FLOOD DAMAGE REDUCTION IN THE UPPER MISSISSIPPI RIVER BASIN: AN ECOLOGICAL ALTERNATIVE

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EXECUTIVE SUMMARY

To truly solve the ecological problems facing the Upper Mississippi River Basin in five states—Iowa, Illinois, Minnesota, Missouri, and Wisconsin—we need an ecological solution. Despite a century of massive capital investment in flood control structures across the 18 million acres of flood zone, flood damages have increased. In addition, the region faces degraded wildlife habitat and water quality due to sediment and nutrient contamination as a result of wetland loss.

The proposed ecological solution is to restore natural hydrological functions by reconnecting some of the leveed floodplains to the parent river. Where lands are frequently flooded, economic activities adversely affected by inundation need to be eliminated. In short, the bottomlands of the Upper Mississippi River (UMR) Basin should be returned to their natural state, which would hold floodwaters for weeks, if not months, at a time, rather than the hours, or at most, days, given the current conditions. Levee districts could be used as part of this strategy, capturing flood crests when needed.

To promote this ecological flood reduction strategy, The Wetlands Initiative (TWI) and its partners conducted a study in 2003-04, funded by the McKnight Foundation, to identify how much of the floodplain could be readily reclaimed for flood storage. We also sought to identify how this flood storage strategy could provide economic benefits to humans and habitat benefits to bird populations. TWI chose 77 counties to be studied—called the "sample"—in the five-state region. The sample included 4.4 million acres, approximately 24 percent of the total 100-year flood zone (as defined by the Federal Emergency Management Agency). For each county, we conducted three analyses, described below.

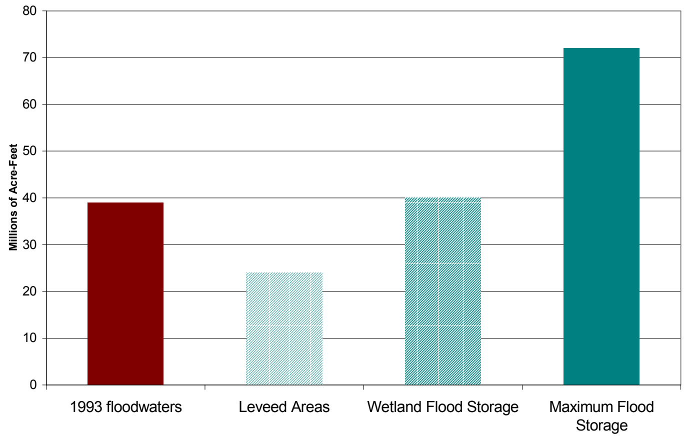
Landscape. First, TWI identified 1.9 million acres in the 100-year flood zone that could readily be used to store floodwaters. These areas are either behind levees (able to store water 10 feet deep) or on existing or drained wetlands outside of levees (able to store water 3 feet deep). Together, these areas could hold 9.6 million acre-feet (one acre covered by a foot of water) of floodwaters. Secondly, TWI sought to find the best opportunities for wetland restoration within these flood storage areas by identifying areas (totaling 740,000 acres) that are drainedwetlands currently used for row crops.

Economic. An agricultural economist calculated the annual social costs and benefits of converting *all* cropland in the 100-year flood zone (1.8 million acres) to wetland. Results of the benefit-cost analysis show that cropland conversion is socially efficient for all counties in the study area except for St. Louis County, Missouri. The estimated total annual net benefit of cropland conversion for all sampled counties is $120.9 million or $68 per acre. This analysis suggests that society would be better off if cropland acreage in the 100-year flood zone in the study counties was restored to wetlands than if it remained as cropland.

Bird species usage. In a third study, Audubon staff assessed how bird diversity would be affected if cropland in the flood zone was converted to wetlands. The numbers are remarkable: 53 species of birds were identified as currently using the cropland on drainedwetland in the study counties, whereas Audubon projects that 145 species of birds would be present in the highly diversified restored habitats.

Using data from the sample counties, TWI then estimated the flood storage and

Figure 1. Potential Flood Storage Volumes Compared to 1993 Floodwaters



wetland restoration potential at a grand scale—a scale that would truly be enough to impact the ecological health of the entire basin and beyond. Our extrapolation suggests that more than 72 million acre-feet of water could be stored within the 100-year flood zone if the flood zone in the entire five-state watershed were to be used for flood storage (Figure 1). A more conservative estimate of available flood storage in the watershed indicates that approximately 40 million acre-feet of water could be stored within the existing levees and outside the levees on existing or drained wetlands. Either of these estimates would supply more than the flood storage needed to hold the 80-day flood of 1993 on the Mississippi River. That flood generated 39 million acre-feet of floodwaters (at St. Louis).

Wetland restoration is a necessary component to this ecological flood damage reduction strategy. Wetlands would form naturally over much of this flood storage area once the hydrology in the floodplain was restored. An estimated 3 million acres of agricultural lands (that is, grass and hay in addition to row crops) in the entire 100-year flood zone are on drained wetlands in the five-state region. These areas, once restored, could provide high quality habitat, sediment and contaminant storage, and nutrient removal, in addition to flood storage.

A more aggressive restoration strategy would include converting all 7 million acres of cropland in the 100-year flood zone of the UMR watershed to wetlands. The total annual net social benefit of this conversion is estimated to be $494 million. On average, only 7 percent of a county's cropland is in the flood zone; thus, this restoration could be achieved while leaving the vast majority of a region's cropland intact.

Additional work is needed to bring this flood reduction strategy into reality. First, further economic analysis is recommended to assess the benefits to the individual landowner who would convert the land to these new landscapes. These benefits should include the potential for recreational income from the restored wetlands or prairies as well as the potential for developing nutrient farms and selling nutrient credits to those who emit high levels of nitrogen, phosphorus or carbon.

Second, consideration should be given to the use of levees as flood control devices. The concept of using levees to permit passive flooding of protected areas during major flood events is not new, yet the details need to be considered: How and where would spillways be constructed in the levee? At what cost and at what scale would these spillways need to be designed and constructed? What would be the most effective spatial distribution?

Third, large-scale pilot projects incorporating the sample areas of this study should be established as soon as possible. The pilot projects should involve at least 3,000 to 20,000 acres of flood zone and 15 miles of stream channel. Each pilot project should be used to evaluate the environmental impacts of conversion and to explore the actual cost of restoring wetlands, providing flood storage, processing nutrients and attracting recreational uses. The results of the pilot projects will help confirm the efficacy of this approach to flood control, as well as to help develop design, management and operation criteria for large-scale environmental control to reduce flood damage, improve water quality, and enhance wildlife habitat.

BACKGROUND

Flooding and, more importantly, flood damages have increased over the past century. From 1904 to 1933 mean annual damages amounted to $1.4 billion in the United States (Richards, 1994). The subsequent 30 years (1934 to 1963) saw a 78% increase in damages, to $2.5 billion. In the next 30 year period (1964 to 1993), mean annual flood damages reached $3.5 billion, a 150% increase over the first 30 years (Richards, 1994). As flood damages have increased, so has federal spending on flood control costs. Since the late 1940s, the U.S. Army Corps of Engineers has spent more than $120 billion federal dollars on flood control projects—ironically corresponding with the period of greatest flood damage increases. The increase in flood control costs has not resulted in a corresponding decrease in flood damages.

The causes of flooding are numerous. Floods are initiated by rainfall and snowmelt in areas of saturated soils, that is, soils that cannot store more water. The volume and rate of water movement down slope, or downstream, depends on the efficiency of the drainage system. Subterranean drainage systems, such as storm drains and tiles, quickly move the water from the surface through the soil and into agricultural out ditches or channelized streams. The receiving drains or streams continue the rapid downstream movement, ultimately forming a flood wave. As the wave grows larger and overflows its channel, it will spread across the riparian lands into its natural storage domain, the flood plain. Damage results if human property is located on these lands. If levees prevent the flood wave from reaching the floodplain, the wave continues downstream with even greater destructive force.

Humans have manipulated the land surface of North America for thousands of years. Prehistoric humans harvested fruits and plants and frequently burned the landscape for hunting and war. Over a mere few hundred years, European settlers altered the land surface and drainage patterns to such an extent that they bear little resemblance to the presettlement conditions. Taking advantage of beaver works, early European farmers fed their cattle and grew their crops on the treeless meadows along drainage ways. They soon learned, however, the benefits of removing beaver dams and imposing their own drainage controls, namely tiles, ditches, and levees. They deepened and straightened swales to efficiently drain excess water, protecting their land from untimely inundation. As they did so, they transferred their unwanted waters to their downstream neighbors. In turn, the downstream neighbors passed this water further downstream.

As farmers or homeowners developed more flood prone land, a new means of drainage control was instigated—levees. Engineers designed levees to prevent seasonal inundation of flood zone lands. Initially, levees appeared to be the ideal solution, protecting the land from inundation with little or no ecological effects. However, as the Army Corps of Engineers expanded the use of levees, the cumulative effects became obvious and disastrous. As early as 1850, engineers began to comment on the deleterious and costly effects of levee construction (Ellet, 1852). Little attention was paid to these warnings and drainage and levee construction continued apace. For example, today nearly 67 percent of the Upper Mississippi River basin has been converted to an agro-ecosystem, a landscape in which natural vegetation and drainage patterns have been highly altered to accommodate cultivated food and fiber crops.[1] Today 2.4 million acres are behind levees in the Upper Mississippi River Basin north of the Ohio River.

On these drained and leveed lands, farmers build their homes and barns and grow their crops. Urban dwellers construct their roads, factories and homes. Because of the engineered flood control structures, the inhabitants of these altered lands feel safe; they are not, as escalating

[1] Data from USDA 1997 Census of Agriculture, as reported in The changing face of the UMR basin: Agriculture, Selected Profiles of Farming and Farming Practices, September 2000, National Audubon Society, St. Paul, MN.

flood damages so clearly illustrate. Even the cost of maintaining the safety structures is high: In 1993, the U.S. Army Corps of Engineers spent more than $55 million to repair damaged levees (Table 1).

Table 1. Upper Mississippi River Basin Levee Districts Damage from the 1993 Flood (Source: U.S. Army Corps of Engineers)

State	Number of Levees Flooded	Acres Flooded	Levees Repaired	Cost of Repairs
Iowa	36	35,291	6	$275,040
Illinois	33	226,600	0	
Missouri	145	436,000	37	$55,397,900
Total	**214**	**697,891**	**43**	**$55,672,900**

Why are agricultural and urban activities allowed on flood prone lands? One reason is that this is where they started, before the consequences of drainage and levees were stamped on the land. Another reason is that federal and state emergency programs cover part of the flood losses incurred by flood victims. The most egregious reasons are the federal subsidies paid to floodplain occupants: crop and insurance subsidies which indemnify those occupying and using flood prone lands.

