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**AN ECONOMIC ASSESSMENT OF WETLAND
MITIGATION IN
NORTHWEST MINNESOTA**

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Abstract

The economic efficiency of wetland mitigation in Minnesota's Red River Valley was examined using the Minnesota Routine Assessment Method on ten wetland case studies to rate the functions of impacted and replacement wetlands. Secondary sources were used to assign dollar values to wetland functions of impacted and replacement wetlands. Mitigation costs for projects ranged from \$279 to \$4,171 per acre. Estimated annual social values ranged from \$207 to \$1,027 per acre for impacted wetlands and from \$268 to \$927 per acre for replacement wetlands. Social values of replacement wetlands exceeded the social value of impacted wetlands in seven cases. Values of replacement wetlands were 1.8 to 4 times greater than the values of impacted wetlands due to 2-to-1 replacement ratios. When society gains benefits from mitigation, public cost-sharing may be appropriate. In one case the value of the impacted wetlands was higher than the value of the replacement wetland. There were insufficient data to evaluate two cases. Results are only indicators of efficiency, since not all social costs and benefits of the impact-mitigation activity are addressed by legislation. These results suggest wetland mitigation policy in Minnesota needs to be reevaluated if efficient use of society's resources is a legislative goal.

Key Words: Wetland(s), mitigation, economics, values, Minnesota, Red River, Wetland Conservation Act, Minnesota Routine Assessment Method, restoration

AN ECONOMIC ASSESSMENT OF WETLAND MITIGATION IN NORTHWEST MINNESOTA

Robert L. Sip, Jay A. Leitch, Aaron J. Meyer*

INTRODUCTION

The legislature finds that the wetlands of Minnesota provide public value by conserving surface waters, maintaining and improving water quality, preserving wildlife habitat, providing recreational opportunities, reducing runoff, providing for floodwater retention, reducing stream sedimentation, contributing to improved subsurface moisture, helping moderate climatic change, and enhancing the natural beauty of the landscape, and are important to comprehensive water management. (Minnesota Board of Water and Soil Resources [BWSR] 1993, WCA Statutes, pp. 1-2).

This claim could have been written about any natural or man-made “good” or “service,” but there are physical and economic limits to the public values of all goods and services. The stated intent of Minnesota’s *Wetland Conservation Act (WCA)* is to **“conserve and use water resources of the state in the best interests of its people, and to promote the public health, safety, and welfare.”** “Best interest” implies limits. One way to assess changes to society’s best interest is with economics, the study of how scarce resources are allocated to satisfy unlimited wants.

The objective of this study was to assess the economic efficiency of Minnesota’s WCA mitigation policy from society’s (Minnesota’s) perspective. A recent study of the impact of WCA on property values surfaced some issues regarding the costs of required mitigation in Minnesota (Holtman et al. 1996). Also, research priorities identified in the *Minnesota Wetlands Conservation Plan (MWCP)* included an economic evaluation of wetland mitigation (Minnesota DNR 1997). The working hypotheses were: (1) some impacted wetlands have social values less than the cost to replace them; and (2) some restored or created mitigation wetlands have social values less than their restoration or creation cost.

It was assumed that individuals who impact wetlands and comply with mitigation requirements made rational decisions to do so. In other words, this is not an assessment of the feasibility of the impacting activity; if a decision was made that led to impacting a wetland, the decision was assumed rational from the decision maker’s perspective.

Wetland Conservation Act Mitigation Policy

WCA policy provides for mitigation of impacted wetlands that may include restoration, enhancement, or creation. According to WCA, wetlands must not be drained or filled, wholly or

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partially, unless replaced by restoring or creating wetland areas of at least equal public value under a replacement plan (Minnesota BWSR 1993). Public value also must be determined, or a comprehensive wetland protection and management plan must be established (Minnesota BWSR 1993).

Wetland mitigation is commonly defined as avoiding, minimizing, rectifying, reducing, and eliminating or compensating negative wetland impacts by restoring, creating, or enhancing impacted wetlands or lost wetland functions. Since the enactment of WCA, wetland mitigation has been considered to be important in maintaining and enhancing Minnesota's existing wetland base. Wetland mitigation policies, in general, require replacing lost wetland functions and associated societal values. Replacement wetlands should be designed to replace important ecological functions provided by impacted wetlands such as wildlife habitat, water quality, and flood storage (Kruczynski 1989).

WCA divides Minnesota counties and watersheds into three groups according to the estimated amount and distribution of presettlement wetlands: (1) *greater than 80 percent* group, where 80 percent or more of presettlement wetland acres exist; (2) *50 to 80 percent* group, where at least 50 percent, but less than 80 percent, of presettlement wetland acres exist; and (3) *less than 50 percent* group, where less than 50 percent of presettlement acres exist (Figure 3). "Replacement wetlands shall be located within the same watershed or county as the impacted wetlands, except that greater than 80 percent areas may accomplish replacement in less than 50 percent areas" (Minnesota BWSR 1996, p. 50).

Wetland Replacement Ratios

Wetland replacement ratios are used to establish the acreage of mitigation wetland that will replace an impacted wetland. The following WCA ratios (Minnesota BWSR 1996, p. 61) are used to replace wetlands:

For impacted wetlands on agricultural land, or in counties or watersheds in which 80 percent or more of the presettlement wetland acreage exists, the minimum replacement ratio is 1:1, requiring an equal area be replaced for the area impacted. Except for counties or watersheds in which 80 percent or more of the presettlement wetland acreage exists, the minimum replacement ratio for impacted wetlands on nonagricultural land is 2:1, requiring two times the impacted area be replaced.

In-kind Replacement and Out-of-kind Replacement

Instead of replacing a wetland in-kind with another wetland, some individuals would argue that society would be as well off with a different type of out-of-kind mitigation. The creation of a recreational area or the addition of acreage to a state park may add more to social well-being than a wetland. For example, replacing "lost" wetland values with increased health care values or increased recreation values would also mitigate social well-being. However, WCA does not allow for this broader type of social values mitigation.

Minnesota Routine Assessment Method for Evaluating Wetland Functions

The Minnesota Routine Assessment Method (MNRAM) Version 1.0 was used to assess and record wetland functions of impacted and replacement wetlands for each case study. MNRAM was developed by the Minnesota Interagency Wetland Group (1996) to be used as a field evaluation tool to assess wetland functions. MNRAM is intended to be used on a regular basis where more rigorous methods are too data-intensive and/or time-consuming (Minnesota Interagency Wetland Group 1996). MNRAM consists of seven sections: (1) general information, (2) scope and limitations, (3) wetland classification, (4) summary of wetland functions, (5) site description, (6) functional assessment; and (7) user guidance.

MNRAM has the user record the actual (estimated) or projected quality of the functions of wetlands as *exceptional*, *high*, *medium*, *low*, or *non-applicable*. The presence of special wetland features and other relevant wetland characteristics is also recorded. Wetland functions included in the functional assessment section of MNRAM are floral diversity and integrity; wildlife habitat; fishery habitat; flood and stormwater storage; water quality protection; shoreline protection; groundwater interaction; aesthetics, recreation, and education; and commercial uses. “Some of these functions have only recently been fully recognized, the last two decades have seen the development of a substantial body of scientific literature in this area” (Scodari 1990, p. 11).

Field observations and interpretations are recorded with best professional judgment. MNRAM was selected over other wetland evaluation methods for this study due to accessible technical support and expertise from BWSR personnel.

