Using ArcGIS to Determine Texas Water Planning Regions with Maximum Municipal Conservation Potential

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Introduction

Over the next fifty years the population of Texas is expected to nearly double (TWDB). This increase is coupled with a rise in municipal water demand of 3.5 million acre-ft per year (TPWD). The state of Texas must act promptly to explore options of increasing water supplies to meet growing current and future demands.

Sixteen regional water-planning groups in conjunction with the Texas Water Development Board are taking steps to meet these mounting water needs. Their plans for action were published in the 2012 State Water Plan, which outlines means of increasing the water supply over the next fifty years to meet projected demand.

Key management strategies evaluated in the plan include: additional surface water reservoirs, groundwater, conjunctive use, bush control, aquifer storage and recovery, desalination, and conservation. Although the State Water Plan successfully outlines how to meet projected demand and gives estimated costs of completing all projects, the Plan is not paired with adequate funding to achieve its objective. Because of this, it is economically sensible to begin projects in the plan that have the largest impact on supply at the lowest cost. In general, the lowest capital cost strategy to increase water supply is to decrease demand through conservation efforts.

Conservation is often considered the "lowest hanging fruit" of water management strategies (Brennan). In addition to its low relative cost, conservation programs are available to be implemented now and at scales to produce measurable increases in water supply. Several examples of conservation measures focus on appliance efficiencies, irrigation control, as well as finding and repairing leaks in water infrastructure.

The potential of reducing municipal water demand and increasing quantity of water

supply varies with location based on several factors, including: population, demand, and available funding. Creating specific conservation programs for planning regions can optimize efficiency of management strategies. With individualized regional programs, Texas will be able to begin making strides to address the critical water issues of the state.

Objective

The objective of this project is to use ArcGIS 10.1 to determine which of the 16 Texas water-planning regions (Figure 1) have the maximum potential to conserve significant quantities of water by implementing municipal water conservation strategies.

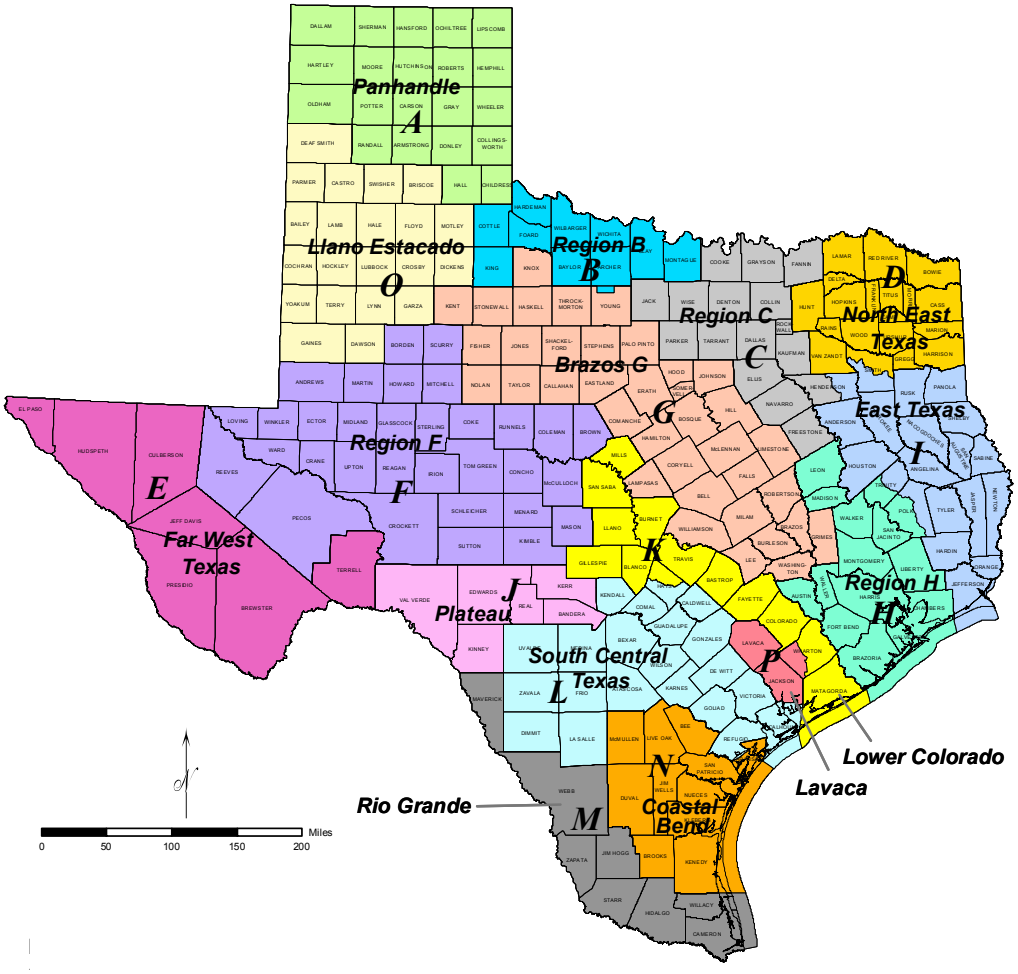


Figure 1: Regional Water Planning Groups, as prepared by the Texas Water Development Board