The current drainage practices, flood control activities, and development practices create economic consequences that can be expressed in three ways. The first is the cost of property damage and emergency response services directly related to a flood. This includes business and residential losses, transportation disruption, drainage structure and levee repair, and land restoration. Viewed a little differently, these costs establish the value of expropriated flood storage (e.g., drained subdivisions and leveed floodplains). For example, in Dane County, Wisconsin, the federal government paid $12.5 million to cover damage costs (e.g., flood response and repair expenses, emergency repairs for homeowners, and agricultural losses) due to flooding in 1993.[2] Iowa, Illinois, and Missouri—the three states with the highest flood damage costs in 1993—also have drained the most wetlands, 87% on average. These three states alone had $12 billion in flood damages in 1993.[3]

The second economic measure is the cost of the high sediment and contaminant load carried in the river. Drainage ditches and storm drains encourage rapid movement of water off the land and into the rivers. The levees continue to focus the energy of the flood on a narrow section of the river system. This accelerates the waters and prevents slow transport through vegetated landscapes where sediments and contaminants would filter or settle out. The result is poor water quality, for humans who use the rivers as a source of their drinking water and for all the flora and fauna dependent on riverine habitats. The continental shelf of the Gulf of Mexico, the ultimate disposal site for the Mississippi River watershed, now has a growing Dead Zone, an area of low dissolved oxygen (<2.0 mg/L) created by the abundance of nutrients carried downstream by the Mississippi River. It is estimated that approximately 50 to 75 percent of the nitrogen delivered to the Gulf by the Mississippi River is from agricultural sources upstream of the Gulf (Turner and Rabalais, 1991; Antweiler et al., 1995).

[2] Personal communication from David Janda, Dane County Department of Emergency Management, March 22, 2002.

[3] Sierra Club, Permitting Disaster in America, 2000.

Despite the nature of the damage (e.g., lost fisheries, reduced agricultural production or diminished recreation), the disposal of the pollutants is an external cost of the agricultural industry and urban activity. The sediment load of the main channel carries its own price—the cost of dredging the navigational channel where sediment has been deposited. The U. S. Army Corps of Engineers has spent $100 million annually on dredging the main channel of unwanted sediments in the past decade.

The third economic consequence is one of lost opportunity. Abundant, well-vegetated and ecologically healthy wetlands—especially within flood zones—provide many vital functions that are extremely cost-effective. These include: reducing flood peaks, removing excess nutrients and sediments from surface waters, recharging groundwater supplies for urban and rural communities, and supporting more diversified and more abundant wildlife populations. Our country has experienced dramatic losses in wetlands in the lower 48 states—from 215 million acres in the 1600s to 101 million acres today (Conservation Foundation, 1988). More than 64 million acres of wetlands in the Mississippi River Basin have been lost since the 1780s. Drainage of wetlands for agricultural production has contributed to agricultural nonpoint source pollution, which has a negative impact on water quality. The *National Water Quality Inventory* indicates that agricultural nonpoint source pollution is the leading source of water quality impacts, the third largest source of impairments to estuaries, and a major contributor to groundwater contamination and wetlands degradation (U.S. Environmental Protection Agency, 2000). In addition, loss of wetlands results in a loss of natural, biodiverse habitat, which supports at least half of all animal species and about one-third of all plant species that are listed under the Endangered Species Act (Noss and Cooperrider, 1994).

The solution to the problem of increasing flood damage costs is two-fold. First, restore the natural hydrology in the floodplain and reconnect some of the leveed floodplains to the parent river to take advantage of the flood storage potential that wetlands provide. Second, where lands are frequently flooded, eliminate economic activities that are adversely affected by inundation. In short, the bottomlands of the Upper Mississippi River Basin should be returned to their natural state, which would hold floodwaters for weeks, if not months, at a time. Levee districts could be used for strategic flood control by capturing flood peaks when and where needed.

To promote this strategy, The Wetlands Initiative (TWI) conducted a planning study in 2002 to determine the areal extent of existing and drained wetlands in the 100-year flood zone and then, using that figure, to estimate the volume of potential floodwater storage in a five-state region of the basin (Minnesota, Wisconsin, Iowa, Illinois, and Missouri). The current work, begun in January 2003, expands the scope and depth of the first planning study.

LANDSCAPE ANALYSIS

Introduction

By finding and compiling disparate sets of geographic information about the 100-year flood zone, TWI aimed to accomplish three primary goals:

- Determine the areal extent of existing and drained wetlands within the 100-year flood zone of the five-state region of the Upper Mississippi River Basin (Illinois, Iowa, Minnesota, Missouri, and Wisconsin);

- Estimate the potential flood storage capacity within the 100-year flood zone of the five-state region of the Upper Mississippi River Basin, identifying both maximum and more conservative potential storage volumes;
- Approximate the distribution of wetland habitats that would naturally form once the hydrology in the floodplain was restored.

To accomplish these goals, TWI conducted a landscape analysis on 77 counties in the five-state UMR watershed (Figure 2). The number of sampled counties varied from state to state, determined by the availability of data and by the location of the county in the state. The counties were selected in groups so that the upstream and downstream characteristics of the flood zones would be included in the analysis.

After completing the landscape analysis in the sample counties, TWI extrapolated the results to the entire 100-year flood zone in the five-state basin. This extrapolation provides an estimate of both the wetland restoration potential and floodwater storage capacity within the five-state UMR watershed.

Landscape Variables

Geographic Information System (GIS) data were gathered for five landscape variables: 100-year flood zone, hydric soil, wetlands, land cover, and leveed area. The sources and uses of these data sets are described below.

100-Year Flood Zone

According to the Federal Emergency Management Agency (FEMA), a 100-year flood is a flood that has a 1 percent chance of being equaled or exceeded in any given year (www.fema.gov/fhm/fq_tern.shtm) The 100-year flood zone is the region that would be inundated during the 100-year flood. The FEMA 100-year flood zone marks the outer limits of our study.

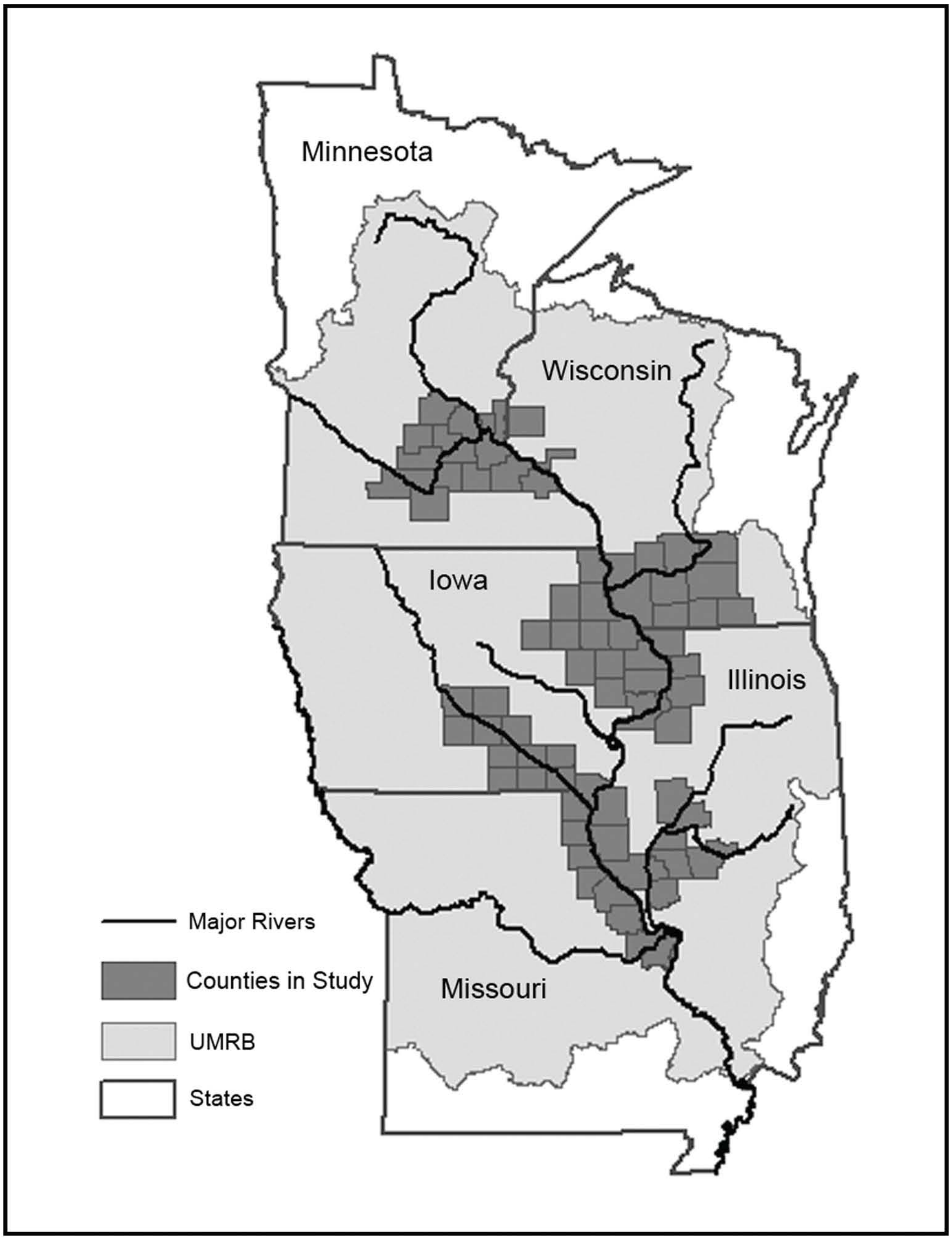
The 100-year flood zone (termed Q3 data when it is available in digital form) was acquired from several sources, including FEMA, state departments of natural resources (Illinois, Minnesota and Wisconsin), the Missouri State Emergency Management Agency, and some county offices in Wisconsin. For each county in the study, the area of the 100-year flood zone was calculated using the x-tools script in ArcView.

The major rivers in the Upper Mississippi River watershed are controlled by numerous locks and dams and are not free flowing bodies of water. The flood zone directly adjacent to these rivers is termed the "managed river flood zone" and was excluded from the study except where levees are present.

Hydric Soil

According to the U.S. Department of Agriculture Natural Resources Conservation Service, "a hydric soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. The concept of hydric soils includes soils developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation. Soils that are sufficiently wet because of artificial measures are included in the concept of hydric soils. Also, soils in which the hydrology has been artificially modified are hydric if the soil, in an unaltered state, was hydric." (http://soils.usda.gov/use/hydric/intro.html) For this study, the presence of hydric soils on the landscape was used as a wetland indicator. It was assumed that areas of hydric soils can support wetlands.

Figure 2. Map of Study Counties within the Upper Mississippi River Basin



Digital county soil maps were available online from the U. S. Department of Agriculture, Natural Resource Conservation Service for most of the counties included in this study. In each county, TWI identified hydric soils using the county hydric soil list. The hydric soils were selected and limited (or clipped) to just those hydric soils mapped within the 100-year flood zone.

