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Costs and Benefits of Wetland Restoration of Hydric Cropland in Missouri: A Preliminary Assessment

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Abstract

This report presents a preliminary analysis of the benefits and costs of restoring hydric cropland sites to wetlands in Missouri. Potential social and private (landowner) benefits and costs were estimated for 25 sites in Livingston county and 23 sites in Linn county. Sites ranging in size from 36 to 68 acres were identified using a geographic information system. Social net benefits of wetland restoration for both counties were highest and positive ($431,248) with high benefits and low costs and negative and lowest (-$579,681) with low benefits and high costs. When wetland construction costs are fully subsidized and easement payments equal the opportunity cost of wetland restoration, private net benefits ranged from $629,905 (high landowner benefits) to -$9,686 (low landowner benefits). It would be economically rational for a landowner to convert hydric cropland to wetland if the easement payment provided by the government is greater than or equal to the opportunity cost of wetland restoration, the cost of wetland construction is fully subsidized, and the income earned from the wetland equals or exceeds maintenance cost of the wetland. The first condition is likely to be satisfied for landowners who bid eligible cropland into the Wetland Reserve Program. The second condition would be satisfied under current cost-sharing provisions for wetlands. The third condition may or may not be satisfied.

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Introduction

National environmental policy has two major goals related to agriculture: reducing nonpoint source pollution (NSP) and preventing further losses in wetlands. Reducing agricultural NSP was established as a Presidential initiative in February 1989. Agriculture has been singled out because it is a major source of NSP (U.S. Department of Agriculture 1989). Agricultural NSP is a major cause of decreased water quality in 6 of 10 EPA regions. Dramatic losses in wetlands (from 200 million acres in the lower 48 states in the 1600's to 99 million acres today) led the President to adopt a no-net-loss policy for wetlands in 1990 as recommended by the National Wetlands Policy Forum (Conservation Foundation 1988). Missouri has lost more than 90 percent of its original 4.5 million acres of wetlands.

Agriculture and wetlands are linked two ways. First, drainage of wetlands for agricultural activities accounts for 87 percent of national wetland losses and two-thirds of the remaining wetlands are in agricultural areas. Second, agricultural NSP can be reduced by headwater wetlands that are upstream of rivers, lakes, estuaries or fringe wetlands adjacent to such water bodies. In addition, vegetative buffers or filter strips along stream corridors and riparian areas can stabilize banks, trap sediments and nutrients and reduce peak flows (U.S. Army Corps of Engineers 1986).

There are many economic benefits associated with the restoration of wetland ecosystems, including flood protection, water quality improvement, shoreline erosion control, fish and wildlife habitat, natural products and recreation and aesthetics (Environmental Protection Agency 1988a). EPA notes that "one of the most important values of wetlands is their ability to help maintain and improve the water quality of our nation's rivers, estuaries, and other water bodies" (Environmental Protection Agency 1988b). To tighten the link between wetlands protection and NSP, the EPA recently developed guidelines to improve the coordination of NSP and wetlands programs. In their guidance document, EPA states "there are many opportunities for wetland restoration projects to achieve NSP [nonpoint source] objectives," and that "certain wetlands may provide water quality functions that benefit adjacent and downstream waters" (Environmental Protection Agency 1990). Examples of the latter include headwater wetlands that are upstream of rivers, lakes, estuaries or riparian areas, or fringe wetlands adjacent to such water bodies. For example, vegetative buffers or filter strips along stream corridors and riparian areas can stabilize banks, trap sediments and nutrients and reduce peak flows. Water quality benefits of wetlands have been documented by the U.S. Corps of Engineers (1986).

The major purpose of this study is to assess the physical and economic aspects of converting hydric cropland to wetlands as a means of reducing agricultural runoff and nonpoint source pollution in an agricultural area within Missouri.

Objectives

The objectives of this research are to:

1. Demonstrate the use of a Geographic Information System (GIS) to identify hydric cropland sites suitable for conversion to wetlands;

2. Estimate the social costs and benefits of restoring hydric cropland sites to wetlands; and

3. Determine how the Wetland Reserve Program (WRP) influences landowners' willingness to convert hydric cropland sites to wetlands.

Related Research

Creation and restoration of wetlands from hydric cropland involves costs and benefits. Costs of wetland restoration include opportunity cost in the form of foregone crop income and direct cost in the form of construction and maintenance. Benefits of wetland protection and restoration include market and nonmarket values associated with improved fish and or wildlife habitat (Parks and Kramer 1990).

Several federal programs and studies deal with wetland protection and restoration. The USDA Water Bank Program implemented in 1972 is a 10-year renewable program. It focuses primarily on 509,000 acres in the Prairie Pothole region of the Northern Great Plains. The program has an average permanent easement cost of $19 per acre per year in 1989 dollars which equates to a present value cost of $240 to $450 per acre at nominal interest rates of 4 and 7.5 percent, respectively. The Water Bank Program includes wetland and surrounding upland areas (Carey, et al. 1990).

The Small Wetlands Acquisition Program (SWAP) offers landowners permanent easements which are paid when the land is enrolled in the program. SWAP is limited to 1.2 million acres of wetlands in the Prairie Pothole region. Average easement costs for the SWAP is $132 per acre during 1987 and 1988 (Carey, et al. 1990). Easement costs for SWAP are considerably below those for the Water Bank Program.

The Swampbuster Provision of the Food Security Act of 1985 is a federal program that makes farmers ineligible to receive price support payments, farm storage facility loans, crop insurance, disaster payments and insured or guaranteed loans in any year in which an annual crop is planted on wetland acreage converted to cropland after 1985 (Carey, et al. 1990). The program affords limited protection of wetlands because it is only effective in areas where program crops are planted on converted wetlands (Heimlich, et al. 1989).

The WRP is a major wetland provision of the Food, Agricultural and Trade Act of 1990 (U.S. Department of Agriculture 1992). This program offers government payments in the form of easements to landowners who are willing to implement plans to convert cropland to wetland. In addition to an easement payment, WRP authorizes 75% cost sharing of construction costs through Agricultural Stabilization and Conservation Service (ASCS). The Missouri Department of Conservation (MDC) will cost share the remaining 25% of construction costs. Unlike the Water Bank Program and SWAP, WRP is specifically designed to encourage the conversion of hydric cropland to wetland and it is not limited to the Prairie Pothole region.

The studies by Heimlich et al. (1989) and Carey et al. (1990) indicate that the average easement cost for a least-cost wetland reserve from hydric cropland would be $845 million for a 2.5 million acre reserve ($338/acre) and $2.4 billion for a 10 million acre reserve ($480/acre) in 1988 dollars. Figures include easement and restoration costs. Their analysis indicates that between 200,000 and 500,00 acres of the reserve would be located in Missouri. Only Minnesota and Iowa have higher acreage. The Heimlich and Cary studies have several limitations. First, it determines the least-cost lands to place in the reserve. Least-cost lands may not necessarily provide the greatest water quality benefits. It would be preferable to select lands based on the costs and benefits of restoration and water pollution control. Second, the study does not consider non-agricultural sources of income from restored hydric cropland such as hunting, fishing, trapping and wildlife observation. These sources of income would offset losses in agricultural income from discontinuing crop production and could reduce easement costs. Third, the study is static and does not consider how spatial and temporal variability in agricultural prices and yields influence easements costs.

Per acre present value of net returns from converting wetlands to agricultural uses have been estimated in several studies. These net returns include land clearing and preparation costs and can be viewed as the opportunity cost of converting an agricultural area to a wetland. Per acre present values were estimated to be $151 in the Mississippi Delta region (Kramer and Shabman 1986), $637 in North Carolina (Danielson et al. 1988, 1989) and $257 in Central Minnesota (Danielson et al. 1986).

Several studies have demonstrated the costs of constructed wetlands to control agricultural NSP. The Des Plains River Wetland Demonstration Project in Wadsworth, Illinois studied the economic efficiency and political acceptability of building and managing wetlands for NSP control in a 450-acre site (Hey 1988). Hey's results can be applied to areas along the Mississippi River, where 61 million acres of wetlands have been lost over the past 150 years. If 10 percent of the lost wetlands along the Mississippi River (6.1 million acres) were restored over a 15-year period, construction and land costs would equal $24 billion or $4,000 per acre. Annual operating cost would be $160 million or $26 per acre. Such restoration effort would entail an annual investment of $1.76 billion.

Wengrzynek and Terrell (1990) studied five prototype nutrient/sediment control systems for controlling NSP from cropland. These systems included watershed land treatment practices, sediment basin, grass filters, wetland, deep pond, and polishing area for reduction of soluble phosphorus, nitrogen, organic matter, bacteria and fine sediments reaching lakes and streams. The construction costs ranged from $14,000 to $22,500 for systems between 21 and 163 acres in size. Average annual costs of construction and maintenance were $20 per acre per year. In addition to controlling NSP in cropland areas, wetlands can also protect forest, wildlife and recreation resources (Leventhal 1990).

Wetland benefits are difficult to estimate because most of the goods and services which they provide are unpriced. Accurate estimation of benefits requires large amounts of site-specific data. Hammack and Brown (1974) conducted a survey to evaluate the value of waterfowl habitat in Prairie Pothole wetlands. Waterfowl habitat values varied from $175 to $292 per acre per year in 1988 dollars (Heimlich, et al. 1989). Gupta and Foster (1976) estimated the economic value of preserving freshwater wetlands in Massachusetts. Estimated annual benefits per acre of wetlands in wildlife production, visual-cultural (open space, recreation, and aesthetics), water supply and flood control were $35, $135, $1400 and $40, respectively. Raphael and Jaworski (1979) estimated the gross annual return from Michigan's 105,855 acres of coastal wetlands. Benefits of sport fishing, non consumptive recreation, waterfowl hunting, trapping of fur bearers and commercial fishing were estimated to be $286, $138.24, $31.23, $30.44 and $3.78 per wetland acre per year, respectively.

Few studies have compared the costs and benefits of restoring wetlands. Parks and Kramer (1990) indicated that wetland protection and restoration policies should balance costs and benefits. With efficient policies wetland development would occur up to the point where marginal social benefits of additional wetlands services equal marginal social costs of providing these services.

Study Area

The area for this study is Livingston and Linn counties in north central Missouri (Figure 1). The two counties cover 1154 square miles and comprise about 18% of the land area in the Missouri portion of the Grand River Basin. Land cover in the basin is 80 percent agricultural, 15 percent forest and 5 percent urban. Small to medium sized manufacturing is also an important source of income in the study area. Economic activity in both counties is dominated by crop and livestock production. Considerable agricultural acreage has been converted from pasture to cropland which has increased the basin's vulnerability to soil erosion and agrochemical contamination of surface and ground water. Soils in the two counties vary widely in texture, natural drainage and other characteristics. Nearly all upland soils in the watersheds are suited to cultivated crops. However, the moderately sloping to steeply sloping soils are subject to severe erosion and runoff. The study area is immediately upstream of the Fountain Grove Wildlife Management Area and the Swan Lake National Wildlife Refuge.

