



Colorado & New Mexico Water Resources

Mapping Wetland and Riparian Areas to Support Rio Grande Cutthroat Trout Habitat Restoration

Project Team

Project Team:

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Project Overview

Project Synopsis: Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) have been reintroduced to the Costilla Creek watershed in Colorado and New Mexico as part of the largest native trout restoration project in North America. However, continued conservation efforts are needed to ensure the success of the trout population and provide quality habitat. This NASA DEVELOP team mapped and classified wetland and riparian areas in the Costilla Creek watershed with remotely sensed environmental parameters to determine the locations of viable trout habitat. This information enabled the project partners to effectively target future conservation efforts.

Abstract:

Over the last century, the Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*; RGCT) population has declined significantly due to habitat loss, competition, and hybridization with non-native trout species; the species currently occupies roughly 11% of its historic habitat. Conservation efforts led by governmental and private actors have succeeded in increasing RGCT populations since the early 2000s. Vermejo Park Ranch, a privately owned 560,000-acre property, partnered with US Fish and Wildlife Service and Colorado Parks and Wildlife (CPW) to begin the largest native trout restoration initiative in North America. Since 2002, these efforts have included wetland and riparian area restoration and RGCT reintroduction. Current restoration efforts focus on restoring the Costilla Creek Watershed to provide cool water temperatures, improve water quality, and create the necessary habitat requirements for the trout species. To guide these restoration efforts, the Colorado – Fort Collins NASA DEVELOP team produced maps to locate and characterize wetland and riparian areas in the Costilla Creek watershed. The team utilized NASA data from Landsat 8 Operational Land Imager, and Landsat 5 Thematic Mapper in conjunction with Sentinel-2 MultiSpectral Instrument, Sentinel-1 Synthetic Aperture Radar, and additional ancillary data for May 2016 to October 2019. In order to produce probability maps of wetland presence, the team used the Software for Assisted Habitat Modeling (SAHM) incorporating predictor variables generated from topographic indices, spectral indices, and radar. The resulting maps allowed Vermejo Ranch and CPW to determine the extent of possible RGCT habitat and identify where habitat restoration efforts are needed.

Keywords:

remote sensing, wetlands, classification, Landsat, Sentinel, Tasseled Cap, NDVI

National Application Area Addressed: Water Resources

Study Location: Costilla Creek Watershed, CO and NM

Study Period: April 2010 to October 2019

Community Concerns:

- The Rio Grande cutthroat trout holds high ecological importance to the southwestern United States. It is listed as a “Species of Concern” in Colorado and is both the state fish and “Species of Greatest Conservation Need” in New Mexico.
- Threats to this species include hybridization and competition with artificially stocked trout species, recreational fishing, habitat fragmentation, extended drought, and wildfires. The changing climate is expected to exacerbate many environmental threats.
- The current habitat of the Rio Grande cutthroat trout is 11% of its historic range. Conservation efforts led by governmental and private actors have successfully restored another 18-30 miles of habitat for genetically pure Rio Grande cutthroat trout.
- A more comprehensive understanding of the available habitat in the upper headwaters of the Costilla Creek Watershed is needed to further extend habitat restoration.

Project Objectives:

- Delineate wetland locations across the Costilla Creek Watershed.
- Classify wetlands based on useful properties for cutthroat trout habitat such as perennial flow, pool to riffle ratio, the density of riparian vegetation, and available shading.

Partner Overview

Partner Organizations:

Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?
Colorado Parks & Wildlife	Estevan Vigil, Aquatic Biologist	End User	Yes
Vermejo Park Range	Sara Holm, GIS Specialist/Energy Les Dhaseleer, Natural Resources Manager	End User	No

Decision-Making Practices & Policies:

Colorado Parks and Wildlife (CPW), and Vermejo Park Ranch have led the effort on the largest restoration project of Rio Grande cutthroat trout in North America. Vermejo Ranch, in collaboration with CPW, has restored approximately 18-30 miles of riparian cutthroat trout habitat and continues to monitor water quality and aquatic insect composition. CPW has monitored and restocked Rio Grande cutthroat trout throughout the region on many tributaries of the Rio Grande, including the East and West Forks of Costilla Creek and Willow Creek. Sampling conducted in 2003 estimated a self-sustaining cutthroat trout population in Willow Creek. Previous research efforts located and classified wetlands and riparian areas on the New Mexico side of the ranch using from the National Agriculture Imagery Program, National Wetlands Inventory, Google Earth imagery, and field-verified observations; however, the Colorado side of Vermejo Park Ranch has not been mapped using remote sensing. Field observations are the only data source for the type and range of habitat in the vital headwaters of Colorado, which feed the tributaries on the New Mexico side of the ranch. These field observations are time-consuming, expensive, and can be hazardous.

