WATER USE, DELIVERY AND THE RIVER

MODELING THE IMPACT OF IRRIGATION ON THE RIO GRANDE'S EFFICIENCY

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BACKGROUND

Understanding the relationship between groundwater and river flow is a particularly germane issue, as it addresses the nature of the Rio Grande, a river which runs dry at the end of every annual growing season. As water is released back into the river from Elephant Butte Reservoir upstream, the first place water flows is back into the aquifer. Dry or not, New Mexico is required to deliver Rio Grande water to Texas per the Rio Grande Compact of 1938. Because those compact deliveries are not being met, the Supreme Court is currently hearing Texas v. New Mexico & Colorado.

This GIS models the interaction between groundwater extraction (GWE) and the Rio Grande in a primarily agricultural section of Mesilla Valley, Doña Ana County, New Mexico. Target areas of groundwater over-extraction are analyzed.

Current water allocation to irrigable farms is based on Stream System Issue (SSI) 97-101 as defined in the ongoing Lower Rio Grande Adjudication - it sets consumptive irrigation requirements (CIRs) at 4.5 acre feet per acre per year (afay), but only delivers a maximum of 3.024 afay of surface water. The remainder is pumped from the aquifer.

STUDY AREA

This project focuses on an approximately 20 x 20 kilometer region, 5 kilometers south of Las Cruces, New Mexico. It straddles the Rio Grande and abuts the Organ Mountains to the east. Approximately 26,000 acres in the region are irrigable farmland - 52% is orchard (predominately pecan) and 47% is row cropping.

