GEOGRAPHY OF THE OGALLALA AQUIFER IN TEXAS

Introduction

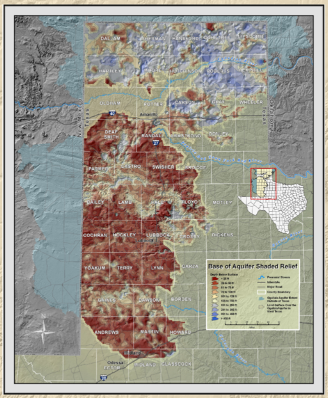
On the Texas High Plains, the Ogallala Aquifer supports one of the most agriculturally productive regions in the world. Although the area is characterized as a semi-arid environment, water drawn from the Ogallala Aquifer is used to sustain large-scale irrigated agriculture, livestock production and rural communities. Thus the landscape and rural economy of West Texas are both are strongly dependent upon the Ogallala Aquifer as a major groundwater resource.

Purpose of the Project

The purpose of this map series is to explore the geography of the Ogallala Aquifer in Texas. The main object is to better understand the characteristics of the aquifer itself and the relationship between the aquifer and the agricultural landscape.

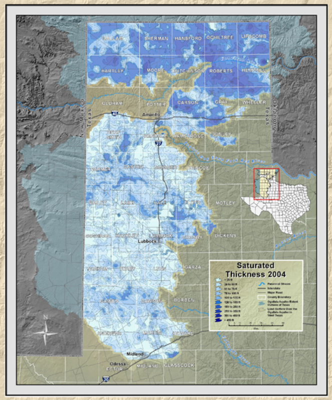
About the Map Series

Over the past several years, the Center for Geospatial Technology at Texas Tech University has been involved in a number of mapping projects that focus on water related issues in the region. The first project involved mapping the saturated thickness of the aquifer and rates of aquifer decline, the second project involved mapping center pivot irrigation systems and the third project involved mapping playa wetlands. This map series represents the integration of these research projects to provide a more comprehensive understanding of the regional geography.



At the time the Ogallala Formation was deposited, about 3 to 10 million years ago, the topography of the region was not as smooth as it is today. Rather, the sediments were laid down over an ancient topography that contained numerous deep channels and hills. As a result, the depth of the aquifer below the present ground surface is highly variable across the region.

The elevation of the base of the Ogallala Aquifer was derived by geoprocessing both contours and point elevations. Spatial Analyst was then used to interpolate the elevation surface with a polygon layer of the Ogallala boundary as a mask. Lastly, a hillshade was created from the base of the aquifer DEM.



These elevation differences in the base of the aquifer are largely responsible for the spatial variability in the saturated thickness of the aquifer. Where there are deep channels or depressions in the base of the aquifer, the saturated thickness of the aquifer can be greater than 400 feet, especially north of the Canadian River. In other parts of the aquifer, where hills or mounds exist in the underlying topography, the saturated thickness of the aquifer is very thin.

The saturated thickness of the Ogallala Aquifer was developed using a series of VB scripts. The scripts were used to calculate the saturated thickness of the aquifer by subtracting the base of the aquifer from the water table elevation for each year in the study.

The Aquifer Geodatabase

The aquifer geodatabase was developed using tabular data and shapefiles obtained from the Texas Water Development Board. The tabular dataset included the geographic coordinates for each well in the state's well monitoring network, the ground surface elevation, the depth of the well, and annual measurements of the depth to the water table for each year from 1990 to 2004. The shapeiles consisted of elevation contours and elevation points for the base of the aquifer.

Once the tabular well data were geocoded and the shapefiles cleaned, Spatial Analyst was used to interpolate a digital elevation model for the base of the aquifer and raster elevation surfaces for the water table for each year. The saturated thickness of the aquifer was then calculated for each year by subtracting the base of aquifer surface from the water table elevation surfaces.

Lastly, to calclulate the change in the saturated thickness of the aquifer, the saturated thickness for 1990 was subtracted from the saturated thickness for 2004.

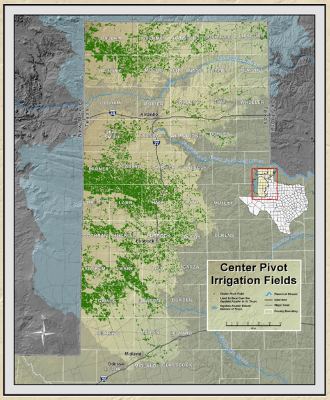
The Center Pivot Geodatabase

The center pivot geodatabase was derived from 1995 county mosaic DOQs and 2004 county mosaic NAIP imagery downloaded from the NRCS Geospatial Data Gateway. The county mosaics were brought into ArcMap at a scale of 1:30,000 and the center of each center pivot field was digitized as a point feature. The point features were then attributized with the diameter of the field and the year of the image. In all, the geodatabase contains records for 24,523 center pivot fields overlying the Ogallala Aquifer in Texas.

The Playa Wetlands Geodatabase

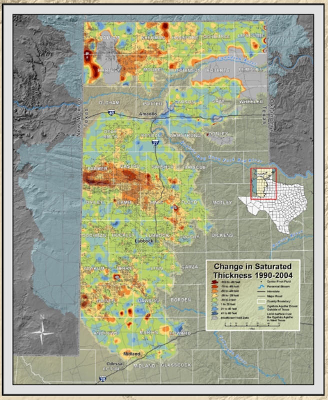
The playa lake wetlands geodatabase was originally developed for the USFWS National Wetlands Inventory using a combination of soils data and 2004 NAIP imagery. To map and classify the playa wetlands, the hydric soils were extracted from the SSURGO database for each county in the study area. The soil polygons were then overlaid on 1 m color-infrared NAIP imagery to aid in the mapping and air photo interpretation. The soil polygons were edited based upon the underlying imagery and classified using the Cowardin Wetlands Classification System.

