Report as of FY2007 for 2007NE152B: "Improving Estimates of the Value of Irrigated Land in the Republican Watershed"

Publications

Project 2007NE152B has resulted in no reported publications as of FY2007.

Report Follows

Final Report

Improving Estimates of the Value of Irrigated Land in the Republican Watershed

(USGS 104B Project: # 2007NE152B)

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EXECUTIVE SUMMARY (ABSTRACT)

This research has generated the following three inter-related sets of results:

1) It increased and made more timely, the sample size of agricultural land sales available for irrigation valuation modeling in the Republican and Platte River watersheds of Nebraska. In particular, 762 additional sales over the 2006-2007 time period were digitized into the existing 2000-2005 land sale transaction database for these two watersheds.

2) It verified that the use of irrigation equipment value estimates in the Nebraska registry of agricultural land sale transactions is relatively accurate. This is based on comparisons of hedonic price estimates for irrigation values in a sample study area of Republican and Platte watersheds that were virtually identical using the state equipment values or more accurate (appraiser confirmed) equipment value estimates.

3) It determined that the most accurate estimator of groundwater well-pumping capacity (as related to irrigation potential and based on a state well registry) was to take the average of reported gallons per minute (GPM) of each well within a sold parcel. Alternatively, more complex geo-spatial approaches (primarily weighted averages of close or nearby well data) did not improve the accuracy of well GPM estimates.

Together these three research results have validated and improved hedonic price modeling procedures that are currently being used to quantify the value of irrigation in the Republican, Platte River and Niobrara watersheds in Nebraska. This will facilitate and improve two related and concurrent irrigation valuation research projects funded by the USDA (NRI-Water and Watersheds Program) and the Nebraska Game and Parks Commission. These results will also help generate key economic data that can be used by elected officials and watershed managers in Nebraska for upcoming water policy planning, and in particular, the design and implementation of irrigation retirement programs.

INTRODUCTION

This USGS 104b research project was intended to validate and/or improve the methodological procedures and data sources which are concurrently being used to estimate the value of irrigation in three Nebraska watersheds (the Republican, the Platte, and the Niobrara). This irrigation value is based on the use of hedonic price modeling to quantify how irrigation along with other parcel-level factors contributes to the sale price of agricultural land. This involves regressing the sale price of agricultural land (on a per acre basis) against the bio-physical characteristics of the land including the percentage of irrigated cropland to quantify how irrigation (defined as the right and ability to irrigate) influences sale prices.

It is expected that the hedonic estimates value of irrigation on land values in site-specific areas could be used to plan and implement successfully irrigation retirement programs that are currently being actively pursued in Nebraska. In particular, accurate marginal implicit price estimates of irrigation values could potentially be used to estimate fair-market payments for irrigation retirement programs. This, in fact, is the objective of following two concurrent research projects undertaken by the same Principal Investigator: 1) 'Payment Incentives Required for Irrigation Retirement' (USDA-NRI Water & Watershed Program), and 2) 'Economic and Social Values of Recreation on the Niobrara National Scenic River' (NE Game and Parks Commission).

The initial irrigation valuation modeling results for the Republican watershed (as part of the USDA-NRI project) appeared promising as measured by high R^2 values, statistically significant explanatory variables, and estimates of irrigation values that vary (change) spatially. However, there are three potential limitations of this original irrigation

valuation research: 1) The time period (2000-2005) does not include the highly productive years of 2006 and 2007 (with increased corn prices); 2) The accuracy of equipment values associated with sales is unconfirmed and potentially inaccurate which might influence irrigation value estimates; 3) A procedure for estimating the well pumping capacity of sold land parcels has not been evaluated for accuracy.

Therefore, this USGS 104b study was intended to generate an extra year of agricultural land sales in the Republican watershed, and obtain complimentary data related to agricultural sales in the region of both the Platte and Republican watersheds. This additional data was deemed necessary to evaluate the accuracy of state-reported equipment values (which are used to adjust sale prices), and to determine the adequacy of geo-spatial approaches being used to estimate the well-pumping capacity of irrigation wells contained in a State well database.

The goal of this research is to improve the accuracy of hedonic modeling of irrigation values in Nebraska in order to improve the effectiveness of pending irrigation retirement programs. In particular, this research should improve and refine recent estimates of the value of irrigation (Shultz and Schmitz, 2006) and be used to update and refine recent estimates of the economic and state budget costs of reducing the consumptive use of irrigation water in the Platte and Republican basins (Suppala, Buell, and McMullen, 2006). The research will also compliment hedonic-based research that has recently been completed in other regions of the county (Faux and Perry, 2000, Petrie and Taylor, 2007). Finally, the research will provide insight into irrigation retirement in the upper Great Plains through direct comparisons with recent USGS research on the effect of irrigation retirement programs on water supplies in the Kansa High Plains (Golden, 2006).

