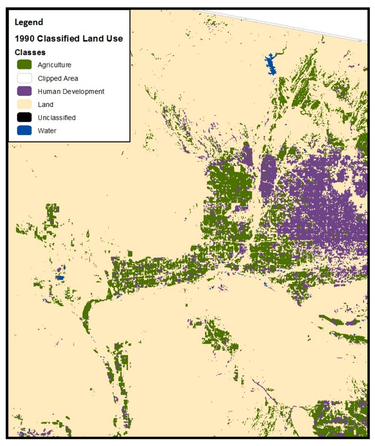
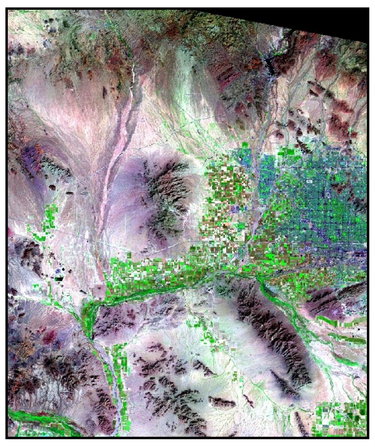
Changing Landscapes: Applying Remote Sensing and GIS to determine Phoenix, AZ Urbanization from 1990 to 2010 and its affects on Potential Groundwater Regions

1990 Reclassification



Raw 1990 Image

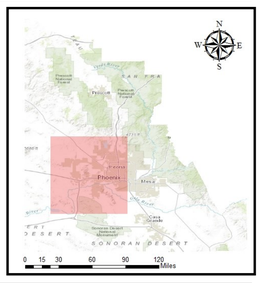


Introduction

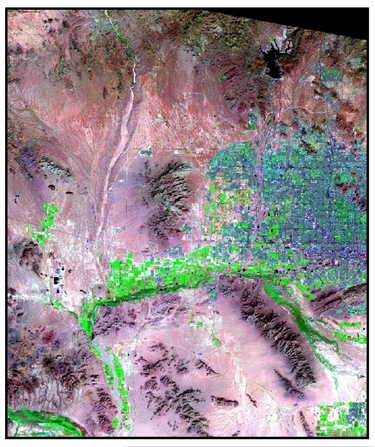
Cities in the United States natural grow and mature as time passes due to their increasing population. New residents place a stress on the availability of housing, goods, and services in the city limits. The natural response, especially in the western United States, is to build new communities and housing at city limits. From 1990 to 2010, Phoenix, AZ had grown from the 10th largest city to the 6th largest city in the United States. In this 20-year period, roughly 120,000 new residents now occupied the Phoenix Motorplex (U.S. Department of Commerce 2010). These quick changes like this place a stress on the city dynamic. Mapping the urbanization changes in the surrounding Phoenix, AZ area can analyze how the city developed.

Studies have found urbanization and industrialization place an intense effect on urban groundwater resources, which in turn correlates to land use (Foster, Lawrence, and Morris 1998). Urban land coverage results in a barrier for rainwater to drain into the underlying groundwater. Direct infiltration into the subsurface decreases. Resulting in an increase in surface water runoff, which would now drain into city's storm-water catch basins. These two conditions would lead to a decrease in groundwater levels. Groundwater prospective maps, using the land use, precipitation, slope, geology, and river system network, determine the potential of groundwater levels. Analyzing the change in land use and the change in prospective groundwater determines the predicted correlation between increased urbanization and decreased groundwater potential.

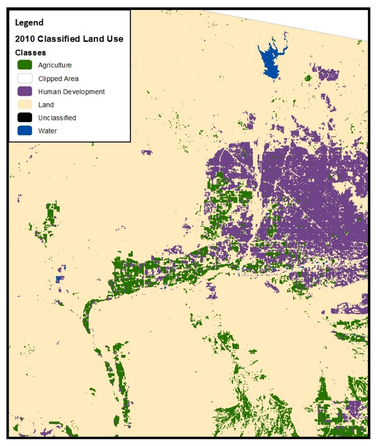
In this semiarid region groundwater is 45% of the water source. High usage for agriculture irrigation and public supply in this area requires more groundwater conservation. Phoenix's development could change the groundwater potential.

