

A Test of Methods to Measure Vegetation Change Adjacent to Gabions in Sonora, Mexico using Landsat imagery

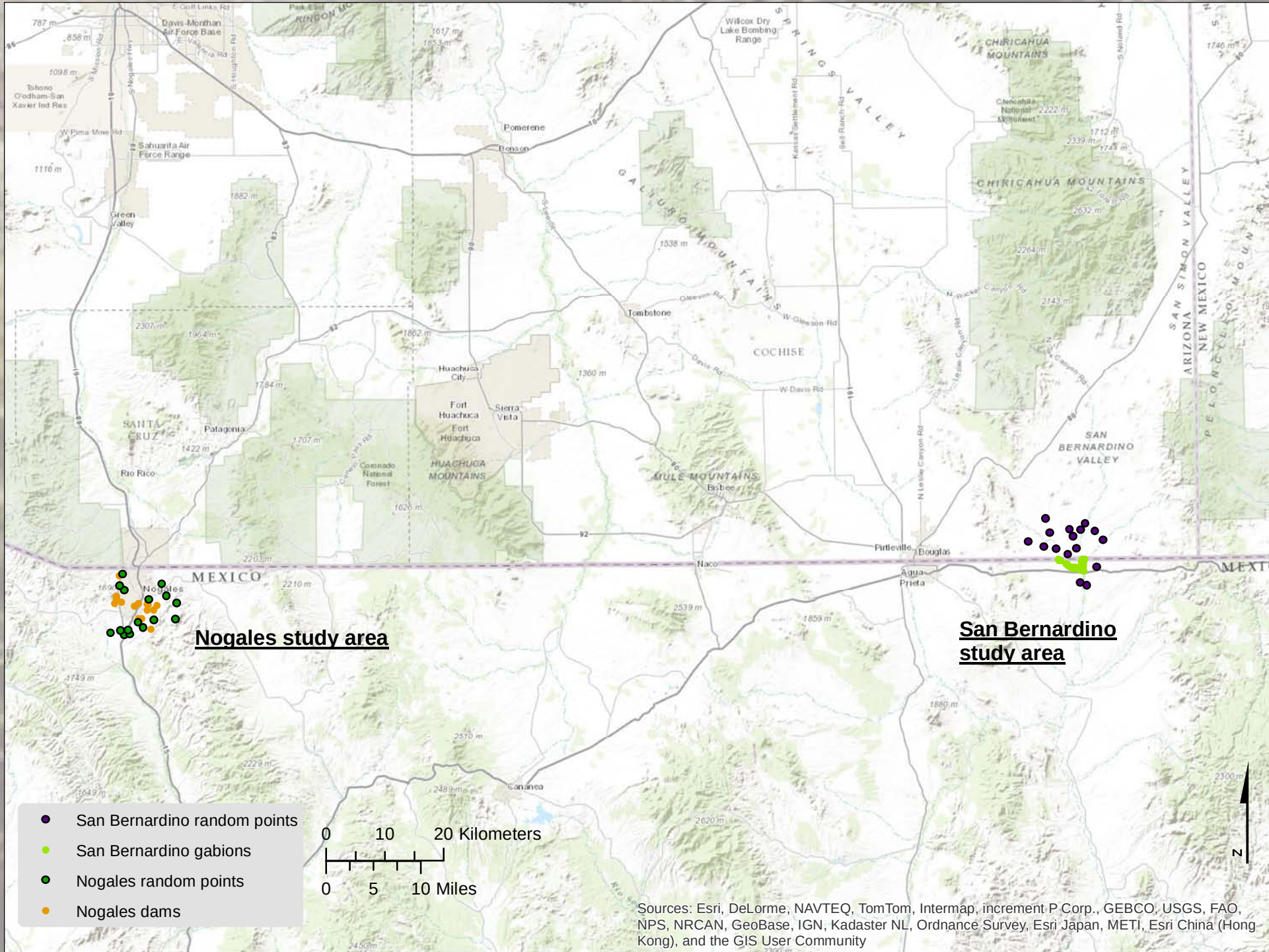
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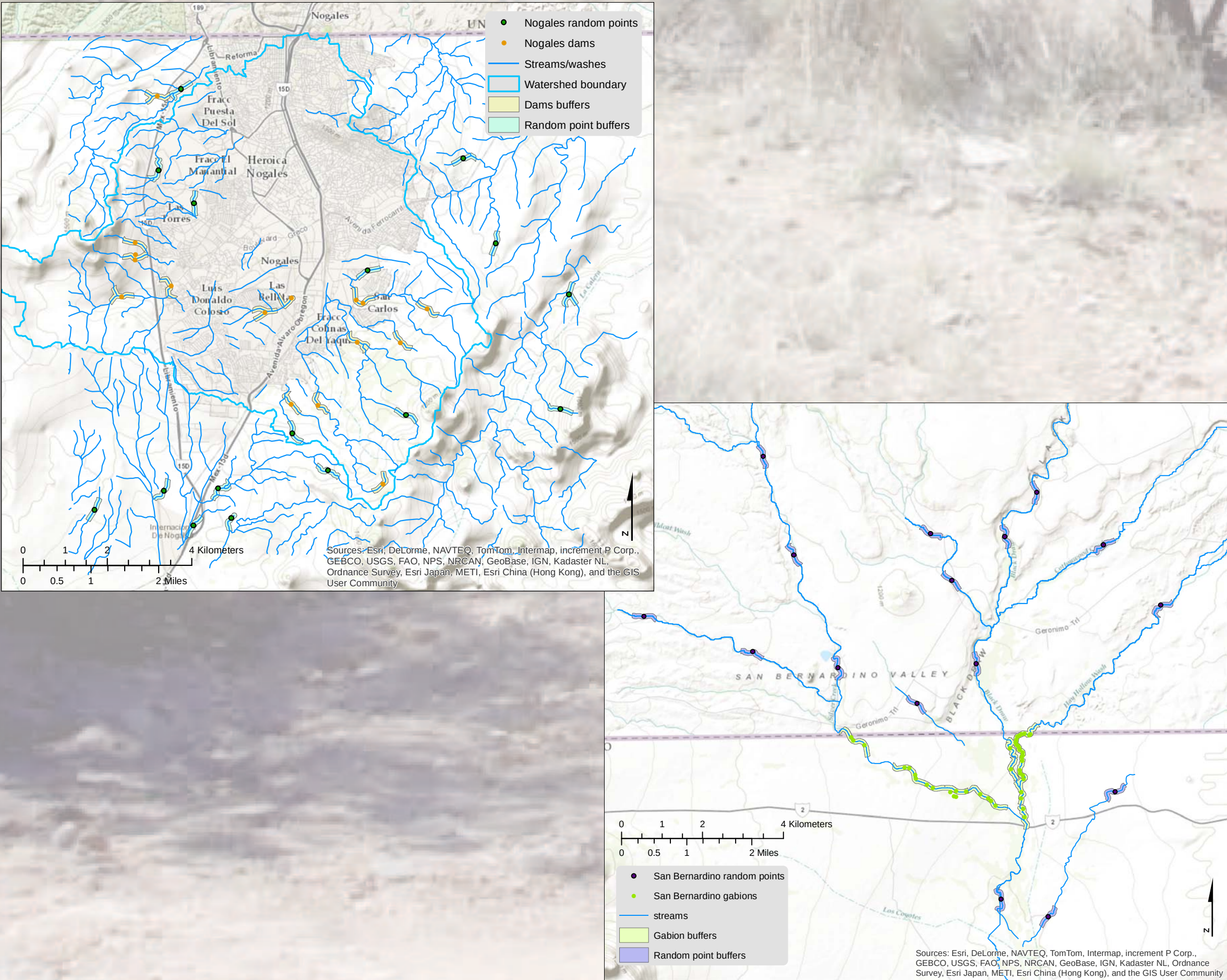
Introduction