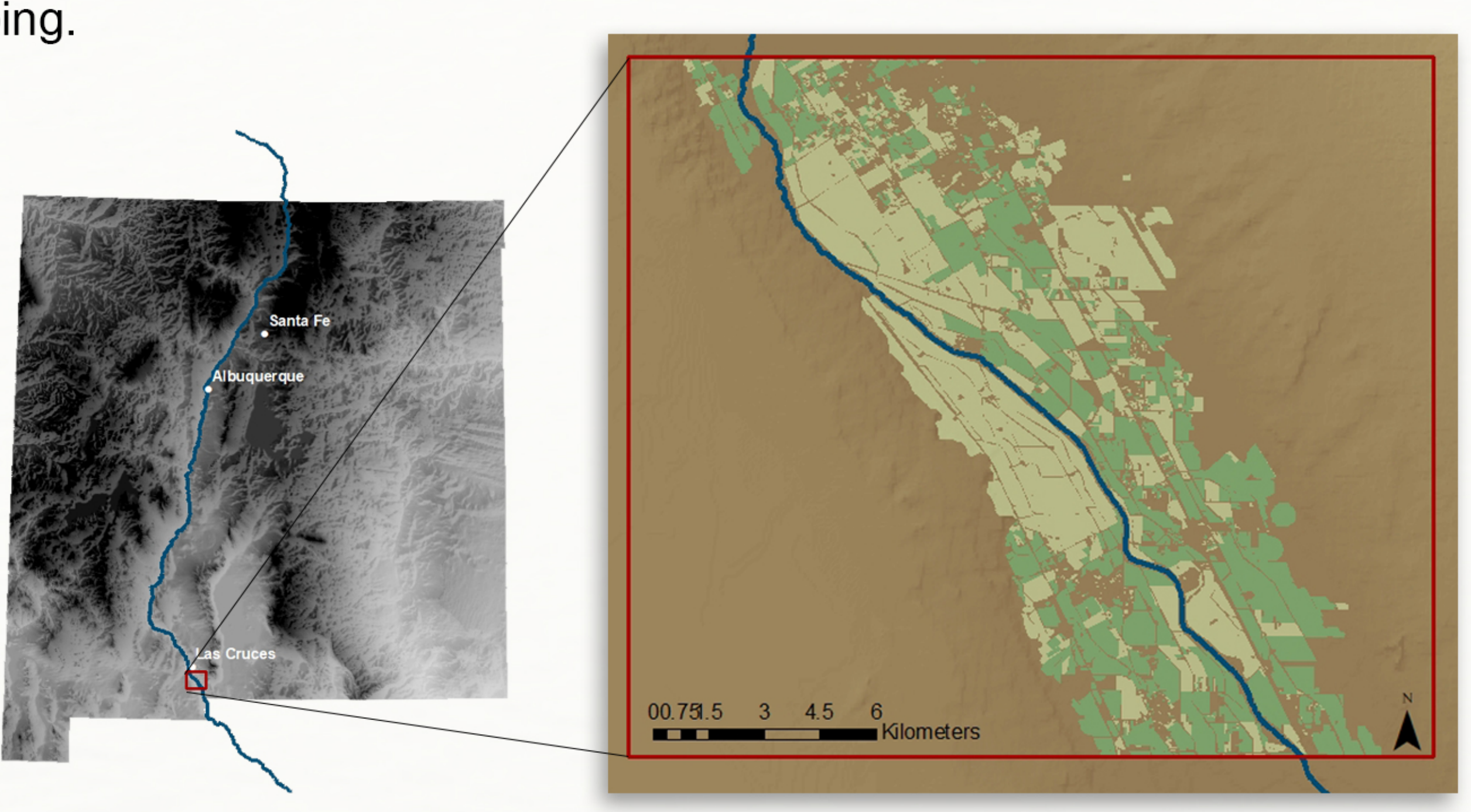


