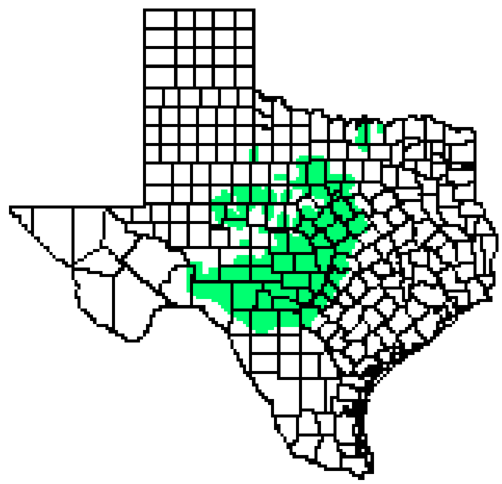
Juniper & Water in Central Texas


Ashe juniper



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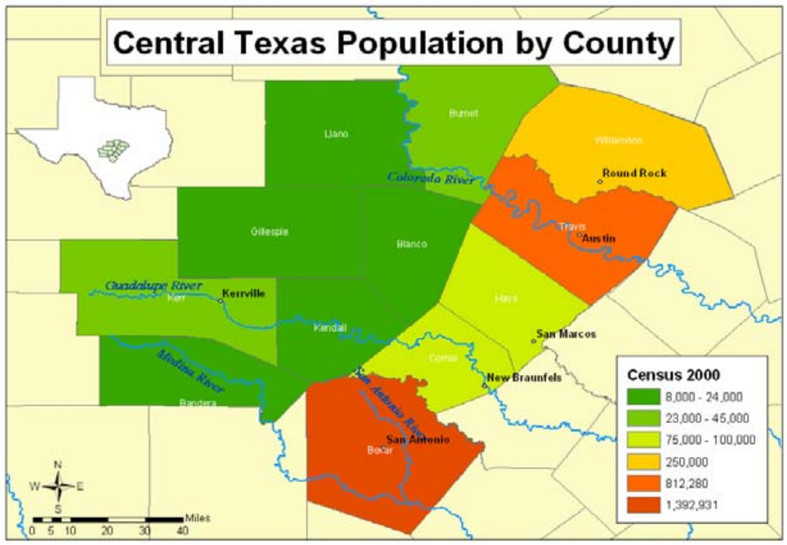
Introduction

The Edwards Plateau region of central Texas, locally known as “the Hill Country”, is perched over several aquifers that provide the area’s inhabitants with drinking water and recreational environments. This precious resource is becoming increasingly important as the area’s population grows and dependency on these aquifers escalates. Precipitation, topography, soil types, and vegetation\ground cover dynamically affect the availability of aquifer ground water. Ashe juniper (Juniperus ashei) has inundated the landscape of central Texas over the past century, restricting precipitation’s ability to infiltrate the soil and recharge underlying aquifers. The objective of this report is to identify correlations between vegetation and water availability using geographic information systems for the purpose of developing sustainable water use and grassland/rangeland management models.

Background

Despite popular conceptions, Ashe juniper, locally referred to as Cedar, is native to Texas. Historical accounts from 18th century Spanish Explorations describe the landscape of Central Texas as “very beautiful, having hills with large oaks…with only the arroyos and creeks being timbered”. In that era, wildfires provided an ecological balance by seasonally burning stands of juniper, leaving only those in breaks, along waterways, and on some hilltops. However, as the region became settled in the mid-19th century, the original juniper population was cut for human use.

The junipers we see today are a result of secondary growth in an environment where wildfires are suppressed and grasslands are over-grazed. Giving this opportunity have dominated the landscape. Juniper's long shallow fibrous roots allow it to grow in rocky soils and draw water from even the driest regions. A single juniper can use 16-20 gallons of water a day and their year-round foliage transpires moisture out of the atmosphere environment that would otherwise remain. Their branches shade out native grasses, shrubs, and forbs that previously covered the hillsides.