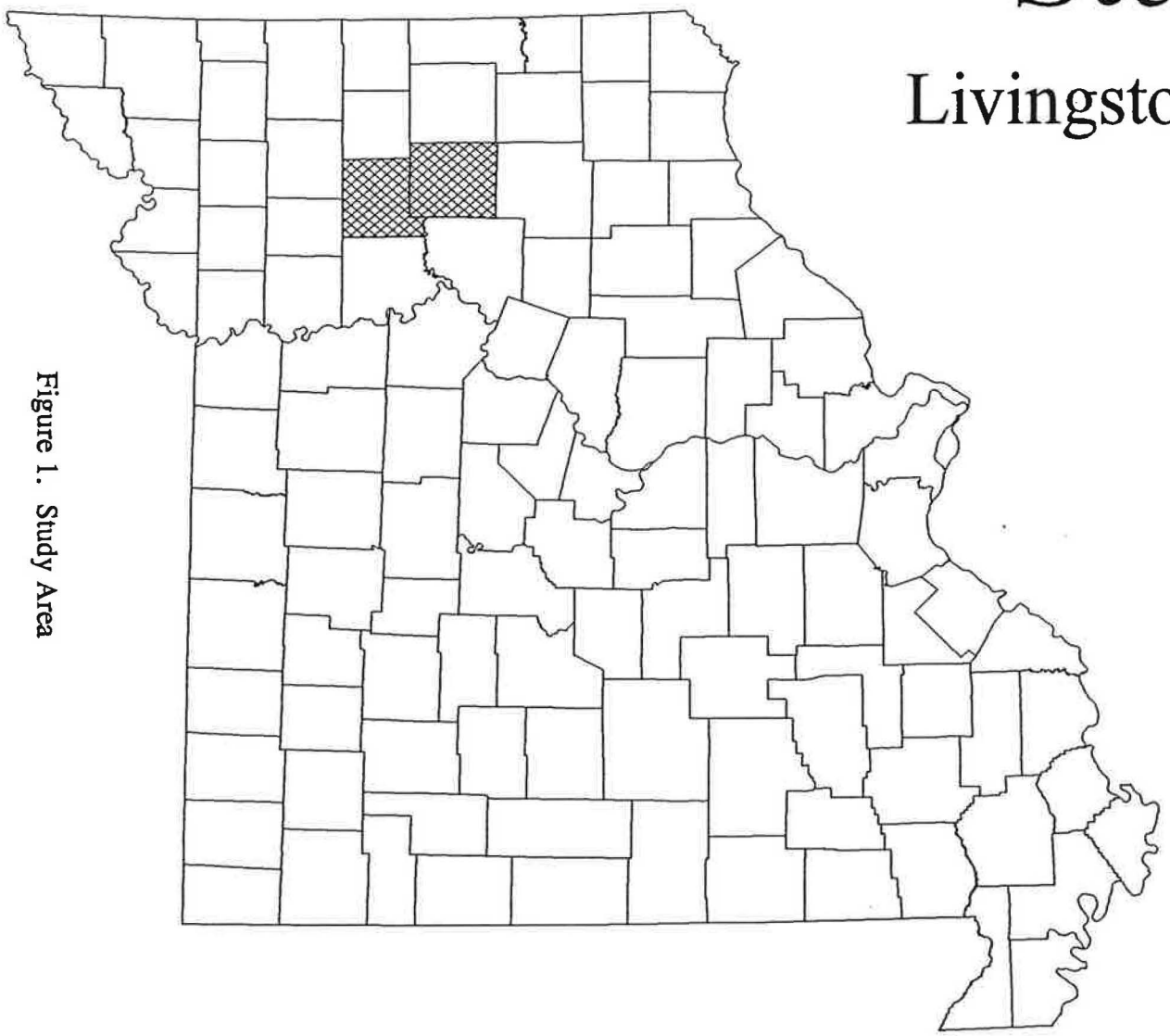

Figure 1. Study Area

Analytical Procedures

The benefits and costs of restoring hydric cropland sites in the study area were evaluated using a two-step procedure. The first step consists of using a GIS to identify hydric cropland sites having a high potential for wetland restoration (site assessment). The second step consists of estimating the social benefits and costs of converting these sites to wetlands (economic assessment). The details of each step are discussed below.

Site Assessment

The site assessment evaluates the suitability of hydric cropland in the study area for wetland restoration. Since soil, land cover, and ownership digital databases were not available and soil type is a major determinant of the ability of a site to support a wetland ecosystem, data analysis focused on developing a soils database for the study area. While the overall site assessment covered both counties, detailed site assessment procedures and maps focus on a portion of the northwest quarter of Linn county. This subarea contains a high concentration of hydric cropland sites which are suitable for wetland restoration. To facilitate data sharing agencies with such as MDC and EPA, ARC/INFO GIS software was used for data development and analysis.

The soil surveys for Livingston and Linn counties vary considerably due to changes in the survey over time. The Livingston county survey was issued in December 1956 and the Linn County survey was issued in July 1990. Soils in the study area vary widely in texture, natural drainage, and other characteristics. Broader ridgetops in the uplands are formed in loess and upland side slopes and narrow ridgetops are formed in loess over glacial till or entirely in glacial till. Nearly all of the upland soils are well suited for cultivated crops. However, the moderately sloping and steeply sloping soils are subject to severe erosion. Soils on the terraces and floodplains are well suited to cultivation, although drainage is a problem.

Development of the soil digital and associated tabular databases for the two counties required the digitization of 44,743 arcs which were then used in describing 15,062 separate soil polygons (Figures 2 and 3). Tabular data sets were created for each of the two soil surveys. Linn county had 25 soil types and Livingston county had 31 soil types. For each soil type, extracts from their respective soil survey were tabulated and encoded to allow the creation of eight associated databases linked to the spatial file by the soil type code. Database names and associated attributes are listed below.

Land Capability and Crop Yield

- Land capability class
- Corn yield (bu/acre)
- Soybean (bu/acre)
- Sorghum (bu/acre)
- Wheat (bu/acre)
- Orchard Grass - Alfalfa (tons/acre)
- Orchard Grass - Clover (tons/acre)
- Orchard Grass (tons/acre)
- Alfalfa Hay (tons/acre)
- Switch Grass (animal unit months)
- Fescue (animal unit months)

Physical and Chemical Properties
- Depth
- Percent clay
- Moist bulk density
- Permeability
- Available water capacity
- pH
- Erosion factor K
- Erosion factor T

Soil and Water Features
- Hydrologic group
- Flooding frequency
- Flooding duration
- Flooding months
- High water table depth
- High water table kind
- High water table months

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- High water table kind
- High water table months

Engineering Index Properties
- Fragment size
- Percent passing sieve 4
- Percent passing sieve 10
- Percent passing sieve 40
- Percent passing sieve 200
- Liquid Limit

Woodland Management Building Development, Sanitary Facilities, and Prime Farmland
- Erosion hazard
- Equipment limitation
- Limitations to shallow excavations
- Limitations to sewage lagoon areas
- Prime farmland

Water Management
- Limitations for pond reservoir areas
- Limitations for embankments, dikes, and levees
- Features affecting drainage
- Features affecting irrigation
- Features affecting terraces and diversions
- Features affecting grass waterways

Wildlife Habitat
- Grain and seed crops
- Grasses and legumes
- Wild herbaceous plants
- Hardwood trees
- Coniferous plants
- Wetland plants
- Shallow water areas
- Open land/ wildlife
- Woodland wildlife
- Wetland wildlife