Data

In order to determine which water planning regions have this potential, data from the 2012 State Water Plan was collected and analyzed. The Texas State Water Plan is a document produced every five years by the Texas Water Development Board and 16 regional water-planning groups to evaluate fifty-year projections of water needs for the state under conditions of the drought of record.

Specific data collected includes 2060 population projections, 2060 water need projections, proposed conservation quantities and new surface water reservoirs, and capital costs per water planning region.

All of this data is readily available online through the Texas Water Development Board website.

Methodology

In order to determine which regions meet criteria to have maximum conservation potential, a straightforward raster analysis was done using the following steps:

1. Data was imported as a spreadsheet into ArcGIS 10.1.
2. Layers were created for each of the following regional variables: 2060 population, 2060 water need, number of proposed new reservoirs, percent of conservation in water plan, and cost of water plan.
3. Each layer was converted to raster using the Spatial Analyst Feature to Raster tool
4. A binary raster was calculated using Spatial Analyst Raster Calculator. Regions that met the following criteria were selected as 1.

    Criteria: 2060 Population > 100,000; 2060 Need > 100,000 acre-ft per year; Cost > $1,000 million; Percent Conservation < 15; New Reservoirs > 1

Results

The results of this study are illustrated in Figures 2 – 7. Figure 2 is the first of the layers created for analysis of the conservation potential. In addition to its value in the calculation potential, the distribution of the 2060 population projection is important for understanding potential migrations or areas of growth in the state. Figure 2 shows regions C and H, which include the Dallas Ft-Worth and Houston metropolises, as the largest population centers. East and West Texas similarly have the lowest population distributions projected for 2060.

Figure 3 maps out the 2060 projected water needs of the Planning Regions. Regions C and H again top the planning regions with the largest projections of water need, 1,588,236 and 1,236,335 acre-ft per year, respectively. However, there is also considerable need projected for the Texas panhandle.

Figures 4 and 5 show the distribution of management strategies listed in each Regional Water Plan. Figure 4 shows which regions meet their projected water needs through proposed new surface reservoirs. Four regions have proposed more than four additional surface reservoirs. Compared to this, Figure 5 shows the percentage of conservation strategies in each regional plan. Regions in the panhandle, west, and along the Texas-Mexico border have the largest percentage of their plans met through conservation measures.

Figure 6 displays the projected capital cost of each regional water plan. The projected costs very from less than $50 million to greater than $20 billion with an average cost of $3 billion. Regions C, H, and L have the most costly plans.

Figure 7 is the consequential map of evaluating the planning regions with the conservation potential criteria described above. It indicates that four regions (C, G, H, & L) meet the criteria for 2060 projected population and water need, proposed new reservoirs, regional plan conservation, and capital cost of regional management strategies.

Discussion

The State Water Plan indicates that in the coming years municipal demand will increase and irrigational demand, which is currently greater, will decrease. This trend is visible in the projected trends in population, water need, and planning costs. As Figure 2 and 3 show, the largest increases in population and water need are anticipated to be in regions with large metropolitan areas. Associated with this growth, are the most expensive regional water plans in the state.

So what is the importance of Regions C, G, H, and L that we can gain from these figures? Each of these regions requires large increases in water supply for future needs and they have an opportunity to significantly impact these supply needs with conservation. Because of large populations and high municipal water demands, application of municipal water programs can save these regions up to a million acre-ft of water yearly. And with the low relative cost of implementing conservation technologies and education programs, this notable water saving strategy will lessen the dependence of these regions on expensive supply strategies like desalination or new surface reservoirs. While conservation savings cannot account for all projected water demands, it can be a low cost, easily implemented means of preparing for the future. By tailoring specific conservation programs to these high potential regions, regions can maximize the efficiency of water planning efforts.