PROBLEM & OBJECTIVES

This research was intended to improve and refine recent estimates of the value of irrigation (and the likely costs of retiring irrigation rights) in the Republican watershed based on multiple-regression modeling of agricultural land sales. Reported irrigation equipment values included with sales and estimated irrigation pumping potential on sold land will be verified, and year 2006 sales will be incorporated into the analyses. The research will involve student training and lead to a larger proposal to replicate the research in the Platte River watershed. The specific objectives of the project include:

1) Updating and increasing the agricultural land sales in the Republican and Platte watersheds (covering the 2006 to mid-2007 time period). This is necessary to increase the accuracy of hedonic price modeling in particular areas of the watersheds (with a limited number of sales) and to account for rapidly increasing land sale prices in 2006 and 2007 associated with historically high corn prices.

2) Working with local appraisers and detailed/confirmed sales data in order to: Determine the accuracy of reported irrigation equipment values reported in the State of Nebraska Property Transaction database. This is needed to evaluate whether currently used land sale price adjustments (adjusting for included non-realty assets such as equipment) are biasing hedonic price estimates of irrigation values.

3) Assessing the accuracy of GIS-based estimates of the well-pumping capacity (GPM) of irrigation wells associated with sold agricultural parcels (based on a State compiled well database). Since well capacity is a critical indicator of irrigation potential the accuracy of this explanatory variable is considered highly relevant to the performance of hedonic price models of irrigation values.

METHOOLOGY

1) Adding Year 2006 Sales to the Existing Database of Republican Land Sales.

Years 2006 and 2007 sale transaction data were obtained from the State of Nebraska Real Estate Transfer Statement database. The sales locations (property boundaries) were digitized by student workers using the legal descriptions of sales in conjunction with public land survey records and satellite imagery.

The location, date, price and other information as could be acquired was obtained and used to build a Geographic Information System (GIS) database of agricultural real estate sales in the state. All sales included were 'Arms Length' i.e., sales that were between family members, or otherwise not sold on a true market were left out of the sample. The legal descriptions of all sales were used to digitize them as polygons in a GIS to form a database of sold parcels. This polygon format made it possible to collect almost all explanatory data using GIS-based technologies. After conducting this spatial analysis the recent sales were appended to an existing database of land sales across the state of Nebraska to form a relatively up-to-date sample of agricultural land sales from the year 2000 to May 2007.

2) Confirmed Appraisal Sales Data (Confirming Equipment Values)

Field visits were made to the office of a local appraiser based in Kearney, NE, who appraises agricultural properties in both the Republican and Platte watersheds. Information associated with agricultural land transactions that were previously collected and/or verified by the appraiser (through site visits and/or phone interviews with buyers and/or sellers) were then compared to corresponding values in our own land sale database (based on State

sales records for equipment values and GIS analyses of a State well database to estimate well-pumping capacities).

For the purposes of this study equipment is considered to be any non-land assets associated with the sale and include items such as farm machinery, irrigation pivots, pumps and pipes, and/or storage buildings. Within our particular study area the most common equipment with values that are included in transactions are irrigation related (pivots, pipes, and pumps). In addition to comparing mean equipment values across the two databases absolute differences from the alternate data sources were also calculated on a sale-by sale basis (i.e. absolute differences)

Finally, to test whether the use of state reported equipment values have a negative impact on the true value or irrigation estimates, four alternative hedonic price models are estimated. These models quantify the determinants of agricultural land sale prices, and in particular, how irrigated acres (pivots versus surface irrigation) influence the sale price of agricultural land while holding other variables constant. The first two models focus on hedonic price estimates separately for pivot and surface irrigation by data source (appraiser data versus state data), while the third and fourth models combine surface and pivot irrigation.

The general specification of these hedonic models is:

$$(Price / Acre)_i = \beta_0 + \sum_{i=1}^{n} \beta_q Q_{ij} + \beta_s S_{ij} + \beta_z Z_{ij} + \beta_c I_i + u$$

where the price per acre is a function of a vector of physical characteristics **Q**, a time trend matrix of dummy variables **S**, location dummies **Z**, a vector representing the presence of irrigation rights and ability **I**, and a random error term **u**. Specific explanatory variables in these models and their expected signs are summarized in Table 1.