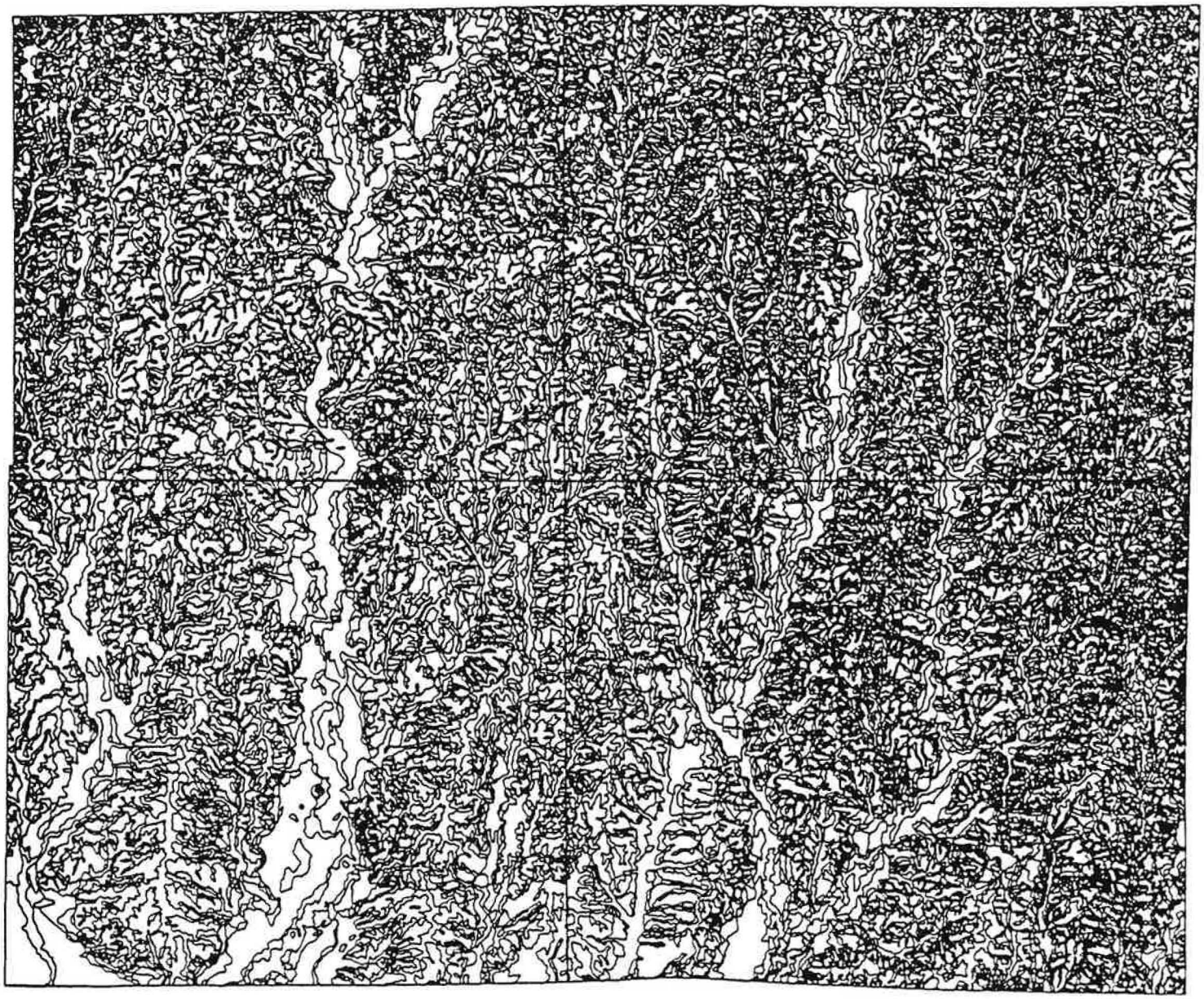

Figure 2. Linn County soil map

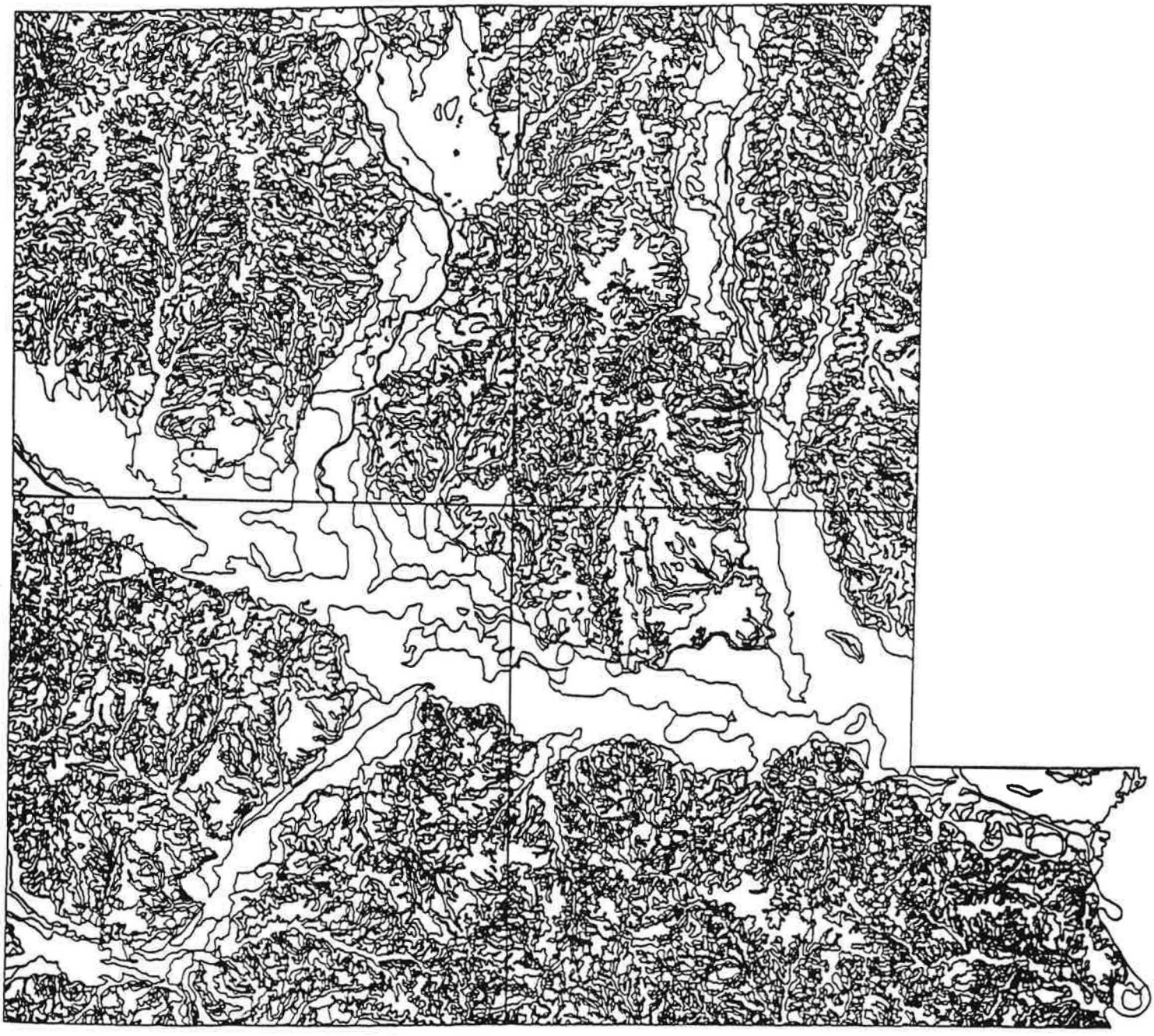

Figure 3. Livingston County soil map

The following initial screening process was used to delineate potential wetland sites based solely on their soil characteristics. Indices were created for overall physical-chemical suitability, overall engineering properties, flooding, water table, and wildlife habitat potential. Each of these indices were calculated within their respective table and then added to that table. In creating the indices for physical-chemical suitability, moist bulk density and permeability parameters were coded to create two separate measures for the physical indexing. The flooding index was created by multiplying the flooding frequency and flood duration parameters. The water table index was calculated by multiplying the depth to water table and the water table kind. The wildlife habitat index was assessed through the evaluation and summation of the wetland associated potential for each type of soil. The engineering index was based on the percent passing sieve 200 which was then ranked.

Individual indices were weighted equally and summed to obtain an overall index of wetland restoration potential for each soil type. Based on this index, the area in Linn county deemed suitable for wetland restoration was reduced to 4,463 acres. This area included 152 different sites scattered throughout the county (Figure 4) (Appendix A). Most of the sites were small in size and fell within the floodplain of the major rivers and streams traversing the area (Figure 5).

A sample of the 152 sites in northwest Linn county were then analyzed utilizing land cover (Figure 6) and land ownership boundaries (Figure 7). These coverages were compiled from plat maps and ASCS aerial slide photography and then digitized. For each potential site, land cover was digitized only for those parcels that intersected potential wetland sites (Figure 8).

Economic Assessment

Two categories of costs and benefits were estimated: social and private. Social benefits accrue to society and private benefits to landowners. Social and private net benefits (benefits minus costs) differ because some of the benefits of converting hydric cropland to wetland are typically not considered by the landowner. Gross private benefits equal the sum of net income from the services provided by the wetland, easement payment received by the landowner and federal/state cost sharing of wetland construction costs. Private (landowner) costs equal the sum of loss in net returns from foregone crop production (opportunity cost), construction cost and maintenance cost. Private net benefits equals gross private benefits minus private costs. Social benefits include reduction in erosion and NSP, flood protection, and enhancement in timber production, fish and wildlife habitat, natural products, recreation and aesthetics (EPA 1988a). Social net benefits equal social benefits of wetland restoration minus social cost. Social and private cost of converting hydric cropland to wetland include the same three components: opportunity cost, construction cost and maintenance cost. Construction and maintenance costs are referred to collectively as restoration cost. Social net benefits usually exceed private net benefits.

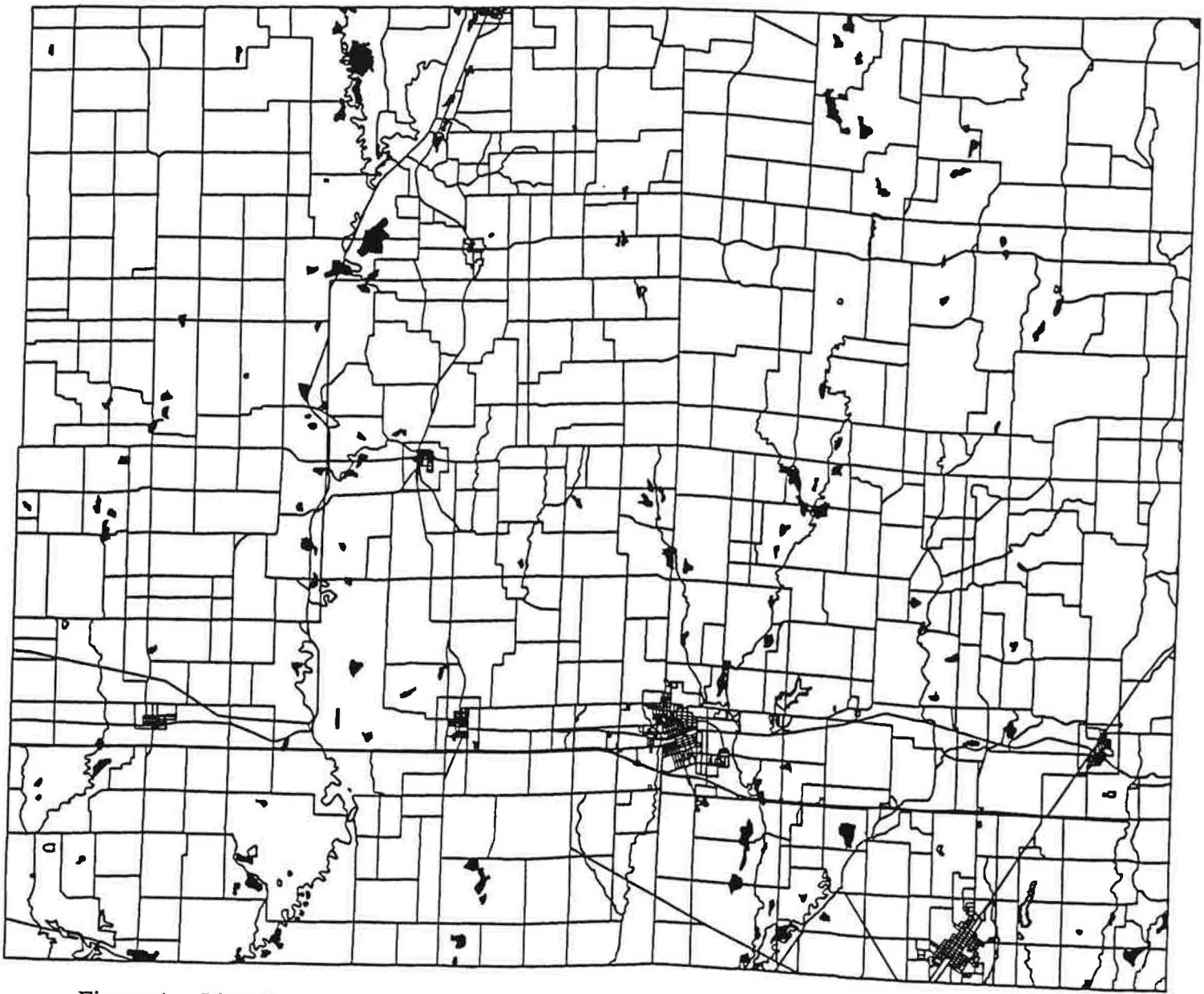

Figure 4. Linn County - potential wetland sites (in black) over block map from TIGER files

