Mapping and Visualizing Socio-Economic and Environmental Data for the Rio Grande Basin

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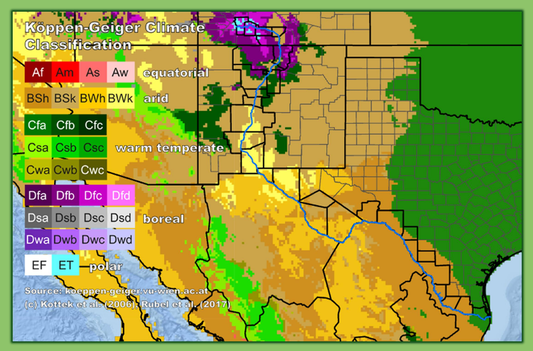
BACKGROUND

- The 5th largest river in North America
- International boarder between Mexico and the United States



- The population along the river has doubled over the past 20 years
- Treaties and Compacts are necessary to water allocation for the river
- The Rio Grande water is fully allocated
- Current water prices do not reflect the value of water
- Small changes in environmental factors relating to the river ecosystems can lead to increased volatility for the populations relying on the Rio Grande water resources

GOALS

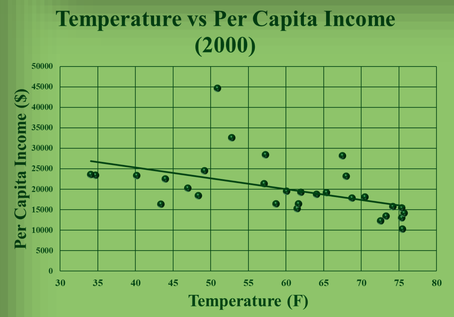
- Develop scripts to analyze geospatial variability for water conditions, socio-economic and environmental measures along the river.
- Visualize environmental factors influence on socio-economic variables in the counties surrounding the river in the three U.S. states.

METHODS

- Datasets (2000 – 2014)

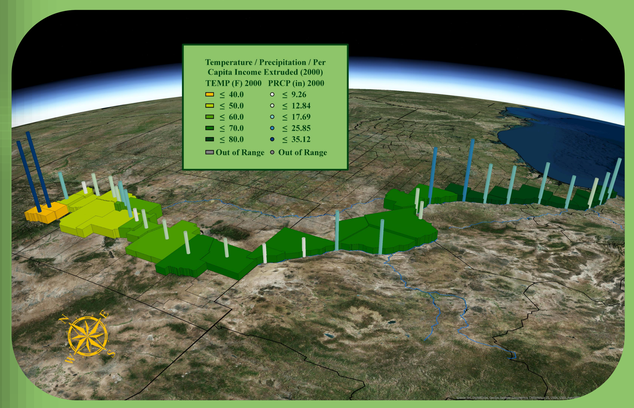
Environmental	Socio-Economic
Palmer Drought Index	Per Capita Income
Precipitation	Personal Income
Streamflow	Population
Temperature	Total Employment
	Total Water Withdrawl

- Data Issues
  - Data aggregated into county per year
  - Missing data
  - River frequently dries in section
- Methodology
  - Organize the data to be used in ArcGIS Pro and R Studio
  - Compile, extract and organize the shapefiles
  - Establish points along the river for each county within ArcGIS Pro
  - Develop a Correl function in R
  - Use the Correl function to quantify correlations between environmental and socio-economic datasets
  - Use ArcGIS Pro and Excel to visualize relations

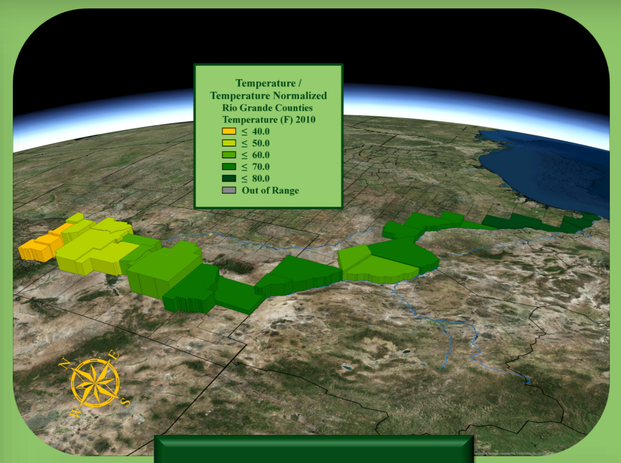


Temperature vs Per Capita Income

Year	Estimate	P Value
2000	-0.67	5.13E-05
2001	-0.65	1.25E-04
2002	-0.65	1.27E-04
2003	-0.66	1.00E-04
2004	-0.63	2.28E-04
2005	-0.60	5.22E-04
2006	-0.59	5.64E-04
2007	-0.64	2.11E-04
2008	-0.63	2.79E-04
2009	-0.65	1.00E-04
2010	-0.62	2.56E-04
2011	-0.55	1.75E-03
2012	-0.51	4.45E-03
2013	-0.47	9.80E-03
2014	-0.48	7.22E-03