Wetlands

The presence of pre-existing wetlands on the landscape was used as a wetland indicator. National Wetlands Inventory data (NWI) was produced by the U.S. Fish and Wildlife service to identify the locations and classification of existing wetlands based on aerial photography from the 1970s to the present. Locations where NWI wetlands are mapped but no longer exist present an opportunity for restoration.

NWI wetland maps were readily available online from the states' departments of natural resources websites for all counties in the study except Wisconsin. The wetland dataset was limited (or clipped) to just those wetlands mapped within the 100-year flood zone.

The hydric soil dataset was merged with the NWI dataset to identify the total area of land within the 100-year flood zone where either hydric soils or NWI wetlands were mapped. Since both hydric soils and NWI wetlands are indicators of pre-existing wetlands, the area of this merged dataset gives an estimate of the total existing or drained wetlands within the 100-year flood zone.

Land Cover

The land cover data were provided by government agencies from each state. (Complete source information is provided in each state section.) To compile the tabular data, some of the discrete land cover classes defined by the state agencies were combined into more general classes. The land cover data were also grouped into broad classes for the report maps, providing a simple visual display of the general land cover on existing or drained wetlands within the 100-year flood zone. Land cover data were only mapped or compiled for areas underlain by hydric soil or NWI wetland in the 100-year flood zone.

The projection of the land cover maps determined the projection of the data for the state. Other data sets (e.g., hydric soils, NWI, levees) were reprojected to match the land cover data when needed.

Levees

The U.S. Army Corps of Engineers district offices in St. Paul, Rock Island, St. Louis, Omaha, and Kansas City provided digital data sets of levee district locations in the UMR watershed. Most of the levees included in the data set are within the 100-year flood zone. They were treated as a separate entity, relative to the adjacent unleveed flood zone, because of their ability to control water flow and to retain floodwater. Only levees in the 100-year flood zone that protect less that 10 percent urban development (determined using the existing land cover maps) were used in the landscape analysis. (In Cass and Mason counties, Illinois, levees outside the 100-year flood zone were used. Refer to the Illinois state section for additional information.) The levees were also subdivided into those within the 100-year flood zone of managed rivers and those within the 100-year flood zone of other rivers.

Flood Storage Area and Volume

The area of the flood zone that could be managed for floodwater storage is termed the Potential Flood Storage Area (PFSA) in this study. Calculating this area differed on leveed and unleveed land, as explained below. The PFSA is the sum of the calculations from these two different areas.

- For unleveed areas, it was assumed that only areas underlain by NWI wetland or hydric soil could be used for flood storage because these areas are existing or drained wetlands. It was assumed that, when flooded, unleeved areas could hold approximately 3 feet of water on the hydric soil or NWI wetland areas.
- For leveed areas, it was assumed that the entire levee district area could hold floodwaters, regardless of the distribution of hydric soils or NWI wetlands. It was assumed that, when flooded, the leveed areas could store approximately 10 feet of water across the entire district. This is a conservative estimate, as a U.S. Army Corps of Engineers study suggests that an average of 12 feet of water could be stored behind the levees along the Illinois River.[4]

Potential Wetland Habitats

Once the areal extent of the hydric soil or NWI wetland in the 100-year flood zone was determined, the hydric soils and NWI wetlands were coded to show the potential wetland habitat they could support once the hydrology in the flood zone was restored. Six wetland habitats were chosen: open water to shallow marsh; shallow marsh to sedge meadow; sedge meadow to wet prairie; wet savanna; wet forest; and fen. Wetland habitats were assigned to the hydric soils based on soil texture; thickness and color of the A horizon (topsoil or surface layer), E horizon (subsurface layer), and B horizon (subsoil); average annual temperature and rainfall; drainage class; and pH range (calcareous or acid). The soil classifications and native plant associations, called edaphic analogs by Sluis and Tandarich (1999), provide a method for deriving a database for restoration planning utilized in this study. NWI data were coded based on the "water1" characteristic included in the Table 2. However, if the NWI classification was forested wetland (FO), the NWI polygon was coded as wet forest regardless of the water characteristic.

Table 2. Potential Wetland Habitat Coding Scheme

Habitat	NWI Characteristics	Example Soils
Open Water to Shallow Marsh	Water1 = G or H	Palms Houghton
Shallow Marsh To Sedge Meadow	Water1 = E or F	Darwin Drummer
Sedge Meadow To Wet Prairie	Water1 = A, B or C	Ambraw Sparta
Wet Savanna	N/A	Niota Vesser
Wet Forest	Code = FO	Dockery Zwingle
Fen	N/A	Harps

In addition, some areas were identified on the land cover maps as forest, wet forest or flood plain forest which were not underlain by forest soils or forested NWI wetlands. In order to retain this forest cover in the potential wetland habitat scheme, these areas were included as wet forest on the potential wetland maps and in the tabular data.

[4] Personal communication (2/27/03) from Kevin J. Landwehr, hydraulic engineer, U.S. Army Corps of Engineers, Rock Island District.

Results

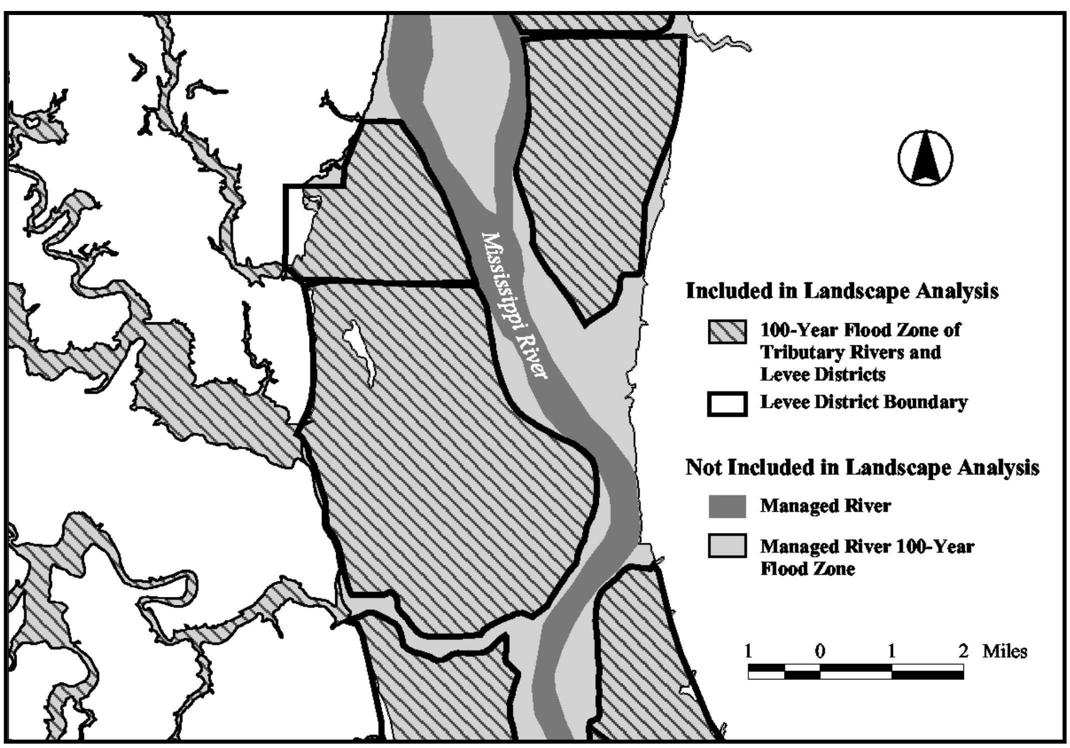
All acreage values discussed in this section refer only to the calculations for the 77 sample counties. Detailed tabular data and maps for each county in the study can be found in the state sections at the end of this report.

Sampled Flood Zone Characteristics

The projected flood storage areas and volumes are given in Table 3. The sampled 100-year flood zone is approximately 4.4 million acres (Table 3). It ranges from 513,000 acres within 13 counties in Wisconsin to 1.8 million acres within the 25 counties in Iowa. This range results from both the uneven number of counties sampled and the changing character of the 100-year flood zone among the states. The sampled flood zone is approximately 24 percent of the total 18.4 million acres of 100-year flood zone present in the five states. In Missouri, where fewer counties were included in the study, the sampled 100-year flood zone makes up only 13 percent of the total Missouri UMRB 100-year flood zone. In Illinois, the sampled flood zone makes up 38 percent of the total Illinois UMRB 100-year flood zone.

Not all of the 4.4 million acres of flood zone in this study area are available for flood storage, however, because flow in the unleveed areas of the major rivers is controlled by the Corps' locks and dams. This area of managed river flood zone was not included in the analysis of wetland flood storage or potential wetland habitats. Leveed areas were included since leveed areas—even those within the managed rivers—could be used for flood storage. Figure 3 illustrates the divisions of the 100-year flood zone used in this analysis.

Figure 3. Illustration of the 100-Year Flood Zone Used



The area of managed river flood zone is smallest in Minnesota and Wisconsin, likely due to the fact that the major rivers have narrower flood zones in this region. In Minnesota, the Minnesota River west of the Minneapolis metro area was not included as a managed river. The area of managed river flood zone is higher in Illinois and Missouri where the major rivers have wider 100-year flood zone boundaries and the Illinois, Missouri and Mississippi rivers are managed throughout the states.

Most of the levee acres are along the major rivers (455,000 million acres); the rest are along other tributaries (119,000 million acres). The Illinois sample has the most land protected by levees, as levees were present in all but one county in the sample. Some sampled Minnesota counties did have levees, but these levees protect urban development and were not included in the landscape analysis.

Table 3 also shows that 1.7 million acres of the sampled area are existing or drained wetlands. (These areas are either underlain by hydric soil or mapped as NWI wetland). This number is useful in that it describes how much of the sampled flood zone could support wetlands if the natural hydrology were restored. This area is where water is most likely to pond naturally.

If flood managers wanted to manage the flood zone for additional water storage, entire levee districts could be used for storage—not just the existing or drained wetland areas. This strategy could provide 1.9 million acres of potential flood storage (573,000 acres within the levees plus 1.3 million acres of existing or drained wetlands not in the levee districts). This area is called the Potential Flood Storage Area (PFSA) on Table 3.