Project Benefit to End User:

A wetlands map targeting areas of high priority for restoration/protection at the headwaters of the Costilla Creek Watershed had not previously been created. This product will save the end user time and money spent on accessing the headwaters by foot in search of wetland habitat and cutthroat trout in the streams. These remote areas are difficult to access and may be unsafe for field observers due to inclement weather and

dangerous animals such as mountain lions, which stopped a field exploration mission in 2015. Understanding the available habitat in these areas will allow for increased conservation of the Rio Grande cutthroat trout species as well as improved habitat restoration efforts. Overall, the end user will be able to use the maps produced by the NASA DEVELOP team to examine the extent of current and potential Rio Grande cutthroat trout habitat and identify areas in need of restoration.

Earth Observations & End Products Overview

Earth Observations:

Platform & Sensor	Parameters	Use
Landsat 8 OLI	Surface reflectance	Landsat 8 OLI was used to identify wetland and riparian spectral signatures between 2013 and 2019. A combination of these signatures was then used to feed into SAHM as predictive variables for wetland maps.
Sentinel-1 C-SAR	Radar, polarizations	Sentinel-1 C-SAR was used to identify water bodies by the polarization of the radar frequency. This allowed the team to better classify perennial wetlands.
Sentinel-2 MSI	Surface reflectance	Sentinel-2 MSI was used to identify wetland and riparian spectral signatures. A combination of these signatures was then used to feed into SAHM as predictive variables for wetland maps.

Ancillary Datasets:

- US Fish and Wildlife Service National Wetlands Inventory (NWI) – Point training, classification, and ocular assessment
- United States Department of Agriculture (USDA) National Hydrologic Dataset (NHD) – Point training and classification
- USDA National Agriculture Imagery Program (NAIP) – High-resolution imagery for ocular assessment
- Vermejo Ranch Rio Grande Cutthroat Trout 2018 and 2002 Sampling Points – Point training data
- Oregon State University Parameter-elevation Regressions on Independent Slopes Model (PRISM) Climate Group – Climate data for determining years from which to collect imagery
- USDA SNOwpack TELemetry (SNOTEL) Network – Climate data for determining years to collect imagery for
- United States Geological Survey National Elevation Dataset (NED) – Raster elevation data used to identify wetlands and riparian areas using topographic variables

Modeling:

- Software for Assisted Habitat Modeling (SAHM) (POCs: Catherine Jarnevich, US Geological Survey & Peder Englestad, Colorado State University) – Assess the viability of the Generalized Linear Model, Boosted Regression Tree, Random Forest, and Multivariate Adaptive Regression Splines models to represent the wetlands and riparian areas within Vermejo Ranch

Software & Scripting:

- R 3.4.3 – SNOTEL and PRISM climate data analysis and graphing
- Google Earth Engine – Exporting Landsat and Sentinel imagery to SAHM, tassell-cap classification
- Esri ArcMap 10.6.1 – Digital elevation modeling, map creation and compilation
- QGIS 3.8.3 – Map creation and compilation

End Products:

End Products	Earth Observations Used	Partner Benefit & Use	Software Release Category
Riparian and Wetland Area Maps	Landsat 8 OLI Sentinel-1 C-SAR Sentinel-2 MSI	Enabled Vermejo Ranch and Colorado Parks and Wildlife to identify areas for habitat restoration.	I
Hydrological and Topographic Wetland and Riparian Area Classification Map	Landsat 8 OLI Sentinel-1 C-SAR Sentinel-2 MSI	Enabled Vermejo Ranch and Colorado Parks and Wildlife to discern potential wetland and riparian habitats suitable for Rio Grande cutthroat trout monitoring and reintroduction.	I
Two Page Project Flier	N/A	Efficiently communicates project summary and findings to Vermejo Ranch and Colorado Parks and Wildlife in a reader-friendly format.	N/A

Project Handoff Package

Transition Plan: At the end of the term, the team hosted a web-based seminar with the project partners. The team presented the final wetlands presence and classification maps to the partners and answered project partners' questions.

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Handoff Package:

- Riparian and Wetland Area Maps
- Hydrological and Topographic Wetland and Riparian Area Classification Map
- Two Page Project Flier
- Technical Report

References

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