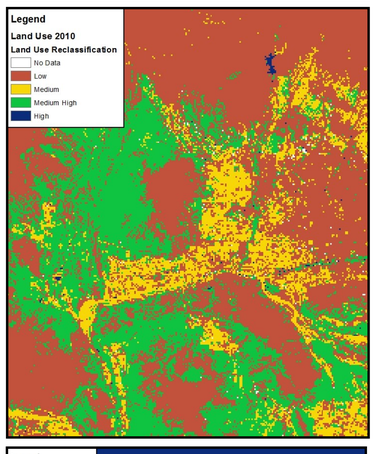


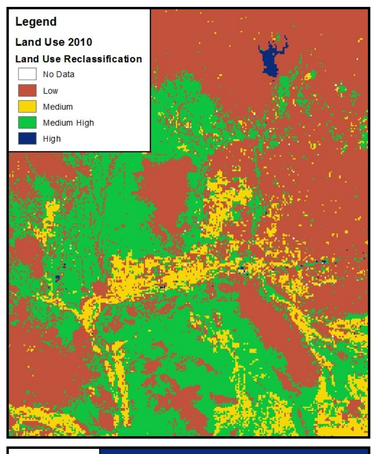
Raw 2010 Image



2010 Reclassification







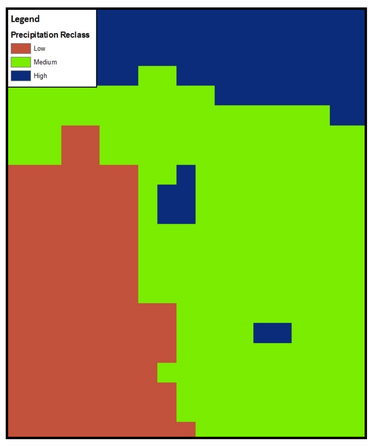
Methods

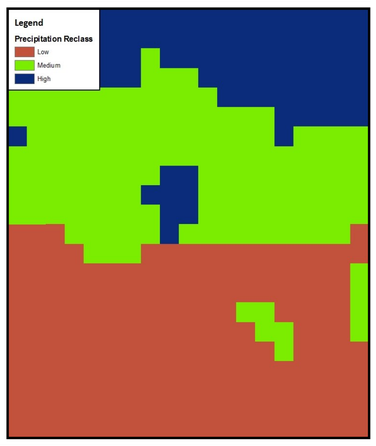
Two Landsat 5 TM images from Earth explorer roughly displays the Phoenix land change from October 25, 1990 to November 1, 2010. The spectral reflectance characteristics determined land cover type, for each surface has its own unique curve. With a 742-band combination and a 2% linear stretch, land features classified by ground-truth ROI training sites. Comparison of the 2010 supervised classification resulted in more accurate with the Maximum Likelihood rather than the Minimum Distance. Post-classification cleanup included combining original classes into four major classes, such as Water, Land, Human Development, and Agriculture. These major classes underwent an 8-neighbor connectivity and 10 minimum cluster size sieve. From this process, there was an increase in unclassified pixels. Applying a major analysis, with 7-by-7 kern, averaged the data and reclassified the unclassified pixels. Applying this method to both Landsat images creates two classified land use. Undergoing a thematic change detection in ENVI, the resulting raster shows the land type change from 1990 to 2010.

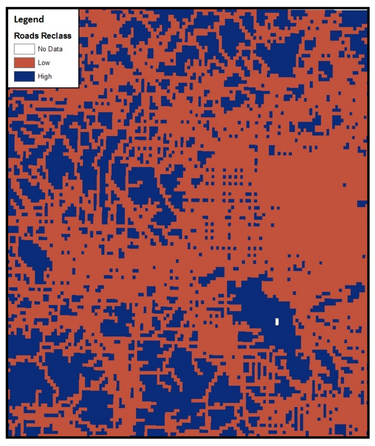
The change in land use was a major aspect of the remote sensing processing. The new land types, coupled with differing precipitation, slope, geology, and river system network, were converted to raster. Reclassified based on previous studies (Abdalla 2010), the layers underwent a raster calculator with weights dependent on map weight. Going through the process twice, the result is two groundwater prospective maps. These maps underwent another raster calculator, which subtracted the 1990 values from the 2010 values. To compare the change detection results, reclassification of the thematic change detection of land use map and the raster change detection of groundwater prospective.

