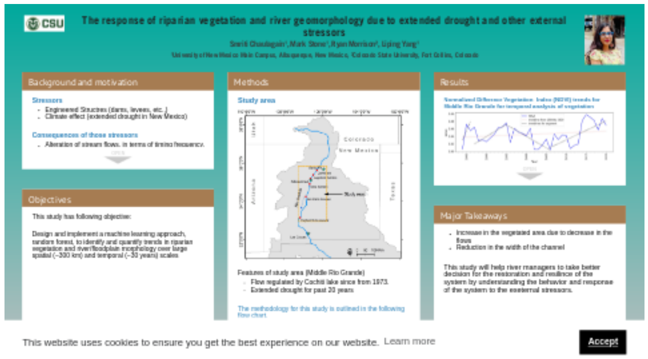
The response of riparian vegetation and river geomorphology due to extended drought and other external stressors



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PRESENTED AT:

BACKGROUND AND MOTIVATION

Stressors

- Engineered Structres (dams, levees, etc.,)
- Climate effect (extended drought in New Mexico)

Consequences of those stressors

- Alteration of stream flows, in terms of timing frequency, magnitude and duration of high and low flows
- Effects on recruitment of vegetation
- Non-native vegetation species replacing native vegetation
- Reduction in the mobility of sediments changing the channel geomorphology

Motivation of Monitoring riparian vegetation and river geomorphology

Riparian vegetation and river geomorphology takes time to show the changes and to reach the equilibrium condition. To observe the changes and to understand the behavior of the system due to external stressors, long term observation is essential. The challenging part is the availability of long term data and the computation speed. However, the availability of big datasets (e.g. Landsat satellite images) in the cloud based platform like Google Earth Engine with cloud computation capability has overcome this limitation. This led us to have spatiotemopral monitoring of riparian vegetation and geomorphology.

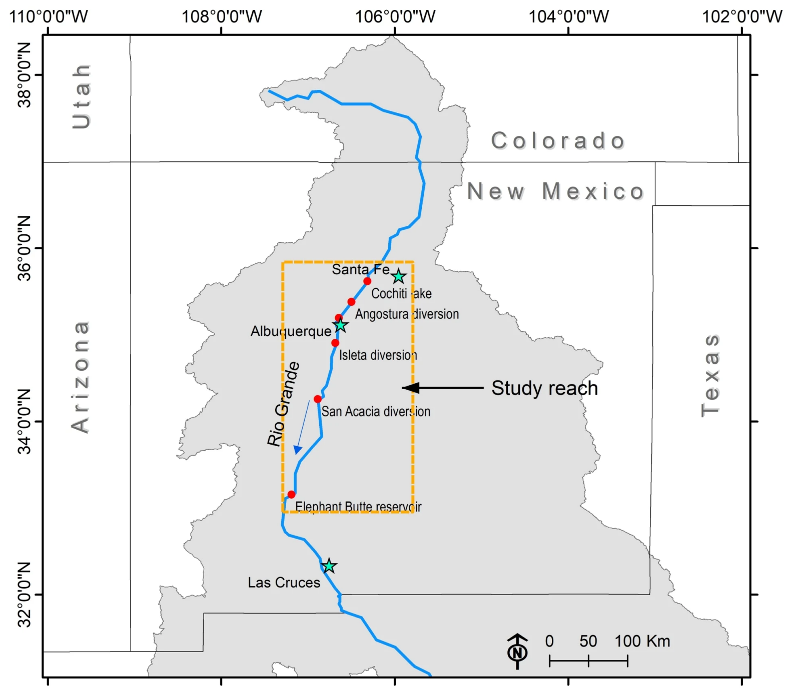
OBJECTIVES

This study has following objective:

Design and implement a machine learning approach, random forest, to identify and quantify trends in riparian vegetation and river/floodplain morphology over large spatial (~300 km) and temporal (~30 years) scales