Table 3. Sampled Flood Zone Characteristics, Five State Summary (acres)

State	Watershed 100-Year Flood Zone[a]	Sampled 100-Year Flood Zone[b]	Percent of Watershed 100-Year Flood Zone in Sample[c]	Managed Major River 100-Year Flood Zone[d]	Total Levee Area Within 100-Year Flood Zone[e]	Major River Levees[f]	Other River Levees[g]	Total Available Flood Zone[h]	Existing or Drained Wetlands: NWI wetland or Hydric Soil in Flood Zone, not in Levee Districts[i]	Existing or Drained Wetlands: NWI Wetland or Hydric Soil in Levee Districts	Existing or Drained Wetlands: Total NWI Wetland or Hydric Soil[j]	Potential Flood Storage Area (PFSA)[k]
IA	6,949,225	1,809,480	26	167,936	43,149	43,149	0	1,684,694	551,247	25,827	577,074	594,396
IL	2,360,821	899,621	38	499,648	381,195	264,631	116,564	664,604	152,879	227,860	380,739	534,074
MN	2,305,215	537,320	23	114,316		0	0	423,004	295,769	0	295,769	295,769
MO	4,821,414	607,765	13	364,482	149,055	146,902	2,153	390,185	96,364	90,771	187,135	245,419
WI	2,012,425	512,701	25	140,417	0	0	0	372,285	233,377	0	233,377	233,377
Total	**18,449,100**	**4,366,888**	**24**	**1,286,799**	**573,400**	**454,683**	**118,717**	**3,534,772**	**1,329,635**	**344,458**	**1,674,093**	**1,903,035**
%				**29**	**13**	**10**	**3**	**81**	**30**	**8**	**38**	**44**

[a] Calculated using the county FEMA Q3 data where available. In counties where Q3 data was not available, the Q3 area was estimated using neighboring counties. In Iowa, the alluvial layer was used to approximate the Q3 data.

[b] Calculatee using the county FEMA Q3 data. In Iowa, the alluvial layers was used to approximate the Q3 data.

[c] Calculated by dividing the samples 100-year flood zone by the watershed 100-year flood zone and multiplying by 100.

[d] The total area of FEMA 100-year flood zone adjacent to the major rivers along the river stretch where the water levels are managed by control structures.

[e] Calculated using the levee database from the US Army Corps of Engineers

[f] Calculated using levees located within the managed river system and protecting less that 10% urban development.

[g] Calculated using levees along tributaries not considered managed which protect less that 10% urban development.

[h] Calculated using the sampled 100-year flood zone minus the managed major river 100-year flood zone plus the area within the major river levees.

[i] Total areal extent of the NWI wetlands or hydric soils within 100-year flood zone, not including the managed major river flood zone but including the levee districts within the managed major river flood zone

[j] Calculated by adding the NWI wetland or hydric soil in the flood zone not in the levee districts with the NWI wetland or hydric soil in the levee districts. Provides the total areal extent of the NWI wetlands or hydric soil within the total available flood zone.

[k] Calculated by adding the area of NWI wetoand or hydric soil in the flood zone not in the levee districts to the total levee area within the 100-year flood zone.

Current Land Cover

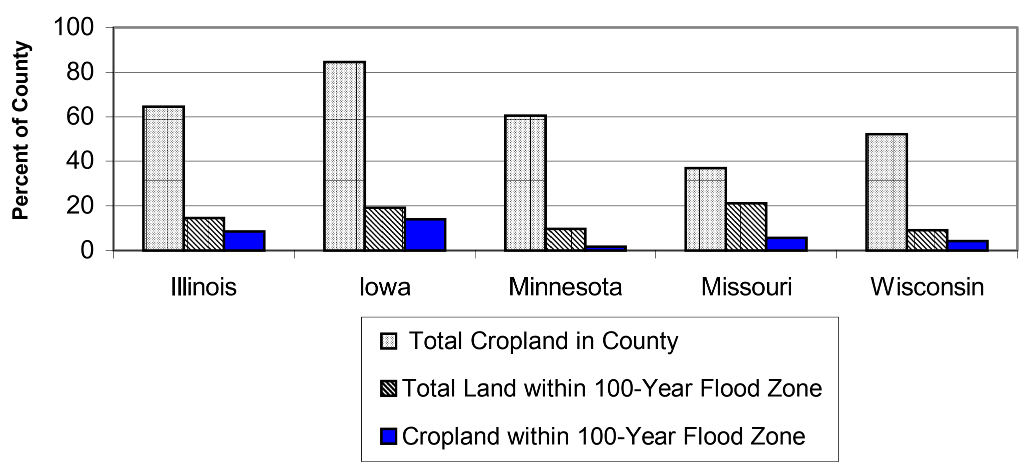
In an effort to identify the best opportunities for wetland restoration within the PFSA, TWI identified the current land cover on the 1.7 million acres of existing and drained wetlands (Table 4). In the sampled counties, 740,000 acres (44 percent) of the landscape in the 100-year flood zone are currently cropland.

Table 4. Sampled Current Land Cover on Existing or Drained Wetlands, Five State Summary

State	Crop Land	Grass	Forest	Urban	Urban Un-develop-ed	Wetland	Floodplain Forest	Open Water	Barren/Exposed	Other	Total Landcover
IA	244,058	126,499	141,500	6,473	0	0	0	65,005	2,506	2,056	588,097
IL	278,194	19,016	12,293	4,555	0	10,839	34,786	19,088	92	219	379,082
MN	41,926	34,767	39,532	5,039	56,517	11,758	0	105,119	1,029	14	295,702
MO	104,843	30,308	20,132	1,144	0	3,645	15,952	11,086	111	0	187,220
WI	70,126	13,669	20,138	1,700	0	72,291	31,095	23,506	744	68	233,337
Total	**739,147**	**224,260**	**233,596**	**18,910**	**56,517**	**98,534**	**81,833**	**223,804**	**4,482**	**2,357**	**1,683,438**
%	44	13	14	1	3	6	5	13	0	0	100

Although 740,000 acres is an extensive amount of cropland, it is only an average 7 percent of the total cropland in the county (Figure 4). By converting this cropland to wetland, crop damage due to flooding would be drastically lowered because the crops would be removed, flood damages downstream would be reduced because more water would be stored on the landscape, and wildlife diversity in the region would increase because the monotypic cover of corn and beans would be replaced by a complex of natural habitats. This restoration strategy, however, would leave the vast majority of a county's cropland intact.

Figure 4. Percent Cropland in County Compared to Percent Cropland in the 100-Year Flood Zone



Potential Wetland Habitats

To determine the potential land cover that would develop under more natural hydrologic conditions, the hydric soils and NWI wetlands were coded to show which of the six potential wetland habitats they would likely support. The coding was done based on the characteristics of the NWI wetlands and hydric soils as explained previously. This analysis is shown in Table 5. The 1.7 million acres of hydric soil and NWI wetlands could support open water to shallow marsh habitat covering 314,000 acres (19 percent), shallow marsh to sedge meadow habitat of 247,000 acres (15 percent) and sedge meadow to wet prairie habitat extending over 631,000 acres (38 percent). Wet savanna might cover 83,000 acres (5 percent) and wet forest could cover 386,000 acres (23 percent). The urban land, which currently is present on 75,000 acres, was left unchanged.

Table 5. Sampled Potential Wetland Habitats, Five State Summary (acres)

State	Open Water to Shallow Marsh	Shallow Marsh to Sedge Meadow	Sedge Meadow to Wet Prairie	Wet Savanna	Wet Forest	Fen	Total Projected Wetland Habitat[1]
IA	65,820	18,776	288,403	42,115	165,989	0	581,816
IL	13,781	114,769	163,150	6,495	76,391	11	374,652
MN	147,388	22,831	74,669	4,351	39,912	1,577	290,731
MO	17,757	47,167	40,237	30,636	50,301	0	186,098
WI	69,460	43,561	65,116	34	53,622	0	231,794
Total	**314,205**	**247,104**	**631,576**	**83,630**	**386,215**	**1,588**	**1,665,090**
%	19	15	38	5	23	0	100

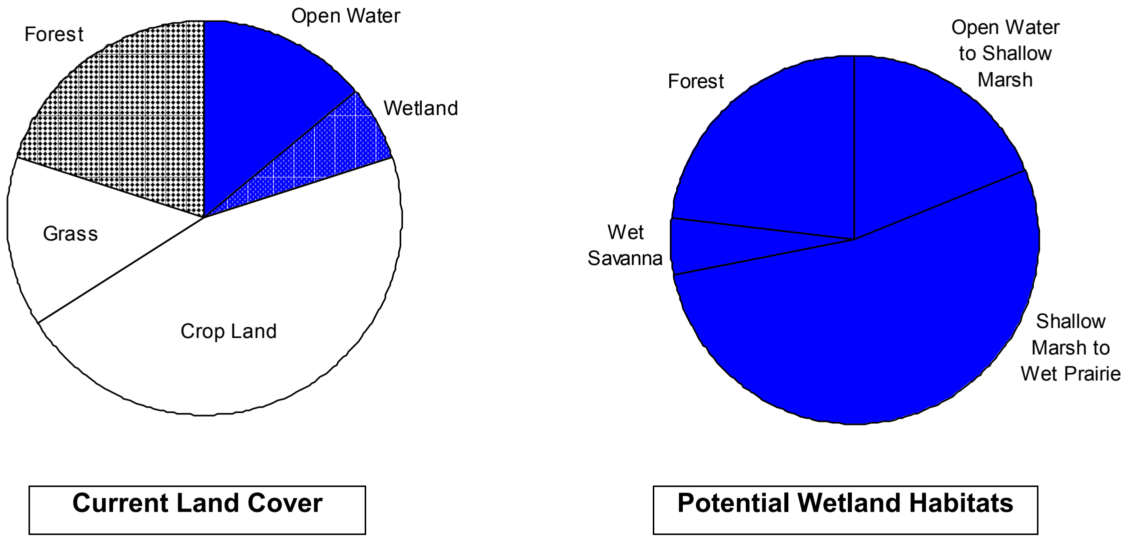
[1]Urban land use areas are not included in this total.

A comparison between the current land cover and the potential wetland habitats shows that of the 1.7 million acres of land that would naturally support wetlands, only 628,000 acres, or 37 percent, currently do so (Figure 5). This suggests that about 1.1 million acres, or 63 percent of the landscape, could be restored to wetlands. A major portion of this area is currently used for row crops, grass or hay (963,000 acres).

Wetland restoration or creation is only projected on areas underlain by hydric soil or NWI wetlands. It is likely that small regions of higher elevations in the flood corridor not underlain by hydric soil or NWI wetlands could revert to wet prairie or prairie if they were not farmed. This would provide additional wildlife habitat, but no estimate of their size or areal extent was made.

A variety of hydrologic factors acting on this region in any one year may change the distribution of potential wetland habitats shown. In years of above average precipitation or during times of flooding, the entire area would support deeper water environments. Floodwaters also may be retained for extended periods of time resulting in a system of backwater lakes, ponds and channels adjacent to the main river. It is also possible that fauna (e.g., beavers) returning to these corridors would increase their water storage capacity.

Figure 5. Comparison of Current Land Cover to Potential Wetland Habitats in the sampled counties



Flood storage capacity

The foregoing landscape analysis was based on a sample of 24 percent of the 100-year flood zone. Approximately 4.4 million acres of flood zone were sampled, out of the 18.4 million estimated in the five-state region (Table 3). In the sampled flood zone, some 38 percent of the flood zone contains NWI wetlands or hydric soils (Table 3); therefore, managed use of this land for floodwater storage could provide a minimum of 9.6 million acre-feet (one acre covered by a foot of water) of floodwater storage (Table 6). This assumes that the 570,000 acres within levee districts could be managed to hold an average column of water 10 feet deep per acre of land, and that 1.3 million acres outside the levees underlain by NWI wetlands or hydric soils could be managed to retain a column of water 3 feet deep per acre of land.

