

## ECONOMIC ANALYSIS OF WETLAND RESTORATION ALONG THE ILLINOIS RIVER<sup>1</sup>

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**ABSTRACT:** Creating and restoring wetland and riparian ecosystems between farms and adjacent streams and rivers in the Upper Mississippi River Basin would reduce nitrogen loads and hypoxia in the Gulf of Mexico and increase local environmental benefits. Economic efficiency and economic impacts of the Hennepin and Hopper Lakes Restoration Project in Illinois were evaluated. The project converted 999 ha of cropland to bottomland forest, backwater lakes, and floodplain wetland habitat. Project benefits were estimated by summing the economic values of wetlands estimated in other studies. Project costs were estimated by the loss in the gross value of agricultural production from the conversion of corn and soybean acreage to wetlands. Estimated annual net benefit of wetland restoration in the project area amounted to US\$1,827 per ha of restored wetland or US\$1.83 million for the project area, indicating that the project is economically efficient. Impacts of the project on the regional economy were estimated (using IMPLAN) in terms of changes in total output, household income, and employment. The project is estimated to increase total output by US\$2,028,576, household income by US\$1,379,676, and employment by 56 persons, indicating that it has positive net economic impacts on the regional economy.

(KEY TERMS: economics; agriculture; water quality; restoration; wetlands.)

Prato, Tony and Donald Hey, 2005. Economic Analysis of Wetland Restoration Along the Illinois River. *Journal of the American Water Resources Association* 42(1):125-131.

### INTRODUCTION

The present-day area of the 48 contiguous states of the United States has experienced dramatic losses in wetlands, from 87.5 million ha in the 1600s to 41.1 million ha today (Conservation Foundation, 1988). Agriculture is a major contributor to wetland losses. Drainage of wetlands for agricultural production accounts for 87 percent of national wetland losses

(Tiner, 1984). Since the 1780s, more than 26 million ha of wetlands in the Mississippi River Basin have been lost. Wetland drainage to allow agricultural production contributes to agricultural nonpoint source pollution, which has negatively impacted water quality. The most recent National Water Quality Inventory conducted by the U.S. Environmental Protection Agency (USEPA) indicates that agricultural nonpoint source pollution is the leading source of water quality impacts to surveyed rivers and lakes, the third-largest source of impairments to surveyed estuaries, and a major contributor to ground water contamination and wetlands degradation (USEPA, 2000). Wetland losses also threaten biodiversity because at least half of all animal species and about one-third of all plant species that are listed under the Endangered Species Act depend on wetlands (Noss and Cooperrider, 1994). The objective of this paper is to evaluate the economic efficiency and economic impacts of restoring a wetland along the Illinois River, and in particular the Hennepin and Hopper Lakes Restoration Project. Although this paper concerns wetland restoration at a small project scale, wetland restoration at a larger basin scale is expected to reduce nutrient loads to and hypoxia in the Gulf of Mexico. Coastal waters have been significantly degraded by nitrogen contamination of receiving waters that results from high levels of nitrogen fertilizer application and significant wetland losses in inland watersheds. Nitrogen loading to the Mississippi River causes the Gulf of Mexico to have the third-largest hypoxic area or dead zone in the world's coastal waters (Downing *et al.*, 1999). The areal extent of the dead zone was 15,540 km<sup>2</sup> to 18,130 km<sup>2</sup> during midsummer surveys done in 1993

<sup>1</sup>Paper No. 04183 of the *Journal of the American Water Resources Association* (JAWRA) (Copyright © 2006). **Discussions are open until August 1, 2006.**

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through 1995 and was 14,128 km<sup>2</sup> on average during the period 1996 through 2000 (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2001). In 2002 the hypoxic area was approximately 22,015 km<sup>2</sup>, which is roughly the size of Massachusetts (Rabalais, 2003). Short term economic costs of the Gulf's dead zone are significant because the Gulf contains some of the nation's most important fisheries. These costs include suffocation of fish, shrimp, crabs, and marine mammals, as well as harmful effects on commercial fishing communities and industries, consumers of commercial fishery resources, and recreational users (Lipton and Strand, 1997; Rabalais, 2003).

Nitrogen loading to the Mississippi River amounts to about 1.6 billion kg/y (Rabalais, 2003). Since approximately 75 percent of the nitrogen delivered to the Gulf by the Mississippi River is from agricultural sources (Antweiler *et al.*, 1995), agriculture contributes as much as 1.2 billion kg/y of nitrogen loading to the Gulf. Based on the more conservative estimate that 50 percent of the nitrogen entering the Gulf is from agricultural sources (Turner and Rabalais, 1991), the nitrogen loss rate is equivalent to about 736 kg of nitrogen for each of the 1,087,500 farms in the region (Downing *et al.*, 1999; Rabalais, 2003).