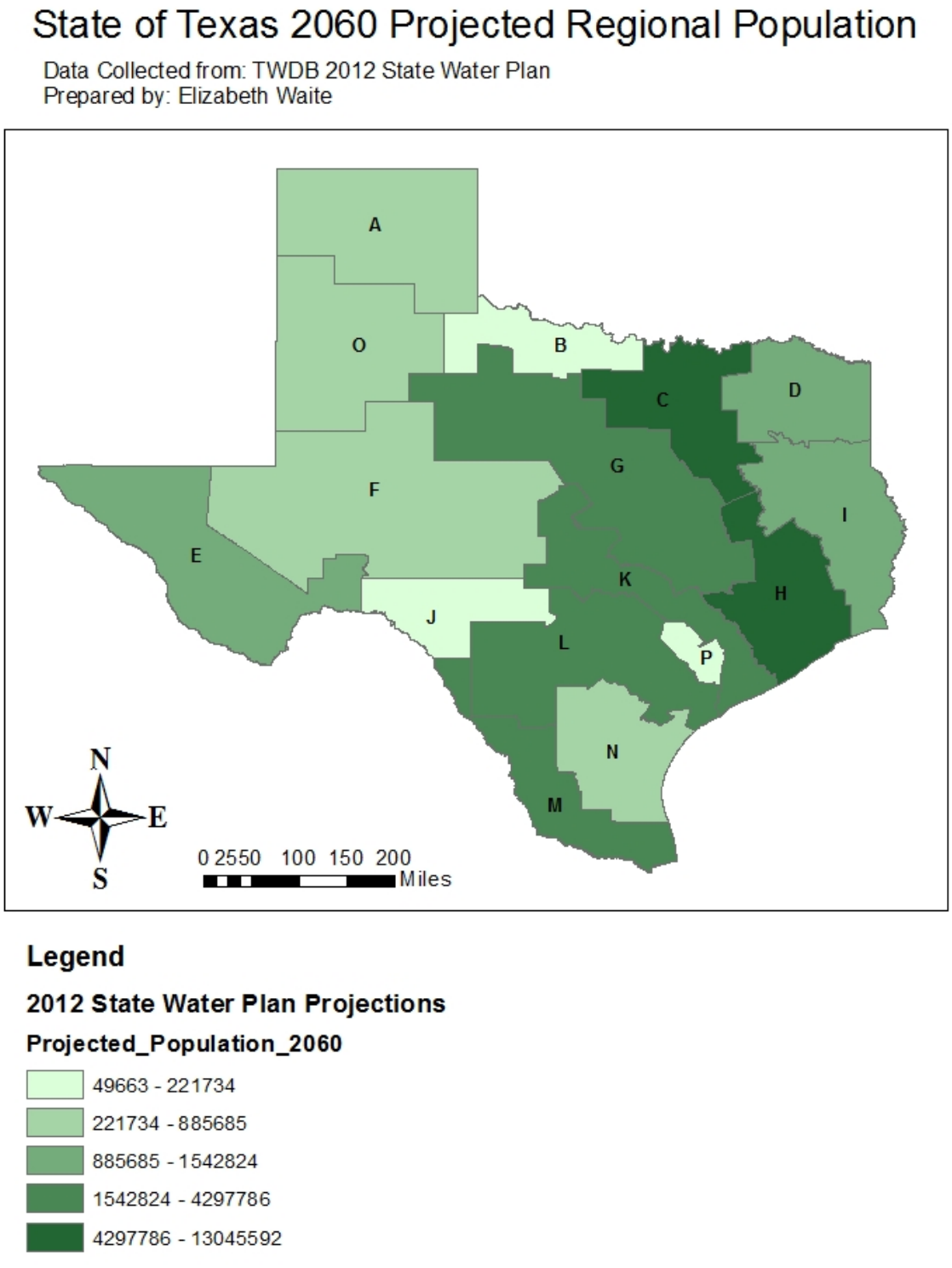


Figure 2: Maps out the 2060 Projected Population Changes in Texas. Population increases are highest in major metropolitan areas and along the Texas-Mexico boarder.