Table 6. Wetland Flood Storage Area and Volume in Sampled 100-Year Flood Zone							
State	Sampled 100-Year Floodzone[a] (acres)	Potential Flood Storage Area (acres)			Potential Flood Storage Volume (acre-feet)		
		Area in Levees[b]	Area not in Levees[c]	Total[d]	Volume in Levees[e]	Volume not in Levees[f]	Total[g]
IA	1,809,480	43,149	563,305	606,455	431,492	1,689,916	2,121,408
IL	891,820	376,516	122,463	498,979	3,765,160	367,390	4,132,550
MN	537,320	0	295,769	295,769	0	887,307	887,307
MO	607,765	149,055	96,364	245,419	1,490,555	289,091	1,779,646
WI	512,701	0	233,377	233,377	0	700,132	700,132
Total	**4,359,086**	**568,721**	**1,311,279**	**1,879,999**	**5,687,207**	**3,933,836**	**9,621,043**

[a] Calculate using the county FEMA Q3 data. In Iowa, the alluvial layers was used to approximate the Q3 data.

b Total area of the levees in the dataset from the US Army Corps of Engineers within the 100-year flood zone of sampled counties

[c] Total areal extent of the NWI wetlands or hydric soils within the 100-year flood zone, not including the managed major river flood zone or the levee districts.

[b] Calculated by adding the area of NWI wetland or hydric soil in the flood zone not in the levee districts or the major river flood zone to the total levee area within the 100-year flood zone (Table 3).

[e] Calculated by multiplying the sampled potential flood storage area in levees by a 10-foot column of water

[f] Calculated by multiplying the sampled potential flood storage area not in levees by a 3-foot column of water

[g] Calculated by summing the flood storage in the leveed area with the flood storage in the unleveed area

Five-state Watershed

To extrapolate the sampled flood storage area to the entire five-state watershed, the total 100-year flood zone for the five-state watershed was estimated. It amounts to 18.4 million acres of land. According to the U.S. Army Corps of Engineers, 2.4 million acres of this is protected by levees, leaving another 16 million acres unleveed. If the entire 100-year flood zone were to be used for flood storage, more than 72 million acre-feet of water could be stored (Table 7). This is a substantial volume of flood storage, 1.8 times greater than the flood volume that caused the flood damage during the 1993 catastrophic flood in the Upper Mississippi River basin. The 39 million acre-feet of water that resulted in the $16 billion flood damage in 1993 was accumulated over an 80-day period. To avoid the flood damages of ’93, this volume of water would need to be stored for the 80 days, and it could be.

If, however, flood storage were allowed only in all the leveed areas plus the current and drainedwetlands in the unleveed available flood zone, then approximately 40 million acre-feet of storage would be available (Table 8). This is more than enough storage for the volume of excess flood waters generated during the 1993 flood. The areal extent of the land area used with these two flood storage strategies is shown in Figure 6.

Table 7. Maximum Flood Storage Available in 100-Year Flood Zone, Extrapolated to the Five-State Region						
	Flood Storage Area (acres)			Flood Storage Volume (acre-feet)		
State	Total 100-Year Flood Zone Estimate[a]	Leveed Area[b]	Unleveed Area Estimate[c]	In Leveed Area[d]	In Unleveed Area[e]	Total[f]
IA	6,949,225	380,000	6,569,225	3,800,000	19,707,675	23,507,675
IL	2,360,821	550,000	1,810,821	5,500,000	5,432,463	10,932,463
MN	2,305,215	390,000	1,915,215	3,900,000	5,745,645	9,645,645
MO	4,821,414	1,040,000	3,781,414	10,400,000	11,344,242	21,744,242
WI	2,012,425	2,000	2,010,425	20,000	6,031,275	6,051,275
Total	**18,449,100**	**2,362,000**	**16,087,100**	**23,620,000**	**48,261,301**	**71,881,301**

[a] Calculated using the county FEMA Q3 data where available. In counties where Q3 data was not available, the Q3 area was estimated using neighboring counties. In Iowa, the alluvial layer was used to approximate the Q3 data.

[b] U.S. Army Corps of Engineers

[c] Calculated as the difference between the total state area in UMR 100-year flood zone and the leveed area within the UMR 100-year flood zone

[d] Calculated by multiplying the leveed area within the 100-year flood zone by a 10-foot column of water

[e] Calculated by multiplying the unleveed area within the 100-year flood zone by a 3-foot column of water

[f] Sum of the flood storage volume in the leveed area with the flood storage volume in the unleveed area

Table 8. Wetland Flood Storage Area and Volume Extrapolated to the Five-State Region								
	Unleveed Flood Zone in Sample			Extrapolated to Five-State Region				
						Unleveed Wetland Flood Storage		
State	Total[a] (acres)	(acres) [b]	(percent) [c]	Total Flood Zone[d] (acres)	Unleveed Flood Zone[e] (acres)	Unleveed Wetland Flood Storage Volume[f] (acre-feet)	Storage Volume[g] (acre-feet)	Watershed Flood Storage Volume[h] (acre-feet)
IA	1,750,091	551,247	31	6,569,225	2,069,186	6,207,559	3,800,000	10,007,559
IL	446,145	152,879	34	1,810,821	620,507	1,861,521	5,500,000	7,361,521
MN	536,108	295,769	55	1,915,215	1,056,618	3,169,855	3,900,000	7,069,855
MO	414,479	96,364	23	3,781,414	879,155	2,637,464	10,400,000	13,037,464
WI	512,701	233,377	46	2,010,425	915,129	2,745,386	20,000	2,765,386
Total	**3,659,523**	**1,329,635**	**36**	**16,087,100**	**5,540,595**	**16,621,786**	**23,620,000**	**40,241,786**

[a]Sampled 100-year flood zone minus the leveed area (see Table 3)

[b]NWI wetland or hydric soil in flood zone, not in levee districts (see Table 3)

[c]Calculated by dividing the sampled wetland area in the unleveed flood zone by the total unleveed flood zone

[d]See Table 7

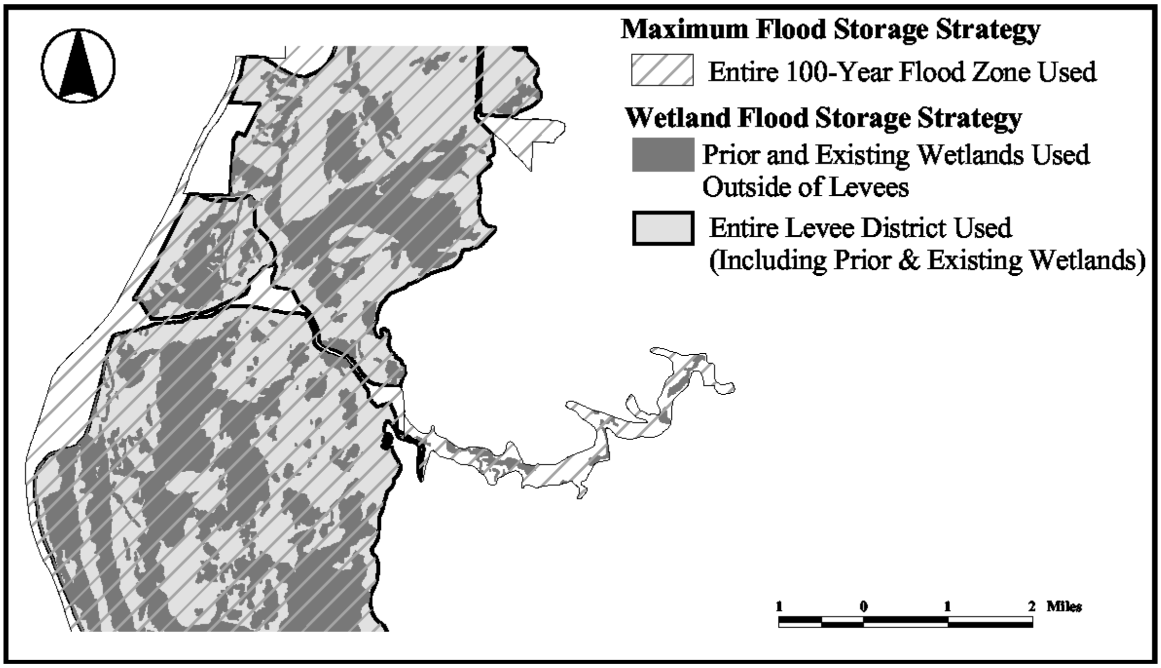
[e]Calculated by multiplying the watershed unleveed flood zone by the percent of wetland unleveed flood zone

[f]Calculated by multiplying the unleveed wetland area in watershed by a 3-foot column of water

[g]From Table 7

[h]Calculated as the sum of the leveed watershed flood storage and the unleveed watershed wetland flood storage

Figure 6. Illustration of Flood Storage Strategies.



Extrapolation of cropland in the sampled counties to cropland in the five-state watershed suggests that more than 7 million acres of cropland are present within the 100-year flood zone of the five-state watershed (Tables 9,10). Much of this area is likely underlain by drain tiles and bordered by drainage ditches, which rapidly move excess water off the land, contributing to the flood peaks and flood damage losses downstream. In addition, these crops are grown on flood prone lands, and are themselves at risk to flooding.

Hydric soil and NWI wetland were documented over 41 percent of the 100-year flood zone of the sampled counties. Extrapolating this to the five-state watershed suggests that nearly 7 million of the 18 million acres of 100-year flood zone are underlain by drained or current wetlands.

Approximately 43 percent of the sampled wetland area has been converted to cropland in the 100-year flood zone. Extrapolating this percent to the watershed indicates that nearly 3 million acres of cropland currently reside on drainedwetlands (Table 11).