Table 1. Descriptions of Variables Included in the Hedonic Price Models

Variable	Description	Expected Sign
Adj. Price per Acre	Price per acre adjusted for the inclusions of non-real property	Dependant
LN Acres	The acres of the parcel logged to account for diminishing marginal effect of economies of scale	-
% Crop	The percentage of the parcel farmed with an implement (row crops, small grains, hay)	+
SRPG	Soil rating for plant growth- a unit-less index created by the NRCS to measure the ability of the soil to support plants.	+
% Slope	The average percent slope of the parcel	-
Precipitation	The average yearly precipitation in Inches	+
D Loess Soil	If the dominant soil parent material is Loess	+
Mile Elevator	Distance in miles to the nearest grain terminal	-
Miles Interstate	Distance in miles to the nearest interstate	-
Miles Major Road	Distance in miles to the nearest major road	-
Pumping Level Ft	The depth to water for the parcel if it is irrigated	-
Gallons/ Minute	The water yield of the nearest well for irrigated parcels	+
% Gravity	Percentage of the parcel gravity irrigated	+
% Pivot	Percentage of the parcel pivot irrigated	+
Year	Dummy matrix representing the year a parcel was sold after the base year of 2000	+

3) Confirmed Appraisal Sales Data (Estimating of Well Pumping Capacity)

A Nebraska groundwater well database maintained by the Department of Natural Resources and containing geo-referenced point locations of wells and characteristics was used to estimate the groundwater pumping capacity (as measured by GPM) of particular sold land parcels. Alternative geo-spatial (GIS) techniques were used to account for GPM pumping capacity:

- Relying on the single well closest to the center pivot of a sold parcel (or the center of the sold parcel in the case of multiple pivots), based on GIS 'Near' measurements.

- Calculating the average, minimum and maximum GPM values of all wells within a sold parcel (through a GIS intersect command)

- Using weighted averages to the nearest wells (weighted by distance to center pivots calculating using GIS 'Near' Commands).

This task required us to match up groundwater wells in our land sale transaction database to corresponding estimates of pumping capacity (GPM) made independently by appraisers. We assume that the appraisers estimates of GPMs of the wells used to irrigate specific sold parcels are the most accurate and these values were compared to alternative estimation approaches (nearest well, average well values, and weighted average well values). The comparisons include measures of the absolute difference between appraiser and state data and two statistical tests intended to evaluate whether observed differences are statistically significant (a paired t-test of means, and signed rank test of medians)

PRINCIPLE FINDINGS

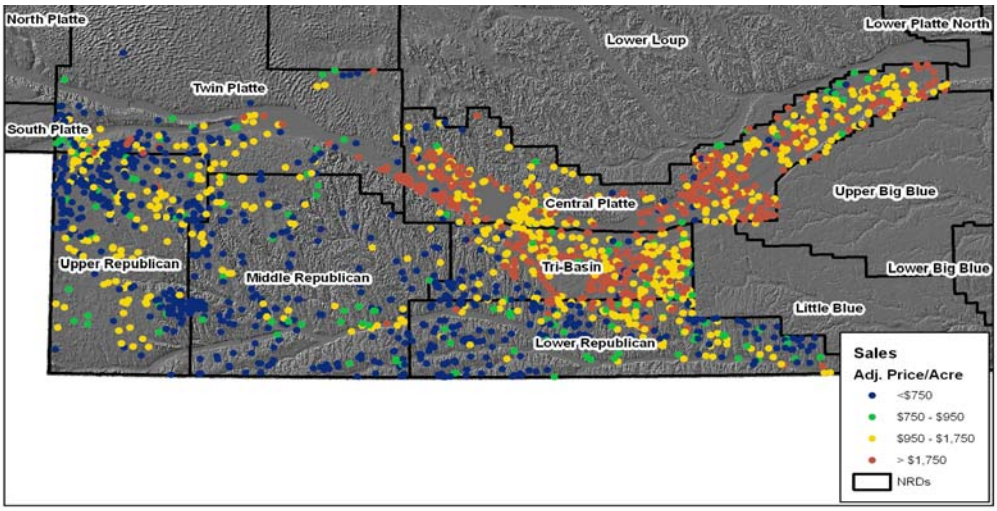
1) The Collection of 2006-2007 Sales Data

A total of 762 sales that occurred over the 2000 to 2006 time period in the Republican (n= 380) and Platte watersheds (n = 382) were digitized and the characteristics of these sales are summarized in Table 2 and their locations are noted in Figure 1. On average, 2006-07 sale values are 27% higher than 2000-05 sale values in each of the watersheds. This highlights the importance of collecting these newer sales and including them in hedonic price estimates of the irrigation values.