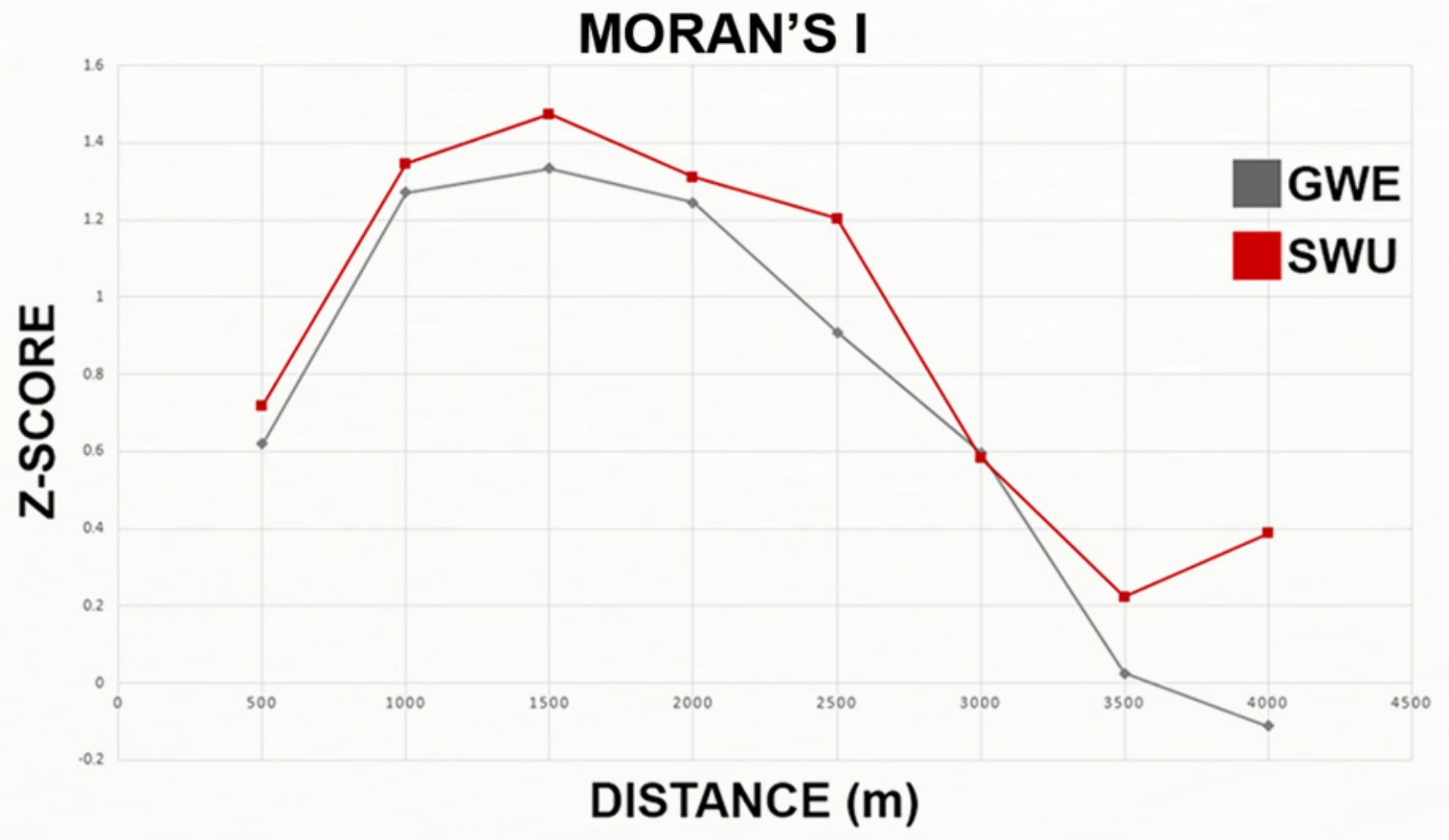
Figure 1: Study area map.