The Austin-San Antonio corridor experienced a surge in population during the 1990's and continues growing rapidly today. This four county strip supports a population of nearly three million and, along with the rest of the Hill Country, depends on a handful of aquifers for drinking water. San Antonio is the largest city in the United States that relies solely on groundwater for their domestic water supply. Whereas other large cities depend on reservoirs, rivers, and runoff to supply water, a million and a half people in Bexar County are continuously pumping water from central Texas aquifers.

Rain infiltrating down through soil and bedrock recharges these aquifers, however, not all precipitation will infiltrate into the aquifer. The plant canopy and litter will intercept some of this water before it reaches the soil surface. Portions of rain fall on plant leafs, flow down the stem, and are absorbed by the plant roots. Different types of vegetation affect the amount of precipitation that reaches the soil and the composition of these soils also impacts the rate at which water will infiltrate into the aquifers.

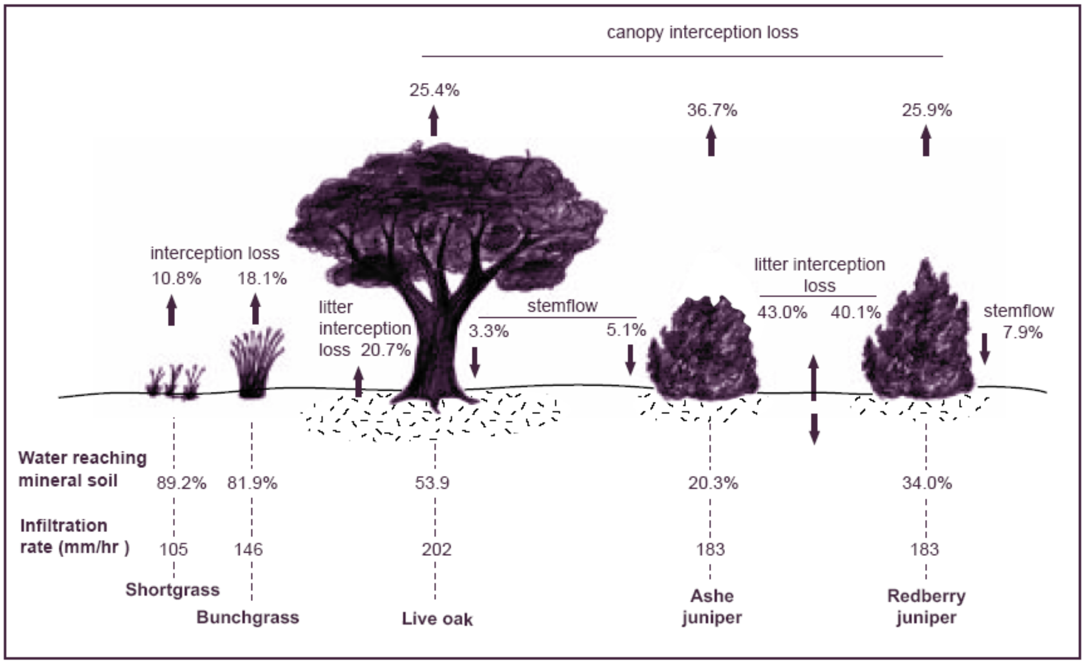


Figure 2. Influence of vegetation type on percentage of annual precipitation reaching mineral soils, and causes of precipitation losses (Thurow and Hester, 1997).

Most of the soil in Central Texas formed from weathered limestone. Bedrock formations of this nature are known as Karst systems, wherein caverns, sinkholes, springs, and perched aquifers are common and indescribably linked to each other. Because of irregularities between the surface and aquifers, it is incredibly challenging to characterize the connections between groundwater and surface water in Karst landscapes. However, generalizations can be made as to the availability of water to infiltrate the soil and recharge aquifers.

Data

The Texas Natural Resource Information System (TNRIS) provided the 1984 vegetation data – a shapefile compiled by the Texas Parks & Wildlife Division (TPWD) using a program to map wildlife habitat statewide from Landsat data and in West Texas by inspecting Bureau of Economic Geology land resource units. The Texas Water Development Board (TWDB) provided precipitation data, aquifer layers, and hydrological unit codes – watersheds delineated by the United States Geological Survey (USGS). The precipitation data was derived from annual and monthly averages from 1961-90. Transportation, population, administrative boundary, stream segment, and city data layers compiled from 2000 US Census Bureau data is available from numerous online sources. The climatic and stream discharge gauging station layers were manually created using information from the National Oceanic & Atmospheric Administration's National Climatic Data Center (NOAA, NCDC) and the USGS.