In the southwestern United States and northern Mexico, climate and land use change have resulted in lowered water tables, reduced vegetation cover, and increased erosion. In Nogales, Sonora, flood detention gabions have been installed in tributaries where flooding is a problem. In the San Bernardino watershed, in southeastern Arizona and adjacent Sonora, gabions of various sizes and design are being installed to restore habitat and improve surface water conditions. The work presented here is a subset of a project aimed at quantifying potential impacts of gabion structures in the US-Mexico border region. We are exploring methods to measure changes in vegetation associated with different types of gabions. Results may help guide future construction and maintenance of these features.

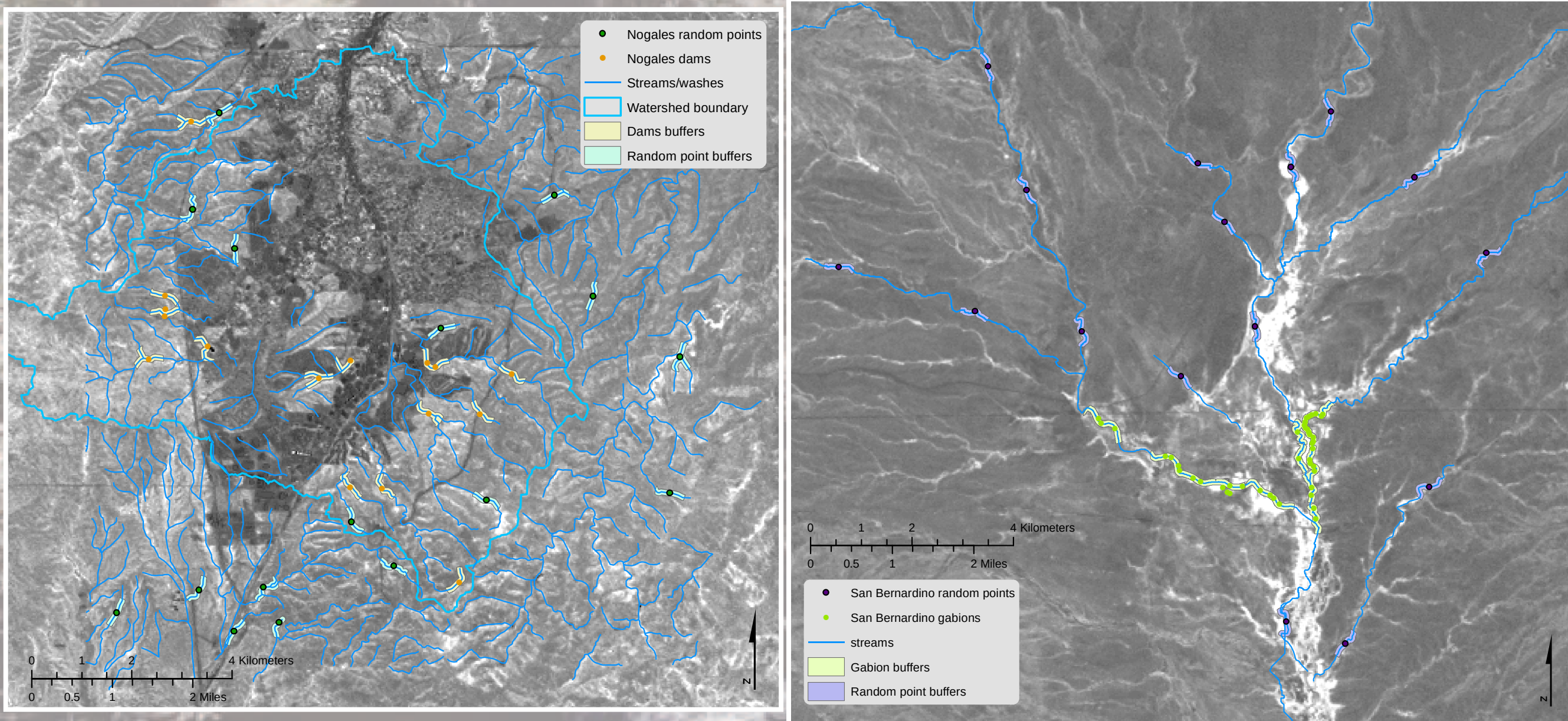


Methods

We mapped 16 point locations of known flood detention gabions (dams) in the upper Nogales watershed, and created 16 random (control) points on streams in the same area. One dam did not map on a stream, so it was not included in the analysis. Because they were so close together, we consolidated 46 point locations of gabions in the San Bernardino watershed into 16 areas for analysis. We also created 16 random (control) points on streams at least one kilometer from the area of concentrated gabions. We created buffers around gabion and random locations, 60 m on each side of the stream and 150 m upstream and downstream. These buffers approximated the expected riparian area of influence of the gabions and the random locations.

