Benefits from Including Wetland Component in Water Supply Projects

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Abstract: A land use management plan is currently under consideration in the Turtle Lake area of North Dakota that would help preserve wetlands and allow land development for irrigation. The plan is unique because it includes a wetland component, recognizing the potential benefits to society from preserving wetland acreage. The contingent valuation method is used to estimate wetland benefits from the plan. The wetland benefits from the proposed plan are estimated to range from $832,000 to $2,100,000 annually. Agricultural benefits from the plan are estimated to be about $1,570,000 annually. The response rate to the mail survey used for this analysis was low. Therefore, survey techniques that increase response rates, such as in-person or telephone surveys, are recommended for future wetland valuation studies. Including a wetland component in the Turtle Lake plan substantially increases benefits while adding a relatively small amount to project costs.

INTRODUCTION

Water projects have historically been designed to support well-defined activities such as irrigated agriculture, recreation, municipal water supplies, flood control, and hydropower. Most water projects are multipurpose. However, few have included fish and wildlife as an integral part of project planning and construction.Traditionally, fish and wildlife concerns are included in project formulation through the off-site mitigation of project impacts.

A land use management plan is currently under consideration by federal and state agencies, irrigation and conservancy districts, and local groups that would allow land development for irrigation and prevent the decline in wetlands near the town of Turtle Lake, North Dakota. The Turtle Lake area covers approximately 31,800 acres and includes a unique mixture of wetlands, cropland, and grassland that supports agricultural production, recreation, and a variety of wildlife. The plan includes the development of up to 13,700 acres for irrigated agriculture plus 3,200 acres for both agriculture and wildlife/wetlands. In addition, water would be supplied to several wetlands, lakes, and creeks in the area to preserve the nesting habitat for waterfowl and to enhance recreation opportunities. The plan is unique because it includes a wetland component, recognizing the potential benefits to society from preserving wetland acreage.

Wetlands generate significant environmental benefits to society by providing temporary storage for runoff, reducing soil erosion, improving water quality, providing recreational opportunities, and providing fish and wildlife habitat. Wetlands benefit agriculture through the provision of forage growth and drinking water for livestock. Recreational activities supported by wetlands include hunting, fishing, wildlife viewing, hiking, and boating. Wetland habitat and the associated uplands are necessary for breeding, nesting, feeding, and protection of fish and wildlife species. In addition to the use-oriented values described earlier, wetlands may also be valued by nonusers, or individuals who never actually visit a site or use a natural resource. Monetary values held by nonusers are referred to as nonuse, passive use, or intrinsic values.

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The primary purpose of this technical note is to show the magnitude of benefits that can potentially be generated by including a wetland component in a water supply project. A framework for estimating the benefits generated by wetlands and agricultural production is briefly presented. Estimates of potential wetland benefits from the implementation of the Turtle Lake plan are presented and compared to the agricultural benefits that would be generated by the plan. A comparison of wetland and agricultural benefits from the proposed Turtle Lake plan indicates the wetland and irrigation components generate benefits of a similar magnitude. This comparison has important policy implications for future water management plans in areas where both wetlands and agricultural land exist.

WETLANDS IN NORTH DAKOTA

Wetlands in North Dakota have been steadily declining since the first European settlements. Approximately 50% of North Dakota's original wetland habitat has been lost (Leitch and Baltezore 1992), which is a source of environmental concern. North Dakota wetlands play an important national role in maintaining waterfowl populations. It has been estimated that the state's wetlands support nearly one-half of the breeding duck population in the lower 48 states ("North Dakota 1991–1995" undated). In addition to the unique values associated with the state's wetlands, Turtle Lake area wetlands are further identified as the primary nesting habitat for the federally endangered piping plover (*Charadrius melodus*).

In a recent study of the benefits from prairie pothole wetlands in North Dakota, Hovde and Leitch (1994) estimated use values, but assumed nonuse values to be zero. The assumption of zero nonuse values by Hovde and Leitch was based on the position that wetlands are not scarce, implying that substitutes exist. However, the decline in wetland acreage in North Dakota and the role of Turtle Lake wetlands in waterfowl breeding do not support the assumption of zero nonuse value.

MEASURING VALUE OF WETLANDS

The value of wetlands to society can be separated into use and nonuse values. Use values are attributed to actual visitation and use of the wetland resource. Nonuse values occur from simply knowing the resource exists, even if use is never intended, or from the knowledge that the resource will be preserved for use by future generations. Nonuse benefit values can be derived from several sources, including: (1) the knowledge that fully functional ecosystems will be maintained; (2) the desire to preserve the resource for future use; and (3) the feeling of environmental responsibility toward plants and animals (Harpman et al. 1993). Empirical evidence has shown nonuse values to be positive and nontrivial (Smith and White 1984).