PROCEDURE

The general study area was the Minnesota portion of the Red River of the North. Ten wetland mitigation projects were opportunistically identified (i.e., we took the first ten we could find, but we had to look hard to find them!). Functions of impacted wetlands (IWL) and functions of mitigated, restored or replacement wetlands (RWL) were assessed using MNRAM. Differences between the net values of functions of IWLs and RWLs were used to indicate the change in social values due to WCA wetland mitigation.

A numerical modifier was used to quantify the MNRAM quality of IWL and RWL functions for each case study. The modifier system was developed by using a pristine wetland to represent the exceptional functional value of MNRAM. If a wetland exhibited an *exceptional* wetland function, the wetland would represent 100 percent of the characteristics that a pristine wetland would have and would be given a modifier rating of 2.0. It was assumed that a pristine wetland was free from obvious human impacts. A *high* wetland function rating would be given a modifier rating of 1.5, which is 75 percent of pristine wetland characteristics; a *medium* wetland function rating has a modifier rating of 1.0, or 50 percent of pristine wetland characteristics; and a *low* wetland function rating has a modifier level of 0.5, or 25 percent of pristine wetland characteristics. Monetary values of wetland functions were taken from the literature. Where more than one value was available, a simple average of values was used. The Consumer Price Index (CPI) was used to adjust dollar values from the literature to 1996 dollar values where

appropriate (Council of Economic Advisors 1997). In cases where the replacement wetland had been recently replaced, the projected condition was used in the analysis, rather than the current condition.

Site Selection

IWLs and RWLs were opportunistically selected in the spring of 1997 (Table 1). Since a list of projects that have impacted wetlands in the RRV does not exist, sites were identified by contacting BWSR, county highway department, county soil and water conservation districts (SWCD), local government units (LGU), and watershed district personnel via telephone, e-mail, correspondence, and office visits. Five of the ten wetland case studies involved road-widening and upgrading projects. The remaining five wetland case studies included wetland impacts such as parking lot expansion, industrial park expansion, lakeshore development, and ditch-widening. Once sites were identified, these organizations provided some history for each site and aided in compiling necessary data.

Secondary Data¹

Due to the nature of the study (i.e., a broad, scoping analysis) and the resources available, most data used were from secondary sources. Using secondary sources is primarily the way most LGUs implement WCA mitigation provisions. It is also largely the way WCA was justified to the Legislature.

When wetlands are impacted, LGU officials, in cooperation with the landowner, must complete necessary documents such as BWSR wetland replacement and/or mitigation banking plans. This process may also include LGU field visits to record unique features, vegetation present, and location within the watershed and to delineate or establish wetland boundaries. Much of the information from replacement and banking plans is public information and was used to complete the various sections of MNRAM.

As part of this study, LGU officials were asked to complete MNRAM forms for the selected IWL and RWL. Comparisons of the results between the completed LGU MNRAM forms and those completed by the two separate teams that aided in evaluating the case study wetlands were to be made. However, LGU officials were unable or unwilling to comply with the request. When discussing this with LGU officials, the general response was that LGU personnel were not comfortable with completing the forms since MNRAM was not used by them on a regular basis. In some circumstances, LGU personnel were not granted permission from supervisory boards to complete the MNRAM forms.

¹See Sip (1998) for a more detailed discussion of secondary data sources.

Table 1. Northwest Minnesota Wetland Case Studies, WCA Mitigation Policy, 1997-98

County	Project Type	Wetland Acres Impacted	Wetland acres Replaced	Type of Mitigation	Costs of Mitigation ^a
Becker	Industrial Park Expansion	2.09	4.18	Mitigation Bank - County	\$21,850
Clay	Drainage Ditch Construction	3.58	7.16	Restoration	\$27,862
Clearwater	Lake Shore Development	0.22	0.36	Restoration	\$200
Kittson	Road Reconstruction	0.89	2.06	Creation	\$6,815
Mahnomen	Lake Shore Development	0.23	0.69	Creation - Restoration	\$500
Mahnomen (Waubun)	Parking Lot Expansion	0.34	0.70	Creation	\$100
Marshall	Road Reconstruction	2.00	N/A	Mitigation Bank - State	N/A
Red Lake	Road Reconstruction	0.40	1.70	Creation	\$5,205
Roseau (Road 6)	Road Reconstruction	8.55	N/A	Mitigation Bank - State	N/A
Roseau (Road 8)	Road Reconstruction	13.77	27.54	Creation	\$3,700

^aCosts include survey and design, construction and excavation, land acquisition, right-of-way, and legal fees. Administration and enforcement costs are not included.

Field Visits

Using MNRAM presented a challenge because expertise from disciplines such as wildlife biology, plant ecology, geology, and hydrology is needed to complete the field data forms. Upon arriving at a study site, IWLs and RWLs were viewed; and, when possible, the wetlands were compared to a reference wetland. Because a reference wetland was not usually nearby for most of the IWLs and RWLs, a conceptual comparison was made using best professional judgment and scientific knowledge in relation to the adjacent landscape areas. MNRAM was applied to the wetland and the forms were completed based on firsthand knowledge about the site and preliminary data.

Each wetland was visited twice, with the first visit in June or July 1997 to become familiar with the location and physical attributes of each wetland. Each wetland was traversed and examined, photographs were taken from various perspectives, and physical information was recorded such as unique features of the wetland and surrounding landscape area. After compiling all necessary data and preliminary information, the second field visits were conducted in July or August 1997 to assess the functions of each IWL and RWL using MNRAM. Depending on the complexity of the site, MNRAM was completed in one to three hours per site.

Case Studies

A wetland mitigation project in Mahanomen County (MCWL) is used to illustrate the evaluation procedure, which was replicated for each of the other nine cases studies. Wetland functions rated for the impacted and replacement wetland include: floral diversity and integrity; wildlife habitat; flood and stormwater storage; water quality protection; groundwater interaction; aesthetics, recreation, and education; and commercial uses.

Functional Assessment of Impacted Wetland

The functional assessment of MCIWL was accomplished primarily by examining the area on foot on August 4, 1997. No field sampling of flora, soils, or other wetland characteristics was done. However, each of the nine MNRAM wetland functions was assessed as diligently as possible in the field.

Description of Impacted Wetland. The MCIWL, a 1.6-acre, Type II wetland with a drainage area of 39.8 acres, is on the southeast shore of Island Lake in Section 29 of Island Lake Township in Mahanomen County in the Wild Rice Watershed. MCIWL was impacted by road construction during development of residential lake homes in 1996. About 0.25 acres of wetland was filled with gravel with a culvert providing an outlet.

MCIWL is a depressional wetland and was assumed to have groundwater as the primary hydrologic source with surface water as the secondary source. The hydrology of the surrounding area has been altered by cultivation, ditching, and road construction. The hydrology of MCIWL was affected by placing a culvert on the north edge of the wetland, which serves as an outlet that eventually drains into Island Lake. MCIWL was observed on August 4, 1997, having a maximum water depth of 10 inches. MCIWL was classified as a semi-permanent wetland.

Vegetation of MCIWL includes emergent (70 percent), shrub (20 percent), and sedge meadow/wet prairie (10 percent) plant communities (Eggers and Reed 1987). Plant species included sedges (*Carex* spp.), willow, and minimal amounts of reed canary grass. Due to fill and/or excavation, 25 percent of the natural vegetation of MCIWL was altered, with no invasive or exotic plant species occurring.

The Mahanomen County Soil Survey (NRCS 1997) was used to determine the soil types of MCIWL and adjacent land area. The soils of the adjacent upland area are Naytahwaush loams

(2 to 8, 8 to 15, and 15 to 30 percent slopes) that are moderately well-drained to well-drained, with soil disturbances due to excavation, fill, and cultivation. Soils of MCIWL are poorly drained Augnash loams, with soil disturbances due to excavation and/or fill (NRCS 1997). Surrounding land uses included developed areas (50 percent), agricultural cropland (40 percent), forest (5 percent), and highways or gravel roads (5 percent).