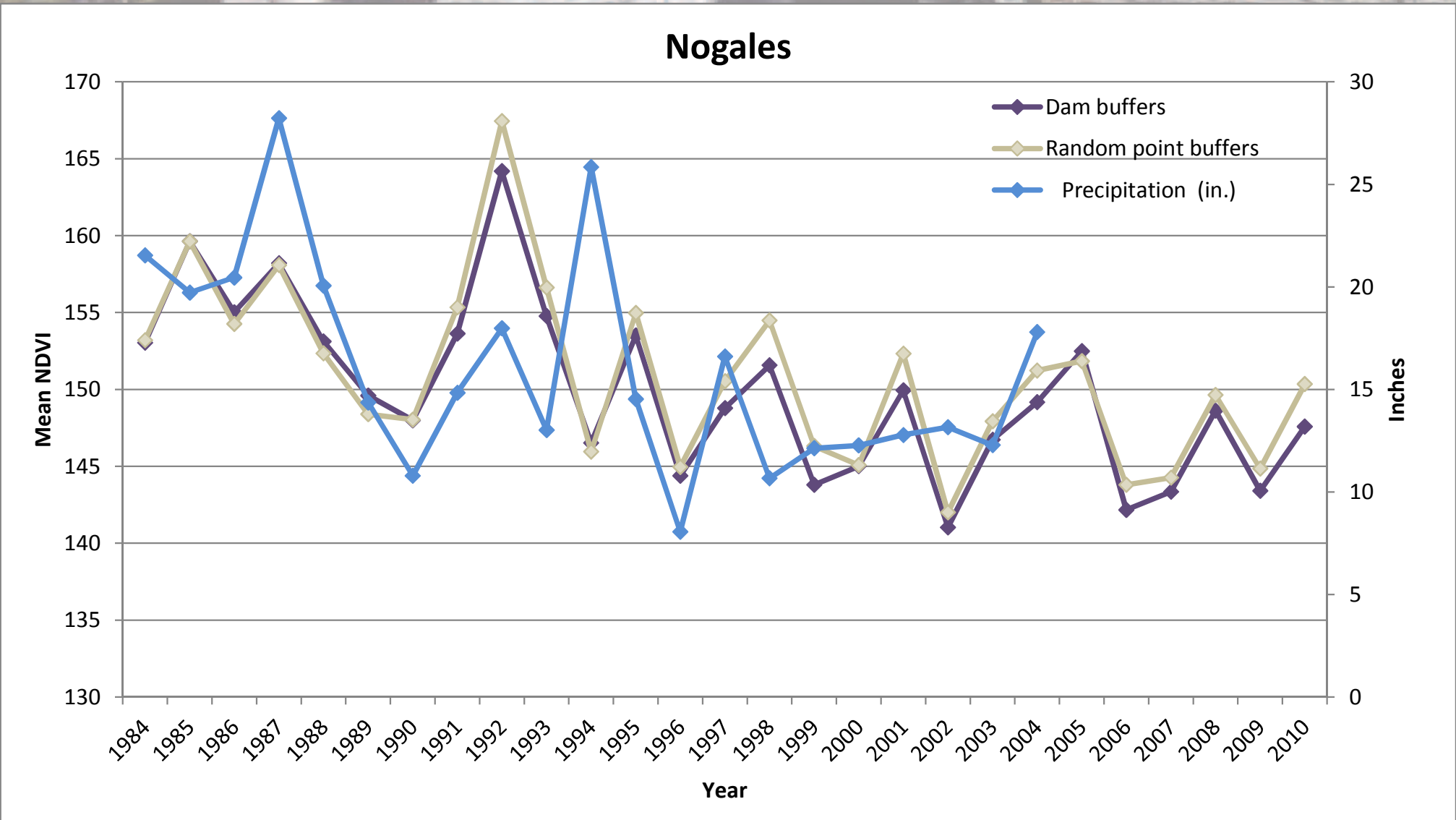


We obtained cloud-free, atmospherically-corrected Landsat Thematic Mapper images (30 m pixels) from May/June (a generally dry period), for the years 1984-2010, and calculated mean Normalized Difference Vegetation Index (NDVI) values, for the buffer areas. NDVI is calculated from the near infrared (NIR) and visible (VIS) bands of Landsat imagery. $NDVI = (NIR - VIS) / (NIR + VIS)$. NDVI values can range from -1 to +1, but absence of green vegetation yields values near zero. Thus, zero means no vegetation and close to +1 indicates the highest possible density of green vegetation. This allowed us to track changes in vegetation greenness around the gabions and control points.