Table 9. Sampled Leveed Cropland Extrapolated to the UMR Watershed						
State	Sampled 100-Year Floodzone (acres)	Sampled Leveed Flood Zone[a] (acres)	Sampled Cropland within Leveed Flood Zone[b] (acres)	Sampled Cropland in Leveed Flood Zone[c] (percent)	Watershed Leveed Flood Zone[d] (acres)	Extrapolated Watershed Cropland within Leveed Flood Zone[e] (acres)
IA	1,809,480	59,389	28,871	49	380,000	184,729
IL	899,621	453,477	307,483	68	550,000	372,931
MN	537,320	1,212	3	0	390,000	965
MO	607,765	193,286	149,628	77	1,040,000	805,093
WI	512,701	0	0	0	2,000	0
Total	**4,366,888**	**707,364**	**485,985**	**69**	**2,362,000**	**1,363,718**

Table 10. Sampled Unleveed Cropland and Total Cropland Extrapolated to the UMR Watershed								
State	Sampled 100-Year Floodzone (acres)	Sample Unleveed Flood Zone[f] (acres)	Sampled Cropland in Unleveed Flood Zone[g] (acres)	Sampled Cropland in Unleveed Flood Zone[h] (percent)	Watershed Unleveed Flood Zone[i] (acres)	Extrapolated Watershed Cropland within Unleveed Flood Zone[j] (acres)	Extrapolated Watershed Cropland within Leveed Flood Zone[k] (acres)	Total Watershed Cropland in 100-Year Flood Zone[l] (acres)
IA	1,809,480	1,750,091	701,367	40	6,569,225	2,632,685	184,729	2,817,414
IL	899,621	446,145	202,620	45	1,810,821	822,398	372,931	1,195,329
MN	537,320	536,108	94,613	18	1,915,215	338,000	965	338,965
MO	607,765	414,479	141,591	34	3,781,414	1,291,774	805,093	2,096,866
WI	512,701	512,701	146,902	29	2,010,425	576,038	0	576,038
Total	**4,366,888**	**3,659,523**	**1,287,093**	**35**	**16,087,100**	**5,660,895**	**1,363,718**	**7,024,613**

Table 9,10. Notes

[a]Total leveed area within the sampled counties, data from the US Army Corps of Engineers

[b]Total amount of crop land identified on the state land cover maps within the levee district boundaries

[c]Calculated by dividing the sampled cropland within the leveed flood zone by the total sampled leveed flood zone

[d]Calculated using the levee database from the US Army Corps of Engineers

[e]Calculated by multiplying the watershed leveed flood zone by the percent cropland in the leveed flood zone

[f]Calculated by subtracting the sampled leveed flood zone from the sampled 100-year flood zone

[g]Determined from the state land cover map

[h]Calculated by dividing the sampled cropland in the unleveed flood zone by the total sampled unleveed flood zone

[i]Calculated by subtracting the watershed leveed flood zone from the total watershed 100-year flood zone (see Table 7)

[j]Calculated by multiplying the watershed unleveed flood zone by the percent cropland in the unleveed flood zone

[k]The sum of the extrapolated leveed cropland and the extrapolated unleveed cropland

Table 11. Cropland on Drained Wetlands Extrapolated to the Watershed

State	Extrapolated Watershed 100-Year Flood Zone[a] (acres)	Sampled 100-Year Flood Zone[b] (acres)	Wetlands in Sampled Area[c] (acres)	Sampled Flood Zone that is Wetland[d] (percent)	Wetlands Area Extrapolated to the Watershed[e] (acres)	Sampled Cropland on Drained Wetlands[f] (percent)	Cropland on Drained Wetlands Extrapolated to Watershed[g] (acres)
IA	6,949,225	1,809,480	577,074	32	2,216,224	41	919,723
IL	2,360,821	899,621	380,739	42	999,149	73	733,236
MN	2,305,215	537,320	295,769	55	1,268,911	14	179,914
MO	4,821,414	607,765	187,135	31	1,484,545	56	831,341
WI	2,012,425	512,701	233,377	46	916,039	30	275,303
Total	**18,449,100**	**4,366,888**	**1,674,093**	**41**	**6,884,868**	**43**	**2,939,517**

[a] Calculated using the county FEMA Q3 data where available. In counties where Q3 data was not available, the Q3 area was estimated using neighboring counties. In Iowa, the alluvial layer was used to approximate the Q3 data.

[b] Calculated using the county FEMA Q3 data. In Iowa, the alluvial layers was used to approximate the Q3 data.

[c]Total area of NWI and Hydric Soil in the sampled flood zone. See Table 3.

[d]Calculated by dividing the wetlands in sampled area by the sampled 100-year flood zone

[e]Calculated by multiplying the extrapolated watershed 100-year flood zone by the percent of sampled flood zone that is wetlands

[f]Using the data on Table 4, calculated by dividing the cropland area by the total land cover area

[g]Calculated by multiplying the wetlands area extrapolated to the watershed by the sampled percent cropland on wetland area

ECONOMIC ANALYSIS

After identifying potential flood storage areas and volumes, researchers sought to evaluate the social economic efficiency of converting cropland to wetlands (referred to as cropland conversion) in the 100-year flood zone. Namely, would the social benefits of this conversion outweigh the social costs? Thus, for each county in the study, annual net social benefits of cropland conversion were computed and defined as follows:

Annual Net Social Benefits = Social Benefits (annual reduction in flood-related crop damages + annual reduction in governmental crop subsidies + annual non-flood related wetland benefits) – Social Costs (annual average rental income + annual wetland construction and operating costs)

Social Benefits

The following social benefits of cropland conversion were evaluated:

- Annual reduction in flood-related crop damages
- Annual reduction in governmental crop subsidies
- Annual non-flood related wetland benefits

Other potential social benefits of cropland conversion that were not evaluated in this report are the potential net income from operating wetlands as nutrient farms and the economic and ecological benefits of reduced nutrient loading to Gulf of Mexico. If evaluated net social benefits of cropland conversion are positive, then it is not necessary to estimate other potential social benefits of cropland conversion because conversion would be socially efficient even without the other potential social benefits. On the other hand, if evaluated net social benefits of cropland conversion are negative, then cropland conversion would not be socially efficient unless the other potential social benefits exceeded the amount by which net social benefits is negative. Hence, if evaluated net social benefits are negative, it would be necessary to estimate the other potential benefits of cropland conversion in order to determine whether or not cropland conversion is socially efficient.

The three components of social benefits were estimated using the procedures described below.

Reduction in flood-related crop damages

Cropland conversion avoids crop damages due to flooding. Avoided flood-related crop damages are a benefit of cropland conversion. Total expected mean annual flood damages to cropland was estimated by the sum of expected mean annual flood damages to cropland that is protected by levees, and expected mean annual flood damages to cropland that is not protected by levees. Expected mean annual flood damages to cropland that is protected by levees equals per-acre flood damages to cropland protected by levees times cropland acreage in the 100-year flood zone that is protected by levees. Expected mean annual flood damages to cropland that is not protected by levees equals per-acre flood damages to cropland not protected by levees times cropland acreage in the 100-year flood zone that is not protected by levees.

Cropland acreages with and without levee protection were estimated using the state land cover maps and the levee district locations from the U. S. Army Corps of Engineers. Flood damage to crops was represented by the cost of replanting. The expected annual damages were estimated for leveed land and non-leveed lands. For the leveed lands, only the 100-year flood damage, total crop loss, was assumed. The estimated annual damages, consequently, were the replanting cost multiplied by 0.01, the probability of the 100-year flood level. As a conservative estimate, all leveed lands were assumed to be protected up to the 100-year flood. For the unleveed lands, the 100-year flood damage was computed as for the leveed lands. The expected annual damage, however, was estimated using the probability distribution of flooding derived from the USGS regional equations. The upper limit of these relationships was set at the 100-year flood level and the mean annual flood damage estimated by assuming the area under the probability curve. The lower limit for flood damage was set at the mean annual flood for which no damage occurred, thus defining the flood frequency curve and flood damage curve (Ries, 2002).

The total estimated replanting costs were determined to be $298 per acre. The costs were assumed to be similar throughout the five-state region. No structural damage was assumed to occur either on the leveed or unleveed land. This is not to say that overtopping the levees would not result in damages during a 100-year flood event or that any structures in the flood zone for either the leveed or unleveed lands would not be damaged by flooding. In large part, these assumptions appear valid for the sampled counties in the five state region.

The probability distribution ranged from the mean annual flood (0.429) to the 100-year flood (0.010). Based on the USGS flood frequency for each state, a discharge distribution was calculated. This, in turn, was converted into a stage distribution. The stages were then used to pro-rate the damages based on the 100-year flood. The mean annual flood was assumed to cause no damage and the 100-year flood the maximum damage. Table 12 gives the damages for each state by mean annual flood probability.

Table 12. Probability and Damage Distribution

Probability for Mean Annual Flood	Damage Distribution (Dollars)				
	IL	IA	MN	MO	WI
0.429	0	0	0	0	0
0.200	79	65	58	76	67
0.100	132	117	113	123	120
0.040	199	187	174	190	192
0.020	249	240	232	242	245
0.010	298	298	298	298	298

An exponential function was used to convert discharge to stage of the form $y=a(q)^b$ where y equals stage, q equals discharge, a equals 1.34, and b equals 0.24. This is a general form for the hydraulic characteristics of moderate to mildly sloped rivers in the Midwest. Each of the stages associated with a probability value was divided by the stage achieved by the 100-year flood. These normalized stages were used to pro-rate the damages from 0 at the mean annual flood to the 100-year flood. Then, the exponential function of damage and probability was developed. Again, this function took on the exponential form: $z=c(x)^d$. The coefficients and exponents for each of the five states are given in Table 13.

Table 13. Coefficients and Exponents for Five States									
Illinois		Iowa		Minnesota		Missouri		Wisconsin	
C	d	c	d	c	d	c	d	c	d
125.28	-0.43	81.88	-0.50	70.71	-0.53	99.58	-0.45	86.72	-0.49

Using these functions, the area bounded by each curve was computed. This area represents the mean annual per acre damage (Table 14). These values range from a high of $73 per acre for the state of Illinois to a low of $53 per acre for Minnesota. The mean annual flood damage per acre within the 100-year flood zone is approximately $60 per acre. The value for each state was used to compute total expected mean annual cropland damages in Table 15.

Table 14. Mean Annual Flood Damages, Five States	
State	$
IA	56.51
IL	72.66
MN	53.05
MO	60.39
WI	58.06
Mean	60.13

Reduction in crop subsidies

Cropland conversion eliminates the need for governmental crop subsidy payments on converted acreage. The savings in crop subsidy payments is a social benefit of cropland conversion. Reductions in crop subsidy payments were estimated by multiplying the average annual per acre USDA total subsidy payment for cropland in the county published by the Environmental Working Group (2004) and cropland acreage in the 100-year flood zone. Average annual per acre crop subsidy payments vary substantially across counties within a state and across states.

Non-flood related wetland benefits

Cropland conversion generates a variety of wetland benefits. These benefits were estimated by multiplying annual average user benefits per wetland acre and cropland acreage in the 100-year flood zone. Annual average user benefits per wetland acre were determined by annualizing the median present values of non-marketed goods produced by wetlands estimated by Heimlich et al. (1998) and updating them to 2002 using the Consumer Price Index for all items. Updated median per-acre present values of wetlands (based on the 50-year time horizon and 6 percent discount rate used in the Heimlich et al. study) are $623 for general users, $362 for fishing, $1,031 for hunting and $244 for recreation, which amounts to a total median present value of $2,260 per acre. These present values were annualized using a 50-year time horizon at 6 percent discount rate resulting in an estimated annual average non-flood related wetland benefit of $217.94 per acre. Total non-flood related wetland benefits are the product of $217.94 per acre and cropland acreage in the 100-year flood zone.

Social Costs

The following social benefits of cropland conversion were evaluated:

- Loss in cash farm rents (loss in net farm income)
- Wetland construction and maintenance costs

The two components of social costs were estimated using procedures described below.