METHODS

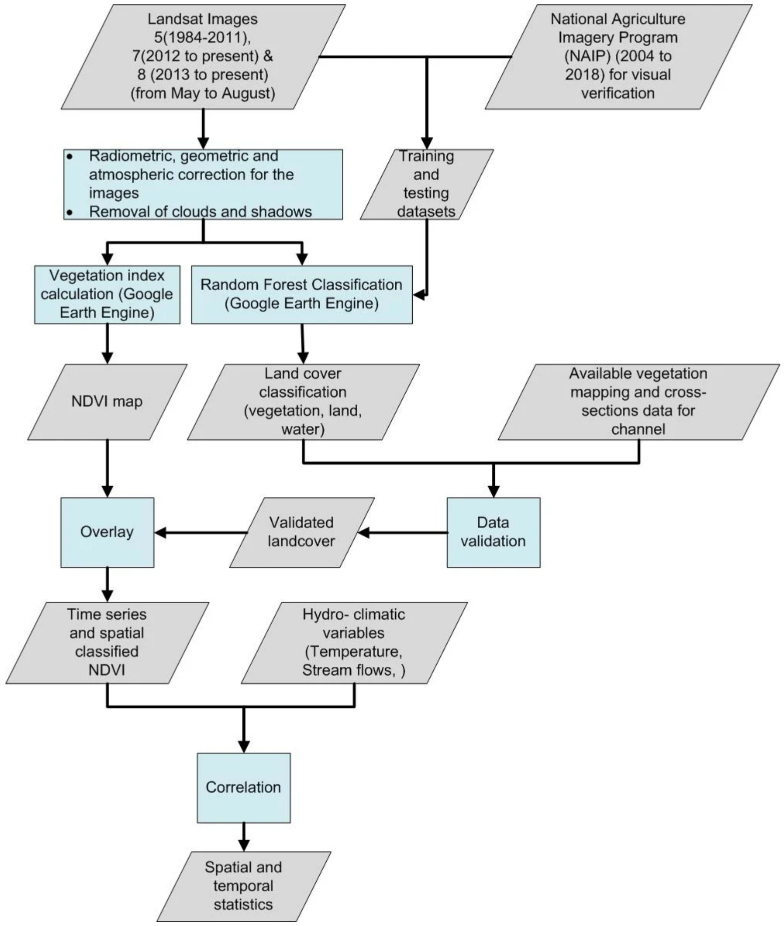
Study area



Features of study area (Middle Rio Grande)

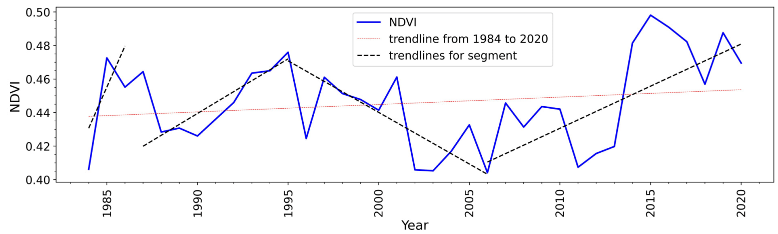
- Flow regulated by Cochiti lake since from 1973.
- Extended drought for past 20 years

The methodology for this study is outlined in the following flow chart.


Landsat Images 5(1984-2011), 7(2012 to present) & 8 (2013 to present) (from May to August)
National Agriculture Imagery Program (NAIP) (2004 to 2018) for visual verification
Radiometric, geometric and atmospheric correction for the images
Removal of clouds and shadows
Training and testing datasets
Vegetation index calculation (Google Earth Engine)
Random Forest Classification (Google Earth Engine)
NDVI map
Land cover classification (vegetation, land, water)
Available vegetation mapping and cross-sections data for channel
Overlay
Validated landcover
Data validation
Time series and spatial classified NDVI
Hydro- climatic variables (Temperature, Stream flows,)
Correlation
Spatial and temporal statistics

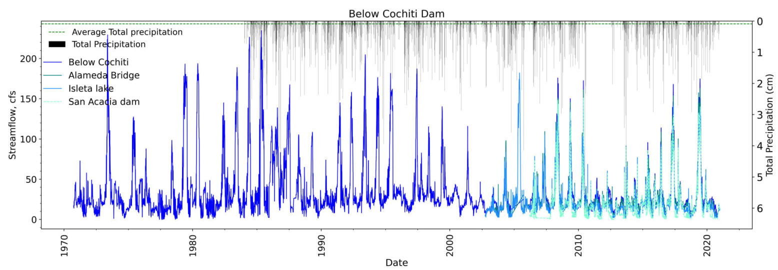
RESULTS

Normalized Difference Vegetation Index (NDVI) trends for Middle Rio Grande for temporal analysis of vegetation



