handed off at the end of the term via web training, allowing the USDA USFS to replicate the methodologies implemented.

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***Handoff Package:***

* Project Summary
* Technical Paper
* Poster
* Presentation
* Watershed Recovery Maps and Tabular Data (based on timeseries analysis)
* Database of Related Environmental Variables

**References**

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