Annual average rental income

Conversion of cropland to wetland results in agricultural economic losses equal to the net income earned on the cropland. Net income per cropland acre was approximated by average cropland rental rates for each state. Annual average rental income for cropland was estimated by multiplying the annual average per-acre cropland rental rate in 2003 for each state reported by the National Agricultural Statistical Survey Service (2003) by cropland acreage in the 100-year flood zone. Annual average per-acre cropland rental rates used in the estimation of cropland rental income were $68 for Wisconsin, $82 for Minnesota, $103 for Iowa, $110 for Illinois, and $122 for Missouri in 2003.

Annual wetland construction and operating costs

Conversion of cropland to wetland entails wetland construction and operating costs. Wetland construction cost was set equal to $1,000 per acre, which is the cost estimated by Shultz and Leitch (2003) for constructing a medium-sized wetland. The present value construction cost was annualized based on a 20-year lifetime and 5 percent interest rate to obtain an annual average wetland construction cost of $80 per acre. Operating cost is set equal to $40 per acre per year, which was determined by updating the $26 per acre per year operating cost reported by Hey (1998) to 2003 using the Consumer Price Index for all items. Per-acre annual average wetland construction and operating costs equal the sum of annual average wetland construction cost of $80 per acre and annual average operating cost of $40 per acre, respectively, or a total annual average cost of $120 per acre per year, times cropland in the 100-year flood zone.

Other Assumptions and Considerations

The long-term goal of this flood reduction strategy is to remove from the 100-year flood zone any economic activity that can be damaged by flooding. In this study, the focus is on the economic activity pertaining to cultivated land. Row crops are an economically significant activity in the 100-year flood zone of the five-state region. Conversion of pasture and hay to wetland would provide habitat benefits, although no damage costs would be incurred by leaving the hay and pasture in the 100-year flood zone. The costs/benefits of this conversion are not included in this study because the economic activity associated with this practice is small in relation to row crops. Also, in the process of converting to wetland, some of the current pasture and hay would become wetland. In the same manner, some of the current row crops could become pasture and hay. Although the amounts would not be equal, they may be close enough to cancel out any economic effects.

There are already exisiting wetlands and forest lands in the 100-year flood zone. It was assumed that these existing open lands are currently being utilized for social and wildlife benefits. This study, then, focuses on the incremental social and wildlife benefits and/or costs related to the conversion of cropland to wetland, and not the total wetland benefit for the region.

Not all the cropland in the 100-year flood zone would convert easily to wetland because it is not all underlain by hydric soil and NWI wetland. Cropland that would not convert to wetland could be managed for hay and pasture or as open prairie, producing income for the landowner.

All levees in the 100-year flood zone were included in the economic analysis section of this study, regardless of presence of urban development.

Results and Conclusions

Total estimated social benefits and costs of converting cropland to wetland in the sampled 100-year flood zone are reported in Tables 15 and 16. Estimated total annual net benefit of cropland conversion for all counties in the study area is $121,761,49 or $68 per acre. Net estimated annual social benefit by county are reported for each state (see state report sections). Annual net social benefits of cropland conversion are positive for all counties in all five states, except for in St. Louis County (MO), where net benefits are -$11,434. [5]Since estimated net social benefits of cropland conversion are positive, it is not necessary to evaluate other potential benefits of cropland conversion. Annual social benefits and costs were estimated assuming all cropland acreage in the 100-year flood zone is converted to wetlands.

Results of the benefit-cost analysis imply that cropland conversion is socially efficient in the study area and for the study area as a whole. It appears, therefore, that society would be better off if cropland acreage in the 100-year flood zone in the study area was converted to wetlands than if it remained in cropland.

It should be noted that this report only evaluates the social efficiency of cropland conversion in the 100-year flood zone of the study area. It is possible for cropland conversion to be *socially efficient* (positive annual net social benefits), but *privately inefficient* (cropland conversion decreases net private returns to landowners) when landowners cannot capture all of the social benefits of cropland conversion. For example, if the only social benefits landowners can capture are the reductions in expected mean annual cropland damages due to flooding and 50 percent of the non-flood related wetland benefits of cropland conversion, then average annual net private benefit of cropland conversion would equal -$84.84 per acre, whereas net social benefit would be $74 per acre. In this case, cropland conversion to wetland would reduce average annual returns to landowners by about -$85 per acre, even though it would increase annual average net social benefits by $74 per acre. In this case, conversion is not likely to occur unless the government subsidizes the conversion through programs such as the Wetland Reserve

[5] Social benefits tend to be lower for cropland conversion in leveed areas because expected mean annual damages are lower in leveed areas. Approximately 88 percent of the 100-year flood zone in St. Louis County is behind levees.

Program, and/or crop producers can earn additional income by selling nitrogen credits produced by the wetlands (e.g., nutrient farming) (Hey, 2002).

This report does not evaluate the economic impacts of cropland conversion in terms of changes in total economic output, household income, and employment for counties in the study area. An economic impact analysis of cropland conversion would require a different analysis. Based on this report, it is not possible to say whether cropland conversion would have positive or negative economic impacts on the economies of counties in the study area.

The estimated mean annual flood damage values are likely to be less than what has been experienced in the region. First of all, no structural damage was included in these estimates. Homes, barns and corncribs were assumed to be non-existent within the 100 year flood zone. Still, some of these structures were observed in the areal photographs used to interpret the land cover. Secondly, the assumption that no structural damage occurred to the levees or farmed fields during a 100-year event likely understates the flood damage costs. During the 1993 flood, over $55 million of flood damage was incurred due to the failure of levees. This cost, by the way, did not reflect the damage done to the farm fields by the sand and gravel washed over them due to catastrophic failure of the levee.

Despite these assumptions, the estimate of flood damage still indicates a significant amount of social cost due to flooding of these agricultural areas. The cessation of farming within the FEMA flood zone would yield a social benefit to the community at large.

The economic analysis clearly indicates that the social benefits far outweigh the social costs. Expressed in more traditional terms, the benefit/cost ratio is 1.3:1. This would more than justify federal investment in this land conversion. The economic analysis indicates that society as a whole would benefit by such conversions. This analysis will need to be done at a later date. Further, the economic analysis did not consider alternative economic uses of the created, restored wetlands. One such use could be for nitrogen and phosphorus control. Most of these flood corridors drain intensively used agricultural lands which net large aqueous loads of nitrogen and phosphorus. Restored wetlands within the corridor could provide the landscapes for trapping, sequestering and recycling these nutrients in a safe and beneficial manner. In the end, these nutrients would not find their way into downstream lakes or ultimately into the Gulf of Mexico. This would be a substantial benefit for the fishing industry in the Gulf of Mexico, where large-scale areas of the Gulf are now considered dead, as well as improving fish habitat in the reaches of rivers between the point of emission and the Gulf and all of the interconnected lakes. Adding the potential income-producing activities of nutrient farming, could make these restored wetlands worth a considerable amount of money and value to the local landowner.

If social costs and benefits were extrapolated for the five-state region, the total annual projected net social benefit would equal $494 million (Tables 17 and 18). Iowa, particularly, would benefit, receiving $239 million in social benefit.

Table 15. Total Estimated Social Benefits of Converting Cropland to Wetland in 100-year Flood Zone

State	Cropland in 100-year flood zone	Leveed cropland in 100-year flood zone	Un-leveed cropland in 100-year flood zone	Benefits: Expected mean annual damages to leveed cropland		Expected mean annual damages to un-leveed cropland		Total expected mean annual cropland damages	Annual reduction in crop subsidies		Non-flood related wetland benefits		Total annual benefits
	(acres)			($/acre)[a]	($)[b]	($/acre)[a]	($)[c]	($)[d]	($/acre)	($)[e]	($/acre)	($)[f]	($)[g]
IA	730,238	28,871	701,367	2.98	85,986	56.51	39,634,249	39,720,236	36.85	28,509,795	217.94	159,148,056	227,378,087
IL	510,103	307,483	202,620	2.98	915,776	72.66	14,722,363	15,638,139	28.51	13,597,521	217.94	111,171,770	140,407,430
MN	94,613	3	94,610	2.98	9	53.05	5,019,079	5,019,087	21.36	2,092,733	217.94	20,620,031	27,731,851
MO	291,219	149,628	141,591	2.98	445,637	60.39	8,550,669	8,996,306	25.11	6,840,370	217.94	63,468,227	79,304,903
WI	146,902	0	146,902	2.98	0	58.06	8,529,130	8,529,130	17.84	2,923,150	217.94	32,015,836	43,468,116
Total	**1,773,075**	**485,985**	**1,287,090**	**2.98**	**1,447,408**	**60.13**	**76,455,490**	**77,902,898**	**25.94**	**53,963,569**	**217.94**	**386,423,920**	**518,290,387**

a. Estimated by Donald Hey, The Wetlands Initiative.

b. Leveed cropland in 100-year flood zone times expected mean annual damages per acre to leveed cropland.

c. Un-leveed cropland in 100-year flood zone times expected mean annual damages per acre to un-leveed cropland.

d. Sum of expected mean annual damages to leveed cropland and expected mean annual damages to un-leveed cropland.

e. Average crop subsidy payments per acre times cropland in 100-year flood zone. Average crop subsidy payment per acre equals total USDA subsidy payments estimated by the Environmental Working Group divided by total cropland acreage in 100-year flood zone for the county (http://www.ewg.org/farm/progdetail.php?fips=19000&progcode=total&page=county).

f. Average user benefits per wetland acre times cropland in 100-year flood zone. Average user benefits determined by annualizing the median present values of non-marketed goods produced by wetlands, including general users ($623), fishing ($362), hunting ($1,031) and recreation ($244). Present values are for 1992 (Heimlich et al. 1998) and updated to 2002 using the Consumer Price Index for all items. Annualized values per acre based on 6 percent discount rate and 50-year evaluation period. Heimlich, R.E., K.D. Wiebe, R. Claassen, D. Gadsby and R.M. House. 1998. Wetlands and Agriculture: Private Interests and Public Benefits. Agricultural Economics Report No. 765, Economics Research Service, USDA, Washington, D.C.

g. Sum of total expected mean annual damages to cropland, annual reduction in crop subsidies and non-flood related wetland benefits.