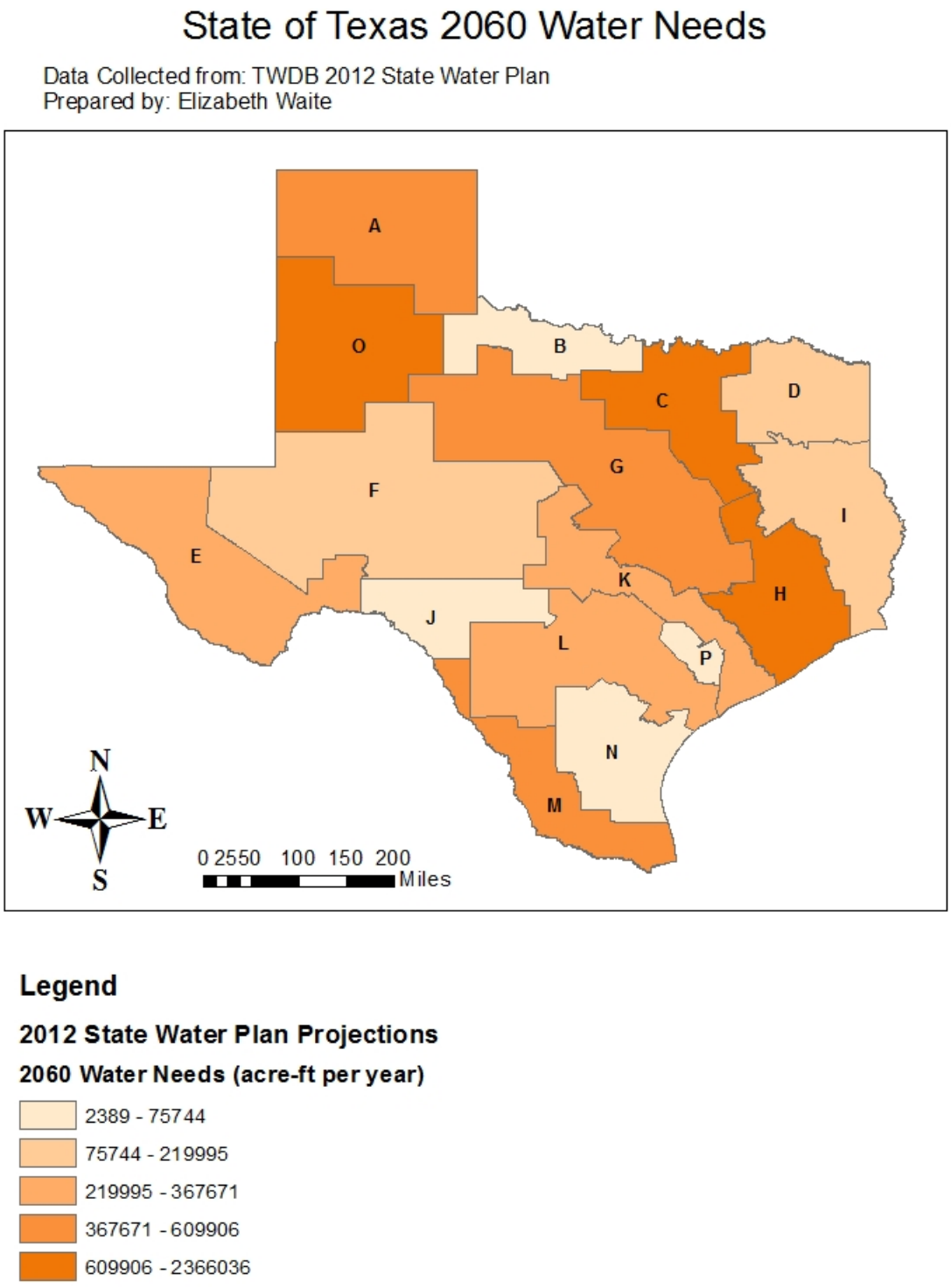


Figure 3: Maps out State of Texas 2060 Projected Water Need. Water need is a function of projected demands and available supply. Regions C, H, and O have the largest projected water needs. The majority of water need in regions C and H is anticipated for municipal demand.

