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Economic Valuation for Groundwater resource in Southern Ogallala Aquifer

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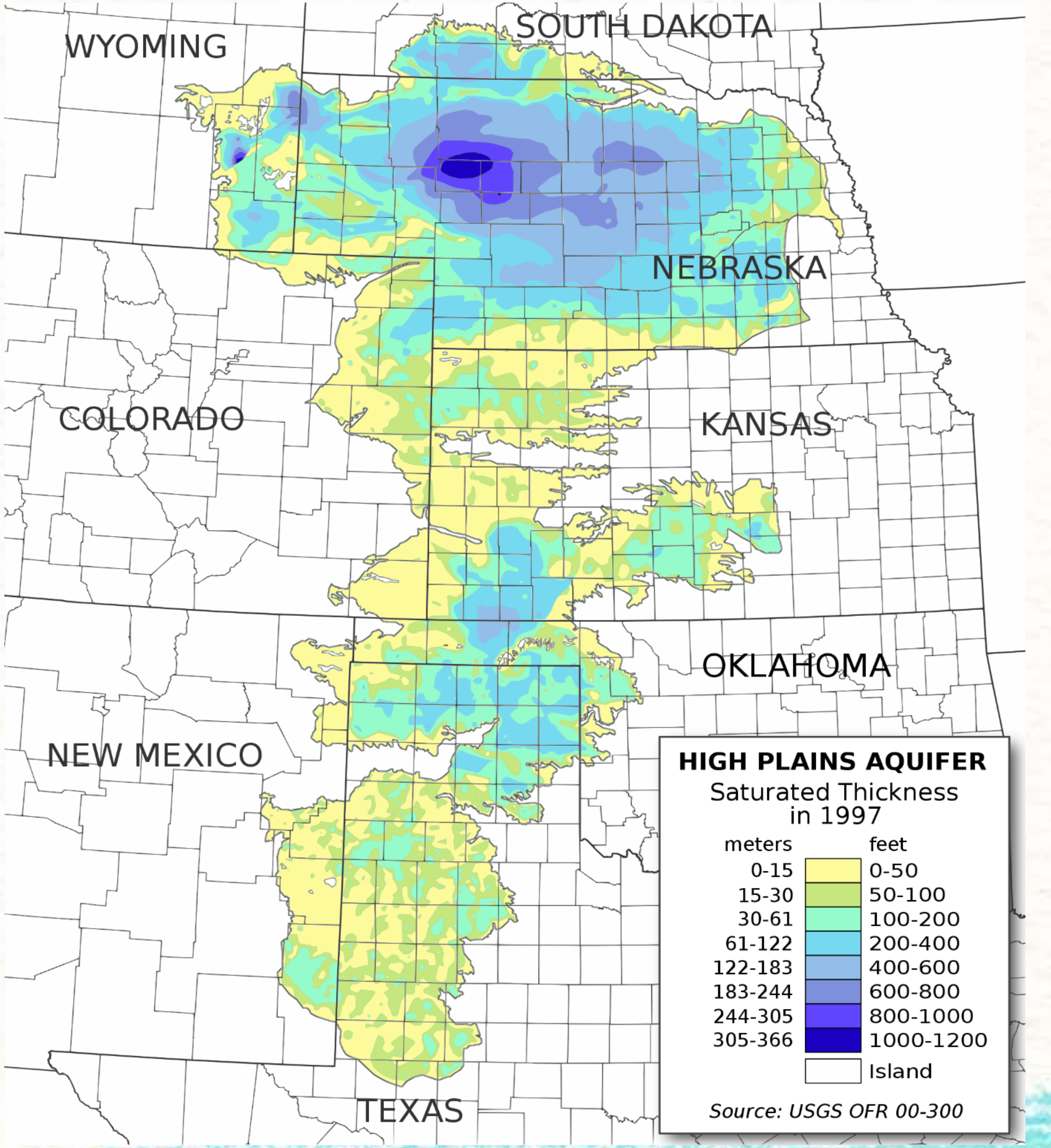
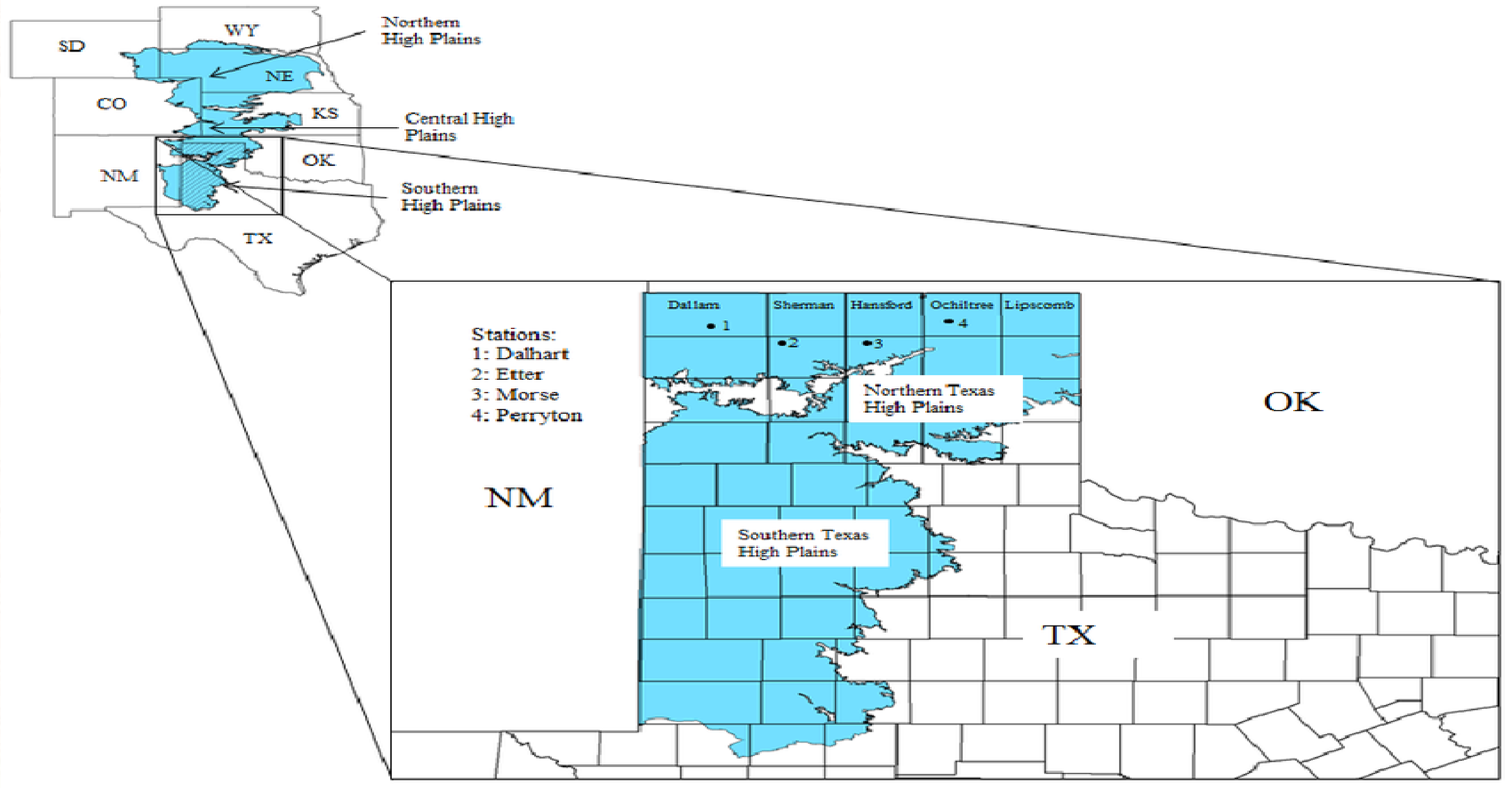
Ogallala Aquifer