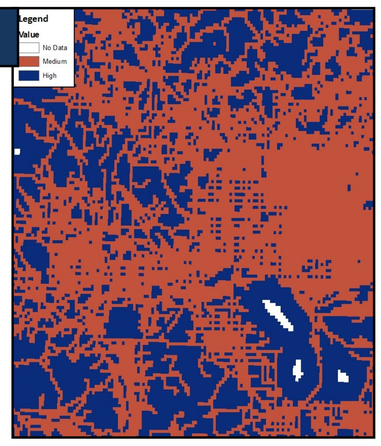
Thematic Layer	Map Weight
Land Use	25%
Annual Rainfall Total Amount	9%
Roads	16%
Slope Percent	16%
Lineation	9%
Water Bodies	25%

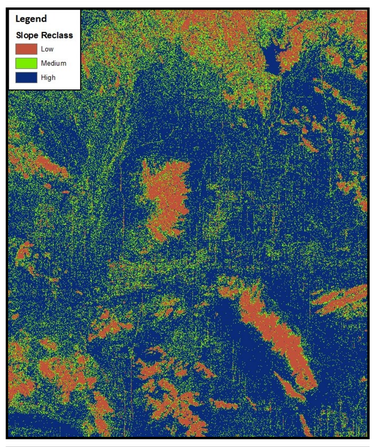
The band collection statistics produced the correlation matrix between the change land use and change prospective maps. Applying remote sensing and GIS produced the correlation between the change in land use and the change in groundwater prospective maps from 1990 to 2010.