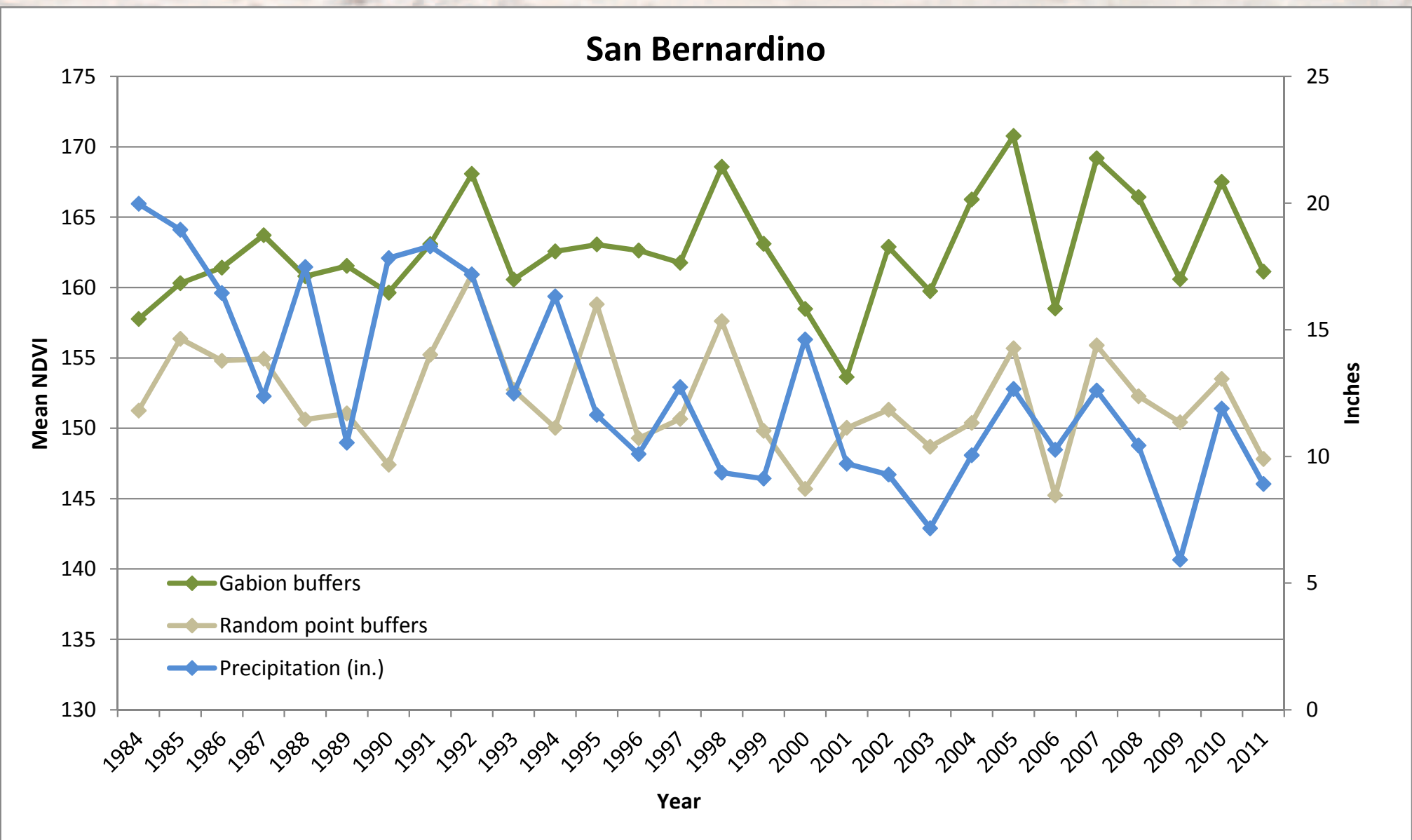


Results

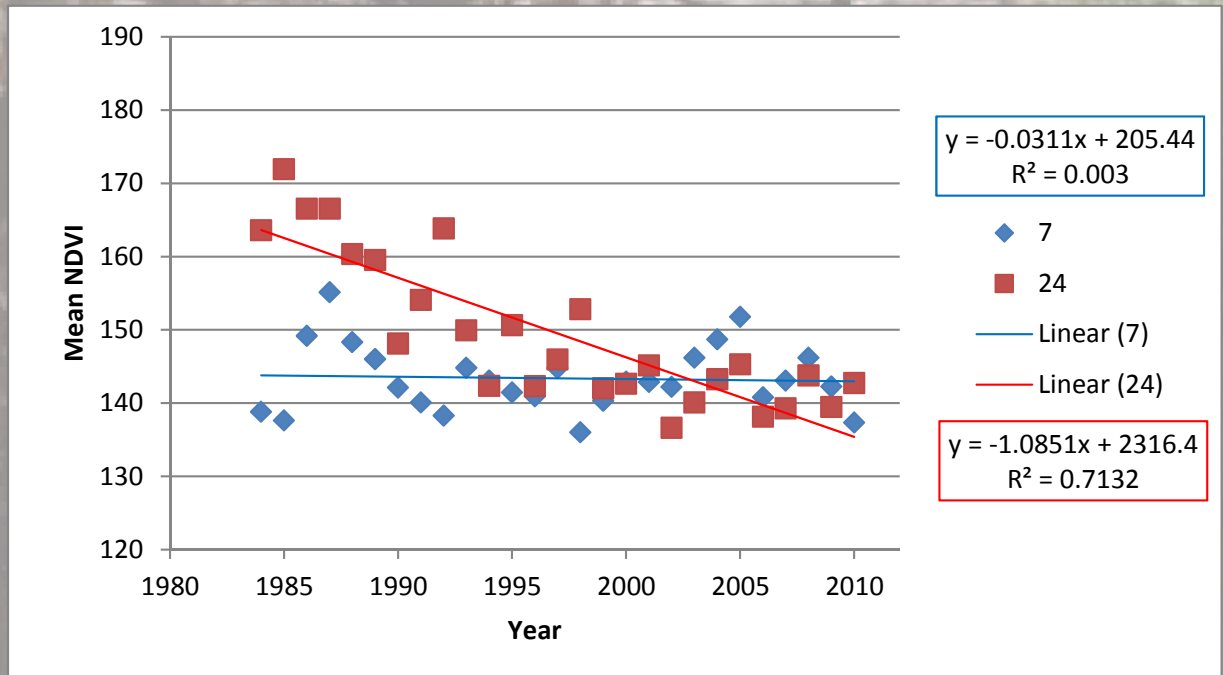
Results show little difference in NDVI for areas with and without dams, in the Nogales area, and an overall trend toward decreased greenness. Precipitation data show a trend of decreasing precipitation for the same time period.