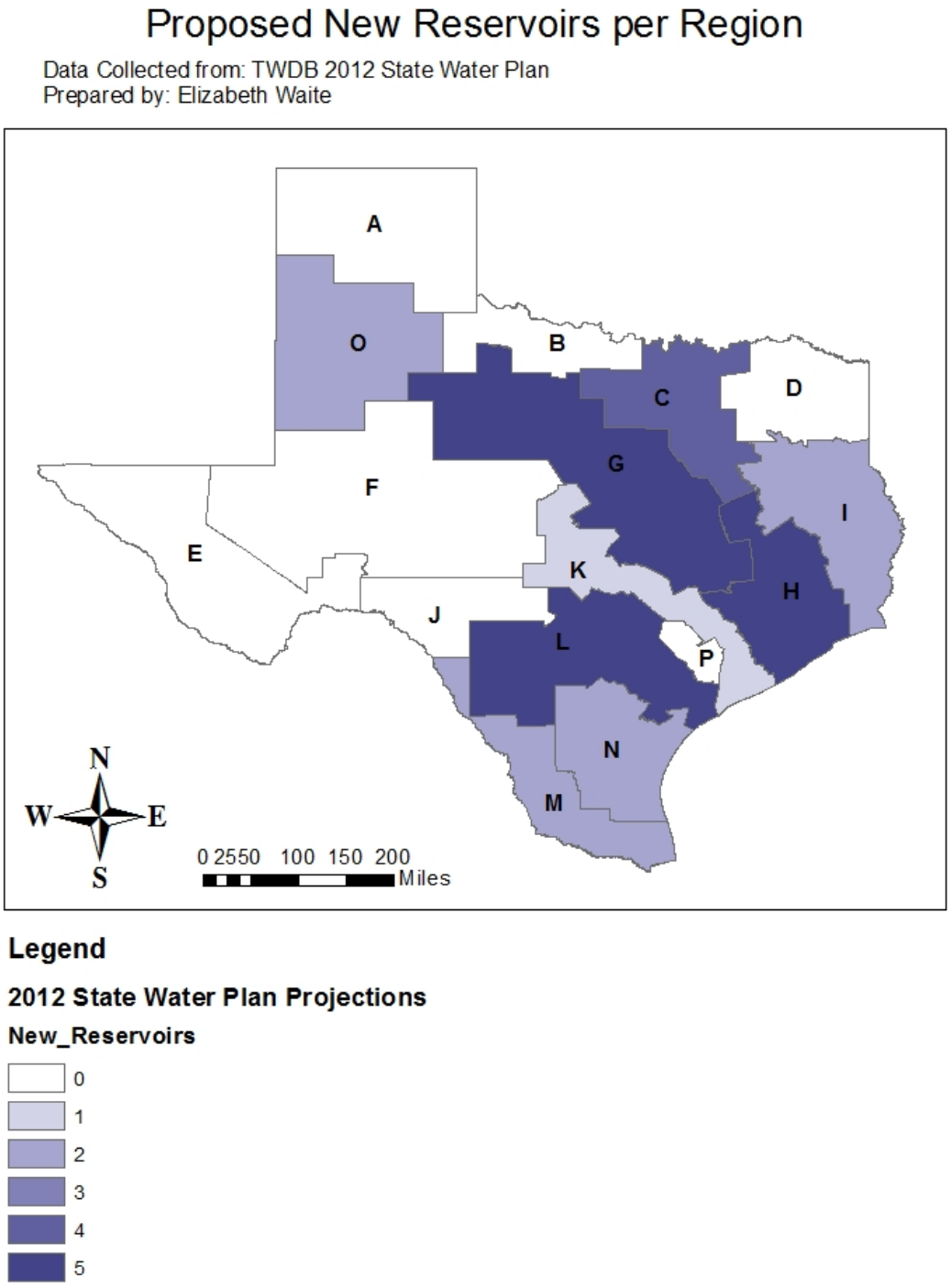


Figure 4: Shows the number of new reservoirs proposed by each Regional Water Plan. Construction of surface water reservoirs is a very expensive and at times inefficient means of supplementing water supply.