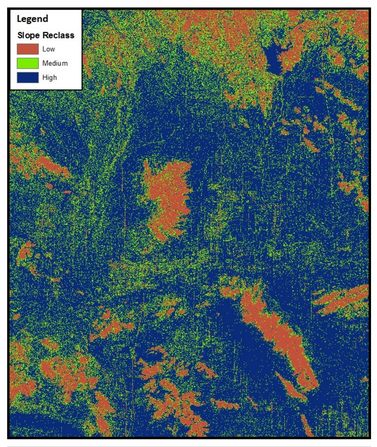


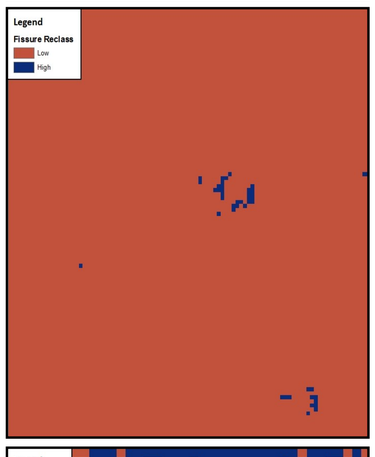


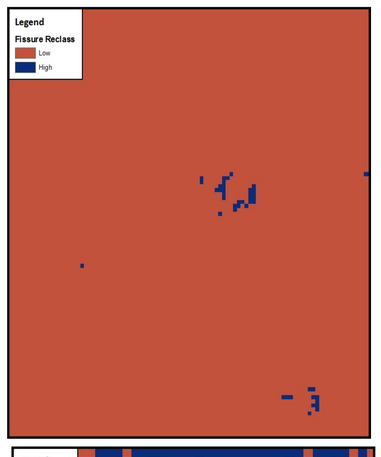


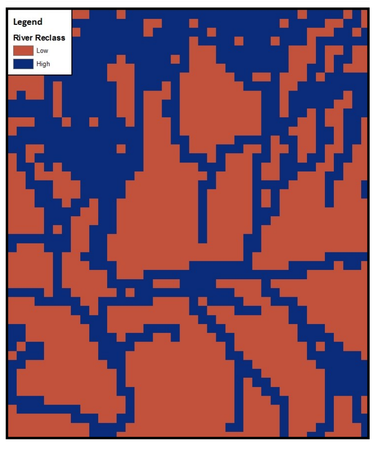


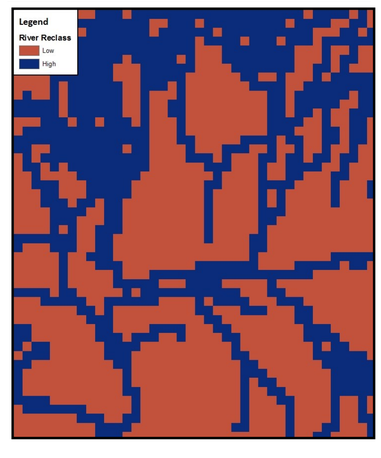






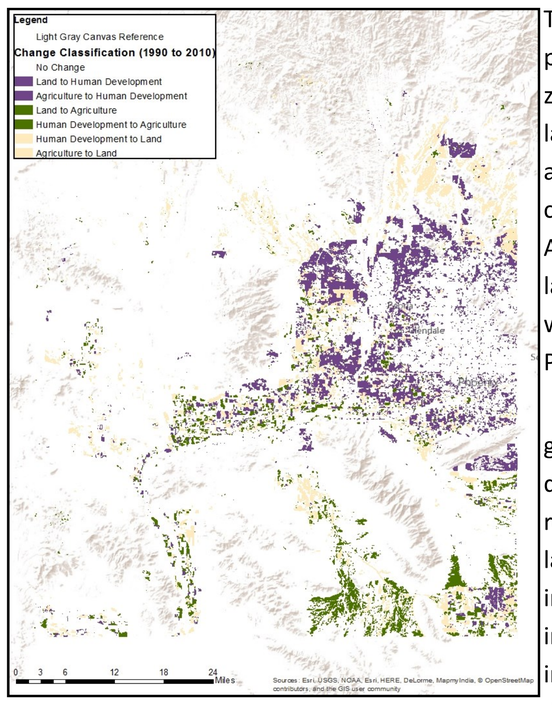


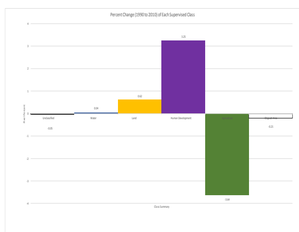




Results & Conclusion

Remote Sensing Thematic Change Detection of Land Use from 1990 to 2010



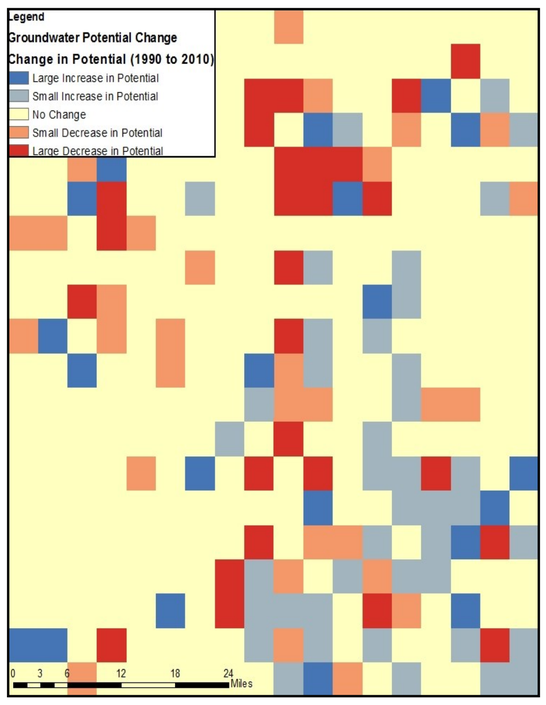


The final thematic change detection shows an increase in urbanization in the western region of the Maricopa County. Through class statistical analysis, there is a 3.25% increase in pixel percent from 1990 to 2010 for the human development zones. Instead of expanding the city limits to unoccupied land, the new developments occurred from old agricultural areas. One theory includes the price of establishing utilities is cheaper to pre-established electrical, water, and sewer lines. Another theory involves the low rent price for agricultural lands, is ideal for expansion because these areas are still within proximity to Phoenix. Either way, from 1990 to 2010 Phoenix had an increase in urban areas.