METHODS

Initial data collection involved generating point data of active conjunctive-use water rights filed with the NM Office of the State Engineer (OSE). A total of 200 water rights in the study area were manually populated with attributes for acreage and values for total surface or groundwater consumed to date. Consumptive use values were adjusted to represent an annual period.

The water table was interpolated from well column data of the 4211 existing wells in the study area showing the depth to water from ground level. Co-Kriging of wells within the study area and 6000 wells outside the boundary produced the most statistically-accurate results. Total groundwater extraction (GWE) and surface water use (SWU) were interpolated with ordinary Kriging. A soil permeability map indicating maximum saturated hydraulic conductivity at 140" below ground was generated from the Soil Survey Geographic (SSURGO) Database.

Statistical clusters of GWE and SWU were analyzed using the Getis-Ord Gi* test. Spatial relationships between data points were defined by the zone of indifference, which was determined by calculating z-scores of spatial autocorrelation at different intervals using Moran's I test.



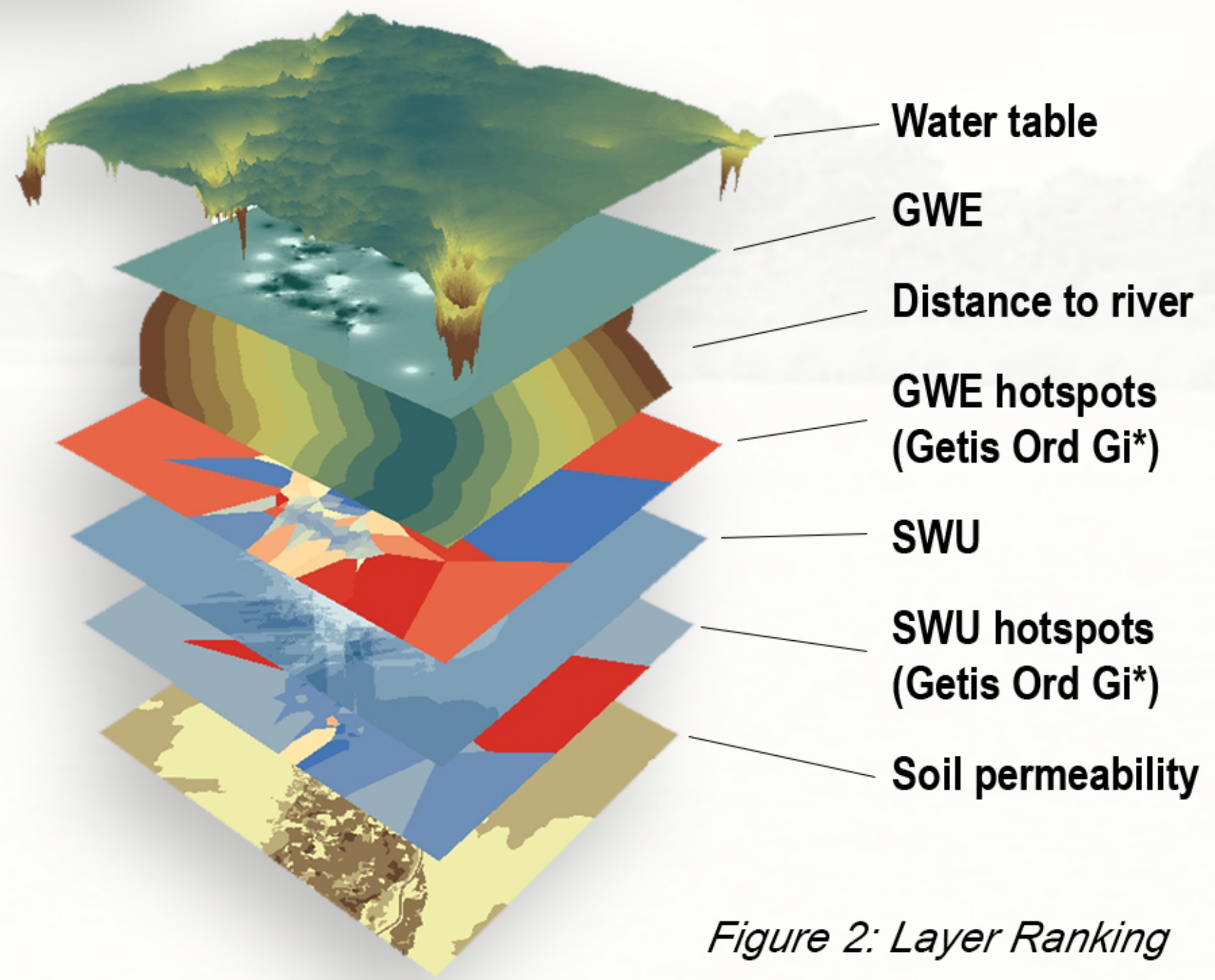


Figure 2: Layer Ranking

In order to identify target management areas, the seven input layers (above) were ranked from most to least impactful: 1) water table, 2) GWE, 3) distance to river, 4) GWE hotspots, 5) SWU, 6) SWU hotspots, 7) soil permeability. Weighted values were then calculated and defined in a fuzzy membership according to the following equation:

$$\mu(x) = \left[\frac{1}{1+\left(\frac{x}{f}\right)^{\frac{n-r_i+1}{\sum_{k=1}^{n}(n-r_k+1)}}}\right] \times 10$$

where μ(x) is the new value, *f* is the midpoint, *i* is the number of criteria and k sums across all criteria. The diagram below indicates the relationship of each variable to riverine impact, whereby larger values may indicate either a high or low membership.