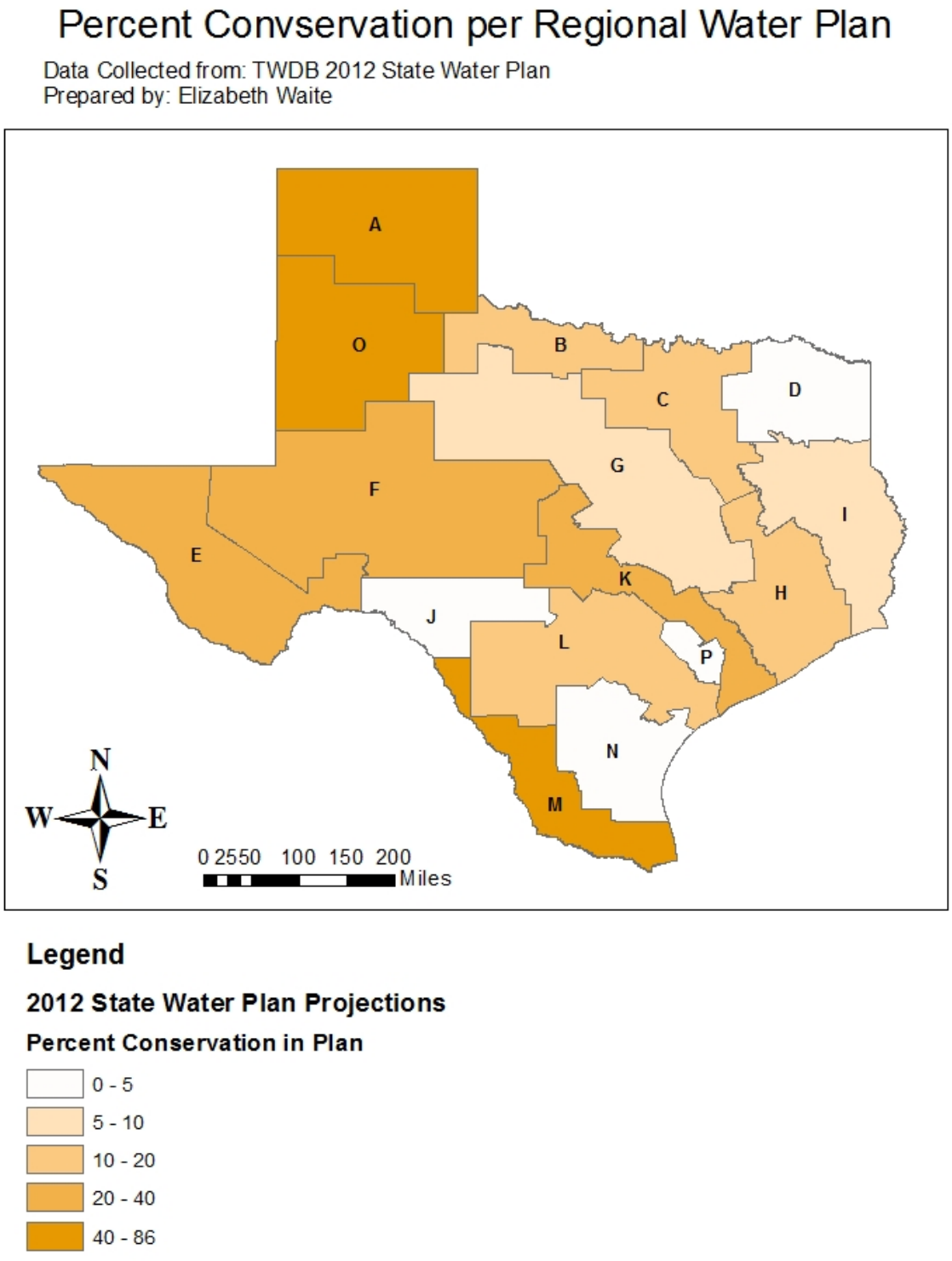


Figure 5: Shows the percent of conservation used as a management strategy in Regional Water Plans.