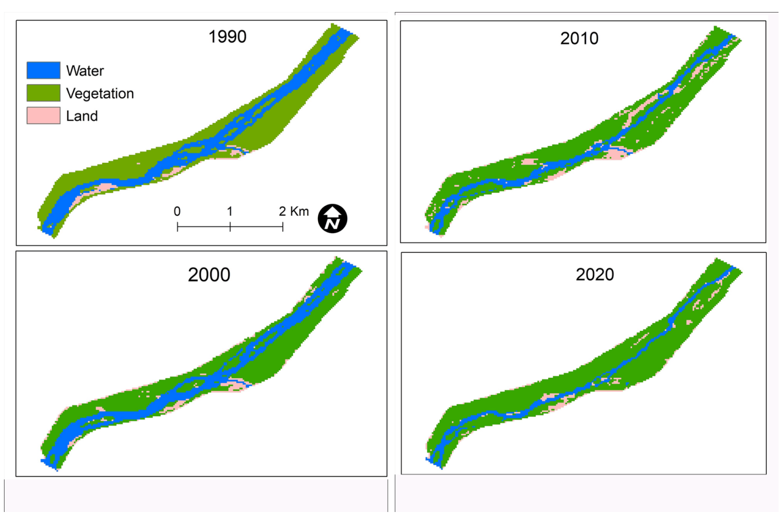
- Non-parametric Mann Kendall test for trendline of NDVI
- No significant trend from 1984 to 2020
- No significant trend from 1984 to 1987, increasing trend from 1987 to 1995 and 2006 to 2020 and decreasing trend from 1995 to 2006

Stream Flows for different four gaguing stations and the precipitation for one station

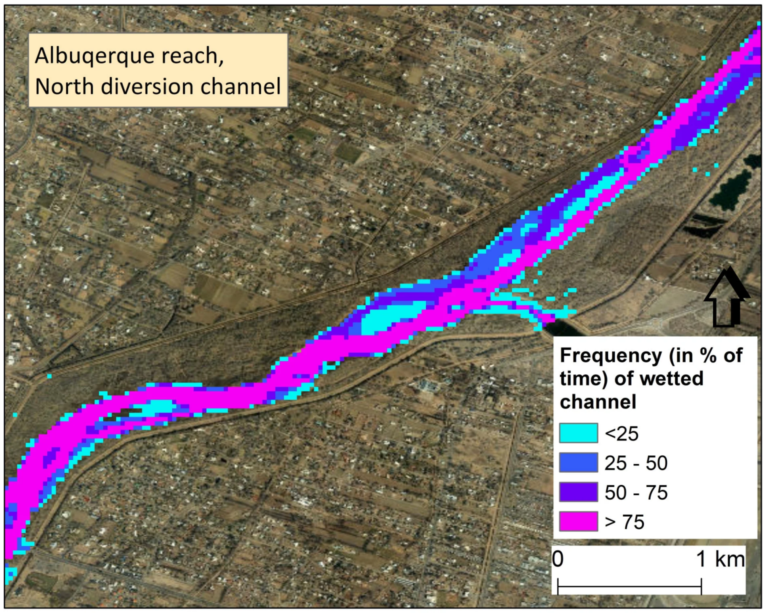


- 1984 to 1999 had enough flows to inundate the floodplain vegetation
- Drought from 1999 to 2020 with reduced flows i.e. reduction in the frequency, duration and magnitude of high flow pulses (for removing encroached vegetation) and low flow pulses (for dispersal and recuitment of seedlings)

Spatial variation of vegetation for sub-reach scale



Spatial variation channel geomorphology (sub-reach scale): Frequncy of occurance (in percentage) of wetted channel from 1984 to 2020



Some major issues due to reduced flows along Middle Rio Grande:

- Increase in the vegetated area in riparian zone due to encroachment of vegetation
- For albuquerque reach, the range of channel width was 137 to 320 m in 1984 which reduces to range of 46 to 137 m
- New islands are formed due to stable vegetation

MAJOR TAKEAWAYS

- Increase in the vegetated area due to decrease in the flows
- Reduction in the width of the channel

This study will help river managers to take better decision for the restoration and resilince of the system by understanding the behavior and response of the system to the exeternal stressors.

DISCLOSURES

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ABSTRACT

Due to long term drought, engineered structures (e.g., dams and levees), and other stressors, river systems are at high risk of degradation. Riparian vegetation and river geomorphology are continuously changing. The change in river hydrology, geomorphology and riparian vegetation have cascading impacts on other ecological aspects of the river corridor system. In this study, spatiotemporal variations of the riparian vegetation and the river geomorphology have been characterized using machine learning techniques (in particular, random forest) over an evaluation period of three decades. The study area is the Middle Rio Grande, located in New Mexico, USA. For the study of vegetation, the normalized difference vegetation index (NDVI) was used. The land cover was classified, using Landsat images (1984 to 2020) collected from Landsat 5, 7 and 8, to determine the change in vegetation cover and river geomorphology. The trends of NDVI shows the increase in vegetation cover even during long term drought due to presence of groundwater dependent vegetation like cottonwoods. Similarly, the formation of new stable channel islands and narrowing of the channel are some major observations and changes in channel from this study. The availability of long-term datasets and machine learning algorithms in Google Earth Engine shows the potential in spatiotemporal analysis of riparian vegetation and river geomorphology. These long-term observations will help river managers to monitor the status of the riparian vegetation and the impacts on the river geomorphology.