Floral Diversity and Integrity. MCIWL did not have any obvious special or unique floral or faunal species or features. The sedge meadow community had a *high* wetland function due to the low occurrence of reed canary grass and the existence of five or more species of native forbs such as marsh skullcap (*Scutellaria galericulata*). The wet meadow community had a *high* to *exceptional* functional level as 10 or more native grasses, sedges, and forbs were present while the shrub-carr thicket community had a *moderate* functional level. The floral diversity and integrity wetland function was *high*.

Wildlife Habitat. The wildlife habitat function of MCIWL was *high*, relatively undisturbed and exhibited nearly the full range of flora and fauna expected to be present in a wetland of that type. Wildlife access from upland habitat was mostly uninhibited, and MCIWL was part of a wildlife travel corridor, but was not actively managed for wildlife habitat. Seasonal and intermittent habitat was evident as amphibians, such as frogs, were present as well as songbirds. Tracks from mammals such as raccoons (*Procyon lotor*) and white-tailed deer (*Odocoileus virginianus*) were also present.

Fishery Habitat. The fishery habitat function of MCIWL did not apply because MCIWL was not contiguous with a permanent water body. MCIWL did not support gamefish during flooding events or native populations of minnows due to the position of MCIWL in the landscape and the topography of the surrounding area.

Flood and Stormwater Storage. The topographic relief of Mahanomen County is nearly level. The landscape is composed of agricultural land, forest, large marshes, and deep lakes (NRCS 1997). The lakes, bogs, and marshes of Mahanomen County receive much of the runoff from adjacent landscape areas and act as natural catch basins. However, these water bodies are gradually becoming shallower due to erosion and sedimentation (NRCS 1997).

The flood and stormwater storage function was *low* because the outlet of MCIWL was constricted by a culvert. MCIWL would have a greater capacity to store flood water if flow was restricted by a smaller diameter culvert or a metal gate on the culvert. Since watershed conditions have been highly modified due to existing rural and urban development, the ability of MCIWL to store flood water has been altered. The soils of the surrounding area are loam soils that allow for infiltration and reduce runoff slightly. MCIWL had dense vegetation which slowed the velocity of overland flow in normal flooding events, did not receive directed stormwater, and was in the upper local (Wild Rice) and upper major (Red River) watersheds. Approximately 95 percent of the wetlands of this type have been lost due to development in the major watershed.

Water Quality Protection. MCIWL's water quality protection was rated *medium* because it did not receive discharge from municipal sources, road or field drainage outlets, or industrial or municipal waste. Although the surrounding land uses have the potential to deliver nutrients and

sediments to MCIWL, the shape and outlet configuration allowed adequate residence time for nutrients and sediments to settle before draining into Island Lake. The vegetative density of MCIWL was such that potential uptake of dissolved nutrients was possible. Also, a vegetative buffer of approximately 30 yards adjacent to MCIWL helped to slow and filter overland flow.

Shoreline Protection. Although wetlands adjacent to lakes or streams can provide shoreline protection by reducing wave energy, shoreline protection was not a factor because MCIWL was approximately 250 feet from Island Lake.

Groundwater Interaction. Groundwater interaction is difficult to assess without physical monitoring. To confidently determine if a wetland is a recharge, discharge, or flow-through system, a piezometer or nest of piezometers would have to be installed around the wetland, and monitoring would have to take place (Freeze and Cherry 1979). The groundwater interaction of MCIWL was *medium*, based on expert judgment, characteristics of MCIWL, and topography of the adjacent area.

Aesthetics, Recreation, and Education. The value of the aesthetics, recreation, and education functions depends on proximity to roads, population centers, and ecological importance. This function was rated *medium* because MCIWL was visible from roads, waterways, and residential homes and added to landscape diversity. MCIWL was relatively free from structures, pollution, and invasive vegetation. MCIWL also provided a spatial buffer between developed areas and could be used for wildlife observation or photography.

Commercial Use. The commercial use value of MCIWL was *non-applicable*. MCIWL was relatively small; therefore, there was little opportunity for commercial uses. There was no potential for wetland hay, wild rice, and/or forest product harvesting.

Functional Assessment of Replacement Wetland

The functional assessment of MCRWL was accomplished primarily by on-site examination on August 4, 1997. No sampling of flora, soils, or other wetland characteristics was done. However, each of the nine MNRAM wetland functions were carefully assessed in the field.

Description of Replacement Wetland. The Mahanomen County Replacement Wetland (MCRWL) is a 0.69-acre, Type III wetland, with an estimated drainage area of 5 acres. MCRWL is in Section 7 of Gregory Township, Mahanomen County. MCRWL is in the Wild Rice Watershed and was created in 1996 adjacent to an existing wetland by excavation. A 2:1 replacement ratio was required for this project according to WCA replacement guidelines. MCRWL represents out-of-kind replacement since MCIWL was a Type II wetland. MCRWL was created on agricultural land with nearly level topography, no trees nearby, and with other wetlands as the only water bodies within the immediate landscape.

A ditch was dug, by the landowner using agricultural equipment, to the adjacent existing wetland to provide a source of water for MCRWL. However, it appears that several feet of soil still need to be excavated, since the existing wetland is lower in elevation than MCRWL. MCRWL is a depressional, temporarily inundated wetland with surface flow as the primary water

source. At the time of observation, MCRWL did not have any standing water, and tillage/ditching practices have altered the hydrology of the adjacent wetland. After sufficient soil is excavated, MCRWL will have the capacity to function as a wetland.

The soils of MCRWL include poorly drained and somewhat poorly drained soils of the Hedman Fram complex (NRCS 1997). The adjacent upland area is comprised of moderately well-drained Fram loams, poorly drained, and somewhat poorly drained soils of the Hedman Fram complex, and very poorly drained Hamre Muck (NRCS 1997). Soil disturbances include tillage and excavation. Surrounding land uses include agricultural cropland (50 percent), forested (20 percent), and water/wetlands (30 percent). The estimated area of the immediate watershed of MCRWL is 5 acres.

Floral Diversity and Integrity. No unique flora or fauna species are present in MCRWL. The vegetation is an emergent community comprised of 70 percent wild oats (*Avena fatua*) and 30 percent barnyard grass (*Echinochloa crusgalli*). The projected plant communities are shallow marsh and fresh wet meadow, both rated *medium* function. Wetland vegetation such as cattail and reed canary grass will eventually become established, as well as other vegetation common to Type III wetlands. Plant species diversity of MCRWL will likely eventually be similar to other wetlands in the wetland comparison domain.

Wildlife Habitat. Wildlife habitat is rated *medium* since there is evidence of disturbance and/or degradation due to invasion of exotic species and/or common weeds. The area surrounding MCRWL is mostly drained, cultivated, and developed for agriculture. Wildlife access to MCRWL is mostly uninhibited. MCRWL was also expected to be part of a wildlife habitat travel corridor. MCRWL may provide seasonal or intermittent habitat for various wildlife species such as moose (*Alces alces*), white-tailed deer, muskrat (*Ondatra zibethicus*), various waterfowl and songbird species, and amphibians. MCRWL is not actively managed for wildlife conservation/preservation.

Fishery Habitat. Fish habitat was *non-applicable* because MCRWL is not contiguous with, nor accessible from, a permanent water body or watercourse such that spawning or nursery habitat are provided. MCRWL will not support game fish or native minnow populations during flood events due to the position of the wetland within the landscape. The nearest water body capable of supporting a fishery is Beaulieu Lake, which is 2 miles east of MCRWL.