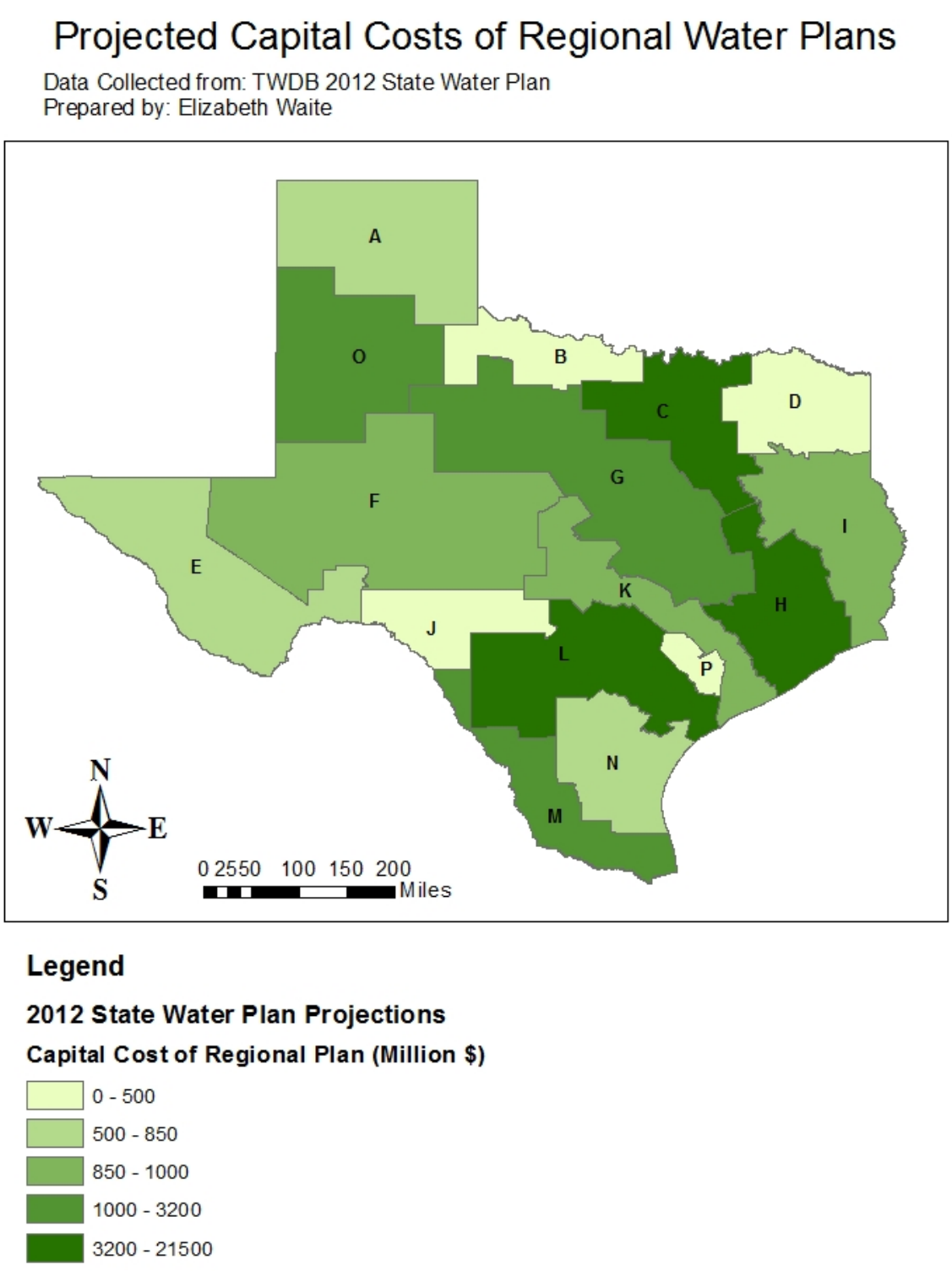
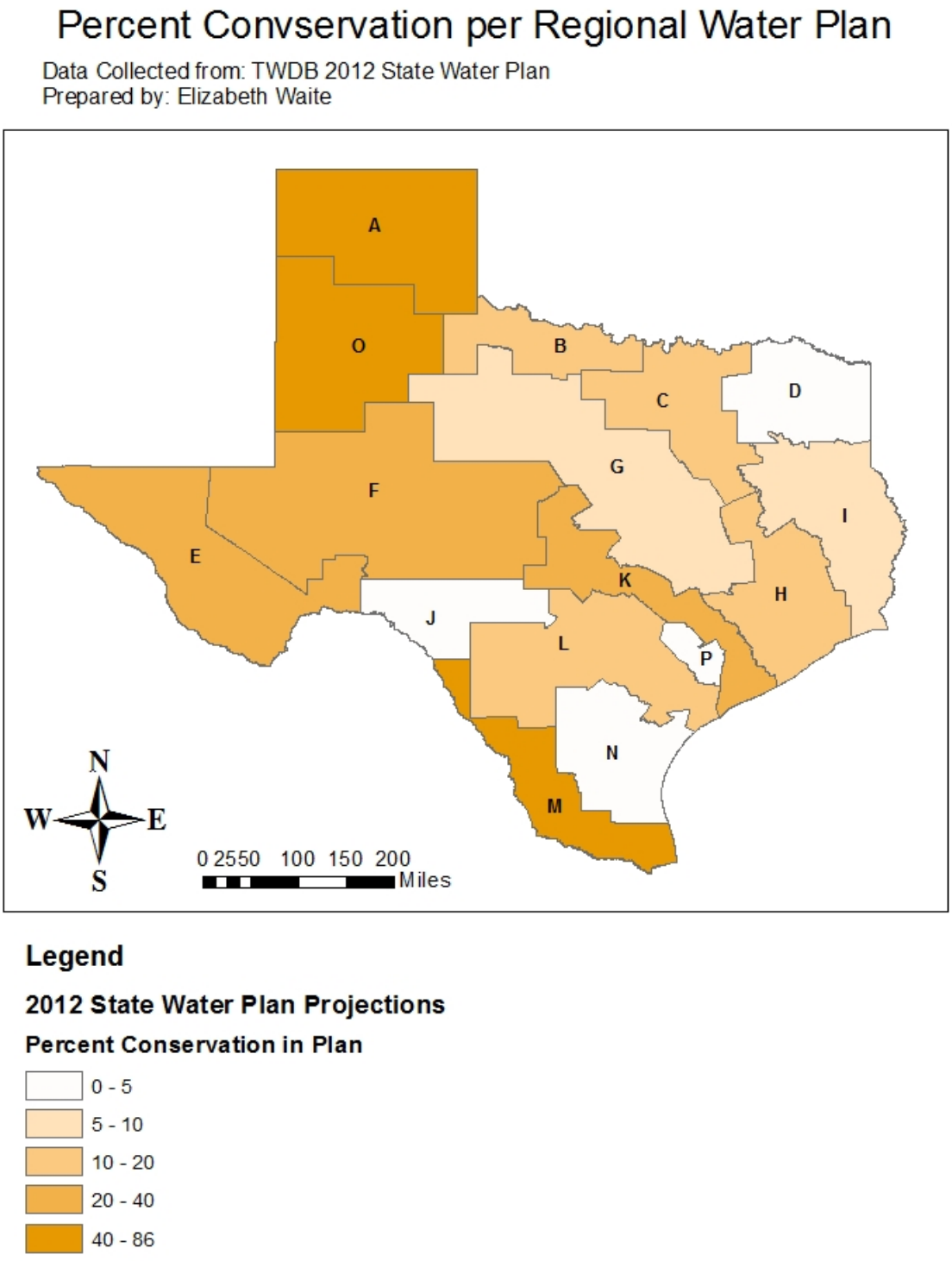