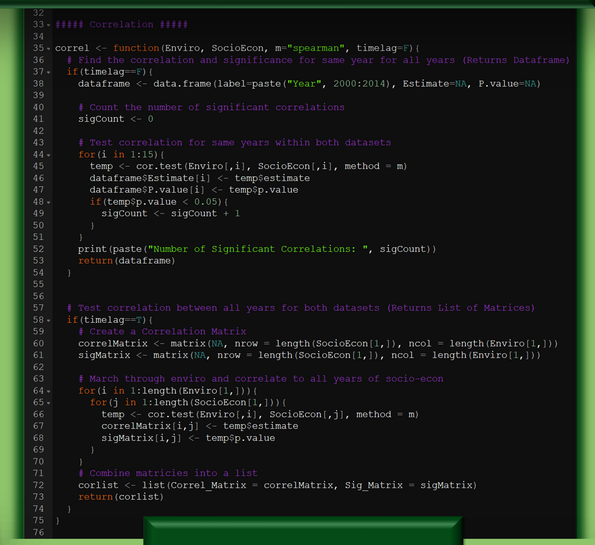


* Example of correlation analysis with developed tools *



ArcGIS PRO

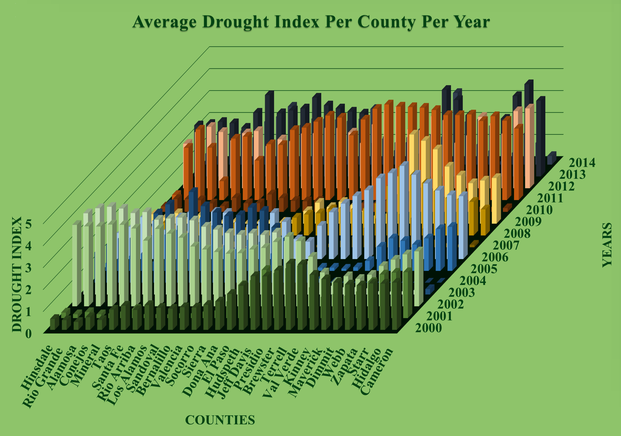
- Establishing River Points
  - The 30 county polygons that exist on the river were extracted
  - The centroid for each polygon was found
  - Points were created along the river nearest to the centroids and within the polygon
- 3D Models
  - Extrusion was applied to normalized datasets
    - The non-normalized dataset was qualitatively analyzed based upon the maximum and minimum values found for the same county
  - Relations between environmental variables and socio-economic variables were visualized
    - By utilizing extrusion and color gradients multiple datasets were visualized together



```
##### Correlation #####
correl <- function(Enviro, SocioEcon, m="spearman", timelag=F){
  # Find the correlation and significance for same year for all years (Returns Dataframe)
  if(timelag==F){
    dataframe <- data.frame(label=paste("Year", 2000:2014), Estimate=NA, P.value=NA)

    # Count the number of significant correlations
    sigCount <- 0

    # Test correlation for same years within both datasets
    for(i in 1:15){
      temp <- cor.test(Enviro[,i], SocioEcon[,i], method = m)
      dataframe$Estimate[i] <- temp$estimate
      dataframe$P.value[i] <- temp$p.value
      if(temp$p.value < 0.05){
        sigCount <- sigCount + 1
      }
    }
    print(paste("Number of Significant Correlations: ", sigCount))
    return(dataframe)
  }

  # Test correlation between all years for both datasets (Returns List of Matrices)
  if(timelag==T){
    # Create a Correlation Matrix
    correlMatrix <- matrix(NA, nrow = length(SocioEcon[1,]), ncol = length(Enviro[1,]))
    sigMatrix <- matrix(NA, nrow = length(SocioEcon[1,]), ncol = length(Enviro[1,]))

    # March through enviro and correlate to all years of socio-econ
    for(i in 1:length(Enviro[1,])){
      for(j in 1:length(SocioEcon[1,])){
        temp <- cor.test(Enviro[,i], SocioEcon[,j], method = m)
        correlMatrix[i,j] <- temp$estimate
        sigMatrix[i,j] <- temp$p.value
      }
    }
    # Combine matricies into a list
    corlist <- list(Correl_Matrix = correlMatrix, Sig_Matrix = sigMatrix)
    return(corlist)
  }
}
```

R Script

- Correl Function
  - Takes an environmental dataset and socio-economic dataset
  - Generates a correlation for the same year between datasets
  - Option to generate a correlation and p value matrix to compare datasets with time-lag
  - Option to change correlation method
- Issues
  - Data must be in a particular format
  - Data must be checked to determine proper correlation method



FUTURE WORK

- Further research
  - Determine relationships for smaller time and spatial scales
  - Include additional environmental indicators
  - Analyzed the Rio Grande's two basins separately
- The relationship strengths can be used to design more efficient water conservation practices
- Applying research to other rivers
  - The Correl Function can be easily adapted and applied to other rivers
  - Similar methods can be used to define points along any river with any political shapefile.

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