Flood and Stormwater Storage. The projected flood and stormwater storage function of MCRWL is rated *medium*. MCRWL has some floodwater storage capacity. MCRWL is in the upper major (Red River) and upper local (Wild Rice) watersheds. The flood damage potential within the major watershed is high, while the flood damage potential in the local watershed is low. Flood damage potentials were considered because wetlands that provide floodwater storage may be important in areas that have a history of high levels of flood damages. Soils of MCRWL are silts or loams that may provide enhanced infiltration compared to impermeable soils (clays or bedrock), perhaps reducing runoff. The projected vegetation will also allow for overland flow energy to be reduced during flooding events. Management of MCRWL for floodwater control is not possible because MCRWL does not receive any directed stormwater.

Water Quality Protection. The water quality protection function of MCRWL is rated *medium*. There is no need to actively manage MCRWL for water quality protection since MCRWL does not receive direct discharge of managed water from such sources as municipal or road stormwater drainage, agricultural ditch drainage, or industrial/municipal wastewater. Although the surrounding land has the potential to deliver nutrients and sediments to the MCRWL, the characteristics of the MCRWL will allow for adequate residence time so that suspended solids will be able to settle. The vegetation of MCRWL will provide the ability to decrease water energy or to assimilate dissolved nutrients. There is no buffer area since a greater part of the adjacent upland area is cultivated for agricultural production. Runoff will be filtered or held due to the vegetation and the position of MCRWL in the landscape.

Shoreline Protection. The shoreline protection function was *non-applicable*, since MCRWL is not adjacent to or near a lake or watercourse.

Groundwater Interaction. The groundwater interaction function is rated *low*. MCRWL does not have a permeable substrate since MCRWL soils are silts and/or loams. The topography of the surrounding area is fairly level and does not slope steeply below MCRWL. Since there is no defined outlet, the water level within MCRWL will stay relatively constant throughout the year except for major wet or dry cycles. The primary source of water for MCRWL is surface water that drains from an adjacent, natural wetland.

Aesthetics, Recreation, and Education. The aesthetic, recreation, and education function of the MCRWL was rated *low* because of its minimal visual diversity and recreational use. It is not visible from roads, waterways, trails, houses, or businesses. MCRWL is not near any population centers to generate aesthetic, recreation, or educational uses.

Commercial Use. The commercial use function of MCRWL is rated *low*, because the wetland is used for infrequent, non-commercial, and non-consumptive uses. Prior to wetland creation the area was cultivated for agricultural production.

Monetary Valuations

Little general, much less site specific, information was found in the scientific literature regarding the economic values of the functions of Minnesota's wetlands. Simple averages of dollar values from secondary sources were used as proxies for the economic values of wetland functions for all IWLs and RWLs (Table 2) (Sip 1998). Averages may be too low for some and too high for others, but without site specific evaluations, they are a reasonable proxy for the value of wetland functions.

Floral Diversity and Integrity. The floral diversity and integrity function was not quantified for IWLs and RWLs for any case studies because no valuation information was found in the literature.

Table 2. Average Per Acre Dollar Values for NW Minnesota Wetland Functions

Wetland Function	Floral Diversity and Integrity	Wild- life Habitat	Fishery Habitat	Flood and Storm- water	Water Quality	Shore- line	Ground- water	Aesth. Rec. Ed.	Comm. Uses
-----Dollars-----									
Per Acre Value	N/A	6	8	256	175	2,950	564	26	21

Source: Sip, Rob. 1998. *Economic Assessment of Wetland Mitigation in Minnesota*. Master Thesis, North Dakota State University, Fargo.

Wildlife Habitat. Anderson and Craig (1984) estimated Minnesota has 8,760,000 acres of wetlands. The Minnesota DNR (1988) estimated that wetlands provide \$53 million (converted to 1996 dollars using the CPI) worth of breeding, migration, nesting, and winter habitat annually (Table 3). The average value of wetlands for wildlife habitat in Minnesota is thus \$6 per acre per year (\$53 million divided by 8,760,000 acres). Although some wetlands may be worth more (or less) per acre and outputs may be greater (or less) in quantity and quality, it was assumed that this dollar value would best represent the per acre value for the wetlands within the study area.

Fishery Habitat. Little information was found regarding the monetary value of PPR wetlands for fishery habitat. The Minnesota DNR (1988) placed a value of \$68 million (inflated to 1996 dollars using the CPI) on the ability of wetlands to provide fishery habitat. An average value of \$8 per acre per year (\$68 million divided by 8,760,000 acres) was used to value the fishery habitat function of study wetlands.

Flood and Stormwater Storage. It was assumed that a wetland in the study area has the capacity to store 1-acre foot/wetland surface area per year. Roberts (1997) estimated that a managed wetland was worth \$440 per acre foot per year for flood control. According to the Minnesota DNR (1988), wetlands are worth \$326 per acre foot per year (converted to 1996 dollars using the CPI) for flood control. Hovde (1993) found that some wetlands in North Dakota's Red River watershed were worth \$3 per acre foot per year for flood control. Monetary values of wetland ecosystems to provide flood control can differ based on the size of the wetland, location in a watershed, and other physical features. Since no single monetary figure best represents the capacity of a wetland to provide flood control, an average per acre foot value, \$256 per acre, was used.

Table 3. Estimates of Wetlands' Contributions to the State's Welfare

Use	Purpose	Annual Value
Wildlands		
Fauna	Habitat - 195 Species (Vertebrate)	Future Use Food Chain
Flora	Habitat - 1000s (Invertebrate) Habitat - 600 Species Wild Rice	Future Use \$14 Million
Wildlife		
Sport Hunting		
Migratory Birds	Breeding/Migration	\$30 Million
Upland Game	Nesting/Winter Cover	\$9 Million
Commercial		
Furbearers	Habitat	\$1.2 Million
Turtle	Food, Aquariums	\$25,000
Fish		
Sport Fishing		
Northern Pike	Spawning	\$20 Million
Bass and Panfish	Habitat	Undetermined
Walleye	Rearing Habitat	\$450,000
Commercial		
Bait Fish	Habitat	\$30 Million
Rough Fish	Habitat	\$1 Million
Environmental		
Education	Outdoor Classroom	\$0.75/Acre
Scientific Research	Outdoor Classroom	\$0.75/Acre
Bird Watching/Aesthetics	Outdoor/Wilderness	\$25/Day
Groundwater Recharge	Water Supply	Undetermined
Flood Control	Reduce Crest Flows	\$245/Acre Foot
Water Quality	Nutrient/Sediment Removal	\$500/Acre
Microclimate Regulator	Rainfall/Carbon Dioxide Levels	70 - 90 % Sediment Removed
Erosion Control	Soil Conservation	Unknown
Agricultural/Commercial		
Grazing	Lowland Pasture	Half of Upland Value
Hay Production	Livestock Feed	1 to 4 Tons/Acre
Water	Livestock	Up to 75 Head/Cubic Yard
Irrigation	Crop Production	Undetermined
Energy	Biomass Production	3 - 5 Times That of Corn
Paddy Rice	Human Food	\$13.3 Million
Peat	Fuel and Bedding	\$500 Million Potential
Sewage Lagoon		\$300 - \$1,400/Acre

Source: Minnesota Department of Natural Resources. 1988. *Regional Review Draft, Long Range Comprehensive Plans, Chapter 41, Wetlands*. Division of Fish and Wildlife, Minnesota Department of Natural Resources, St. Paul.