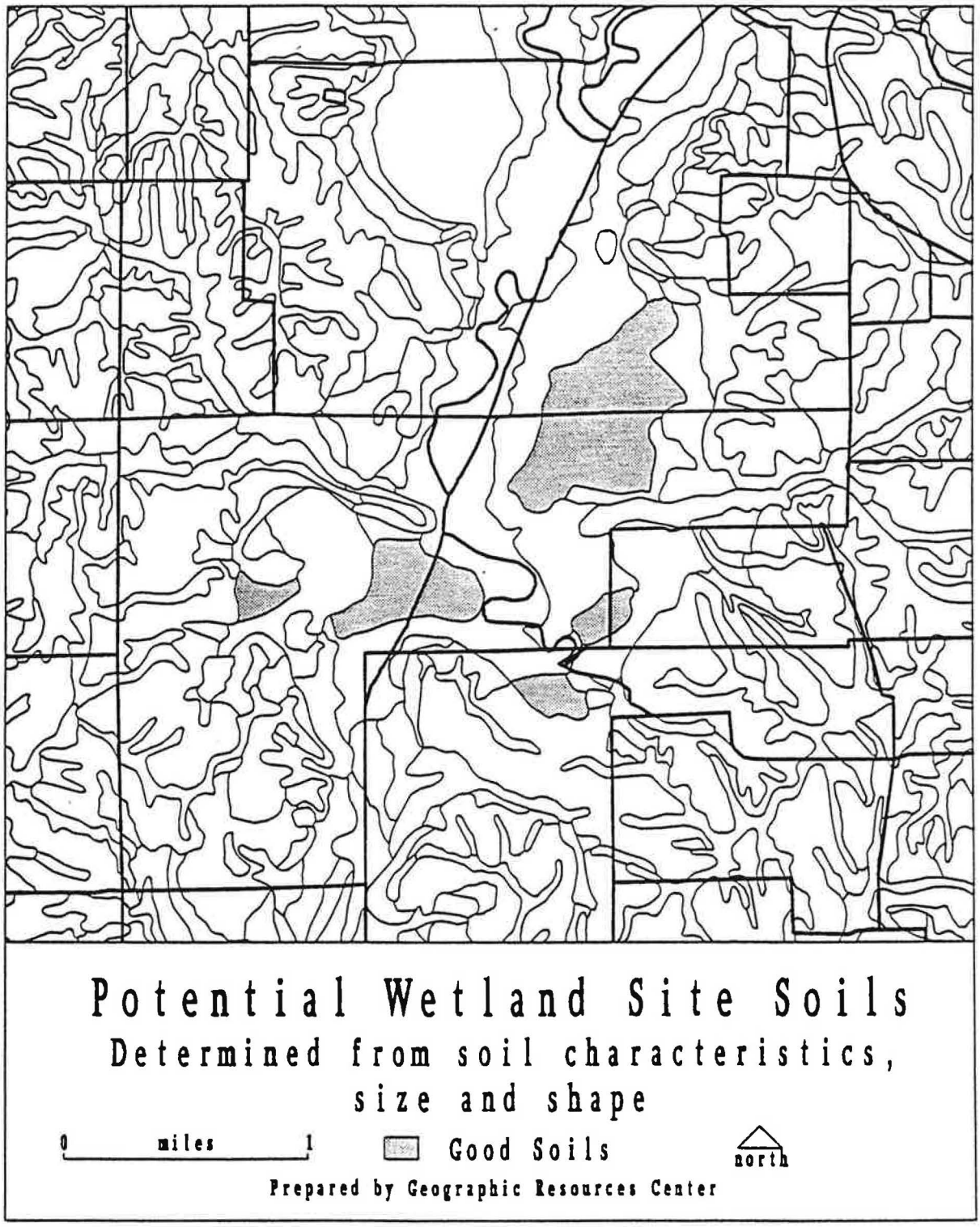

Figure 5. Soil polygons suitable for wetland restoration, Northwest Linn County

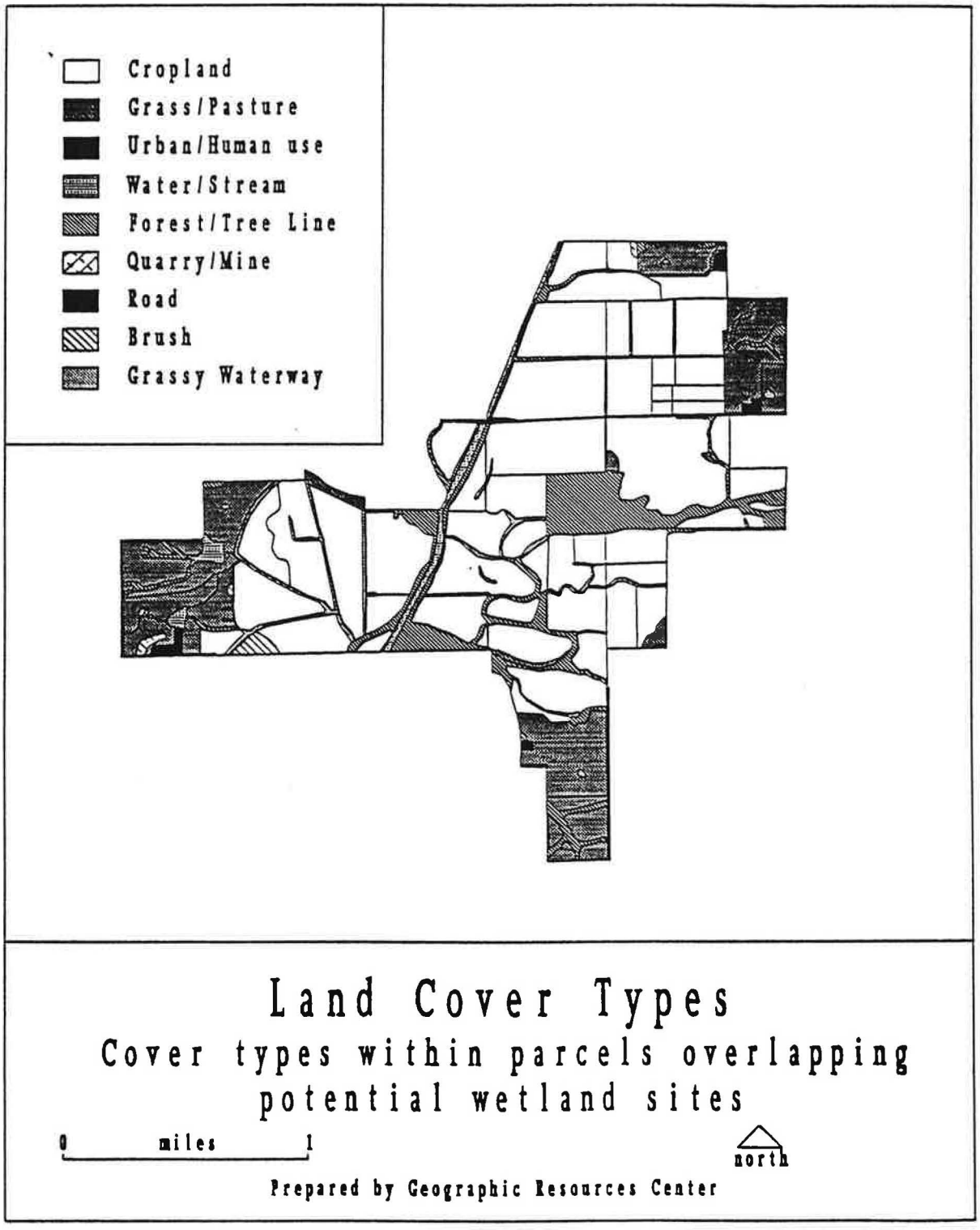

Figure 6. Land cover map of potential wetland sites, Northwest Linn County

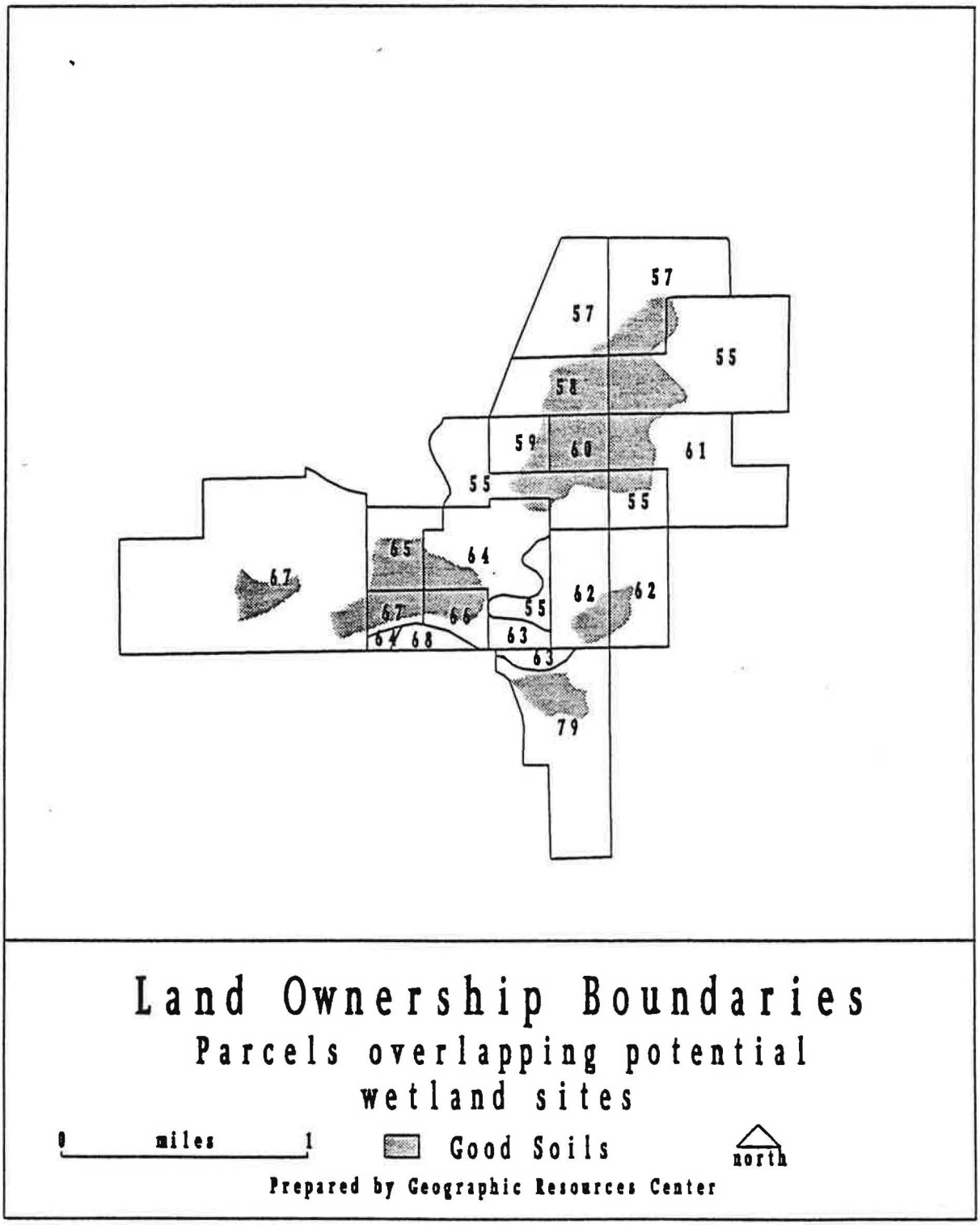

Figure 7. Land ownership parcels of overlapping potential wetland sites, Northwest Linn County