The raster change detection indicates the change in groundwater potential from 1990 to 2010. A large potential decrease appears in the northern half of the region. This area represents the newly developed urban zones and a change in land soil from loam to roads. These areas will experience an increase in surface runoff and a decrease in surface infiltration. The study area's southern region experienced an increase in groundwater potential. New sand and gravel deposits in this area, coupled with increased vegetation, has intensified the infiltration in this region. One issue however comprises of the bedrock having a severe decrease in size. Extreme weathering would not change the landscape in this semiarid region in only 20 years; thus, the classification scheme needs reevaluation for future projects.

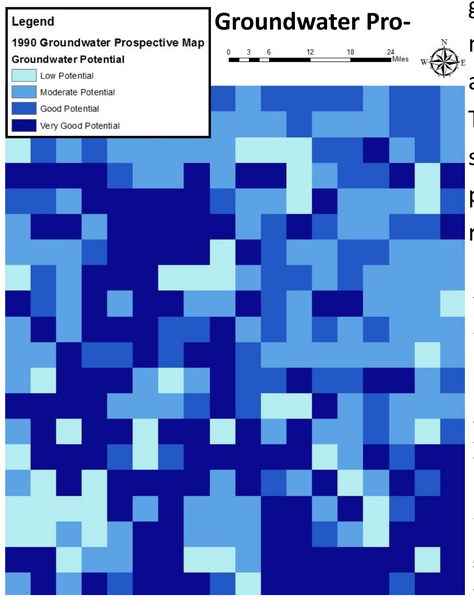
The band collection statistics determines the correlation between the reclassified land cover types change and reclassified groundwater potential change. With a 1 to -1 relationship, there is a negative correlation between these layers. Overall, the increasing urban areas have a direct correlation in decreasing the groundwater potential. The results indicate how humans had an impact on the groundwater supply in Phoenix, AZ. With projections indicating double the population in 2050, the area should be monitored if groundwater is to remain the major source of water.

Raster Change Detection of Groundwater Prospective Maps from 1990 to 2010

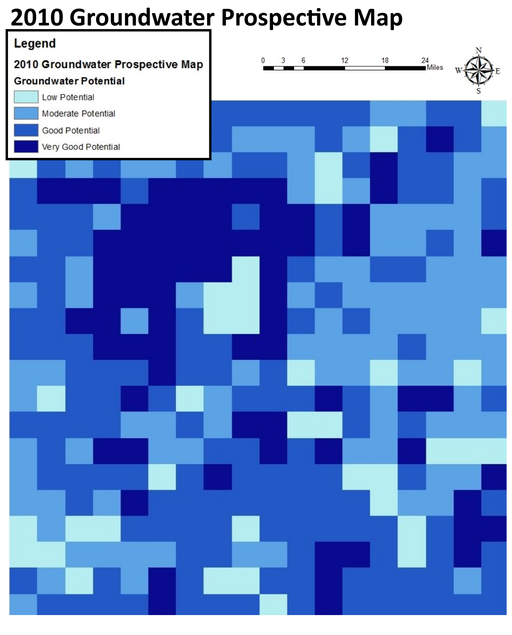


CORRELATION MATRIX		
Layer	1	2
1	1	-1.09352
2	-1.09352	1

1990 Groundwater Prospective Map



2010 Groundwater Prospective Map



Data Sources:

Landsat 5 TM Images: https://earthexplorer.usgs.gov/

Water Bodies: http://repository.azgs.az.gov/uri_gin/azgs/dlio/1655

Roads: http://data.opengeoportal.org/

Lineation and Fissures: https://geo.library.arizona.edu/

Precipitation: http://prism.oregonstate.edu/recent/

References:

Abdalla, F. (2012). *Mapping of groundwater prospective maps using remote sensing and GIS techniques: A case study from the Central Eastern Desert, Egypt.* Journal of African Earth Sciences, v. 70, pgs. 8-17.

Foster, S., Lawerence, A., Morris, B. (1998). *Groundwater in Urban Development*. World Bank Technical Paper No. 390. Library of Congress.

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U.S. Department of Commerce, Office of Economic Opportunity. (2010). *2010 Population.* Arizona. Retrieved from: population.az.gov/census-data

Coordinate System: WGS 1984 UTM Zone 12N

Projection: Transverse Mercator

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CEE 194: Remote Sensing