- located in the High Plains, one of the largest underground reservoir in the world.
- provides freshwater for agricultural, industrial, residual and energy use across eight states (South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas) in the United States.
- supplies roughly one-fifth of the total annual agricultural products in the United States, which worth more than $20 billion of food and fiber in the world’s food market.
- More than 90% of the water pumped out of aquifer is used for agriculture.
- It has severe depletion problem, and if drains, it would take more than 6000 years to be refilled naturally



WYOMING
SOUTH DAKOTA
NEBRASKA
COLORADO
KANSAS
OKLAHOMA
NEW MEXICO
TEXAS
HIGH PLAINS AQUIFER
Saturated Thickness in 1997
meters feet
0-15 0-50
15-30 50-100
30-61 100-200
61-122 200-400
122-183 400-600
183-244 600-800
244-305 800-1000
305-366 1000-1200
Island
Source: USGS OFR 00-300

Southern Portion of Ogallala Aquifer



Problems

- Extensive demand for water and the very limited recharge
- The absence of a market mechanism as public goods
- The current prices of water don’t adequately reflect its scarcity
- Uncertainty about future needs
- However, simply postponing water use could be problematic

The Purpose of this Paper

- Investigate the possibility of the marketable option value for maintaining groundwater resources in the southern Ogallala Aquifer as compared to an estimated existence value.
- Utilize a referendum format contingent valuation (CV) survey of the western portion of Texas.
- Factors that influence both estimates include age, the existence of children, importance of the aquifer for household income, and pro-environmental attitudes.
- Comparing the two estimates, we conclude option value is the appropriate social value measure

Definitions of different economic values

- Use value reflects the direct use of the environmental resources. It reflects the value derived from current use.
- Nonuse value: reflects the common observation that people are more than willing to pay for improving or preserving resources that they will never use. A pure nonuse value is also called existence value.
- Option value reflects the willingness to preserve an option to use the environment in the future even if one is not currently using it. It reflects the desire to preserve a potential for possible future use.

Note: all definitions are from Tom Tieteberg(2006).

Literature Review

- The concept of option value was first introduced by Weisbrod in 1964, who argued that under uncertainty and risk of the availability of the goods, people are willing to pay a sum over and above consumer’s surplus for their future demand of the goods.
- Other related option value studies include Biship(1982), Cicchetti and Freeman (1971).
- Haab and McConnell(2002) give distinct definition of the option value and the existence value.
- Walsh, Loomis & Gillman(1984) define option value as insurance premium.

Contingent Valuation Method

- A survey-based approach to collect detailed information of people's preferences or willingness to pay regarding a specific certain environmental good.
- The use of a referendum question for CV is a recommended approach by Arrow et al. (1993)
- Widely used on environmental, cultural, health, transportation and any other nonmarket resources or public goods or services virtually.
- Jiang et al (2010) employed CV to estimate the WTP of Fuzhou City residents for pollution control by the livestock farms located at the upstream Min River.
- EPA estimates the benefit of individual regulations on the Clean Water Act by applying CV to the targeted water bodes and industries.
- Nagin et al (2006), Johnson and Whitehead (2007) , Carson. Wilks, et al (1994),
- Carson, Mitchell, et al(2003).

Methodology

- Approach towards the economic valuation of water for agricultural use: calculate the difference between the net returns from irrigated production and from dryland production respectively, and then dividing the value by total volume of water pumped for irrigation on a per acre basis (Rogers et al., 2002).
- **<u>The upper bound for marginal value of groundwater:</u>**
- The average marginal value of the groundwater resource in production: the difference in net revenues between an irrigated crop and a dryland crop.
- Production of upland COTTON in the southern high plains region of Texas.
- A price of $0.60 per pound of cotton is applied to the yield difference to arrive at a total average value generated from irrigation.
- Yield data: USDA – NASS for irrigated and dryland cotton in the study region at the county level for the period of 1997 through 2006.

Methodology

- Assumed that producers irrigate to 75% of the crop water requirement.
- Crop water requirements, precipitation data were obtained from the Texas High Plains Evapotranspiration (TXHPET) Network.
- Effective rainfall using the USDA Soil Conservation Service (SCS) method and CROPWAT 8.0 made available by the Food and Agriculture Organization of the United Nations.
- Water applications were calculated to be the difference between 75% of the crop water requirement and effective rainfall on a weekly basis.
- **<u>The lower bound for marginal value of groundwater:</u>**
- A lower bound for the marginal value of groundwater in irrigated agriculture is the marginal cost of acquiring and applying groundwater.

Methodology

- Estimate for the value of water for municipalities:
- A user of municipal water supplies pays not only for the water itself, but also for treatment and conveyance of that water.
- Municipal water rates (business and residential) are obtained for the 31 municipalities which sit above the Ogallala aquifer with populations in excess of 15,000 people.
- Prices were collected from websites maintained by the municipalities.
- Since the price of water is oftentimes too low to allow the market to clear. Given that observation, we argue that the municipal water rates represent a lower bound on the marginal value of water for municipalities.
- No upper bound was estimated here.