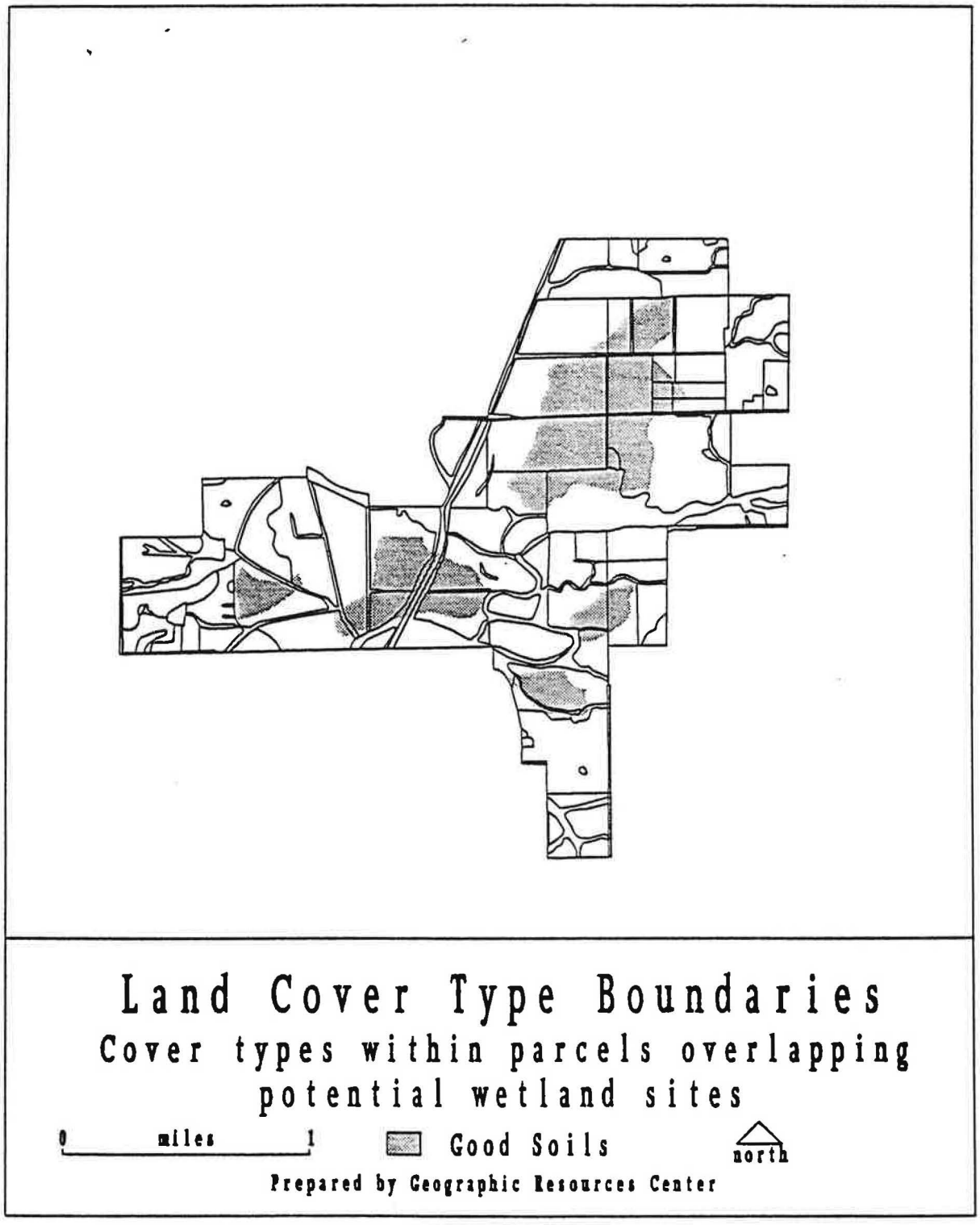

Figure 8. Land cover boundaries over potential wetland sites that intersect ownership boundaries, Northwest Linn County

Easement cost (EC) for a finite time horizon of T years and an infinite time horizon are defined as follows:

$$EC = \sum_{t}^{T}[(1/n)\sum_{i}^{n}(P_iY_i-C_i]/(1+r)^t = \sum_{t}^{T}[(1/n)\sum_{i}^{n}NR_i/(1+r)^t]$$

$$EC = (1/rn)\sum_{i}^{n}(P_iY_i-C_i) = (1/rn)\sum_{i}^{n}NR_i$$

Construction and maintenance costs are:

$$CM = CC + \sum_{t}^{T}MC/(1+r)^t$$

where:

EC = present value of easement cost;
P_i = price of the ith crop in the rotation;
Y_i = yield of the ith crop in the rotation;
C_i = total cost of production of the ith crop in the rotation;
NR_i = net return from production of the ith crop;
n = number of crops in crop rotation;
CM = construction cost plus present value of maintenance cost;
CC = construction cost;
MC = maintenance cost;
r = discount rate (10%); and
T = length of time horizon (years).

Lack of data and appropriate process models prevented estimation of many of the social benefits of wetland restoration, including water quality benefits. This study accounts for only the waterfowl hunting benefits of wetland restoration. Such simplification should not unduly distort the wetland benefits estimated here because marsh is the most common wetland in Missouri. Furthermore, waterfowl hunting, and duck hunting in particular, is likely to be a major wetland benefit in the study area because of its proximity to Swan Lake National Wildlife Refuge and Fountain Grove State Wildlife Area.

Hunting is significant in Missouri. Forty-three percent of Missouri landowners post their land and 75% of the landowners allow some hunting on their land. Fifteen percent of Missouri's population is hunters which is higher than national level of 10% (Bassett 1987). Hunting and fishing permits account for approximately 20% of the Missouri Department of Conservation's (MDC's) annual revenue (Missouri Department of Conservation 1991). The landowner allows a hunter access to his private property by charging a hunting fee or leasing the hunting rights. The hunter benefits from the hunting experience and the landowner receives income. It is estimated that the annual income from duck hunting leases ranges from $30 to $300 per acre (Byford 1990). The costs of management for duck hunting are summarized in Table 1. Using the consumer price index, the management costs of waterfowl hunting were extrapolated from 1986 to 1990 to obtain a cost range of $28.91 to $40.71. Net waterfowl benefits to the landowner, which equal income from waterfowl hunting minus waterfowl management costs, range from $1.09 to $259.29 in 1990 dollars.

Table 1. Costs of Management for Duck Hunting, 1986, $/ac

Practice	Cost
Installing nesting boxes	0.41 - 3.00
Fencing	2.25
Building shallow dike	0.46 - 2.39
Planting duck fields (browntop, corn or buckwheat)	21.12 - 27.50
Total	24.24 - 35.14

Costs of converting hydric cropland to wetlands include easement cost, construction cost and maintenance cost. Easement cost equals the payment to landowners for converting eligible cropland to wetland. This payment depends on the amount bid by the landowner and the maximum amount which the government is willing to pay for an easement. From the landowner's viewpoint, the easement payment is a source of income which offsets the loss in crop returns from wetland conversion. For purposes of this analysis, it is assumed that: each site is owned by only one landowner; waterfowl hunters are willing to pay to hunt at the sites; wetland sites are enrolled in the WRP, easement payment made by the government equals the present value of the loss in average net returns from cropland production for each site, and restoration cost are subsidized according to the cost-share provisions of the WRP and the MDC. In the pilot WRP, the easement payment is in the form of a periodic or lump-sum payment for a permanent easement. The range for annual benefits and costs of wetland restoration is summarized in Table 2.

Table 2. Range for Annual Benefits and Costs of Wetland Restoration, 1990, $/ac.

	High	Low
Benefits	259.29	1.09
Costs		
Easement		
Linn	31.15	31.15
Livingston	29.65	29.65
Construction	200.00	50.00
Maintenance	5.00	5.00

Gross returns per acre for each crop in the rotation equals crop yield times market price for each crop. Since about 70 percent of hydric cropland meets the USDA prime farmland definition, hydric cropland usually has higher crop yields and net returns than other types of land (Heimlich 1989). The typical crop rotation in the study area is corn-wheat-soybeans. Crop yields are similar for Linn County and Livingston County. Five-year average crop prices are used in calculating gross crop returns. Average prices for corn, wheat and soybeans for the 1986-90 period are shown in Table 3 (Missouri Department of Agriculture 1991).

Table 3. Market Prices for Corn, Wheat and Soybeans, $/bu.

Year	Corn	Wheat	Soybeans
1986	1.45	2.37	4.61
1987	1.82	2.53	5.70
1988	2.63	3.45	7.45
1989	2.38	3.72	5.60
1990	2.35	2.70	5.70
Average	2.13	2.95	5.81

Source: Missouri Department of Agriculture, 1991.

Crop production costs per acre are based on Management Information Records (MIR) for Linn County and Livingston County for 1990 (Ehlmann 1992). Estimated net returns to land and management in 1990 for corn, wheat and soybeans are summarized in Table 4.

Table 4. Estimated Net Returns for Corn, Wheat and Soybeans, Linn and Livingston Counties, 1990.

	Livingston			Linn		
	Corn	Wheat	Soybeans	Corn	Wheat	Soybeans
Yield (bu/ac)	99.80	2.40	29.20	96.20	42.10	29.90
Price ($/bu)*	2.13	2.95	5.81	2.13	2.95	5.81
Gross Return ($/ac)	212.57	125.08	169.65	204.91	24.20	173.72
VC ($/ac)	150.37	91.10	87.80	150.37	91.10	87.80
FC ($/ac)	38.55	20.19	25.86	38.55	20.19	25.86
Total Nonland Cost ($/ac)	188.92	111.29	113.66	88.92	111.29	113.66
Return to Land & Mgt.($/ac)	23.65	13.79	55.99	15.99	12.91	60.06

* Average market prices, 1986-1990

Construction costs are the costs for establishment or installation of the eligible wetland restoration practices. Construction costs includes three items: earth work for dikes and levees, water control structures, and grass seeding for erosion control. Construction costs are very site-specific. Based on the restoration practices on private land in Missouri, average construction costs vary from $50 per acre to $200 per acre. Most restored wetland sites are in the high end of this cost range (Young 1992). In the WRP, landowners receive cost-share payments from the Agricultural Stabilization and Conservation Service (ASCS) equal to 75% of construction costs. In addition, the MDC will pay the remaining 25% of construction costs. Maintenance costs are incurred to mow levees and keep vegetation growing and are estimated to be $5 per acre per year (Young 1992).

Social and private net benefits of wetland restoration were evaluated for four time horizons: 25 years, 50 years, 75 years and infinite. An infinite time horizon corresponds to a permanent easement. Of the 65 potential wetland sites identified with the GIS, only sites with 10 or more acres were included in the benefit-cost analysis because this appears to be the minimum acceptable size for wetlands in Missouri (Young 1992). Twenty-five (25) potential sites in Linn County and 23 potential sites in Livingston County exceed 10 acres. Constructed wetlands on private land range in size from 10 to 300 acres with an average size of 25 acres. Average acreage of the 25 sites in Linn County is 36 acres. The 23 sites in Livingston County average 68 acres (Table 5).

Results

The efficiency of wetland conversion is evaluated in terms of social and private net benefits. Because of uncertainty regarding the benefits and costs of wetland restoration, high and low benefits and costs were used in estimating net benefits. High benefits correspond to high waterfowl benefits and high costs correspond to high restoration costs (Table 6). Low benefits correspond to low waterfowl benefits and low costs correspond to low restoration costs (Table 7). Combining high and low benefits and costs gives four net benefit scenarios: high benefits-high costs (Table 8); low benefits-low costs (Table 9); high benefits-low costs (Table 10); and low benefits-high costs (Table 11). Benefits and costs are reported on an annual (undiscounted) basis and for 25-year, 50-year, 75-year and permanent easements.

Net benefits are positive for all sites when waterfowl hunting benefits and construction costs are high. For this scenario, conversion of hydric cropland to wetlands is socially efficient. Linn County has lower social net benefits per acre than Livingston County because income losses from crop production are greater in Linn County. As expected, choice of time horizon influences the efficiency of wetland conversion. Compared to annual net benefits, social net benefits are 77.88%, 85.95%, 86.70% and 86.77% higher in Linn County and 73.64%, 81.28%, 81.98% and 82.05% higher in Livingston County for 25-year, 50-year, 75-year and permanent easements, respectively. Net benefits of wetland restoration increase with the time horizon but at a decreasing rate for both counties. Conversion of hydric cropland to wetlands is not socially efficient when waterfowl hunting benefits and restoration costs are low. Linn County has greater losses in net social benefits per acre than Livingston County.