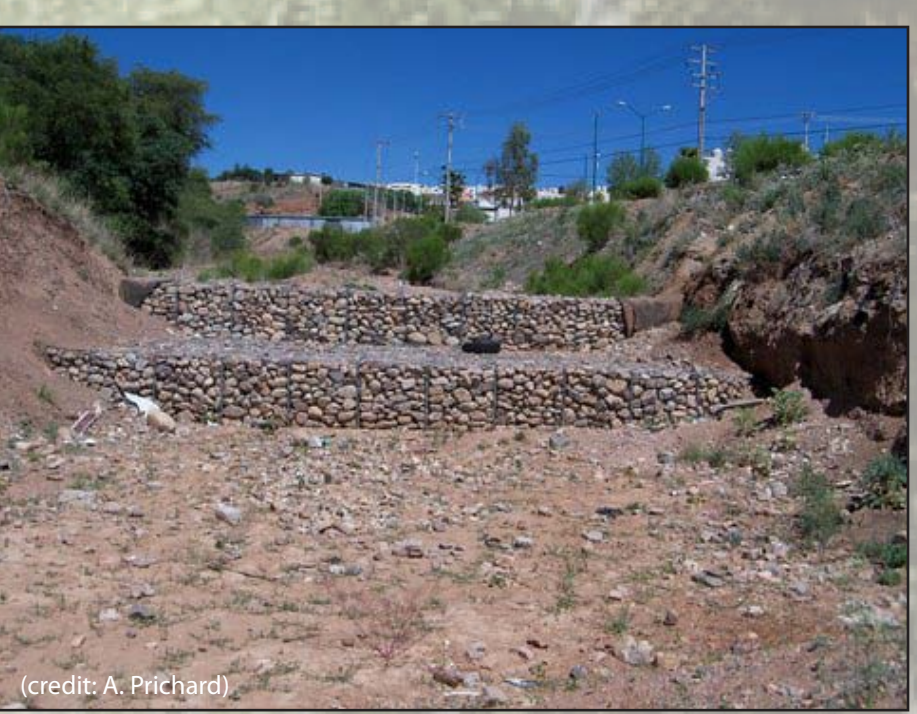
In the San Bernardino region, however, areas with gabions are greener than areas without, and there are slight trends toward increased greenness in the gabions areas, and decreased greenness in the "control" areas. Again, precipitation data from Douglas, Arizona show a trend of decreasing precipitation.



Initially, we averaged NDVI across all dams, regardless of dam age. When we singled out a newer dam (# 24, Bellotas Fraccionamiento), the NDVI values decline over time, in the same trend as the precipitation. However, the NDVI values for an older dam (#7, El Represo Chimeneas) remain steady over time. Dams installed 20 years ago may help maintain vegetation during a time of increased drought.



Dam #7 (El Represo Chimeneas)



Dam #24 (Bellotas Fraccionamiento)

Nogales v. San Bernardino

- The Nogales area has higher topographical relief and the dams are in areas of oak savanna.
- The San Bernardino area is generally flatter, and the gabions are in a grassland basin with cottonwood riparian vegetation at the confluence of several streams.
- The Nogales dams were installed for flood control, and were installed higher in the stream reaches and farther above the water table.
- San Bernardino gabions were installed to restore the hydrology of the watershed (increase stream flow and raise the water table), and were installed lower in the stream reaches and closer to the water table. Also, more than 700 trees have been planted every year for the last five years, along stream banks and berms.
- In general the Nogales dams were installed in the late 2010s, and the San Bernardino gabions were installed beginning in the 1990s.



Represo Maquillas, Nogales

A San Bernardino gabion



Ideas for future analyses

- improve our sampling design: e.g., is there a better way to produce control points?
- look at NDVI values for a different season (e.g., post-monsoon)
- classify the structures by type or purpose (e.g., flood control, erosion control/channel restoration, aquifer/water table restoration, habitat restoration)
- obtain dates of installation for the structures and classify them by time period
- classify the hydrologic regimes
- expand the use of precipitation data in our analyses
- obtain measures of flow rates in the focal streams
- expand analysis of NDVI values for individual dams, look for outliers, and compare them within/between study areas, and to control points
- change the buffer size/shape
- characterize the geologic surface material to determine porosity
- test data with statistical analyses suited to these data and our questions

A. Prichard photos from: Norman, L.M., Levick, L., Guertin, D.P., Callegary, J., Quintanar Guadarrama, J., Zulema Gil Anaya, C., Prichard, A., Gray, F., Castellanos, E., Tepezano, E., Huth, H., Vandervoet, P., Rodriguez, S., Nunez, J., Atwood, D., Patricio Olivero Granillo, G., and Octavio Gastelum Ceballos, F., 2010, Nogales flood detention study: U.S. Geological Survey Open-File Report 2010-1262, 112 p.