Table 2. Summary Statistics of the Original and Newly Digitized Sales

	Republican		Platte	
Variables	Original 2000 – 05	New 2006 - 07	Original 2000 – 05	New 2006 – 07
Price per Acre	$670	$853	$2,060	$2,622
% Crop	50%	53%	66%	71%
Slope %	4.0	3.3	3.3	3.4
Precipitation [in]	21.6	21.0	26.4	26.7
Dummy Loess Soil	70%	68%	53%	57%
Miles to Elevator	5.9	6.4	4.3	4.4
Acres	236	228	135	131
Sample Size	1391	380	1861	382

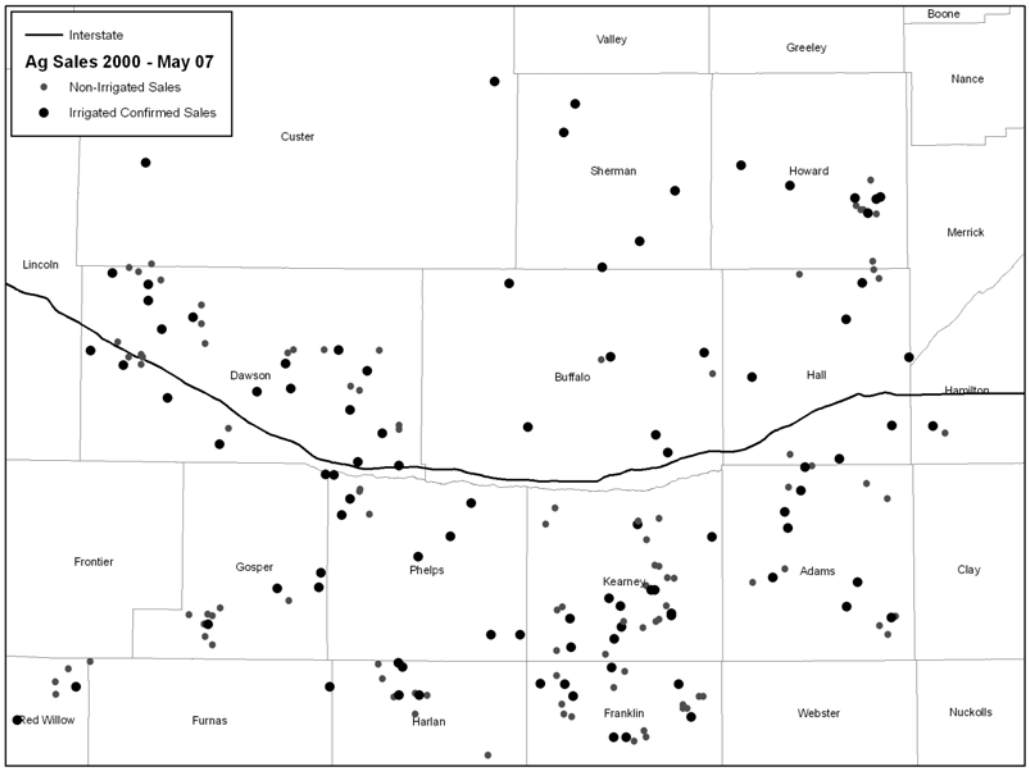
Figure 1. Agricultural Sales in the Republican and Platte Watersheds (2000-2007)



2) Confirming the Accuracy of State Reported Non-Realty Values

It was possible to collect matched sales data for 110 agricultural land sales across the Republican and Platte watersheds (appraisal records that confirm sale details and state sales). The locations of these matched sale comparisons are shown in Figure 2.

Figure 2. Locations of 110 Appraisal Sales Compared to State Sales Data (by irrigation status and over the 2000-07 time period)



Based on mean values for all 110 sales, the appraiser equipment values are $12,508 or 38% higher than state reported values. However, when absolute differences are evaluated for specific sales, than state values are on average only $3,502 (4%) higher than appraiser-based values. What appears to be happening is that in general sellers are exaggerating or inflating equipment values when reporting sales to the county and the

state, but in other cases, some of the state sales records are completely missing equipment values.

The Impact of Equipment Values on Hedonic Price Estimates for Irrigation.