Methodology

- The value of water in oil and gas recover operations(lower bound)
- We observe the average price that firms are willing to pay for delivery of water to the production site, and know that if the value of the water resource were sufficiently low the delivery of water would be discontinued.
- Similar to the case of municipal water use, we are able to arrive at a lower bound for the value of water in oil and gas recover operations, but not an upper bound.

Contingent Valuation(CV)

- The survey was approved by the Texas Tech University Human Research Protection Program and was administered through Qualtrics Panels, LLC.
- Participants were recruited by Qualtrics within the geographic region outlined by the Texas-New Mexico border, the Texas-Oklahoma border, Dallas, TX, and 100 miles south of Interstate 20 in Texas.
- The sample was specified to have a minimum of 10% of respondents from "rural" locations. For the purpose of the study we defined "rural" as a county with population less than 10,000.
- Participants were provided with background information about the Ogallala aquifer and volumes of water used for a variety of human activities (including agricultural production and household usage).
- They were then asked a series of demographic questions as well as being administered the New Ecological Paradigm (NEP) scale.

Contingent Valuation(CV)

- Participants were asked to suppose that a referendum appeared on the next state ballot that asked for a one-time tax that would be used to postpone the use of one million acre-feet of water from the Ogallala aquifer.
- The dollar amount combinations that were presented were as follows: ($5, $10), ($25, $50), ($75, $150), and ($150, $300).
- A lower bound value of zero for all respondents, as a negative WTP for the option to use groundwater doesn’t make economic sense.
- Upper bound at $600, which is twice the maximum value that any respondent was presented with.

Results and Conclusion

- The marginal value of groundwater applied to irrigated agriculture in the southern High Plains of Texas is between $3 and $25 per acre-inch.
- Municipalities water value:
- The rates range between $0.98 and $7.93 per 1,000 gallons for residential users and $1.00 and $7.93 per 1,000 gallons for commercial users.
- The average residential price is $3.00 per 1,000 gallons and the average commercial price is $3.07 per 1,000 gallons.

	Municipal Water Rates $/Acre-Inch	
	Residential	Commercial
Mean	$ 81.36	$ 83.27
Median	$ 71.96	$ 75.22
St. Deviation	$ 43.00	$ 43.30
Min	$ 26.61	$ 27.15
Max	$ 215.33	$ 215.33
Mean +1 SD	$ 124.35	$ 126.57
Mean -1 SD	$ 38.36	$ 39.97

Results and Conclusion

- Firms pay about $1.30 per 1,000 gallons of water delivered to the site, or $35.30 per acre-inch. The typical fracturing job requires 4 – 6 million gallons, or up to 240 acre-inches, to complete.
- Our survey results suggest a mean WTP of $87.70 per household in Texas to postpone the use of one million acre-feet of Ogallala aquifer groundwater for the option of using it in the future. Given approximately ten million households in the state of Texas, this equates to $877 per acre-foot, or $73 per acre-inch.

Mean Values for Explanatory Variables in Option Value Analysis.

NEP	50.92926
Personal_relative	-1.0418
rural	0.073955
Age	4.189711
Male	0.424437

Results and Conclusion

- The results of this project provide insight into the relative values of the remaining groundwater resources in the Ogallala aquifer in their alternative uses.

	Parameter Estimate	Standard Error	Pr > ChiSq
Intercept	0	0	
NEP	1.23	0.586	0.036
Personal Env Responsibility	-1.97	4.979	0.692
Rural County	5.81	29.129	0.842
Age	0.87	7.770	0.911
Male	-22.86	14.820	0.123
Stay	-24.16	36.894	0.513
Children	-38.93	21.749	0.074
Children_Stay	35.49	17.959	0.048
Education	8.37	7.604	0.271
Income	3.53	6.785	0.603
Agriculture	63.39	35.583	0.075
Groundwater	-41.72	21.297	0.050
Drinking	3.93	14.896	0.792
Familiar	49.70	16.047	0.002

Conclusions and Discussions

- The mean willingness to pay for preserving groundwater in the Ogallala Aquifer exceeds the average price that most households currently pay for their residential water.
- People are willing to pay more to preserve Ogallala Aquifer for their option to use in the future.
- Finally, those respondents whose livelihood was related to agricultural production had a significantly higher willingness to pay, all else equal, to preserve the groundwater resource for future potential use.
- The results of this project provide insight into the relative values of the remaining groundwater resources in the Ogallala aquifer in their alternative uses. It is clear that the groundwater likely has the potential to provide greater value to activities other than irrigated agriculture.