The vegetation layer outlines the distributions of juniper in central Texas and is the most important data for this study. An analysis of the vegetation classes provided an indication, with subsequent correlative research, of the density of junipers. I was able to use this data both in its native vector format and in a converted raster format. This information combined with aquifer and precipitation data, reclassed, and calculated, became to represent much more than a spatial distribution, but a basis for a decision-making process. Fortunately, the spatial projection of each layer was accurate and aligned properly when imported into ArcMap, indicative of the data's thorough and efficient government authorship.

Methods

Determining the relationship between distributions of vegetation and hydrological features requires a spatial analysis made possible through the use of a geographic information system – ArcGIS. This software program allows us to interpret, manipulate, interpolate, manage, and graphically present spatial associations.

Two spatial analysis were conducted, one raster based and one vector based. Each employs a distinctly different method of interpolating to describe an area based on common or similar characteristics. Raster analyses more easily accommodate a multivariable approach. The variables used to determine the juniper management priorities for central Texas included vegetation class (juniper density), precipitation, and positions of underlying aquifers, both major and minor. The study area was established by identifying the counties containing hydrological unit codes (HUCs) wherein existed any part of a juniper vegetation class. Each layer of data (variable) was converted from vector format to raster format and clipped to the size of the study area to expedite processing time. The values of each layer were then reclassed to establish a qualitative ranking. Locations over aquifer outcrops (recharge zones) were ranked higher than those over aquifer downdips or locations over no type of aquifer. Precipitation was classed into three categories representative of naturally occurring proportions.

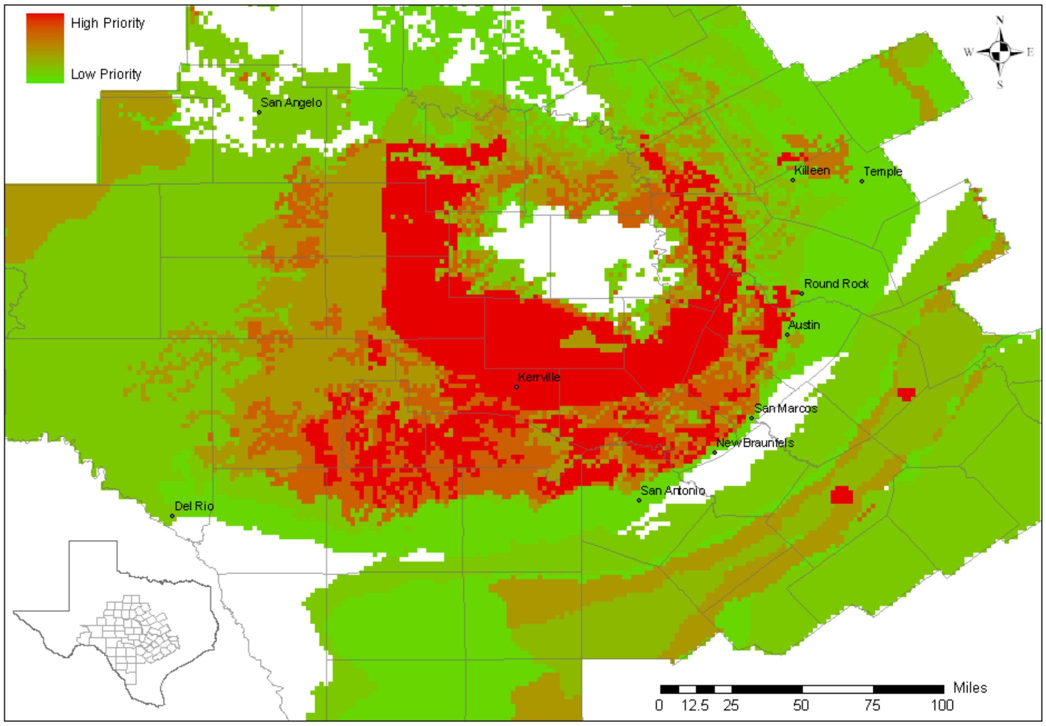
The vegetation data contained three classes of interest to this study: Live Oak-Ashe Juniper Woods, Live Oak-Ashe Juniper Parks, and Live Oak-Mesquite-Ashe Juniper Parks. "Parks" are considered areas with woody plants mostly equal to or greater than nine feet tall generally dominant and growing as clusters, or as scattered individuals within continuous grass or forbs (11 to 70 percent woody canopy cover overall) and "woods" are considered areas with woody plants mostly nine to 30 feet tall with closed crowns or nearly so (71 to 100 percent canopy cover). Cross-referenced with vegetation density data from sites within each zone, these three classes were ranked in the aforementioned order, greatest to least. Finally, using the raster calculator, each layer was multiplied together to determine areas of the highest priority for juniper removal/management.