Reducing nitrogen loading from agricultural sources would not only benefit the Gulf marine fishing industry and communities but also increase efficient use of organic and inorganic fertilizers and the energy associated with them, lower overall fertilizer costs, reduce health risks from contamination of public and private drinking water supplies and foodstuffs, and improve aquatic habitat of streams, lakes, rivers, and estuaries (Downing *et al.*, 1999). One of the reports on hypoxia in the Gulf of Mexico (Diaz and Solow, 1999) indicated mixed results for the environmental benefits of reducing hypoxia in the Gulf of Mexico. It concluded that data were not available to estimate benefits in terms of the restoration of ecological communities and increased recreational harvesting. Based on available data, there were no estimable benefits in terms of increased commercial harvesting of white and brown shrimp, Gulf menhaden, and red snapper.

A comprehensive assessment of hypoxia by the Committee on Environmental and Natural Resources (2000) identified two principal ways to reduce agricultural nitrogen loading to the Gulf – by reducing nutrient runoff and by restoring damaged ecosystems. The first way, reducing nutrient runoff, is accomplished by modifying cropping systems and drainage patterns and increasing the efficiency of fertilizer and manure application through better timing and placement of fertilizer and lower application rates. Modifying agricultural management practices could reduce overall

nitrogen loading by 20 percent (Doering *et al.*, 2001). While this is a significant reduction, it is not enough to meet the goal of the Hypoxia Action Plan: “By the year 2015, subject to the availability of additional resources, reduce the five-year running average areal extent of the Gulf hypoxic zone to less than 5,000 square kilometers through implementation of specific, practical, and cost-effective voluntary actions by all States, Tribes, and all categories of sources and removals within the Mississippi/Atchafalaya River Basin to reduce the annual discharge of nitrogen into the Gulf” (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2001, p. 9). Achieving this goal requires a 65 percent reduction in the five-year (1996 through 2000) average size of the hypoxic area. While the Hypoxia Action Plan does not indicate the amount of nitrogen loading needed to reduce the size of the hypoxic area by this amount, a 40 percent reduction in total nitrogen flux to the Gulf would be needed to return to the average nitrogen loads of the period 1955 to 1970 (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2001).

The second way, indicated by hypoxia related studies, suggests that nitrogen loading to the Gulf could be reduced by restoring 9.45 million ha of ecosystems, principally wetlands, riparian buffers, and riparian forests. It would be best to locate the restored ecosystems between farms and adjacent streams and rivers along the main stem of the Mississippi (Mitsch *et al.*, 1999, 2001). Besides reducing nitrogen loading to the Gulf, wetland restoration would stabilize streambanks; reduce sediment, nutrient, and pesticide loadings to receiving waters; lower peak flood flows and damages; create wildlife habitat; improve recreational water uses such as fishing and swimming; enhance consumptive uses such as drinking water; increase aesthetic values associated with wetlands; create wildlife habitat; and increase biological diversity (USACE, 1986; USEPA, 1988; Doering *et al.*, 1999).

A recent estimate has been made of the area of wetlands needed to control the nitrogen loading emanating from the seven treatment plants of the Metropolitan Water Reclamation District of Greater Chicago. To achieve a 3.0 mg/l total nitrogen (TN) standard for the seven plants would require creating 71,300 ha of treatment wetlands (Hey *et al.*, 2005). This could be done at an annual average cost, including land, of US\$2,041/metric ton (tonne) TN. In comparison, removing the same amount of TN using conventional treatment would cost an average of US\$7,375/tonne TN – more than three times the cost of wetland treatment (Hey *et al.*, 2005). The study estimates that using wetlands for nitrogen control would cost US\$897 per ha, and the total cost for operating the 9.45 million ha of restored ecosystems would be US\$8.5 billion.

Government programs stimulate wetland restoration; examples include the Wetland Reserve Program sponsored by the U.S. Department of Agriculture and wetland mitigation projects funded by the U.S. Army Corps of Engineers and state conservation agencies. However, these programs are unlikely to achieve the Hypoxia Action Plan's goal of restoring 9.5 million ha of wetlands. Reducing nitrogen loading with market-based approaches such as nutrient farming/trading could provide economic incentives for farmers to convert cropland acreage to wetland acreage (nutrient farming) and produce nutrient credits. Nutrient farming involves constructing wetlands that are designed, built, and operated to process nutrients, trap sediments, and/or store floodwaters (Hey *et al.*, 2005). These treatment wetlands would be funded by revenue from the sale of nutrient credits to nutrient dischargers that are required to reduce nutrient concentrations. Point sources could buy these credits to achieve the 3.0 mg/l TN standard.