The two models used to estimate the marginal implicit prices of pivot and surface irrigation on sale prices (using both state and appraiser equipment values) are summarized in Table 3. Both models have similar R2 values around 0.76 indicating that 76% of the variation in price is explained by the model and F-values of each are sufficiently high indicating that all variables considered jointly have a significant impact on the dependent variable.

The model based on appraiser equipment values generates a contributory (or marginal) value of an acre of pivot irrigation at $1,029 versus $978 for an acre of surface irrigation. In contrast, the model based on State equipment values generates corresponding irrigation values of $1,054 and $951. Therefore the use of the State reported equipment values do not appear to have a major impact on estimates of irrigation values (pivot irrigation is over-estimated by 2.4% and gravity irrigation is under-estimated by 2.8%. It is also important to note that these differences are not statistically significant at the 5% level (based on a paired t-test).

Finally, if no differentiation is made between pivot and surface irrigation, the estimated coefficient measuring the contribution of irrigation to sales prices is identical ($1,004) whether appraiser or State data is used for equipment values (Table 4).

Table 3. Hedonic Price Models of Irrigation Values by Equipment Value Source

	Appraiser Data			State Data		
	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
%Pivot	1029.18	114.15	0.000	1054.66	116.87	0.000
%Gravity	978.29	115.92	0.000	951.06	118.67	0.000
lift_2	1.05	0.57	0.064	1.18	0.58	0.042
gpm_2	0.17	0.09	0.051	0.15	0.09	0.087
ln_totalac	-127.76	44.66	0.005	-123.00	45.72	0.008
Slope	-36.10	13.08	0.006	-41.52	13.39	0.002
Precip	51.72	18.29	0.005	46.25	18.72	0.014
d_loess	59.39	65.36	0.364	65.19	66.91	0.331
dist_elev	-12.08	12.69	0.342	-11.62	13.00	0.372
d_2001	168.36	147.57	0.255	169.13	151.08	0.264
d_2002	238.65	109.17	0.030	234.24	111.77	0.037
d_2003	69.66	109.82	0.527	64.92	112.43	0.564
d_2004	170.02	101.04	0.094	183.22	103.44	0.078
d_2005	287.45	104.13	0.006	307.20	106.61	0.004
d_2006	378.27	106.36	0.000	362.74	108.89	0.001
d_2007	596.16	159.31	0.000	559.22	163.10	0.001
_cons	84.84	546.34	0.877	211.89	559.33	0.705
Number of obs	231			231		
F(16, 214)	44.13			42.68		
Prob > F	0			0		
R-squared	0.7674			0.7614		
Adj R-squared	0.75			0.7436		
Root MSE	383.66			392.79		

Table 4. Hedonic Price Models of Irrigation Values by Equipment Value Source (without differentiating by type of irrigation)

	Appraiser Data			State Data		
	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
%Irrigated	1004.71	102.70	0.000	1004.85	105.32	0.000
lift_2	1.13	0.54	0.038	1.34	0.56	0.017
gpm_2	0.16	0.08	0.059	0.14	0.09	0.122
ln_totalac	-125.14	44.27	0.005	-117.66	45.40	0.010
slope	-35.54	13.01	0.007	-40.38	13.34	0.003
precip	53.13	18.03	0.004	49.11	18.49	0.009
d_loess	58.66	65.22	0.369	63.70	66.89	0.342
dist_elev	-11.97	12.67	0.346	-11.39	12.99	0.382
d_2001	171.68	147.16	0.245	175.89	150.91	0.245
d_2002	236.44	108.89	0.031	229.74	111.67	0.041
d_2003	71.05	109.59	0.517	67.76	112.39	0.547
d_2004	170.30	100.86	0.093	183.78	103.43	0.077
d_2005	288.71	103.91	0.006	309.78	106.56	0.004
d_2006	383.54	105.64	0.000	373.46	108.34	0.001
d_2007	598.55	158.96	0.000	564.08	163.01	0.001
_cons	35.37	536.16	0.947	111.17	549.83	0.840
Number of obs	231			231		
F(16, 214)	47.22			45.47		
Prob > F	0			0		
R-squared	0.7671			0.7603		
Adj R-squared	0.7509			0.7436		
Root MSE	382.99			392.76		

Measuring the Pumping Capacity of Groundwater Wells.