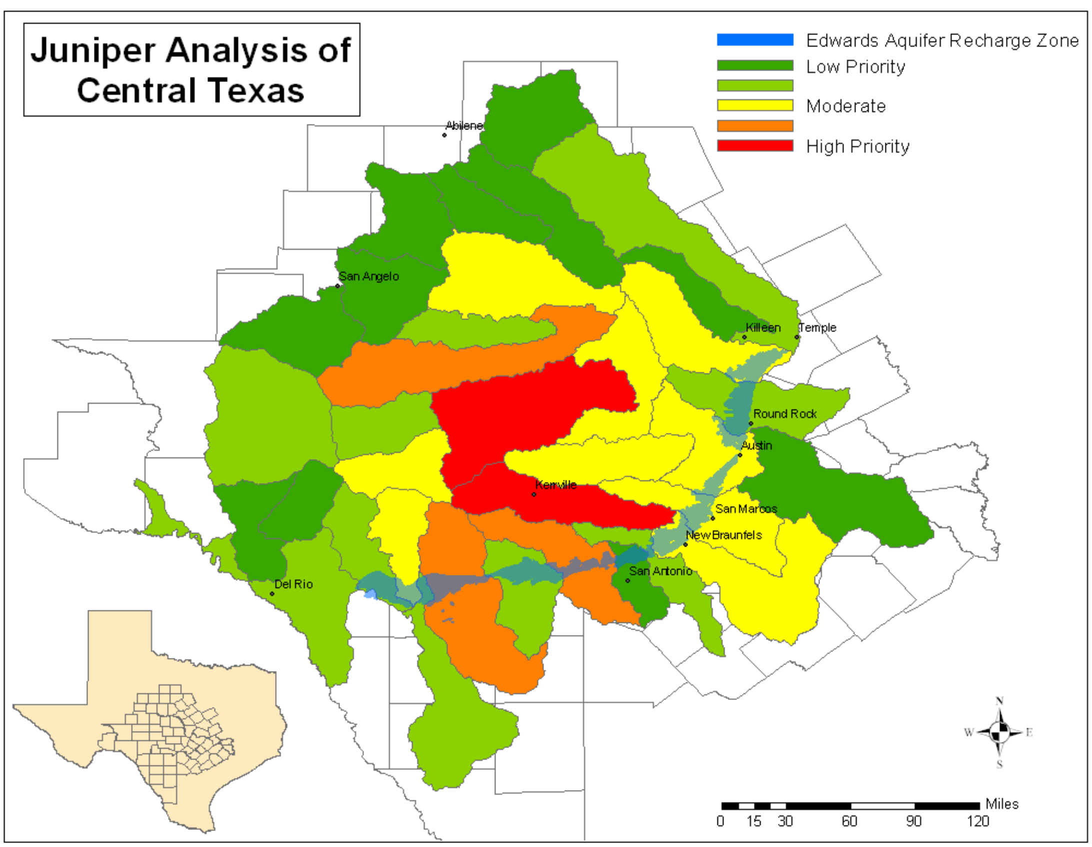
The raster analysis followed a similar path, but relied on areas of ranked vegetation within each hydrological unit code to determine which central Texas watershed needed the most attention. The vegetation layer was clipped to the study area using the GeoProcessing Wizard and three juniper vegetation classes were isolated into a new layer and ranked by creating a new field in the layer attribute table. Watersheds (HUCs) containing any portion of a juniper class were identified using the Select by Location feature in ArcMap, made into a separate layer, and then unioned with the juniper layer. Using the field calculator, a new field was created in the unioned layer by multiplying the rank of each polygon by its area. These values were then summarized by HUC and quantitatively mapped.