Groundwater Interaction. Groundwater interaction was valued using information from Roberts (1997), who placed a value of \$94 per acre foot on the ability of wetlands to provide surface water for a variety of uses using the next best alternative method. Hovde (1993), based on information from Nelson and Coon (1981), stated that a wetland would provide \$1,034 of groundwater recharge per year based on replacement costs. A simple average of the two values results in a value of \$564 for groundwater interaction. Although this function may exist in a wetland, the groundwater function may not have any value if water from or near the wetland is not used for consumption.

Water Quality Protection. According to Hubbard (1989), a comprehensive valuation has not been done regarding the ability of wetlands to assimilate nutrients and sediments in the PPR. However, Hovde (1993) evaluated two prairie potholes and estimated that the study wetlands did not provide sediment entrapment and nutrient assimilation wetland functions; thus, these wetlands functions did not have any monetary value. Roberts (1997) estimated that 1,000 acres of wetlands within the managed Mud Lake complex provide a negative value of -\$315 per acre per year based on the costs to treat water with lime, sodium carbonate, and powdered activated carbon in Fargo, North Dakota, and Moorhead, Minnesota. However, the Minnesota DNR (1988) places a value of \$665 per acre per year (converted to 1996 dollars using the CPI) on the ability of wetlands to remove nutrients and sediments from the environment in Minnesota. A value of \$175 per acre (a simple average of -\$315 and \$665) per year was used as a proxy for the value of water quality protection.

Shoreline Protection. Little information was found regarding the monetary value of shoreline ecosystems in Minnesota. An alternative to wetlands within a shoreline ecosystem is rip-rap materials (rock or concrete) or vegetative seedings that stabilize or enhance the shoreline. Prairie Restorations, Inc. (1997) estimates vegetative plantings cost from \$725 to \$9,000 per acre depending on the diversity level and the number of grass and wildflower species planted, and four cost per acre categories are established (Prairie Restorations, Inc., 1997). For this study, a diversity level of 3 and the 1-acre cost category were used to quantify the shoreline protection function. A diversity level 3 includes 4 to 7 grass and 4 to 6 wildflower species, seeded for \$2,950 per acre which includes site preparation, materials, seeding, and first year maintenance (Prairie Restorations, Inc., 1997). Plant species are selected according to geographic and topographic area, and sites are usually planted with 1,500 to 2,500 seeds per acre (Schaffer 1998).

Aesthetics, Recreation, and Education. Johnson (1984) estimated that, on average, wetlands in South Dakota are worth \$39 per acre per year (converted to 1996 dollars using the CPI) for hunting, while the Minnesota DNR (1988) placed a value of \$33 per user day (converted to 1996 dollars using the CPI) on wetlands for aesthetic experiences and \$0.75 per acre per year (which was ignored in the valuation) on wetlands for education and research.

Excluding fishing, Minnesota wetlands are annually linked to 3.3 million recreational days (Minnesota DNR and Minnesota Trade and Economic Development 1990). Multiplying 3.3 million recreation days by \$33 per user day and dividing the result by 8,760,000 wetland acres results in a value of \$12 per acre per year. Averaging \$12 per acre per year and \$39 per acre per year results in a value of \$26 per acre per year for aesthetics, recreation, and education.

Commercial Use. Assuming that the only reasonable commercial use of the wetlands would be for hay production, information from Aakre (1996) was used to estimate the returns to hay production. The cost to produce hay on an acre of wetland is about \$39, and the revenue is about \$60, for net revenue per acre of \$21 per year.

Mitigation Costs.

Landowners and society (i.e., LGU, BWSR) each incur costs to mitigate for wetland impacts. Mitigation projects require LGU resources in the form of personnel time and travel expenses. LGU costs were not estimated in this analysis. BWSR estimated that expenditures exceeded \$2.8 million in 1996 to administer WCA, or about \$700 per acre “saved” in 1996.

Mitigation costs incurred by landowners vary from minimal to substantial. Costs include locating a mitigation site, foregone use of private land or purchasing the land to replace an IWL, private engineering costs if the LGU is unable or unwilling to design mitigation plans, 100 percent of construction costs if cost-share funding is unavailable, and the value of the landowner’s time. BWSR (1995) found that construction costs for wetland replacement projects ranged from \$95 per mitigation acre to as much as \$73,500 per mitigation acre. For road projects, the average cost per mitigation acre was \$46,150 in the seven-county metropolitan region compared to \$7,536 per mitigation acre in the non-metropolitan region. For other projects, the Minnesota BWSR (1995) found that costs ranged from \$95 per mitigation acre to \$30,633 per mitigation acre (Table 4). Actual (reported) mitigation costs were used in this analysis, including BWSR expenses but not including LGU costs.

Table 4. Wetland Mitigation Costs in Minnesota

Type of Project	Average Cost Per Mitigation Acre (\$)	Range of Costs Per Mitigation Acre (\$)
Restored Wetlands	3,094	95 to 30,633
Created Wetlands	6,277	201 to 22,280
- By Impoundment	1,441	201 to 20,050
- By Excavation	6,412	1,360 to 22,280
Projects Less Than 1 Acre	7,818	1,260 to 22,280
Projects Greater Than 1 Acre	7,744	95 to 30,633
In Road Right Of Way	6,664	1,260 to 30,633
In Seven-County Metro Area	3,983	2,505 to 5,460
In Non-Metro Areas	5,280	95 to 30,633

Source: Minnesota Board of Water and Soil Resources. 1995. *Minnesota Wetland Replacement/Mitigation Cost Summary Survey*. Minnesota Board of Water and Soil Resources, St. Paul.

Sensitivity of Results

The results of this study are sensitive to the data that were available and to several assumptions. The authors attempted to carry out the analysis as objectively as possible, trying not to bias results either too high or too low. While a replication of this study may result in different absolute values, it is unlikely that the implications for policy would be different.

Quality Modifier and Replacement Ratios.

Estimated dollar values depend on the quality modifier (from 0.5 to 2.0) and the replacement ratio used (1:1, 2:1, or higher). The quality modifier was developed to account for the differences in functional quality of impacted and replacement wetlands. Considerable thought was given to which type of modifier system would best represent the quality of wetlands within the study area. Although other modifier systems may be appropriate, the system used was considered appropriate to quantify the differences in function quality among wetlands.

The replacement ratio has an obvious impact on social value. When a wetland 1-acre or less is impacted and replaced with a 2- or 3-acre wetland, the replacement wetland will generally have higher total social value due simply to its greater size.

Dollar Values.

Average values were used to quantify some wetland functions because an appropriate, single dollar value was not available in the literature. Two or three values were found in the literature for some functions. For example, three values for the flood and stormwater storage wetland function were averaged. More research is needed to estimate site-specific values of wetland functions. However, dollar values from the literature do not have as large an effect on the results as the quality rating modifier and/or replacement ratio, since the same dollar values were used to quantify both the impacted and replacement wetland values.

RESULTS

Evaluations of IWLs and RWLs yielded varying results across the study wetlands (Table 5). The MCWL case study was used to illustrate how MNRAM was applied and served as a model for the other nine wetland case studies. While these results may not be generalizable across the state, they are representative of mitigation economics in the Red River watershed.

Mahnomen County Wetland Case Study Results

The MCIWL (0.23 acres) was replaced with a larger wetland (0.69 acres) of lesser quality. The replacement wetland's functions were each worth more than the functions displaced at the impacted wetland.

Floral Diversity and Integrity

Floral diversity and integrity was not quantified in dollar terms. However, it was rated for quality with the MCIWL rating *high* and the MCRWL rating *medium* (Table 5).