As expected, net benefits are highest when benefits are high and construction costs are low. Estimated net social benefits of wetland restoration are negative when waterfowl hunting benefits are low and wetland restoration costs are high. Even for cases where estimated net social benefits are negative, actual net social benefits could be positive when other benefits of wetland restoration are considered. The ranking of the four benefit-cost scenarios in descending order of estimated net social benefits is: high benefits and low costs; high benefits and high costs; low benefits and low costs; and low benefits and high costs.

Landowner net benefits for high and low benefit values are displayed in tables 12 and 13. Since only waterfowl hunting benefits are considered, landowner benefits are the same as social benefits. However, landowner costs would only include maintenance cost if the sites are enrolled in the WRP. Results indicate that if a landowner receives high benefits from waterfowl hunting, enrolls land in the WRP and receives full cost sharing of construction costs, then wetland restoration is profitable. The income from one acre of converted wetland substantially exceeds the loss in net returns from cropland production. However, if low waterfowl hunting benefits prevail, then net benefits from restoration are negative. There is an incentive for a landowner to enroll hydric cropland in the WRP as long as the easement payment equals or exceeds the

Table 5. Acreage for Potential Wetland Sites in Linn County and Livingston County.

Linn	Acres	Livingston	Acres
NE1	21.88	NE1	40.44
NE2	11.29	NE2	15.03
NW1	14.52	NE3	59.43
NW2	26.11	NE4	176.78
NW3	18.38	NE5	57.21
NW4	15.09	NE6	41.18
NW5	107.61	NW1	67.93
NW6	16.43	NW2	136.24
NW7	46.29	NW3	89.59
NW8	73.50	NW4	21.31
SE1	30.81	NW5	13.92
SE2	97.02	NW6	13.16
SE3	13.59	NW7	11.59
SE4	11.13	SE1	37.33
SE5	20.30	SE2	133.42
SE6	30.14	SE3	14.83
SE7	12.48	SE4	44.11
SE8	10.08	SE5	108.58
SW1	64.53	SE6	146.57
SW2	11.51	SE7	154.41
SW3	46.14	SE8	84.51
SW4	136.32	SW1	19.41
SW5	21.57	SW2	84.63
SW6	17.42		
SW8	31.36		
Total	905.50		1571.61
Average	36.22		68.33

NE indicates the Northeast section of the county.
NW indicates the Northwest section of the county.
SE indicates the Southeast section of the county.
SW indicates the Southwest section of the county.

Table 6. High Benefits and High Costs to Society of Wetland Restoration, Linn and Livingston Counties

	Benefits ($)				
Linn	Annual	25-year	50-year	75-year	Permanent
NE1	5673	51496	56249	56688	56733
NE2	2927	26572	29024	29251	29274
NW1	3765	34174	37328	37619	37649
NW2	6770	61452	67124	67647	67701
NW3	4766	43259	47252	47620	47658
NW4	3913	35516	38794	39096	39127
NW5	27902	253269	276645	278803	279022
NW6	4260	38669	42238	42568	42601
NW7	12003	108947	119003	119931	120025
NW8	19058	172989	188955	190428	190578
SE1	7989	72514	79207	79824	79887
SE2	25156	228345	249420	251365	251563
SE3	3524	31985	34937	35210	35238
SE4	2886	26195	28613	28836	28859
SE5	5264	47778	52187	52594	52636
SE6	7815	70937	77484	78089	78150
SE7	3236	29373	32084	32334	32359
SE8	2614	23724	25914	26116	26136
SW1	16732	151877	165895	167188	167320
SW2	2984	27090	29590	29821	29844
SW3	11964	108594	118617	119542	119636
SW4	35346	320841	350453	353186	353464
SW5	5593	50767	55452	55885	55929
SW6	4517	40999	44784	45133	45168
SW8	8131	73808	80621	81249	81313
Subtotal	234787	2131172	2327870	2346025	2347871
Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	10486	95179	103964	104774	104857
NE2	3897	35374	38639	38941	38971
NE3	15410	139874	152783	153975	154096
NE4	45837	416067	454468	458012	458373
NE5	14834	134649	147076	148223	148340
NE6	10678	96921	105866	106692	106776
NW1	17614	159879	174635	175997	176136
NW2	35326	320653	350247	352979	353257
NW3	23230	210858	230319	232115	232298
NW4	5525	50155	54784	55211	55255

Table 6. High Benefits and High Costs to Society of Wetland Restoration, Linn and Livingston Counties (Continued)

	Benefits ($)				
Livingston	Annual	25-year	50-year	75-year	Permanent
NW5	3609	32762	35786	36065	36093
NW6	3412	30973	33832	34096	34123
NW7	3005	27278	29796	30028	30052
SE1	9679	87859	95968	96717	96793
SE2	34594	314015	342998	345673	345945
SE3	3845	34904	38125	38422	38453
SE4	11437	103817	113399	114283	114373
SE5	28154	255552	279139	281316	281537
SE6	38004	344965	376804	379743	380041
SE7	40037	363417	396959	400055	400370
SE8	21913	198902	217259	218954	219126
SW1	5033	45683	49899	50289	50328
SW2	21944	199184	217568	219265	219437
Subtotal	407503	3698919	4040314	4071824	4075028

	Costs ($)				
Linn	Annual	25-year	50-year	75-year	Permanent
NE1	5167	11555	12217	12278	12285
NE2	2666	5962	6304	6336	6339
NW1	3429	7668	8108	8148	8152
NW2	6166	13788	14579	14652	14660
NW3	4340	9706	10263	10314	10320
NW4	3563	7969	8426	8468	8472
NW5	25412	56828	60087	60387	60418
NW6	3880	8677	9174	9220	9225
NW7	10931	24445	25847	25977	25990
NW8	17357	38815	41041	41246	41267
SE1	7276	16271	17204	17290	17298
SE2	22911	51236	54173	54445	54472
SE3	3209	7177	7588	7626	7630
SE4	2628	5878	6215	6246	6249
SE5	4794	10720	11335	11392	11398
SE6	7117	15917	16829	16914	16922
SE7	2947	6591	6969	7003	7007
SE8	2380	5323	5628	5657	5659
SW1	15238	34078	36032	36212	36231
SW2	2718	6078	6427	6459	6462
SW3	10896	24366	25763	25892	25905
SW4	32191	71990	76118	76499	76537

Table 6. High Benefits and High Costs to Society of Wetland Restoration, Linn and Livingston Counties (Continued)

	Costs ($)				
Linn	Annual	25-year	50-year	75-year	Permanent
SW5	5094	11391	12044	12104	12111
SW6	4114	9199	9727	9776	9781
SW8	7406	16561	17511	17598	17607
Subtotal	213830	478188	505608	508139	508396

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	9489	20807	21981	22089	22100
NE2	3527	7733	8170	8210	8214
NE3	13945	30578	32303	32462	32478
NE4	41481	90957	96088	96562	96610
NE5	13424	29436	31096	31250	31265
NE6	9663	21188	22383	22494	22505
NW1	15940	34951	36923	37105	37124
NW2	31969	70098	74053	74418	74455
NW3	21022	46096	48696	48937	48961
NW4	5000	10964	11583	11640	11646
NW5	3266	7162	7566	7603	7607
NW6	3088	6771	7153	7188	7192
NW7	2720	5963	6300	6331	6334
SE1	8759	19207	20291	20391	20401
SE2	31307	68647	72520	72878	72914
SE3	3480	7630	8061	8101	8105
SE4	10350	22695	23976	24094	24106
SE5	25478	55867	59018	59309	59339
SE6	34393	75413	79668	80061	80101
SE7	36232	79447	83929	84343	84385
SE8	19830	43482	45935	46162	46185
SW1	4555	9987	10550	10602	10608
SW2	19858	43544	46000	46227	46250
Subtotal	368778	808624	854246	858457	858885

Table 7. Low Benefits and Low Costs to Society of Wetland Restoration, Linn and Livingston Counties

	Benefits ($)				
Linn	Annual	25-year	50-year	75-year	Permanent
NE1	24	216	236	238	238
NE2	12	112	122	123	123
NW1	16	144	157	158	158
NW2	28	258	282	284	285
NW3	20	182	199	200	200
NW4	16	149	163	164	164
NW5	117	1065	1163	1172	1173
NW6	18	163	178	179	179
NW7	50	458	500	504	505
NW8	80	727	794	801	801
SE1	34	305	333	336	336
SE2	106	960	1049	1057	1058
SE3	15	134	147	148	148
SE4	12	110	120	121	121
SE5	22	201	219	221	221
SE6	33	298	326	328	329
SE7	14	123	135	136	136
SE8	11	107	109	110	110
SW1	70	638	697	703	703
SW2	13	114	124	125	125
SW3	50	457	499	503	503
SW4	149	1349	1473	1485	1486
SW5	24	213	233	235	235
SW6	19	172	188	190	190
SW8	34	310	339	342	342
Subtotal	987	8959	9786	9862	9870

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	44	400	437	440	441
NE2	16	149	162	164	164
NE3	65	588	642	647	648
NE4	193	1749	1910	1925	1927
NE5	62	566	618	623	624
NE6	45	407	445	449	449
NW1	74	672	734	740	740
NW2	149	1348	1472	1484	1485
NW3	98	886	968	976	977
NW4	23	211	230	232	232

Table 7. Low Benefits and Low Costs to Society of Wetland Restoration, Linn and Livingston Counties (Continued)

		Benefits ($)			
Livingston	Annual	25-year	50-year	75-year	Permanent
NW5	15	138	150	152	152
NW6	14	130	142	143	143
NW7	13	115	125	126	126
SE1	41	369	403	407	407
SE2	145	1320	1442	1453	1454
SE3	16	147	160	162	162
SE4	48	436	477	480	481
SE5	118	1074	1173	1183	1184
SE6	160	1450	1584	1596	1598
SE7	168	1528	1669	1682	1683
SE8	92	836	913	920	921
SW1	21	192	210	211	212
SW2	92	837	915	922	922
Subtotal	1713	15549	16985	17117	17131

		Costs ($)			
Linn	Annual	25-year	50-year	75-year	Permanent
NE1	1885	8273	8935	8996	9003
NE2	973	4269	4611	4642	4645
NW1	1251	5490	5930	5970	5974
NW2	2249	9872	10663	10736	10743
NW3	1583	6949	7506	7557	7563
NW4	1300	5705	6162	6205	6209
NW5	9270	40687	43945	44246	44276
NW6	1415	6212	6710	6756	6760
NW7	3988	17502	18904	19033	19046
NW8	6332	27790	30016	30221	30242
SE1	2654	11649	12582	12668	12677
SE2	8358	36683	39620	39892	39919
SE3	1171	5138	5550	5588	5592
SE4	959	4208	4545	4576	4579
SE5	1749	7675	8290	8347	8353
SE6	2596	11396	12308	12393	12401
SE7	1075	4719	5097	5131	5135
SE8	868	3811	4116	4145	4147
SW1	5559	24398	26352	26533	26551
SW2	992	4352	4700	4733	4736
SW3	3975	17445	18842	18971	18984
SW4	11743	51542	55670	56051	56089