### HENNEPIN AND HOPPER LAKES RESTORATION PROJECT

The 1,052 ha Hennepin and Hopper Lakes Restoration Project along the Illinois River north of Peoria, Illinois, is being managed by The Wetlands Initiative (TWI), a nonprofit organization (see Figure 1). Goals of the project are to restore the site's wetlands, prairie, savanna, and two lakes and thereby reestablish biodiversity on former corn and soybean fields in the Hennepin Drainage and Levee District (Sullivan, 2002). Restoration was initiated in 2001 by turning off the drainage district's pumps but retaining the levees and other drainage structures in order to exclude multiple flow paths to and from the river. The latter facilitates quantification of the sources and sinks of water and nitrogen. The existing pump permits easy manipulation of water depth (critical to denitrification and competing wildlife functions). Water is withdrawn from the river and passed through the restored wetland complex at metered rates. The Wetlands Initiative continues to manage the restoration to improve habitat for fish, waterfowl, and other wildlife by increasing the availability of water across the site and improving water quality. Water quality is improving through reestablishing wetland functions that reduce nutrient, silt, and sediment loads to the Illinois River. The completed project will include 502 ha of lake, 179 ha of seasonally inundated communities (e.g., wet mesic prairie, wet prairie, and shoreline marsh), 295 ha of prairie, 33 ha of wetland, and 60 ha of forest (Figure 2). Approximately 998 ha of cropland have been converted to wetland areas. Estimated cost

of the project is US\$15 million. The project demonstrates how wetland restoration can be carried out along the Illinois River and elsewhere in the Upper Mississippi River Basin.

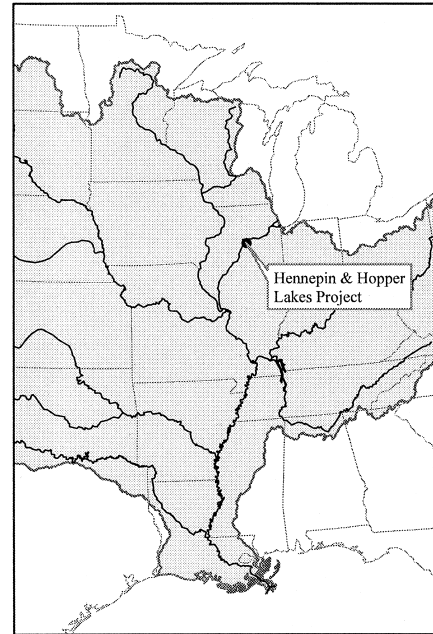


Figure 1. Location of Hennepin and Hopper Lakes Restoration Project in Illinois.

### METHODS

#### *Benefits and Costs of Project*

Economic efficiency of wetland restoration (converting cropland to wetland) in the project area is assessed by the difference between the estimated benefits of restored wetlands (benefits) and the estimated losses in cropland production (costs). Expected benefits of wetland restoration include the value of: increased production of ecological goods such as commercial and recreational fishing, hunting, and other forms of recreation; increased production of ecological services in the form of better habitat for native plants and animals; and improved water quality. Estimating the value of increased production of ecological goods and services would require estimating people's willingness to pay for these goods and services, as well as total recreational expenditures and consumer surplus for each recreational activity likely to be supported by the project. Since it was not feasible to directly estimate the value of increased production of ecological goods and services from wetland restoration in the project area, a benefits transfer approach was used that applies estimated median values of ecological

goods and services provided by wetlands to the project area. The estimated median annual economic value of wetlands (updated from 1992 to 2005 U.S. dollars) is US\$2,577.48 per ha, which is the sum of the values for general non-users, general users, fishing users, hunting users, other recreational users, and ecological, amenity, and cultural services (Heimlich *et al.*, 1998). A potential drawback of this approach is that the median value of the ecological goods and services provided by the project wetland could be significantly different from the median value of the wetlands estimated in Heimlich's study.