Wildlife Habitat

MCIWL wildlife habitat was rated *high*, while the MCRWL habitat was rated *medium* (Table 5). The capacity of MCIWL to provide migratory bird habitat, for example, was minimal since little standing water was present. MCRWL was projected to have standing water, therefore providing migratory bird habitat.

The annual wildlife habitat value of MCIWL was \$2 ($\$6 \times 0.23 \text{ acres} \times 1.5 = \2 , where \$6 is the estimated annual value of the wildlife habitat function, 0.23 acres is the wetland area impacted, and 1.5 is the quality modifier). The annual value of MCRWL was \$4 ($\$6 \times 0.69 \text{ acres} \times 1.0 = \4). Wildlife habitat functions of MCIWL were replaced with a wetland having lower functional levels, but with more area. The difference between the two wetlands resulted in a gain of \$2 per year.

Fishery Habitat

The value of the fish habitat function was *non-applicable* in this case (Table 5). MCIWL and MCRWL were not adjacent to any lakes, streams, or rivers to generate spawning or nursery habitat areas.

Flood and Stormwater Storage

MCIWL had *low* floodwater storage function and was replaced with a larger wetland estimated to have a *medium* flood and stormwater storage function (Table 5). MCIWL was worth \$29 per year ($\$256 \times 0.23 \text{ acres} \times 0.5 = \29 , where \$256 is the estimated value for the flood and stormwater storage function, 0.23 acres is the impacted area, and 0.5 is the quality modifier). MCRWL was valued at \$177 per year ($\$256 \times 0.69 \text{ acres} \times 1.0 = \177). The difference between the two wetlands resulted in a gain of \$148 per year.

Water Quality Protection

MCIWL and MCRWL were both rated *medium* for the water quality protection function (Table 5). MCIWL was valued at \$40 per year ($\$175 \times 0.23 \text{ acres} \times 1.0 = \40 , where \$175 is the estimated value for the water quality protection function, 0.23 acres is the impacted area, and 1.0 is the quality modifier). MCRWL was valued at \$121 per year ($\$175 \times 0.69 \text{ acres} \times 1.0 = \121). The difference between the two wetlands' water quality protection function values was \$81 per year.

Table 5. Minnesota Routine Assessment Method for Evaluating Wetland Functions, Ten Case Studies^a

County	Floral Diversity and Integrity	Wildlife Habitat	Fishery Habitat	Flood and Storm- water	Water Quality	Shore- line	Ground- water	Aesth. Rec. Ed.	Comm. Uses
Mahnomen									
MCIWL	High	High	N/A	Low	Med	N/A	Med	Med	N/A
MCRWL	Med	Med	N/A	Med	Med	N/A	Low	Low	Low
Becker									
Impacted	Med	Med	N/A	Med	Low	N/A	Low	Med	Low
Replacement	High	High	N/A	Med	Med	N/A	Low	High	N/A
Clay									
Impacted	Med	Med	N/A	Low	Low	N/A	Low	Low	Low
Replacement	High	Med	N/A	Med	Med	N/A	Med	Med	Low
Clearwater									
Impacted	Med	High	Med	Low	Med	High	Med	Med	N/A
Replacement	Low	Med	N/A	Low	Med	N/A	Low	Low	Low
Kittson									
Impacted	Med	Med	N/A	Med	Med	Low	Med	Med	N/A
Replacement	High	High	N/A	Med	Med	Low	Med	Med	N/A
Mahnomen (Waubun)									
Impacted	High	Med	N/A	Med	Low	N/A	Low	Med	N/A
Replacement	Med	Med	N/A	Low	Low	N/A	Low	Med	Low
Red Lake									
Impacted	Low	High	Low	Low	Med	Low	Low	High	N/A
Replacement	High	Med	N/A	Med	Med	N/A	Low	Med	N/A
Roseau (Road 8)									
Impacted	High	Med	N/A	Med	Med	N/A	Low	Med	N/A
Replacement	Low	Med	N/A	Med	Low	N/A	Low	Low	N/A
Marshall									
Impacted	Med	Med	N/A	Med	Med	N/A	Low	Low	Low
Replacement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Roseau (Road 6)									
Impacted	High	High	N/A	High	High	N/A	High	Med	N/A
Replacement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

^aMNRAM results from the Mahnomen County wetland case study are highlighted and were used in the narrative to illustrate the procedure. The Roseau (Road 6) and Marshall County wetland case studies were not completed due to insufficient data for the replacement wetlands.

Shoreline Protection

Shoreline protection was *non-applicable* for either MCIWL or MCRWL (Table 5). These wetlands were not located within a shoreline ecosystem and were not adjacent to any lakes or rivers.

Groundwater Interaction

MCIWL was rated *medium* for groundwater interaction (Table 5) and was valued at \$130 per year ($\$564 \times 0.23 \text{ acres} \times 1.0 = \130 , where \$564 represents the estimated value for the groundwater interaction function, 0.23 acres is the impacted area, and 1.0 is the quality modifier). MCRWL was rated *low* for groundwater interaction (Table 5) and was valued at \$195 per year ($\$564 \times 0.69 \text{ acres} \times 0.5 = \195). The difference between the two wetlands' groundwater interaction function values was \$65 per year.

Aesthetics, Recreation, and Education

MCIWL was rated *medium* for aesthetics, recreation, and education wetland (Table 5) and was valued at \$6 per year ($\$26 \times 0.23 \text{ acres} \times 1.0 = \6 , where \$26 represents the estimated value for this function, 0.23 acres is the impacted area, and 1.0 is the quality modifier). MCRWL was rated *low* for this function (Table 5) and was valued at \$9 per year ($\$26 \times 0.69 \text{ acres} \times 0.5 = \9). The difference between the two wetlands' aesthetics, recreation, and education values was \$3 per year.

Commercial Use

Commercial uses were rated *non-applicable* for MCIWL because there was no opportunity for commercial activity (Table 5). The commercial use function of MCRWL was rated *low* (Table 5). Commercial uses of MCRWL were valued at \$7 per year ($\$21 \times 0.69 \text{ acres} \times 0.5 = \7 , where \$21 represents the estimated value for the commercial use function, 0.69 acres is the replacement area, and 0.5 is the quality modifier).

Mitigation Costs

The direct cost to mitigate for impacting MCIWL was estimated to be \$500 by the landowner, which included earth work and seeding of the site (Danks 1997). The direct cost to the landowner may be minimal; however, replacing the impacted wetland on productive agricultural land has a positive opportunity cost.

Opportunity costs of conserving wetlands are the net monetary benefits which could have been realized from the next best alternative use of the land, which must be foregone to conserve a wetland (Bardecki 1989). According to BWSR, conservation easement payment rates for wetlands in this area are worth \$231 per acre, which is based on 50 percent of the county assessor's township market value for tillable land in Gregory Township, Mahanomen County (Fredbo 1997). Therefore, the opportunity cost of MCRWL is \$159 ($\$231 \text{ per acre} \times 0.69 \text{ acres}$). Administrative and enforcement expenses were also included in the total mitigation costs. Total

one-time mitigation cost for MCRWL was \$694, or \$35 per year when amortized at 5 percent over an infinite time horizon (Table 6). Estimated annual mitigation costs ranged from \$14 to \$1,493 per wetland mitigation project, or from \$20 to \$277 per replaced acre (Table 6).