Results

Raster analysis determined an area of high priority in a ring pattern around the Llano Uplift in Mason and Llano counties. This is a result of calculating the presence of perched aquifers – aquifers on top of aquifers. In this case, three and sometimes even four aquifers underlie certain areas as a geological result of Karst landscape formation. Vector analysis indicates two Hydrological unit codes with the highest degree of priority. These are the Upper Guadalupe River Basin and the Llano Watershed, the former calculating a higher value than the latter.

Priority Analysis of Juniper Removal in Central Texas





Discussion

Although the results of these analyses do not provide direct evidence of juniper affecting actual aquifer recharge rates, it does provide an indication of where research and management efforts should be focused. Several large rangeland watershed projects have been conducted throughout the study area to determine the systematic hydrological effects of juniper removal.

The Seco Creek Water Quality Demonstration Project is a cooperative effort between the USDA, the State of Texas, and 22 other state, federal, and local groups. Located on 32,500 acres over the Edwards Aquifer west of Bexar County, results of juniper management have proven successful. On an 8-acre tract, 80% percent of the juniper canopy was removed and nearby spring flow increased 20%. On a separate plot of land, 40% of regrowth juniper was removed yielding a 35,000 gallon/acre/year increase based on three years of data.

On 5,500 Bamberger Ranch in Blanco County, juniper management has yielded an increase in spring occurrence and ecological health. Known as "the worst piece of land in Blanco County" when Church's Chicken owner David Bamberger purchased this cedar-choked land 30 years ago, the land has become a conservation and range management model. Within two years of clearing the land of junipers, 11 springs

surfaced, the diversity of bird species rose from 48 to 155, and over 100 native grasses were able to flourish. Similar results have been found in studies on Annandale Ranch in Uvalde County and on the Kerr Wildlife Management Area in Kerr County.

There has been much research illustrating the effectiveness of juniper management in central Texas. In my research, I did not find any study of *where* juniper removal should occur provided the financial and logistical means of instituting juniper management in a water use model. Juniper management's role in water planning is not at the forefront of central Texas conversation. The raster analysis might be used by the Texas Extension Service to identify where to begin educating landowners on the benefits and methods of juniper management. The vector analysis provides a good indication of where future research should occur.

There were many data and logical considerations during the collection and use of data for this project. Possible sources of error include skewed raster cell sizes and misalignment of data layers in ArcMap. The vegetation map from TPWD was created in 1984 and likely does not represent the distribution of vegetation in Texas today. A newer version of that map would have likely produced more accurate results. Originally, I had intended to incorporate a trend analysis into the project by correlating watershed discharge data with Theissen polygons created from NCDC climatic data. My inability to operate these functions in ArcGIS forced me to change the direction of my analysis.

Given the acquisition of vegetation trend data, conclusions could be more accurately made on the effects of historical vegetational changes on the Edwards Plateau. The application of a geographical information system provided an empirical and easily understood method for analysis. Further studies, including the use of GIS, are necessary to determine direct correlations between vegetation and water availability. However, given the complex nature of this interaction, generalization is necessary to understand their basic relationship.

Conclusion

Geographical information systems provide an analysis method for describing the complex spatial relationships between vegetation and water in central Texas. Spatial analyses conducted in this study indicate a priority for juniper management in the lands surrounding the Llano uplift and within the Upper Guadalupe River Basin. Studies have shown that proper juniper management/removal can increase the infiltration of an area producing greater spring flow, increased spring occurrence, improved wildlife habitat, and increased water availability for aquifer recharge. These considerations are necessary to develop a sustainable water use plan supporting the growing population of central Texas.

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