Due to the nonmarket nature of nonuse values, it is not possible to measure them using traditional market data. The only currently available approach for measuring the nonuse values associated with the Turtle Lake plan is the contingent valuation method. The contingent valuation method has been used successfully in several previous wetland valuation studies (Loomis et al. 1990; Whitehead 1990; Stevens et al. 1995).

A contingent valuation mail survey was developed to evaluate the value North Dakota residents would place on implementation of the wetland portion of the Turtle Lake conceptual plan. A mail survey was implemented by the University of North Dakota Bureau of Governmental Affairs in Grand Forks, North Dakota. A total of 4,000 North Dakota households were selected at random and sent a copy of the questionnaire, with 30 questionnaires returned as undeliverable. A second mailing was provided to a portion of those who had not responded after one month, and was followed by a telephone survey of 50 nonrespondents. The final response rate, including telephone responses, was 13.9% after adjusting for undeliverable questionnaires. The poor response rate was expected, given the large number of surveys that have been implemented recently in North Dakota and the historically low response rates experienced in North Dakota (D. Cozzetto, personal communication, 1995).

The survey focused on wetland values, but also described the agricultural components of the plan, to indicate wetland improvement would not occur at the expense of agricultural activities. The survey also included questions pertaining to knowledge and attitudes about wetlands, current and future expectations regarding recreation use, demographics, and willingness to pay for implementation of the plan and for the protection of all wetlands in North Dakota. A copy of the survey is available from the writers.

SURVEY AND MODELING RESULTS

The average willingness to pay for preserving wetlands in the Turtle Lake area was estimated from the survey to be $8.69 per household per year. To understand the factors influencing willingness to pay, the data were used to estimate willingness to pay models. The willingness to pay question format used in the Turtle Lake questionnaire included both a table of potential willingness to pay responses and a continuous/open-ended question. The range of values presented in the table provided the respondents with possible amounts they could react to. The open-ended responses following the table represented individual total willingness to pay. The responses to the open-ended willingness to pay question were used to estimate ordinary least-squares and tobit models [for a description of the tobit model, see Maddala (1983)]. The variables hypothesized to have an effect on willingness to pay and their expected signs are presented in Table 1.

TABLE 1. Variables Hypothesized to Influence Willingness to Pay

Variable (1)	Description of variable (2)	Expected variable sign (3)
Importance	One if wetlands are considered unimportant for any factor; zero otherwise	Negative
Visit	One if the respondent had visited or expected to visit Turtle Lake; zero otherwise	Positive
Age	Age of respondent	No prior expectation
Gender	One if male; zero if female	No prior expectation
Environment	One if respondent belongs to an environmental group; zero otherwise	Positive
Farm	One if respondent belongs to a farm organization; zero otherwise	Negative
Income	Gross household income	Positive

The initial tobit model was tested for heteroskedasticity and normality using conditional moment based specification tests outlined in the *LIMDEP version 7.0 user's manual* (Greene 1995). The Lagrange Multiplier test did not indicate that heteroskedasticity was a problem, but the null hypothesis of normality was rejected based on a chi-square test. As a result, the tobit model was reestimated using both Weibull and log-logistic distributions [see Greene (1995)].

The regression results for each of the modeling approaches are presented in Table 2. The explanatory variables for each of the models have the expected sign. Each of the regressions is statistically significant based on F- and chi-square statistics. The modeling results indicated an average willingness to pay of $8.69 per household per year using ordinary least-squares, $6.87 per household per year using the Weibull based tobit model, and $7.41 per household per year using the log-logistic based tobit model.

Potential Data Problems

Due to the low level of response to the survey, the average survey age and income were compared to state estimates com-

TABLE 2. Willingness to Pay Regression Results

Variable (1)	Ordinary Least-Squares: Coefficient (2)	Ordinary Least-Squares: t-statistic (3)	Weibull Tobit: Coefficient (4)	Weibull Tobit: t-statistic (5)	Log-Logistic Tobit: Coefficient (6)	Log-Logistic Tobit: t-statistic (7)
Importance	−0.3826	−0.13	−11.5170	−1.64	−10.2820	−1.50
Visit	10.6210	3.81[a]	30.4450	6.10[a]	32.4150	5.96[a]
Age	−0.0993	−1.21	−0.3501	−2.05[a]	−0.36620	−1.97[a]
Gender	−5.2098	−1.91[b]	−12.0030	−2.27[a]	−12.5080	−2.22[a]
Environment	20.1120	4.93[a]	16.9540	3.12[a]	22.8450	3.25[a]
Farm	−4.0578	−1.38	−11.8470	−1.75[b]	−14.5380	−2.09[a]
Income	0.000192	4.38[a]	0.000232	3.54[a]	0.0003410	4.23[a]
Constant	6.4596	—	−14.5860	—	−10.9450	—
(a) Test of Significance						
Adjusted R-squared	— 0.17	—	—	—	—	—
F-statistic	12.07[a]	—	—	—	—	—
Likelihood ratio	—	—	94.11[a]	—	98.44[a]	—

[a]Significant at the 5% level of confidence.
[b]Significant at the 10% level of confidence.

piled by the U.S. Dept. of Commerce (1996) Bureau of the Census. The survey average age and income data were not statistically different from the Bureau of the Census estimates at the 5% level based on t-tests.