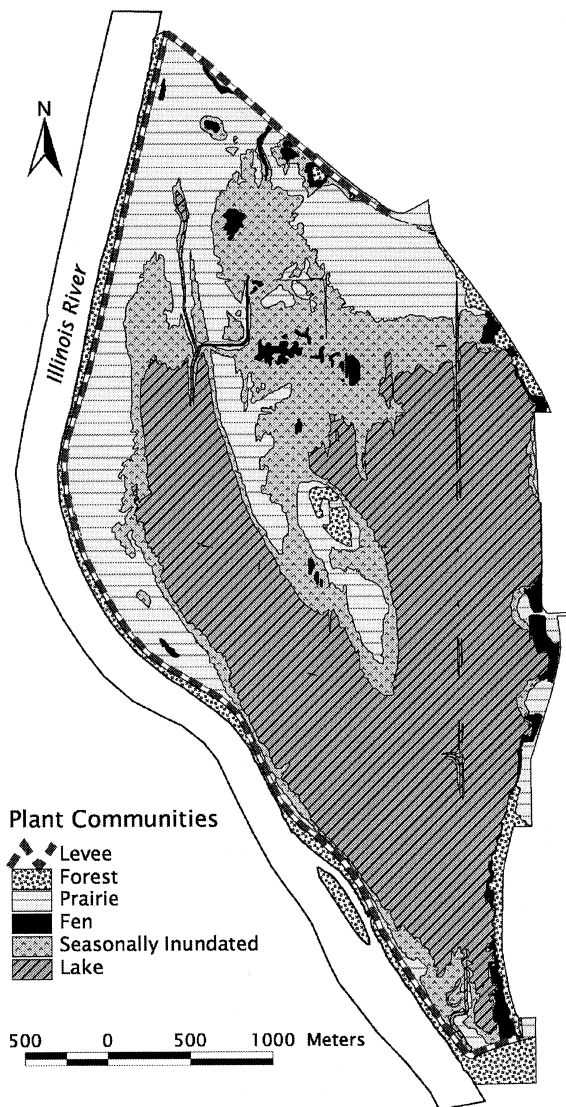


Figure 2. Proposed Natural Communities at Hennepin and Hopper Lakes Restoration Project.

One way to estimate the economic value of water quality improvements from wetland restoration is in terms of the value of the nutrient credits produced by a restored wetland. While USEPA developed a new Water Quality Trading Policy (USEPA, 2003), nutrient trading has not occurred in the project area. Hence, market prices of nutrient credits are not available for valuing the improvements in water quality in the project area. For this reason, water quality benefits were not included in the benefit-cost assessment.

The loss in cropland production from wetland conversion of the project area is estimated by the loss in the gross value of corn and soybean production in Illinois. Corn and soybeans are the two primary crops grown in the project area before wetland conversion. The estimated annual gross value (updated from 2002 to 2005) is US\$874.78 per ha for corn and US\$626.99 per ha for soybeans (Illinois Agricultural Statistics Service, 2003). These values imply an estimated average annual gross value of a corn-soybean rotation of US\$750.88 per ha in 2005 (the average of US\$874.78 and US\$626.99 per ha). The project is economically efficient because estimated annual net benefits (benefits minus costs) are positive, namely US\$1,827 per ha (US\$2,577.48 per ha minus US\$750.88 per ha), or US\$1.83 million per year for the entire project area (US\$1,827 per ha times 999 ha).

#### *Net Economic Impacts of Project*

Net economic impacts of the project were estimated by determining the difference between the economic impacts of the restored wetlands and the economic impacts of the loss in crop production. Economic impacts of the restored wetlands include the positive economic benefits generated by project expenditures for overhead and maintenance (O&M), and administration of the project; research, monitoring, and education at the project site; and restoration of the site (construction and maintenance of wetlands). Economic impacts of the loss in crop production is estimated by determining the decrease in the gross value of crop production from the conversion of corn and soybean acreage to wetlands in the project area. Economic impacts were estimated using the Impact Modeling for PLANning (IMPLAN) model for Putnam County, Illinois, the county in which the project area is located.

IMPLAN is a menu driven computer software program developed by the U.S. Forest Service that permits nonsurvey regional input-output analysis of any county or combination of counties in the United States (Lindall and Olson, 1993). It predicts economic impacts in terms of changes in total economic output,

household income, and employment associated with changes in final expenditures in up to 528 sectors (Lindall and Olson, 1993). IMPLAN is a nationally recognized and widely used modeling system for estimating the economic impacts of economic activities. It has sufficient depth and breadth of detail to assess the relative importance of each sector to a county's economy (Prato and Hamed, 1999). The basic geographic unit of analysis in IMPLAN is the county.