Table 6. Annualized Costs of Mitigation Projects (In 1996 Dollars)

	Mahnomen	Becker	Clay	Clear- water	Kittson	Mahnomen (Waubun)	Red Lake	Roseau (Road 8)
	-----Dollars-----							

Mitigation Costs	500	21,850	27,862	200	6,815	100	5,205	3,700
Opportunity Costs ^a	159	1,279	1,969	53	752	144	248	3,304 ^d
Administrative Costs ^b	<u>35</u>	<u>35</u>	<u>35</u>	<u>35</u>	<u>35</u>	<u>35</u>	<u>35</u>	<u>35</u>
Total Costs	694	23,164	29,866	288	7,602	279	5,488	7,039
Annualized Cost ^c	35	1,158	1,493	14	380	14	274	352

^aOpportunity costs are based on Minnesota BWSR conservation easement payment rates for wetlands which represent 50 percent of the county assessor's township market value for tillable land (Fredbo 1997).

^bAdministrative costs are based on information from Jaschke (1998).

^cAnnualized costs were estimated by assuming an infinite time horizon and a 5-percent social discount rate.

^dThe opportunity cost for Roseau (Road 8) was estimated by averaging values from Grimstad, Palmville, and Poplar Grove Townships.

The replaced Mahnomen County wetland was of lesser quality than the impacted wetland. The replacement wetland's functions were each worth more than the functions displaced at the impacted wetland, except for the Flood and Stormwater Storage function. However, due to the larger size of the MCRWL, higher dollar values were associated with the functions of the replaced wetland than the impacted wetland.

Results for the Other Nine Case Study Wetlands

The procedure used to estimate the social values of the functions of the MCWL case study was repeated for the other nine wetland case studies. The Marshall and Roseau (Road 6) Counties wetland case studies were not completed due to insufficient data on the replacement wetlands. The floral diversity and integrity wetland function was not estimated for any of the wetland case studies. Estimated annual social values of impacted wetlands ranged from \$527 to

\$5,468 per acre (Table 7). Estimated annual social values of replacement wetlands ranged or from \$743 to \$3,981 per acre (Table 7).

Table 7. Estimated Annual Monetary Values of Impacted and Replacement Wetlands, by Function (In 1996 Dollars)

County	Wild. Hab.	Fish. Hab.	Flood and Storm- water	Water Quality	Shore- line	Ground- water	Aesth. Rec. Educ.	Comm. Uses	Annual Sum	Annual Cost of Mitiga- tion
Mahnomen										35
MCIWL	2	N/A	29	40	N/A	130	6	N/A	207	
MCRWL	4	N/A	177	121	N/A	195	9	7	513	
									+306	
Becker										1,158
Impact.	13	N/A	535	183	N/A	1,179	54	22	1,986	
Replace.	38	N/A	1,070	732	N/A	2,358	163	N/A	<u>4,361</u>	
									+2,375	
Clay										1,493
Impact.	21	N/A	458	313	N/A	1,010	47	38	1,887	
Replace.	43	N/A	1,833	1,253	N/A	4,038	186	75	<u>7,428</u>	
									+5,541	
Clearwater										14
Impact.	2	2	56	39	974	124	6	N/A	1,203	
Replace.	2	N/A	92	63	N/A	102	5	4	<u>268</u>	
									-935	
Kittson										380
Impact.	5	N/A	228	156	2,626	502	23	N/A	3,540	
Replace.	19	N/A	527	361	6,077	1,162	54	N/A	<u>8,200</u>	
									+4,660	
Mahnomen (Waubun)										14
Impact.	2	N/A	87	60	N/A	192	9	N/A	350	
Replace.	4	N/A	90	123	N/A	395	18	7	<u>637</u>	
									+287	
Red Lake										274
Impact.	4	2	51	70	590	226	16	N/A	959	
Replace.	10	N/A	435	298	N/A	959	44	N/A	<u>1,746</u>	
									+787	
Roseau (Road 8)										352
Impact.	83	N/A	3,525	2,410	N/A	7,766	358	N/A	14,142	
Replace.	165	N/A	7,050	2,410	N/A	15,533	358	N/A	<u>25,516</u>	
									+11,374	

Becker County Wetland Case Study

The BCIWL was in Section 23 of Detroit Township, Becker County. This wetland, a 2.09-acre, Type II wetland, was filled in 1997 for development of an industrial park north of Detroit Lakes, Minnesota. The BCIWL was mitigated by purchasing 4.18 acres of wetland credits from the county mitigation bank at \$0.12 per square foot. This mitigation bank is an 80-acre tract of land that includes 31.64 acres of restored wetlands and 23.73 acres of public value credits. The mitigation bank was developed in 1995 and is in Section 30 of Spring Creek Township, Becker County. MNRAM was applied to a Type III wetland located in the mitigation bank to evaluate BCRWL.

Fishery habitat and shoreline protection wetland functions were *non-applicable*. Since the BCRWL was replaced within the mitigation bank, the commercial use wetland function was *non-applicable*. Excluding mitigation costs, the BCRWL has an estimated annual social value of \$2,375 greater than the BCIWL (Table 7). The estimated annual cost to mitigate was \$1,158 for this project. Because society realized more value from the BCRWL than it lost due to the impact, this is evidence that WCA mitigation policy may be socially inefficient by allocating more resources (as represented by mitigation costs) than necessary to replace the social values lost due to impacting a wetland.

Clay County Wetland Case Study

The Clay County case study involves wetland impacts in Dilworth, Minnesota, in Section 11 of Moorhead Township, Clay County. The wetlands impacted were Types I, II, and III, covering approximately 3.58 acres with a drainage area of 8.53 acres, and were impacted due to a road/ditch upgrading and widening project that filled portions of the wetlands.

The CCRWLs are 4 miles southeast of Hawley, Minnesota, in Section 15 of Eglon Township, Clay County. A minimum of 3.58 acres of Types II and III wetlands, with a drainage area of 18.7 acres, were restored on agricultural land with 3.58 acres of upland being included to replace the CCIWLs, for a total of 7.16 acres. Earthen dikes were built and tile was removed or plugged to restore the wetlands.

The CCRWLs have an estimated annual social value of \$5,541 greater than the impacted wetlands (Table 7). The estimated annual cost to mitigate was \$1,493.

Clearwater County Wetland Case Study

This case study involves wetland impacts on the northeast shore of Pine Lake in Pine Lake Township, Clearwater County. The CLCIWLs, Types VI and VII, were 0.22 acres and had a drainage area of 133 acres. This site was cleared of vegetation, and fill was placed in the wetland in 1995 as a residential building site. The commercial use function was *non-applicable* because the area became a residence.

The CLCRWL is in Section 19 of Equality Township, Red Lake County. This wetland is a 0.36-acre, Type II wetland with a drainage area of 2.4 acres. It was restored by constructing an earthen dike on the north end of the wetland. The CLCRWL has an estimated annual social value of \$935 less than the CLCIWLs (Table 7). The estimated annual cost to mitigate was \$14. Society was clearly worse off with mitigation.

Kittson County Wetland Case Study

This case study involves a wetland impact in Section 2 of Red River Township, Kittson County. The KCIWL was a 0.89-acre, Type III wetland with a drainage area of 58 acres. The wetland was impacted in 1995 by a road improvement project.

The KCRWL was mitigated on-site by creating 2.06 acres of Type III wetland by excavating. Soils from the KCIWL were used to enhance the characteristics of the created wetland. The run-off from the replaced wetland was designed to flow into the Two River.

The KCRWL has an estimated annual social value of \$4,660 greater than the KCIWL (Table 7). The estimated annual cost to mitigate was \$380.

Mahnomen County Wetland Case Study (Waubun)

This case study involves impacted wetlands in Waubun, Minnesota, in Section 19 of Lake Grove Township, Mahnomen County. The MCWIWLs were contiguous with a 4.0-acre wetland with a drainage area of 90 acres. The owner filled 0.34 acres of wetland Types II and IV for a parking lot expansion project in 1994. The MCWRWL, 0.70 acres of wetland Types II and IV, was created on-site by excavating the soil on the north end of the existing wetland.