In addition to the comparison between survey and statewide demographics, a separate survey of nonrespondents was conducted. A total of 50 randomly selected households included in the original sample group of 4,000 that did not mail back a completed survey were asked a subset of the original survey questions over the telephone. The questions included the Turtle Lake willingness to pay question, two wetland visitation questions, and four demographic questions.

The purpose of the nonresponse survey is to help determine if the characteristics of those who did not respond to the mail survey are different than the characteristics of those who did respond. The results from the respondents and the nonrespondents were compared using three methods. First, the percentage of those who responded with a zero willingness to pay was compared for the two groups. A total of 67.8% of the full survey respondents indicated zero willingness to pay, while 84.0% of the 50 nonrespondents contacted indicated zero willingness to pay. Second, the average willingness to pay for the two groups was compared looking at the simple mean values. The average willingness to pay of those who responded to the full survey was $8.69 per household per year compared to $5.37 for the nonrespondent group. Last, the mean willingness to pay for the two groups was compared using a pooled t-test. The calculated t-value was 1.0, which is less than the critical value at the 5% level of significance. The hypothesis that the mean willingness to pay for the respondents and nonrespondents is the same cannot be rejected.

These comparisons provide three possible methods for adjusting the willingness to pay estimates obtained from the full survey. The first method is to accept the estimate from the survey, given that the difference between the full survey and nonresponse means is not significantly different based on the pooled t-test. The second method is to estimate a weighted mean, using the response rate as a weight for the main survey average and one minus the response rate as the weight for the nonresponse average. For example, the weighted willingness to pay using the simple survey averages would be

$$(0.1225 \times 8.69) + (0.8775 \times 5.37) = \$5.78 \qquad (1)$$

The third method is to apply the percentage of zero responses from the nonresponse results to the full survey. This reduces the average willingness to pay from the full survey by 50% to $4.35 per household per year.

A potential problem associated with the contingent valuation method is the possibility that respondents will place the entire value of a category of resources to one specific resource under consideration, or embedding (Kahneman and Knetsch 1992). For example, asking someone to place a value on a specific North Dakota wetland may actually result in a value for all North Dakota wetlands. To address this potential problem, the Turtle Lake survey included wetland valuation questions for the Turtle Lake study area and for all wetlands in North Dakota. The statewide wetland question did not impose a Turtle Lake wetland value greater than zero for a positive statewide value. Approximately 30% of those respondents indicating a statewide value greater than zero indicated a Turtle Lake value equal to zero.

The statewide and Turtle Lake average willingness to pay values ($16.24 and $8.69, respectively) were compared using a pooled t-test. The null hypothesis is that there is no difference between the average values. The calculated t-value is 2.61. The null hypothesis can be rejected at the 5% level, indicating that the mean values are significantly different. This result does not rule out that some embedding is occurring; however, as a group, the respondents recognize that the Turtle Lake wetlands are not equivalent to all wetlands in North Dakota.

TOTAL VALUE OF TURTLE LAKE WETLANDS

The U.S. Bureau of the Census estimated the population of North Dakota in July 1995 to be 641,367 (U.S. Dept. of Commerce 1996). Using the 1994 average household size for North Dakota of 2.65 people (U.S. Dept. of Commerce 1996), there were approximately 242,000 households in North Dakota in 1995. The total willingness to pay estimates and the total number of households in North Dakota can be used to estimate the total nonuse value of the Turtle Lake plan to the population of North Dakota. The values based on the modeling results are presented in Table 3.

The use values presented in Table 3 can be compared to Turtle Lake recreation values estimated in a draft Turtle Lake report ("The benefits" 1996). Using a benefit transfer approach, the Bureau of Reclamation estimated the value of recreation at Turtle Lake to be about $310,000 annually. Comparing the value from the draft report to the survey based total value estimates indicates a large majority of Turtle Lake wetland values is attributable to nonuse values.

Agricultural Benefits from Plan

The Turtle Lake plan includes the provision of water for irrigated agriculture in addition to wetland benefits. The agricultural benefits of the Turtle Lake plan are presented in this section as a point of reference for understanding the importance of the wetland component of the project.