A total of 84 groundwater wells in our sales database were found to have corresponding estimates of pumping capacity compiled by the local appraiser. The values of our geo-spatial estimates versus these appraiser values are summarized in Table 5. From this it can be seen that the most accurate estimates of the pumping capacity of wells associated with a sold irrigation parcel can be derived from the intersected mean of all wells within a sold parcel (difference of only 104 GPM which is 10% less than the mean appraisal value across the entire sample). However, based on the paired t-tests and the

Sign-Rank probability tests, either the mean intersects of the single closest well generate acceptable estimates. In other words ore complex estimates of GPM based on geo-spatial weighted averages do not generate improved estimates.

Table 5. The Accuracy of Different Approaches to Measuring Well-Pumping Capacity (GPM) Based on Comparisons with Appraisal Estimates (mean GPM: 953)

Geospatial Approach	Abs Diff (GPM)	T test Probability	Sign-Rank Rank Probability
Closest Well	**296**	**0.87**	**0.86**
Intersect Mean (n=66)	**104**	**0.65**	**0.43**
Intersect Min (n=66)	112	0.64	0.39
Intersect Max (n=66)	110	0.20	0.05
Weight 2	311	0.88	0.35
Weight 3	296	0.54	0.95
Weight 4	304	0.43	0.46
Weight 5	303	0.32	0.41

CONCLUSIONS (SIGNIFICANCE)

This research has increased the sample size of agricultural land sales available for irrigation valuation modeling in the Republican and Platte River watersheds of Nebraska. In particular, 762 additional sales over the 2006-2007 time period were digitized into the existing 2000-2005 land sale transaction database for these two watersheds. This will improve the quality of site-specific estimates of irrigation values in the Republican and Platte watersheds and account for recently higher land prices.

This research has also verified that the use of irrigation equipment value estimates in the Nebraska registry of agricultural land sale transactions is relatively accurate. This is based on comparisons of hedonic price estimates for irrigation values in a sample study

area of Republican and Platte watersheds that were virtually identical using state equipment values or more accurate (appraiser confirmed) equipment value estimates.

Finally, this research has determined that the most accurate estimator of groundwater well-pumping capacity (as related to irrigation potential and based on the state well registry) was to take the average of reported GPM of each well within a sold parcel. Alternatively, more complex geo-spatial approaches (primarily weighted averages of close or nearby well data) did not improve the accuracy of well GPM estimates. Hopefully this will validate and improve hedonic price modeling procedures that are currently being used to quantify the value of irrigation in the Republican, Platte River and Niobrara watersheds in Nebraska. These results will also help generate key economic data that can be used by elected officials and watershed managers in Nebraska for upcoming water policy planning, and in particular, the design and implementation of irrigation retirement programs.

REFERENCES

Golden, B. 2006. “Evaluation of policy options aimed at achieving reductions in groundwater consumption in Western Kansas.” *USDS-CSREES Abstract of Funded Projects (Water and Watersheds Program* (http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1135)

Faux, J and G. Perry. 2000. “Estimating Irrigation Water Value Using Hedonic Price Analysis: A Case Study in Malheur County, Oregon,” *Land Economics* 75(3): 440-452.

Petrie R. and L. Taylor. 2007. “Estimating the value of water use permits: A Hedonic approach applied to farmland in the southeastern U.S.” *Land Economics*.

S. Shultz, 2006 and N. Schmitz. “A GIS-based Approach to Target Low Cost Agricultural Land Sensitive to Degradation.” *Managing Agricultural Landscapes for Environmental Quality.* Soil and Water Conservation Society, Oct 11-13, 2006.

Suppala, R, T. Buell, and B. McMullen, 2006. “Economic and state budget cost of reducing the consumptive use of irrigation water in the Platte and Republican basins.” *Draft Study Report, Department of Agricultural Economics, University of Nebraska-Lincoln.*

Appendix A: Information Transfer Activities

Presentations to State and Regional and National Stakeholders and other Researchers Summarizing these Research Results

1) Shultz, S. "Integrating Water Management Research with Land Valuation Modeling Across Nebraska" ***UNL Water Center Spring Seminar.*** January 31, 2007.

2) Shultz, S. and N. Schmitz. 2007. "Using Spatial Information on Land Values in Targeting Conservation Practices." Paper Presented: ***Heartland Region Conference*** "Targeting Critical Areas for Implementation of BMPs" Roundtable, Jan 9-10, 2007.

Appendix B: Student Support

Graduate Students funded by this Project:

1 graduate student, 1 year (assistantship and tuition)

2 Undergraduate students (hourly, part time): total: 1000 hours.

Appendix B:

Information Transfer Activities