Figure 6: Shows the distribution of costs of each Regional Water Plan. The highest cost plans coincide with regions with high population and demand projections.



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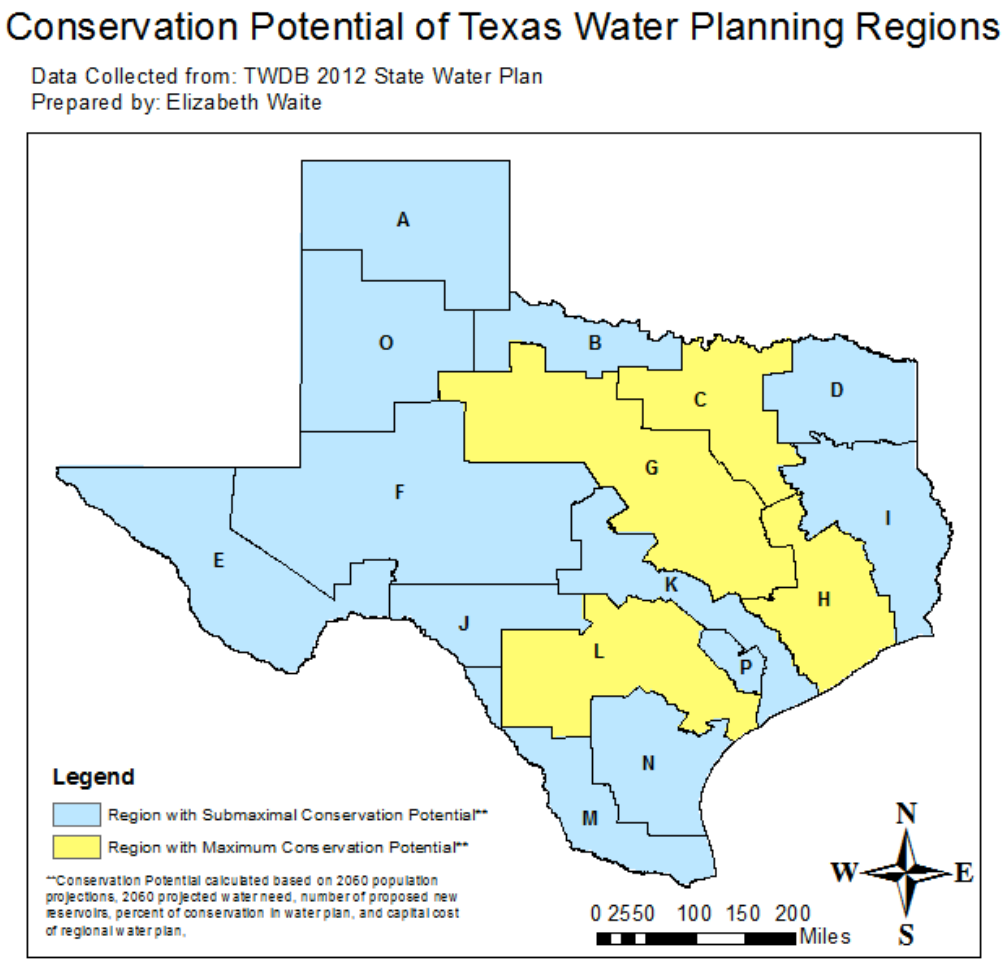

Figure 7: Calculated Water Planning Regions with Maximum Water Conservation Potential. Regions with the highest potential to conserve maximum amounts of water include regions C, G, H, and L.

Conclusions & Future Work

The use of ArcGIS 10 to analyze information in the Texas State Water Plan was a valuable tool for both evaluating and visualizing conservation potential of the Water Planning Regions. Based on the findings that Regions C, G, H, and L meet the maximum conservation criteria, further work can focus on developing conservation plans that can serve this potential. Due to the limited funding currently allocated for expanding regional water supplies, designs should couple economic and water savings efficiency, such that programs implemented are able to obtain the maximum water savings per dollar spent. Texas will greatly benefit from utilizing conservation strategies to meet future water needs.

References and Data Sources

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