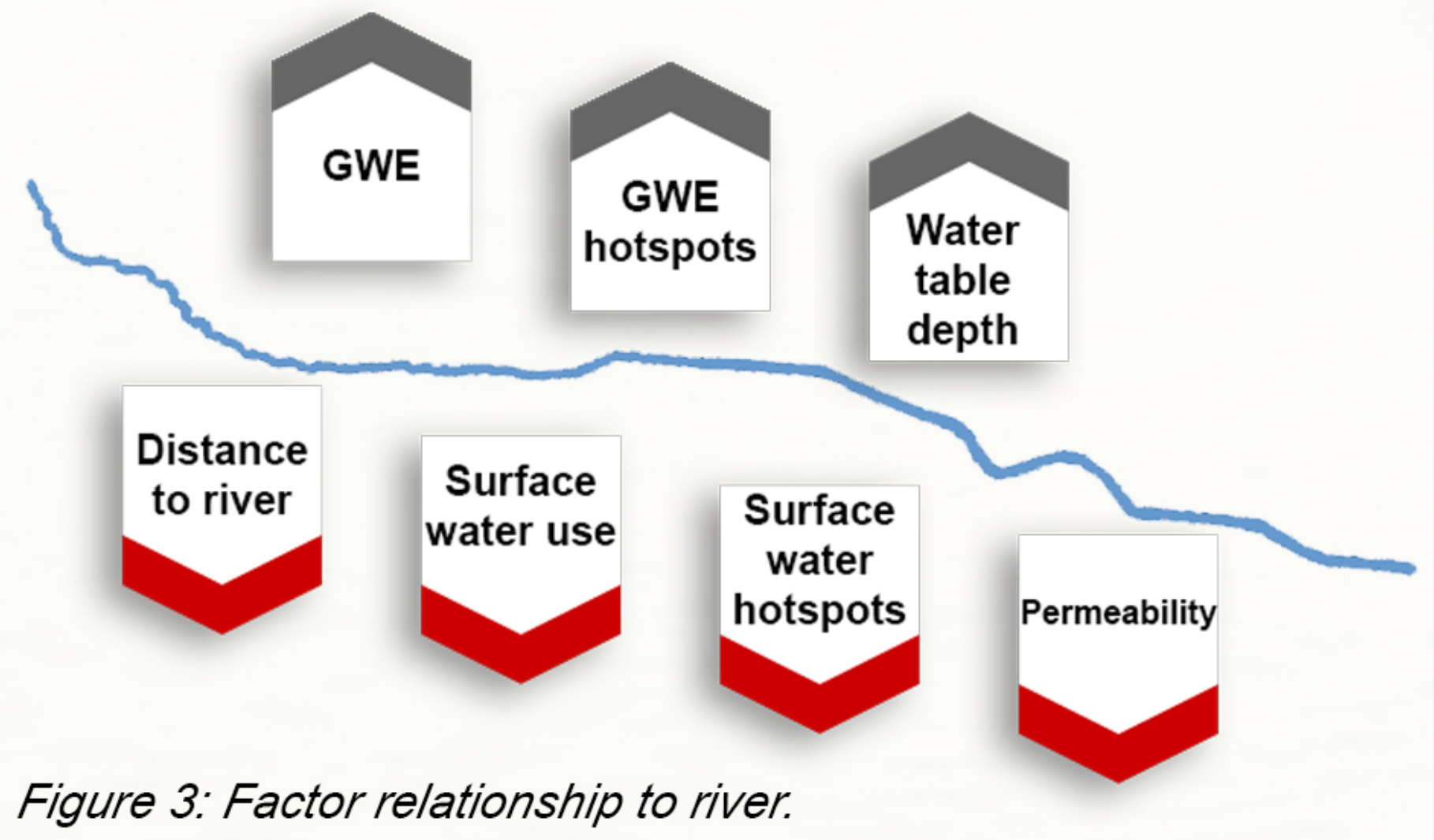
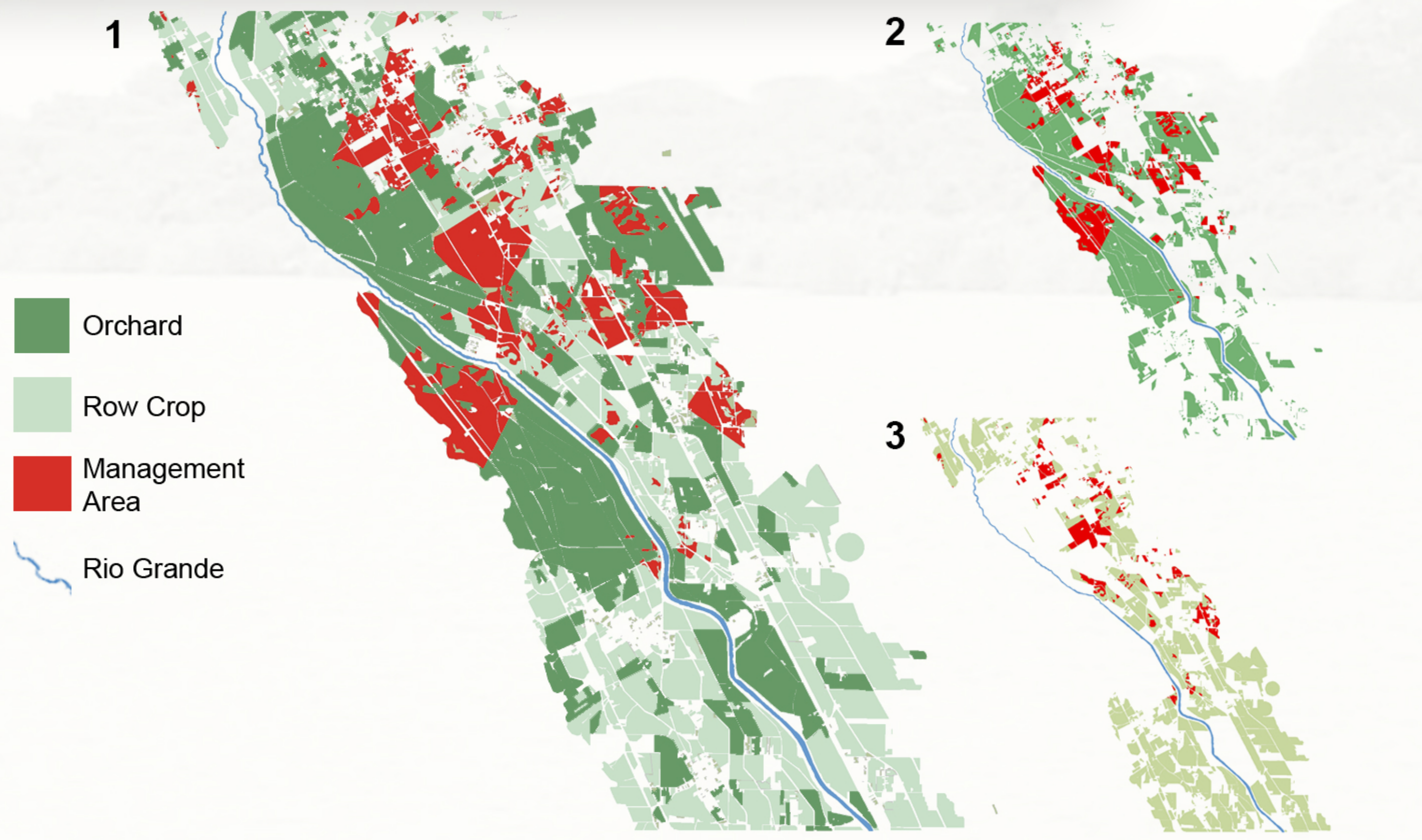


Figure 3: Factor relationship to river.

RESULTS



1) All irrigable farmland within study area overlaid with targeted primary management areas. 2) All orchards overlaid with associated primary management zones. 3) All row crops overlaid with associated primary management zones.

Areas of primary management consideration were selected from the top 10% of results of the fuzzy overlay. Targeted management in orchards represents 9.8% of total irrigable farmland in the study area, while targeted management in row crops represents 4.8%. Furthermore, 18% of all orchards were identified as critical in the model while only 10% of row farms were.

DISCUSSION

Varying impacts from depletion of the water table are areal and management of water consumption is largely a behavioral construct. As the drought cycle in New Mexico and litigation over interstate water delivery continues, future management of water use in irrigable farmland needs to account for geographic variations of individual farms. Furthermore, the results of this model indicate that agricultural production informs water consumption, suggesting that groundwater use can be offset by differing operations. Future research should utilize sensitivity analysis to explore potential management procedures while considering the historico-cultural aspects of water delivery in the state, agricultural competition and more cooperative paradigms.

DATA SOURCES

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