IMPLAN calculates total output for a sector, such as agriculture, as

$$x_{rut} = \sum_{s=1}^s a_{rs} f_{sut}$$

where  $x_{rut}$  is total output (US\$) for sector  $r$  in county  $u$  in time period  $t$ ,  $a_{rs}$  is the dollar value of input from sector  $r$  required to produce one dollar of output from sector  $s$ , and  $f_{sut}$  is the output (US\$) of sector  $s$  in county  $u$  in time period  $t$ . In the context of wetland restoration, this equation is used to estimate the changes in total county output (the sum of outputs over all sectors in the county) of a contraction in agricultural output (the agricultural element of  $f_{sut}$  decreases) due to wetland restoration in an agricultural area. The county is the basic geographic unit in IMPLAN because county-level data are used to calculate the input-output coefficients. A limitation of IMPLAN is that the input-output coefficients are linear and constant over time, although the coefficients are periodically updated. County level changes in total output, household income, and employment from changes in  $f_{sut}$  are determined by summing the changes in total output ( $x_{rut}$ ), household income, and employment, respectively. Household income is the sum of labor income, other property income, and indirect business taxes resulting from the project. Employment is the number of persons employed in all sectors.

Losses in the value of agricultural production from the conversion of cropland to wetland were estimated based on average crop yields (by soil type) and crop acreages for each agricultural parcel in the project area and corn and soybean prices in Illinois for 1999 and 2000. Soil types and crop acreages for fields in the project area were taken from a soils map and data provided by TWI. No attempt was made to adjust the estimated losses in the value of agricultural production downward due to flood damages. In other words, the economic losses due to wetland restoration assume that had the project area remained in crop production, there would have been no agricultural production losses due to flooding.

Economic impacts of the project were first estimated on an annual basis for a 20-year period (2000

through 2019) and then converted to net present value using an inflation adjusted discount rate of 3 percent. Net present value of changes in total output, household income, and employment for the project were calculated by subtracting the reduction in total output, household income, and employment caused by the loss in the value of agricultural production from the increase in total output, household income, and employment, respectively, associated with increased expenditures on research, monitoring, education, O&M, administration, and wetland restoration associated with the project. Since the cost of most projects is incurred in the early years and benefits are spread out over several years, a higher discount rate decreases net present value, and a lower discount rate increases net present value.

Table 1 summarizes the estimated positive, negative, and net economic impacts of the project. Expenditures on research, monitoring, and education have the largest positive impact on total output (US\$1,560,525), household income (US\$1,171,903), and employment (49.7 persons). The next highest positive economic impacts result from expenditures on O&M and administration (US\$937,035 total output; US\$207,784 household income; and 6.6 persons employed). The lowest positive economic impacts result from restoration expenditures (US\$396,953 total output; US\$69,189 household income; and 1.1 persons employed). Total positive economic impacts of the project are a US\$2,894,513 rise in total output, a US\$1,448,876 increase in household income, and a 57-person increase in employment. Negative economic impacts of the project indicate that the loss in corn production has a greater negative impact on total output than the loss in soybean production (US\$826,412 versus US\$640,552); the decline in household income is slightly greater from the loss in soybean production than from the loss in corn production (US\$208,728 versus US\$191,067); and the loss in employment is greater from the loss in soybean production than from the loss in corn production total (6.4 versus 3.1 persons).

## CONCLUSIONS

The Hennepin and Hopper Lakes Restoration Project is economically efficient and has positive economic impacts on the regional economy. Estimated annual net benefit is US\$1,827 per ha of restored wetland, and estimated total net benefit for the entire project area is US\$1.83 million. Estimated net present value with the project is US\$2,028,576 in total output, US\$1,379,676 in household income, and in employment of 56 persons. The positive net economic

TABLE 1. Estimated County-Level Economic Impacts of Project.

	Positive Impact			Negative Impact		
	O&M and Administration	Research Monitoring and Education	Restoration	Corn	Soybeans	Net Change*
Total Output (US\$)	937,035	1,560,525	396,953	826,412	640,552	2,028,576
Household Income (US\$)	207,784	1,171,903	69,189	191,067	208,728	1,379,676
Employment (persons)	6.6	49.7	1.1	3.1	6.4	56.3

\*Equals positive impacts minus negative impacts of project.

impacts of the project were underestimated because the evaluation did not account for the positive economic impacts of increased recreation due to improved habitat for native plants and animals and use of the site for recreational purposes, the value of reducing nitrogen loading to the Gulf of Mexico, lower agricultural income losses due to flooding, or government savings from not paying subsidies on crops produced in the project area. Finding positive economic impacts for the Hennepin and Hopper Lakes Restoration Project does not imply that other wetland conversions in the Upper Mississippi Basin would have positive economic impacts or that the economic impacts of other wetland conversions in other areas would be of the same order of magnitude as for the Hennepin and Hopper Lakes Restoration Project. Further research is needed to identify sites in the Upper Mississippi River Basin where wetland restoration is physically and economically feasible.

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