The Cowardin Wetlands Classification System is used by the National Wetlands Inventory to describe wetland habitats. The system uses a hierarchical approach with six different levels: System, Subsystem, Class, Subclass, Water Regime and Special Modifers. Of particular interest to this study are the playa wetlands that are classified as farmed playas.



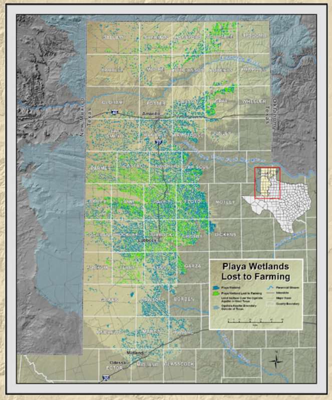
The spatial variability in the saturated thickness of the Ogallala Aquifer has a profound influence on the agricultural landscape at the surface. Center pivot irrigation fields are not randomly distributed across the region. Comparing this map of center pivots to the previous map of saturated thickness, it becomes obvious that the spatial pattern of center pivots is strongly correlated with the saturated thickness of the aquifer. For example, the map shows the intensive nature of irrigated agriculture in Castro, Parmer and Gaines county.

The saturated thickness of the Ogallala Aquifer in Parmer County has declined as much as one-third in a 15-year period. Castro and Gaines counties have lost about one-fourth of their aquifer in this same period.



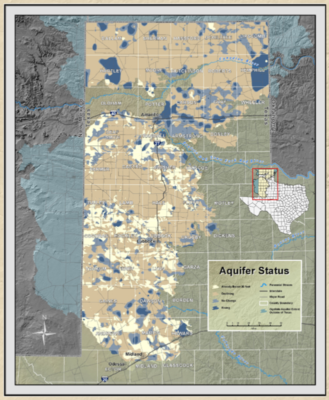
When a map of center pivot irrigation fields is overlaid on a map of saturated thickness change, it again becomes obvious that the most intensive irrigated agriculture has developed where the aquifer is thickest - and these areas closely correspond to the highest rates of aquifer depletion.

North of the Canadian River, where the aquifer is thickest, the largest declines in the aquifer occur in the northwest where the denisty of center pivots is greatest. In the northeast, the rolling hills and undulating topography of the land surface lends itself more toward grazed rangeland and there is less intensive use of the aquifer.



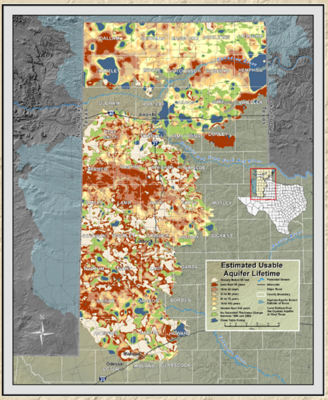
The results from this study can also be applied to explain the spatial variability in the loss of wetland habitat on the Texas High Plains. When a map of playa wetlands is compared to the map of center pivots, it becomes clear that the greatest loss of playa wetlands has occurred in those areas of intensive irrigated agriculture - where the density of center pivot fields is greatest. In turn, this density of center pivot fields is strongly correlated with the saturated thickness of the aquifer. Thus, we find a strong spatial correlation among the saturated thickness of the aquifer, the density of center pivots and the loss of playa wetlands.

In West Texas playa wetlands provide critical habitat for migratory birds in the Central Flyway, and local wildlife populations.



The observed changes that have occurred in the saturated thickness of the Ogallala Aquifer are highly variable across the region. This map is a generalized summary showing the status of the aquifer; where the saturated thickness is already below 30 feet, where the aquifer is rising, where the aquifer is declining and where the aquifer is relatively stable.

In areas were the saturated thickness of the aquifer is greatest, there is intensive irrigated agriculture and the aquifer is being depleted. In areas where the aquifer is relatively thin, there is very little irrigated agriculture and the saturated thickness of the aquifer shows little or no change. These areas are dominated by dryland farming land use and land enrolled in the Conservation Reserve Program.



To calculate the "time to depletion" or "usable lifetime" of the aquifer, it was assumed that the aquifer was essentially depleted for large-volume irrigation when the saturated thickness is drawn down to minimum threshold of 30 feet (Kansas Geological Survey). In many parts of West Texas the saturated thickness is already below 30 feet. In most other parts of the aquifer, the usable lifetime is on the order of 30 years or less.

The time to depletion layer was calculated by subtracting 30 feet from the saturated thickness of the aquifer in 2004 and then dividing this result by the average rate of aquifer decline for the 15 year period from 1995 to 2004.

Significant Findings

In many parts of West Texas the saturated thickness of the Ogallala Aquifer is already below 30 feet, the minimum threshold to sustain large-volume irrigation. In other parts of the aquifer, the usable lifetime is on the order of 30 years. This result suggests that the era of irrigated agriculture on the Texas High Plains will probably come to an end within the next generation.

Acknowledgments

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