The MCWRWLs have an estimated annual social value of \$287 greater than the MCWIWLs (Table 7). The estimated annual cost of mitigation was \$14. Society was somewhat better off with mitigation. This case study is evidence that WCA mitigation policy can lead to socially efficient mitigation results.

Red Lake County Wetland Case Study

The impacted wetlands were 0.40 acres of Types II, III, and IV, with a drainage area of 22 acres, in Sections 33 and 34 of North Equality Township, Red Lake County. The wetlands were impacted in 1994 by a county road improvement project. A MNRAM assessment could not be completed for the RLCIWLs since the wetlands no longer exist. An LGU technical evaluation panel assessment completed for the project in 1994 was used.

The RLCRWLs were mitigated on-site by creating 1.70 acres of Types II and IV wetlands with a drainage area of 22 acres. The RLCRWLs were created by constructing earthen dikes and excavating upland areas. The run-off from these wetlands flows through grassed spillways that were designed to drain into the Clearwater River.

The RLCRWLs have an estimated social value of \$787 greater than the RLCIWLs (Table 7). The estimated annual cost to mitigate was \$274 for this project.

Roseau County Wetland Case Study (County Road 8)

This case study involves wetlands impacted in 1996 by a 14-mile road-widening and upgrading project in Poplar Grove, Palmville, and Grimstad Townships, Roseau County. A total of 13.77 acres of Types I (0.48 acres), II (6.81 acres), III (0.23 acres), V (0.02 acres), VI (5.90 acres), and VII (0.33 acres) wetlands were impacted at 45 separate locations. Whenever practical, segments of the roadway were constructed entirely with borrow material so that excavation in larger wetland areas was avoided.

Each filled wetland was replaced 2:1-- a total of 27.54 acres -- on-site by constructing flat ditch grades with elevated culverts and placing earthen dikes in the bottom of the ditch. Soils from the impacted wetlands were salvaged and redeposited in the ROCRWLs to re-establish wetland vegetation. A large wetland complex in the project area was used as a proxy for application of MNRAM. The ROCRWLs have an estimated annual social value of \$11,374 greater than the ROCIWLs (Table 7). The estimated annual cost to mitigate was \$352.

Marshall County Wetland Case Study

This case study involves wetland impacts in Sections 9 and 10 of Cedar Township, Marshall County. The road improvement project impacted 2 acres of Types I and II in 1997. Data on replacement wetlands were not available, so no further analysis was done.

Roseau County Wetland Case Study (County Road 6)

This case study involves 8.55 acres of wetland Types I, II, VI, and VII impacted in Sections 19, 20, 29, and 30 of Poplar Grove Township, Roseau County. These wetlands were impacted in 1997 by the widening and upgrading of an existing 2-mile portion of County Road 6. Included in the wetland impacts was a 0.66-acre DNR protected wetland that was mitigated on-site using 30-inch culverts compared to 60-inch culverts, placing new culverts at higher elevations, and placing ditch blocks where necessary to reduce wetland runoff. Since the replacement wetlands have not been identified, that portion of the case study was not carried out.

Case Study Findings

Eight wetland case studies were evaluated using dollars as a common denominator. It was assumed the private net benefits of activity impacting wetlands were positive since the decision was made to pursue them. When considering only WCA mitigation policy (not a broader social well-being perspective), two outcomes occur (1) society realized a net gain in benefits (seven of eight cases) or (2) society realized a net loss in benefits in wetlands (one of eight cases). Although society gained wetland benefits in seven cases and lost wetland benefits in one case, mitigation policy may still be inefficient. Clearly, if resources used to mitigate wetlands in Minnesota cannot be allocated to better uses and social well-being is not reduced, mitigation is efficient (but, then, why not restore even more?). However, WCA mitigation policy requires

individuals to replace impacted wetlands without a consideration of the effects on overall social well-being.

CONCLUSIONS AND IMPLICATIONS

The objective of this study was to estimate the social efficiency of the implementation Minnesota's *WCA* wetland mitigation policy in the Red River watershed. Placing value upon impacted and replacement wetlands was a formidable task because data on wetland functions and outputs in the PPR and RRV are limited. Although much biological information has been compiled regarding wetland ecosystems in general, the economic values of specific wetlands still need considerable attention.

A preliminary assessment of social efficiency was accomplished by evaluating impacted and replacement wetlands. Society gained wetland benefits in seven cases and lost wetland benefits in one case. When mitigation is mandated, it affects both individual and social well-being. When society gains wetland benefits due to mitigation policy, society should bear part of the mitigation costs. The individual should be compensated for mitigation costs through a cost-share program where society pays in proportion to the increase in wetland values. If society is willing to bear the cost of excess mitigation, it is more than likely efficient.

Mitigating lost values beyond 1-to-1 happened in seven of eight cases and represents an allocation of resources that may or may not be efficient. If society gains value from replacement wetlands and there was no better or higher use for the resources allocated for mitigation, social well-being may not be adversely affected. If society could have used the resources better, such as for infrastructural development or education, inefficiency occurs, and social well-being is reduced. This research does not consider whether the resources used to mitigate could have been allocated elsewhere in society, but it is a concern that should be addressed by policy makers.

The social benefits of activities that impact wetlands are also not considered in *WCA* analyses, such as the social value of residential development. For this study, it was unknown how activities that impact wetlands contribute to social well-being, and the activities were not included in the valuation process, although they should be included to efficiently allocate resources.

The added private and social costs of avoiding wetlands and *WCA* altogether are not included in mitigation costs. For example, the best site for a project may be avoided altogether just to avoid the *WCA* mitigation process. This may result in higher costs to the individual because an alternative site may require additional resources than originally allocated to complete the project. Social well-being will be adversely affected because avoiding wetland mitigation brings about increased project costs.

This research does not imply that all wetland mitigation in Minnesota is socially inefficient, but it does show that there is evidence to conclude that *WCA* mitigation policy does not adequately account for changes in social well-being and should be re-evaluated by the Minnesota State Legislature if the intent is to "conserve and use water resources of the state in the best

interests of its people, and to promote the public health, safety, and welfare” (Minnesota Board of Water and Soil Resources 1993, WCA Statutes, pp.1-2).

Five implications for policy makers to follow from this study:

1. Poor/insufficient data: The data (and resources) available to anyone, especially LGUs, to evaluate wetland functions and values are woefully inadequate, resulting in decisions that are only by remote chance efficient. However, the data available in 1998 are marginally more robust than that available when WCA was enacted, which raises questions about the original basis for WCA provisions.
2. Mitigation excess (providing more than was given up) is pervasive, inefficient, and not in the best interests of the state’s citizens. WCA does not suggest that society should be provided with more wetland benefits at individuals’ expense than existed before an impacting activity. The intent is to make Minnesota’s citizens whole again, not to increase the amount of wetland benefits available to them. This raises questions about WCA replacement ratios.
3. If mitigation excess is intended, society should pay for the excess mitigation expenses. The “impactee” should not be required to pay for wetland values above and beyond what was lost by the project requiring mitigation. Excess mitigation is neither efficient nor equitable.
4. WCA ignores the social values of other potential uses for society’s scarce resources that are now being allocated to mitigation. There may be other uses that better serve the interests of the state’s people and contribute more to public health, safety, and/or welfare.
5. WCA ignores the benefits of the impacting activity to the state’s citizens. Nowhere in WCA mitigation policy is the benefit to society that is gained by the impacting activity considered. In an efficient world, these should offset/reduce the amount of mitigation required.

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