The benefits from agricultural production are estimated to be the net value of increased agricultural output or savings in the cost of production ("Economic" 1983). The farm budget method is used to estimate the benefits from irrigating 13,700 dryland acres in the Turtle Lake area. A farm budget represents input and production relationships for an agricultural operation.

Input requirements and prices used for this analysis are based on information from North Dakota State University Extension Service crop budgets. The cropping patterns represented in the farm budgets are based on information from the 1992 Census of Agriculture ("1992 Census" 1994), and the 1994 North Dakota Agricultural Statistics ("North Dakota agricultural" 1994). Rangeland, wheat, barley, and hay are the predominant crops in the area. These crops, along with fallow land as a rotation requirement, are included in the nonirrigated farm budget. Based on information obtained from producers

TABLE 3. Estimated Turtle Lake Wetland Values for North Dakota Residents

Scale (1)	Total willingness to pay (2)	Total wetland value (3)
(a) Ordinary Least Squares		
High (no nonresponse adjustment)	$8.69	$2,103,000
Medium (weighted average)	$5.78	$1,398,700
Low (weighted by zero responses)	$4.35	$1,052,600
(b) Weibull Based Tobit		
High (no nonresponse adjustment)	$6.87	$1,662,500
Medium (weighted average)	$4.57	$1,105,900
Low (weighted by zero responses)	$3.44	$832,500
(c) Log-Logistic Based Tobit		
High (no nonresponse adjustment)	$7.41	$1,793,200
Medium (weighted average)	$4.93	$1,193,100
Low (weighted by zero responses)	$3.70	$895,400

in the area, the primary crops that would be grown on irrigated land in the region are alfalfa, hay, and potatoes.

The crop yields used in the farm budgets need to reflect average farm management and future improvements in physical conditions that would improve yields. These yields are based on information obtained from local producers and North Dakota State University Extension specialists. U.S. Dept. of Agriculture normalized crop prices for 1995 are used to value the crops budgeted in this analysis, except for rangeland values. U.S. Dept. of Agriculture normalized prices are not available for rangeland. The average cash rental rate for pastureland in North Dakota was obtained from Doane-Western ("Doane's" 1994).

Farm Budget Results

The nonirrigated farm budget shows a net income of −$34.10 per acre adjusted for return to management and family labor. The negative result does not indicate that farm operations are losing money under current conditions or would lose money under dryland conditions in the future, but is due to the assumptions required by the U.S. Water Resources Council guidelines ("Economic" 1983). The irrigated farm budget showed a return of $80.20 per acre. The agricultural benefits from irrigation in the Turtle Lake area are estimated to be the difference in irrigated and nonirrigated income ($114.30 per acre) times the number of acres that will be developed (13,700 acres), or about $1,570,000 annually.

CONCLUSIONS

The benefits from the proposed Turtle Lake management plan include use and nonuse wetland benefits, as well as agricultural benefits. The wetland benefits are estimated to range from $832,000 to $2,100,000 annually. Agricultural benefits from the plan are estimated to be about $1,570,000 annually.

The wetland benefits estimated in this analysis include only North Dakota households. Additional benefits could accrue to households outside North Dakota; therefore, the wetland values presented in this analysis may underestimate benefits. However, given the small number of acres involved in the Turtle Lake plan and the relatively unknown nature of Turtle Lake compared to other wilderness areas and parks, additional Turtle Lake nonuse benefits attributable to households outside of North Dakota would probably be small.

Due to the poor survey response rate, a portion of the nonrespondents were sampled to help determine if the survey sample was representative. Although the comparison of respondents and nonrespondents did not necessarily indicate that nonresponse bias was a problem, the low response rate obtained from the Turtle Lake mail survey reduces the reliability of the wetland value estimates. Therefore, survey techniques that increase response rates, such as in-person or telephone surveys, are recommended for estimating wetland values.

Including a wetland component in the Turtle Lake plan appears to substantially increase project benefits. Although the costs of the proposed plan have not been developed beyond the conceptual level, a description of the project features ("Turtle Lake" 1993) indicates that a relatively small portion of pipeline, structure, and other construction features are attributable to the wetland components. Therefore, the wetland component adds substantial benefits to the Turtle Lake plan at a relatively low cost. These same results would be expected for a municipal water supply or other use project that could provide a reliable water supply to a nearby wetland.

The Turtle Lake results indicate that substantial benefits can be generated by including wetland preservation and enhancement in traditional water projects. Wetland benefits can be similar in magnitude to agricultural benefits, depending on the quality and national significance of the wetlands. The cost of including a wetland component can be relatively low in areas where agricultural land and wetlands are located adjacent to each other. However, good management of nearby agricultural land is essential to prevent wetland contamination from fertilizers and pesticides. Otherwise, the wetland benefits from the project could be lost.

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