Table 7. Low Benefits and Low Costs to Society of Wetland Restoration, Linn and Livingston Counties (Continued)

	Costs ($)				
Linn	Annual	25-year	50-year	75-year	Permanent
SW5	1858	8155	8809	8869	8875
SW6	1501	6586	7114	7163	7168
SW8	2702	11857	12807	12894	12903
Subtotal	78005	342363	369783	372314	372571

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	3423	14741	15915	16023	16034
NE2	1272	5479	5915	5955	5959
NE3	5031	21663	23389	23548	23564
NE4	14964	64440	69571	70045	70093
NE5	4843	20854	22515	22668	22684
NE6	3486	15011	16206	16317	16328
NW1	5750	24762	26734	26916	26934
NW2	11533	49662	53617	53982	54019
NW3	7584	32657	35258	35498	35522
NW4	1804	7768	8387	8444	8449
NW5	1178	5074	5478	5515	5519
NW6	1114	4797	5179	5214	5218
NW7	981	4225	4561	4592	4595
SE1	3160	13608	14691	14791	14801
SE2	11294	48634	52507	52865	52901
SE3	1255	5406	5836	5876	5880
SE4	3734	16079	17359	17478	17490
SE5	9191	39580	42731	43022	43052
SE6	12407	53428	57682	58075	58115
SE7	13071	56285	60768	61181	61224
SE8	7154	30806	33259	33485	33508
SW1	1643	7075	7639	7691	7696
SW2	7164	30849	33306	33533	33556
Subtotal	133037	572882	618504	622715	623143

Table 8. Net Benefits to Society of Wetland Restoration with High Benefits and High Costs, Linn and Livingston Counties ($)

Linn	Annual	25-year	50-year	75-year	Permanent
NE1	506	39942	44032	44410	44448
NE2	261	20610	22720	22915	22935
NW1	336	26506	29221	29471	29497
NW2	604	47664	52545	52995	53041
NW3	425	33553	36989	37306	37338
NW4	349	27547	30368	30628	30655
NW5	2491	196441	216558	218415	218604
NW6	380	29993	33064	33348	33377
NW7	1071	84502	93156	93954	94036
NW8	1701	134174	147914	149182	149311
SE1	713	56243	62003	62535	62589
SE2	2245	177109	195247	196921	197091
SE3	315	24808	27349	27584	27607
SE4	258	20318	22398	22590	22610
SE5	470	37058	40852	41203	41238
SE6	698	55020	60655	61175	61228
SE7	289	22782	25115	25331	25352
SE8	233	18401	20285	20459	20477
SW1	1494	117799	129863	130976	131089
SW2	266	21011	23163	23362	23382
SW3	1068	84228	92854	93650	93731
SW4	3155	248851	274336	276688	276927
SW5	499	39376	43408	43780	43818
SW6	403	31800	35057	35357	35388
SW8	726	57247	63110	63651	63706
Subtotal	20957	1652984	1822263	1837886	1839475
Avg.NB/Ac	23.14	1825.49	2012.44	2029.69	2031.45

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	996	74372	81983	82685	82756
NE2	370	27641	30470	30731	30757
NE3	1464	109296	120480	121513	121618
NE4	4356	325110	358380	361450	361763
NE5	1410	105213	115980	116974	117075
NE6	1015	75733	83483	84198	84271
NW1	1674	124928	137712	138892	139012
NW2	3357	250554	276194	278561	278802
NW3	2207	164762	181623	183179	183337
NW4	525	39191	43201	43571	43609

Table 8. Net Benefits to Society of Wetland Restoration with High Benefits and High Costs, Linn and Livingston Counties ($) (Continued)

Livingston	Annual	25-year	50-year	75-year	Permanent
NW5	343	25600	28220	28461	28486
NW6	324	24202	26679	26907	26931
NW7	286	21315	23496	23697	23718
SE1	920	68652	75678	76326	76392
SE2	3287	245368	270478	272795	273031
SE3	365	27273	30064	30322	30348
SE4	1087	81121	89423	90189	90267
SE5	2675	199686	220120	222006	222198
SE6	3611	269552	297136	299682	299941
SE7	3805	283970	313030	315712	315985
SE8	2082	155419	171324	172792	172941
SW1	478	35696	39349	39686	39721
SW2	2085	155640	171567	173037	173187
Subtotal	38724	2890295	3186068	3213367	3216143
Avg.NB/Ac	24.64	1839.07	2027.26	2044.63	2046.40
NB/Ac	24.09	1834.10	2021.84	2039.17	2040.93

Table 9. Net Benefits to Society of Wetland Restoration with Low Benefits and Low Costs, Linn and Livingston Counties ($)

Linn	Annual	25-year	50-year	75-year	Permanent
NE1	-1861	-8056	-8699	-8758	-8764
NE2	-960	-4157	-4489	-4519	-4522
NW1	-1235	-5346	-5773	-5812	-5816
NW2	-2221	-9614	-10380	-10451	-10458
NW3	-1563	-6767	-7307	-7357	-7362
NW4	-1283	-5556	-5999	-6040	-6044
NW5	-9153	-39622	-42782	-43074	-43104
NW6	-1397	-6050	-6532	-6577	-6581
NW7	-3937	-17044	-18403	-18529	-18542
NW8	-6252	-27063	-29221	-29420	-29441
SE1	-2621	-11344	-12249	-12333	-12341
SE2	-8252	-35723	-38572	-38835	-38862
SE3	-1156	-5004	-5403	-5440	-5444
SE4	-947	-4098	-4425	-4455	-4458
SE5	-1727	-7474	-8071	-8126	-8131
SE6	-2564	-11098	-11983	-12064	-12073
SE7	-1061	-4595	-4962	-4995	-4999
SE8	-857	-3711	-4007	-4035	-4038
SW1	-5489	-23760	-25655	-25830	-25848
SW2	-979	-4238	-4576	-4607	-4610
SW3	-3924	-16989	-18344	-18469	-18482
SW4	-11595	-50193	-54196	-54566	-54603
SW5	-1835	-7942	-8576	-8634	-8640
SW6	-1482	-6414	-6926	-6973	-6978
SW8	-2667	-11547	-12468	-12553	-12561
Subtotal	-77018	-333404	-359997	-362451	-362701
Avg.NB/Ac	-85.06	-368.20	-397.57	-400.28	-400.55

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	-3379	-14341	-15478	-15583	-15594
NE2	-1256	-5330	-5753	-5792	-5796
NE3	-4966	-21075	-22746	-22901	-22916
NE4	-14772	-62691	-67661	-68120	-68166
NE5	-4780	-20288	-21897	-22045	-22060
NE6	-3441	-14603	-15761	-15868	-15879
NW1	-5676	-24090	-26000	-26176	-26194
NW2	-11384	-48314	-52145	-52498	-52534
NW3	-7486	-31771	-34290	-34522	-34546
NW4	-1781	-7557	-8156	-8212	-8217

Table 9. Net Benefits to Society of Wetland Restoration with Low Benefits and Low Costs, Linn and Livingston Counties ($) (Continued)

Livingston	Annual	25-year	50-year	75-year	Permanent
NW5	-1163	-4936	-5328	-5364	-5368
NW6	-1100	-4667	-5037	-5071	-5074
NW7	-968	-4110	-4436	-4466	-4469
SE1	-3119	-13238	-14288	-14385	-14394
SE2	-11149	-47314	-51065	-51412	-51447
SE3	-1239	-5259	-5676	-5715	-5718
SE4	-3686	-15643	-16883	-16997	-17009
SE5	-9073	-38505	-41558	-41840	-41868
SE6	-12247	-51977	-56098	-56479	-56517
SE7	-12902	-54758	-59099	-59500	-59540
SE8	-7062	-29969	-32345	-32565	-32587
SW1	-1622	-6883	-7429	-7479	-7484
SW2	-7072	-30012	-32391	-32611	-32633
Subtotal	-131324	-557333	-601520	-605598	-606013
Avg.NB/Ac	-83.56	-354.63	-382.74	-385.34	-385.60
NB/Ac	-84.11	-359.59	-388.16	-390.80	-391.07

Table 10. Net Benefits to Society of Wetland Restoration with High Benefits and Low Costs, Linn and Livingston Counties ($)

Linn	Annual	25-year	50-year	75-year	Permanent
NE1	3788	43224	47314	47692	47730
NE2	1955	22303	24414	24609	24629
NW1	2514	28684	31399	31649	31675
NW2	4521	51580	56461	56912	56958
NW3	3182	36310	39746	40063	40095
NW4	2613	29810	32631	32892	32918
NW5	18632	212583	232700	234557	234745
NW6	2845	32457	35529	35812	35841
NW7	8015	91446	100099	100898	100979
NW8	12726	145199	158939	160207	160336
SE1	5335	60865	66625	67156	67210
SE2	16798	191662	209800	211474	211644
SE3	2353	26847	29388	29622	29646
SE4	1927	21987	24068	24260	24280
SE5	3515	40103	43897	44248	44283
SE6	5219	59541	65176	65696	65749
SE7	2161	24654	26987	27203	27224
SE8	1745	19913	21797	21971	21989
SW1	11173	127479	139542	140656	140769
SW2	1993	22738	24890	25088	25108
SW3	7989	91149	99775	100571	100652
SW4	23603	269299	294784	297136	297375
SW5	3735	42611	46644	47016	47054
SW6	3016	34413	37670	37970	38001
SW8	5430	61951	67814	68355	68410
Subtotal	156782	1788809	1958088	1973711	1975300
Avg.NB/Ac	173.14	1975.49	2162.44	2179.69	2181.45

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	7062	80438	88049	88751	88822
NE2	2625	29896	32724	32985	33012
NE3	10379	118210	129395	130427	130532
NE4	30873	351627	384897	387967	388280
NE5	9991	113794	124561	125555	125656
NE6	7192	81910	89660	90375	90448
NW1	11863	135117	147902	149081	149201
NW2	23793	270990	296630	298997	299238
NW3	15646	178200	195061	196617	196775
NW4	3722	42387	46397	46768	46805

Table 10. Net Benefits to Society of Wetland Restoration with High Benefits and Low Costs, Linn and Livingston Counties ($) (Continued)

Livingston	Annual	25-year	50-year	75-year	Permanent
NW5	2431	27688	30308	30549	30574
NW6	2298	26176	28653	28881	28905
NW7	2024	23053	25234	25436	25456
SE1	6519	74252	81277	81926	81992
SE2	23300	265381	290491	292808	293044
SE3	2590	29498	32289	32546	32573
SE4	7703	87738	96039	96805	96883
SE5	18962	215973	236407	238293	238485
SE6	25597	291537	319122	321667	321926
SE7	26966	307132	336191	338873	339146
SE8	14759	168096	184001	185469	185618
SW1	3390	38608	42261	42598	42632
SW2	14780	168335	184262	185732	185881
Subtotal	274466	3126036	3421810	3449108	3451884
Avg.NB/Ac	174.64	1989.07	2177.26	2194.63	2196.40
NB/Ac	174.09	1984.10	2171.84	2189.17	2190.93

Table 11. Net Benefits to Society of Wetland Restoration with Low Benefits and High Costs, Linn and Livingston Counties ($)

Linn	Annual	25-year	50-year	75-year	Permanent
NE1	-5143	-11338	-11981	-12040	-12046
NE2	-2654	-5850	-6182	-6213	-6216
NW1	-3413	-7524	-7951	-7990	-7994
NW2	-6137	-13530	-14297	-14368	-14375
NW3	-4320	-9524	-10064	-10114	-10119
NW4	-3547	-7820	-8263	-8304	-8308
NW5	-25294	-55763	-58924	-59215	-59245
NW6	-3862	-8514	-8997	-9041	-9046
NW7	-10881	-23987	-25347	-25472	-25485
NW8	-17277	-38088	-40246	-40445	-40466
SE1	-7242	-15966	-16871	-16954	-16963
SE2	-22805	-50276	-53125	-53388	-53415
SE3	-3194	-7042	-7441	-7478	-7482
SE4	-2616	-5768	-6094	-6125	-6128
SE5	-4772	-10519	-11116	-11171	-11176
SE6	-7085	-15619	-16504	-16585	-16594
SE7	-2933	-6467	-6834	-6867	-6871
SE8	-2369	-5223	-5519	-5547	-5550
SW1	-15168	-33439	-35335	-35509	-35527
SW2	-2705	-5964	-6302	-6334	-6337
SW3	-10845	-23910	-25265	-25390	-25403
SW4	-32043	-70641	-74644	-75014	-75051
SW5	-5070	-11178	-11811	-11869	-11875
SW6	-4095	-9027	-9539	-9586	-9591
SW8	-7371	-16251	-17172	-17257	-17265
Subtotal	-212843	-469229	-495822	-498276	-498526
Avg.NB/Ac	-235.06	-518.20	-547.57	-550.28	-550.55

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	-9445	-20407	-21544	-21649	-21660
NE2	-3510	-7585	-8007	-8046	-8050
NE3	-13880	-29990	-31661	-31815	-31831
NE4	-41289	-89208	-94178	-94637	-94683
NE5	-13362	-28870	-30478	-30627	-30642
NE6	-9618	-20780	-21938	-22045	-22056
NW1	-15866	-34279	-36189	-36365	-36383
NW2	-31820	-68750	-72581	-72934	-72970
NW3	-20925	-45209	-47728	-47961	-47984
NW4	-4977	-10754	-11353	-11408	-11414

Table 11. Net Benefits to Society of Wetland Restoration with Low Benefits and High Costs, Linn and Livingston Counties ($) (Continued)

Livingston	Annual	25-year	50-year	75-year	Permanent
NW5	-3251	-7024	-7416	-7452	-7456
NW6	-3074	-6641	-7011	-7045	-7048
NW7	-2707	-5849	-6174	-6205	-6208
SE1	-8719	-18838	-19887	-19984	-19994
SE2	-31162	-67327	-71078	-71425	-71460
SE3	-3464	-7484	-7901	-7939	-7943
SE4	-10302	-22259	-23499	-23614	-23625
SE5	-25360	-54792	-57845	-58127	-58155
SE6	-34233	-73963	-78084	-78464	-78503
SE7	-36064	-77919	-82261	-82661	-82702
SE8	-19738	-42646	-45022	-45241	-45264
SW1	-4533	-9795	-10341	-10391	-10396
SW2	-19766	-42706	-45086	-45305	-45328
Subtotal	-367065	-793074	-837261	-841340	-841754
Avg.NB/Ac	-233.56	-504.63	-532.74	-535.34	-535.60

opportunity cost of restoration and waterfowl hunting income generated by the restored wetland exceeds wetland maintenance costs.

Conclusions

This study provides preliminary estimates of the social and private (landowner) benefits and costs of converting hydric cropland to wetlands for 25 potential wetland sites in Linn county and 23 potential sites in Livingston county, Missouri. Four social benefit-cost scenarios were evaluated which represent combinations of high and low benefits and costs from wetland restoration. The ranking of the four scenarios in descending order of total net benefits is: high benefits-low costs ($431,248), high benefits-high costs ($59,681), low benefits-low costs (-$208,342), and low benefits-high costs (-$579,908). Only the first two scenarios are socially efficient.

Private net benefits of wetland restoration were evaluated for high and low benefits with fully subsidized wetland construction costs and easement payments equal to the opportunity cost of wetland restoration. The high benefit scenario resulted in total net benefits of $230,260 in Linn county and $399,645 in Livingston county. Hence, it would be profitable for landowners in both counties to convert hydric cropland sites to wetland when high benefits occur. The low benefit scenario resulted in total net losses of $3,541 in Linn county and $6,145 in Livingston county. Hence, it would unprofitable for landowners to restore wetlands when low benefits occur.

It would be economically rational for a landowner to convert hydric cropland to wetland if the easement payment provided by the government is greater than or equal to the opportunity cost of wetland restoration, the cost of wetland construction is fully subsidized, and the income earned from the wetland equals or exceeds maintenance cost of the wetland. The first condition is likely to be satisfied for landowners who bid eligible cropland into the WRP. The second condition would be satisfied under current cost-sharing provisions for wetlands. The third condition may or may not be satisfied.

Since this is a preliminary analysis, several refinements are offered. First, other economic and environmental benefits should be considered in addition to those generated by waterfowl hunting, such as flood protection, water quality improvement, wildlife viewing and timber harvesting. These other benefits would not be equally important for all potential sites. Second, the effect of wetland location on construction costs should be investigated. Locational factors such as soil type, slope, size, shape and the function or purpose of the wetland can influence the cost of constructing and maintaining wetlands. Third, variability in crop yields across sites should be considered in estimating the loss in net crop returns from converting hydric cropland to wetland. All three improvements can be facilitated using the GIS developed in this study. These and other refinements would improve the accuracy of the benefits and costs of converting hydric cropland to wetlands.

Table 12. Landowner Net Benefits with High Benefits, Linn and Livingston Counties ($)

Linn	Annual	25-year	50-year	75-year	Permanent
NE1	5564	50503	55165	55595	55639
NE2	2871	26060	28465	28687	28709
NW1	3692	33515	36608	36894	36923
NW2	6640	60267	65830	66343	66395
NW3	4674	42425	46340	46702	46739
NW4	3837	34831	38045	38342	38372
NW5	27364	248385	271310	273426	273641
NW6	4178	37924	41424	41747	41780
NW7	11771	106847	116708	117618	117711
NW8	18690	169653	185311	186756	186903
SE1	7835	71116	77679	78285	78347
SE2	24671	223942	244611	246518	246712
SE3	3456	31368	34264	34531	34558
SE4	2830	25690	28061	28280	28302
SE5	5162	46856	51181	51580	51621
SE6	7664	69569	75990	76583	76643
SE7	3174	28806	31465	31710	31735
SE8	2563	23267	25414	25612	25632
SW1	16409	148948	162695	163964	164093
SW2	2927	26567	29019	29246	29269
SW3	11733	106500	116330	117237	117329
SW4	34665	314654	343695	346376	346648
SW5	5485	49788	54383	54807	54850
SW6	4430	40209	43920	44262	44297
SW8	7975	72385	79066	79683	79745
Subtotal	230260	2090076	2282981	2300786	2302596

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	10283	93344	101959	102754	102835
NE2	3822	34692	37894	38190	38220
NE3	15112	137176	149837	151006	151125
NE4	44953	408044	445704	449180	449534
NE5	14548	132052	144240	145365	145479
NE6	10472	95052	103825	104634	104717
NW1	17274	156796	171268	172603	172739
NW2	34644	314469	343493	346172	346445
NW3	22782	206792	225878	227639	227818
NW4	5419	49188	53728	54147	54189
NW5	3540	32130	35096	35369	35397

Table 12. Landowner Net Benefits with High Benefits, Linn and Livingston Counties ($) (Continued)

Livingston	Annual	25-year	50-year	75-year	Permanent
NW6	3346	30376	33179	33438	33465
NW7	2947	26752	29221	29449	29472
SE1	9493	86165	94118	94852	94926
SE2	33927	307960	336384	339007	339274
SE3	3771	34231	37390	37682	37711
SE4	11217	101815	111212	112079	112167
SE5	27611	250624	273756	275891	276108
SE6	37271	338313	369538	372420	372713
SE7	39265	356409	389304	392340	392649
SE8	21490	195066	213070	214732	214900
SW1	4936	44802	48937	49319	49358
SW2	21521	195343	213372	215036	215206
Subtotal	399645	3627591	3962403	3993305	3996447

Table 13. Landowner Net Benefits with Low Benefits, Linn and Livingston Counties ($)

Linn	Annual	25-year	50-year	75-year	Permanent
NE1	-86	-777	-848	-855	-856
NE2	-44	-401	-438	-441	-441
NW1	-57	-515	-563	-567	-568
NW2	-102	-927	-1012	-1020	-1021
NW3	-72	-652	-713	-718	-719
NW4	-59	-536	-585	-590	-590
NW5	-421	-3819	-4172	-4204	-4208
NW6	-64	-583	-637	-642	-642
NW7	-181	-1643	-1795	-1809	-1810
NW8	-287	-2609	-2849	-2872	-2874
SE1	-120	-1093	-1194	-1204	-1205
SE2	-379	-3443	-3761	-3790	-3793
SE3	-53	-482	-527	-531	-531
SE4	-44	-395	-431	-435	-435
SE5	-79	-720	-787	-793	-794
SE6	-118	-1070	-1168	-1178	-1178
SE7	-49	-443	-484	-488	-488
SE8	-39	-358	-391	-394	-394
SW1	-252	-2290	-2502	-2521	-2523
SW2	-45	-409	-446	-450	-450
SW3	-180	-1638	-1789	-1803	-1804
SW4	-533	-4838	-5285	-5326	-5330
SW5	-84	-766	-836	-843	-843
SW6	-68	-618	-675	-681	-681
SW8	-123	-1113	-1216	-1225	-1226
Subtotal	-3541	-32137	-35103	-35377	-35405

Livingston	Annual	25-year	50-year	75-year	Permanent
NE1	-158	-1435	-1568	-1580	-1581
NE2	-59	-533	-583	-587	-588
NE3	-232	-2109	-2304	-2322	-2324
NE4	-691	-6274	-6853	-6907	-6912
NE5	-224	-2030	-2218	-2235	-2237
NE6	-161	-1462	-1596	-1609	-1610
NW1	-266	-2411	-2633	-2654	-2656
NW2	-533	-4835	-5282	-5323	-5327
NW3	-350	-3180	-3473	-3500	-3503
NW4	-83	-756	-826	-833	-833
NW5	-54	-494	-540	-544	-544

Table 13. Landowner Net Benefits with Low Benefits, Linn and Livingston Counties ($) (Continued)

Livingston	Annual	25-year	50-year	75-year	Permanent
NW6	-51	-467	-510	-514	-515
NW7	-45	-411	-449	-453	-453
SE1	-146	-1325	-1447	-1458	-1460
SE2	-522	-4735	-5172	-5213	-5217
SE3	-58	-526	-575	-579	-580
SE4	-172	-1566	-1710	-1723	-1725
SE5	-425	-3854	-4209	-4242	-4245
SE6	-573	-5202	-5682	-5726	-5731
SE7	-604	-5480	-5986	-6033	-6037
SE8	-330	-2999	-3276	-3302	-3304
SW1	-76	-689	-752	-758	-759
SW2	-331	-3004	-3281	-3306	-3309
Subtotal	-6145	-55778	-60926	-61402	-61450

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