Table 16. Total Estimated Social Costs and Annual Net Benefit of Converting Cropland to Wetland in 100-year Flood Zone

State	Cropland in 100-year flood zone	Leveed cropland in 100-year flood zone	Un-leveed cropland in 100-year flood zone	Costs					Annual Net Benefit
				Annual average rental income		Annual wetland construction and operating costs		Total annual costs	
	(acres)			($/acre)	($)[h]	($/acre)	($)[i]	($)[j]	($)[k]
IA	730,238	28,871	701,367	103	75,214,508	120	87,628,553	162,843,061	64,510,665
IL	510,103	307,483	202,620	110	56,111,291	120	61,212,317	117,323,608	23,083,822
MN	94,613	3	94,610	82	7,758,294	120	11,353,601	19,111,895	8,619,956
MO	291,219	149,628	141,591	122	35,528,695	120	34,946,257	70,474,952	8,829,951
WI	146,902	0	146,902	68	9,989,340	120	17,628,248	27,617,588	15,850,528
Total	**1,773,075**	**485,985**	**1,287,090**	**97**	**184,602,128**	**120**	**212,768,976**	**397,371,104**	**120,919,283**

h. Annual average rental income per acre times cropland in 100-year flood zone.

i. Wetland construction cost of $1,000/acre is for a medium-sized wetland taken from: Shultz, S.D. and J.A. Leitch. 2003. The feasibility of restoring previously drained wetlands to reduce flood damage. Journal of Soil and Water Conservation 58: 21-29. Annualized wetland construction cost is $80/acre based on a 20-year time horizon and 5 percent interest rate. Operating cost of $40/acre is determined by updating the $26/acre operating cost to 2003 using the Consumer Price Index. $26/acre operating cost taken from Hey, D. L. 1988. Wetlands: a future nonpoint pollution control technology. Technical Publication Series No. 88-4, American Water Resources Association, Minneapolis, MN.

j. Annual average rental income plus annual wetland construction and maintenance costs.

k. Total annual wetland benefits minus total annual wetland cost.

Table 17. Total Estimated Social Benefits of Converting Cropland to Wetland Extrapolated to the UMRB 100-Year Flood Zone									
				Benefits					
State	Extrapolated cropland in watershed 100-year flood zone	Extrapolated leveed cropland in watershed 100-year flood zone	Extrapolated un-leveed cropland in watershed 100-year flood zone	Expected mean annual damages to leveed cropland	Expected mean annual damages to un-leveed cropland	Total expected mean annual cropland damages	Annual reduction in crop subsidies	Non-flood related wetland benefits	**Total annual benefits**
	(acres)			($)[b]	($)[c]	($)[d]	($)[e]	($)[f]	($)[g]
IA	2,817,414	184,729	2,632,685	550,494	148,773,017	149,323,511	103,826,070	614,027,244	867,176,825
IL	1,195,329	372,931	822,398	1,110,700	59,755,427	60,866,128	34,616,720	260,509,947	355,992,795
MN	338,965	965	338,000	2,875	17,930,911	17,933,785	7,241,431	73,874,121	99,049,337
MO	2,096,866	805,093	1,291,774	2,397,807	78,010,205	80,408,012	52,646,419	456,991,001	590,045,432
WI	576,038	0	576,038	0	33,444,790	33,444,790	10,278,925	125,541,811	169,265,527
Total	**7,024,613**	**1,363,718**	**5,660,895**	**4,061,875**	**337,914,351**	**341,976,226**	**208,609,566**	**1,530,944,124**	**2,081,529,916**

Table 18. Total Estimated Social Costs and Annual Net Benefit of Converting Cropland to Wetland Extrapolated to the UMRB 100-year Floodzone								
				Costs			**Benefits**	
State	Extrapolated cropland in watershed 100-year flood zone	Extrapolated leveed cropland in watershed 100-year flood zone	Extrapolated un-leveed cropland in watershed 100-year flood zone	Annual average rental income ($)[h]	Annual wetland construction and operating costs ($)[i]	Total annual costs ($)[j]	Total annual benefits ($)[g]	**Annual Net Benefit** ($)[k]
	(acres)							
IA	2,817,414	184,729	2,632,685	290,193,660	338,089,700	628,283,360	867,176,825	238,893,465
IL	1,195,329	372,931	822,398	131,486,162	143,439,450	274,925,612	355,992,795	81,067,183
MN	338,965	965	338,000	27,795,163	40,675,849	68,471,012	99,049,337	30,578,325
MO	2,096,866	805,093	1,291,774	255,817,666	251,623,934	507,441,600	590,045,432	82,603,833
WI	576,038	0	576,038	39,170,612	69,124,609	108,295,221	169,265,527	60,970,305
Total	**7,024,613**	**1,363,718**	**5,660,895**	**744,463,263**	**842,953,542**	**1,587,416,804**	**2,081,529,916**	**494,113,112**

HABITAT BENEFITS

Introduction

Since presettlement times, wholesale changes in land use have occurred across much of the five-state watershed in the UMR Basin. The current land cover was produced, almost entirely, by substituting rich, diversified ecological communities of native vegetation in wetlands, prairies, and forests for intensively farmed row-crops and other agricultural systems. This loss of natural plant communities and the over-simplification of land cover across broad watersheds resulted in drastic and severe hydrological and ecological impacts from the smallest streams, to the Mississippi River, and all the way to the Gulf of Mexico. The loss of natural plant communities has also resulted in a loss of diversity and abundance of birds.

In an attempt to determine how the ecological flood reduction strategy would affect the wildlife in the region, The Wetlands Initiative contracted with the Upper Mississippi Campaign of National Audubon for technical assistance. It was assumed that changes in the bird population could be used as an indicator for changes in the wildlife population as a whole.

Audubon's Important Bird Area (IBA) Programs, currently underway in 132 nations and in 46 states in the U.S, strive to: identify those habitats (IBAs) that are essential to the species of birds that are of highest conservation priority within the state; survey and monitor bird populations and habitat components, and create education programs at those IBAs, and; partner with public conservation agencies, private conservation organizations, corporations, and individual landowners to achieve maximum long-term protection, restoration, enhancement and improved management of those IBAs. The IBA coordinators for the five states in this study have provided a species analysis for this study, which includes the following:

- Bird species currently using the cropland, forest, and open water land-cover types within the 100-year flood zone;
- Bird species expected to use restored wetland habitats of three primary types: shallow marsh/sedge meadow; sedge meadow/wet prairie; and wet savanna;
- Comparison of the avifauna using the cropland land cover with the avifauna expected to use the three types of restored wetlands.

Methods

Birds are the most readily visible and most easily counted form of wildlife. Thus, birds have gained great popularity, and are well known among nature-oriented people—both professional and amateur biologists and naturalists. In recent years there has been an enormous increase in data and overall understanding of the distribution and frequency of occurrence of birds across the entire United States. This report has relied upon the accumulated knowledge and wisdom of a large number of birders (many of them Audubon members or staff) who have contributed information that has enhanced this understanding.

Determining which species make use of dynamic habitats that often occur immediately adjacent to each other, especially for highly mobile and long-range migrating animals like birds, is challenging at best and problematic at the other end of the spectrum. It was recognized early on that establishing lists of species around artificial divisions of landscapes such as those used in this study almost inevitably creates opportunities for debate among field ornithologists, birders and conservationists. Yet these data were derived from excellent ornithological reference materials and from years of first-hand bird watching experience.

The Audubon analysis of the wildlife benefits of this activity is specific to those areas within the 100-year flood zone that are row crops, pasture or hay that will readily convert to wetland. This assumes the non-wetland prone land in the 100-year flood zone will be retained as agriculture land (which will not benefit the birds) and will not be managed as open prairie. Audubon's analysis focuses on the minimal wildlife benefit of converting only the cropland to wetland and does not include any potential benefits of converting crop land to prairie.

In each state, Audubon staff first identified species of birds currently using the existing cropland, forest and open water areas. Then, Audubon staff identified species of birds that would be expected to use three types of wetland habitat in the restored wetland complex. Birds use the biologically poor, man-created landscape that is cropland only infrequently or sporadically; however, the majority of bird species listed in the potential wetland habitats are *dependent* on each of the three specific wetland habitat types.

Each of the three wetland habitat types has a unique hydrological and ecological role to play. These communities are shown in order of the amount of water each normally has: open water to shallow marsh is the deepest and retains water for the longest length of time; shallow marsh to sedge meadow is medium in amount of water present and length of time water is retained; sedge meadow to wet prairie has the least water and retains it the shortest length of time.

Results and Conclusions

The presence or absence of birds and the diversity of the birds present explains much about a particular unit of property. Being highly visible and readily recognizable, birds are an excellent and relatively easy-to-use tool for measuring the health and sustainability of an ecological community. Where there are few kinds of wild birds there is usually *little* environmental or biological diversity, health, stability or ecological integrity. Where there are numerous kinds of wild birds, there is generally a *great deal* of environmental and biological diversity, health, stability and integrity.

In the critically important 100-year flood zones evaluated in this study, ecological functions are very closely correlated with hydrologic conditions. This is to say, there is a direct and very important connection between presence or absence of birds, and relative bird diversity, and the hydrologic functions of the ecosystem under consideration.

The contrast is dramatic when comparing the number of species of birds using cropland with the number of species of birds using wetland habitats that could be restored within the 100-year flood zones (Table 19). The number of bird families dramatically increases as well (Table 19). Currently the cropland within 100-year flood zone in the sampled 77 counties is being used by only 53 species of birds; 8 of these are species of high conservation concern or IBA Criteria species in the five states. However, the majority of these species are uncommon or rare in row crops, particularly the high conservation priority birds. Most of the species listed use cropland for foraging; very few occur as nesting species. Many of these birds, including all of the high conservation priority species, are more common on less intensively used agricultural lands such as lightly grazed pastures or old fields. In fact, the high conservation priority birds appear on the list largely because of the small grass component currently present. Therefore, cropland generally can be considered to be a species-poor environment. This is especially so when it is the dominant habitat type on the landscape. Each of the wetland habitat types considered supports much higher numbers of species and more high conservation priority birds.

When three wetland habitats are restored on the cropland acres, 120 bird species (2.3 times more species, including 50 high-priority species), are expected to use shallow marsh–sedge meadow wetlands; 90 bird species (1.7 times more species, and 32 high-priority species), are expected to use sedge meadow–wet prairie wetlands; and 66 bird species (1.2 times more species, 25 of which are high priority species), are expected to use wet savanna wetlands. Specific conclusions are given in each of the state chapters.

Table 19. UMRB Bird Summary

Habitat	Acres	%	Number of Species	Number of High Priority Species	Population
Today					
Cropland	739,100	44	53	8	Very low
Tomorrow					
Wetland Complex	962,300	58	145	62	Med-high
Shallow Marsh to Sedge Meadow	247,100	15	120	50	Med-high
Sedge Meadow to Wet Prairie	631,600	38	90	32	Med-high
Wet Savanna	83,600	5	66	25	Med-high

The major portions of this study were completed after the 2003 nesting season for birds was over, and no attempt was made to do exhaustive field investigations to analyze relative bird densities found in cropland situations or in each of the wetland habitat types that would be restored. It must be noted, however, that after decades of analysis, ornithologists, wetland ecologists, and other field researchers have an excellent understanding upon which to compare "before and after" plant communities, as well as "before and after" habitat use by various species of birds. Researchers have consistently and forcefully described, in both technical and popular publications, that simplified plant communities such as cropland (totally dominated by a single species such as corn, soybeans or alfalfa) are much less stable ecologically and support fewer species of birds and less bird density than do highly diversified plant communities such as wetlands (typically having hundreds of species of plants that vary in height, size, abundance, dominance, timing of fruiting cycle, and other important ecological characteristics) (Egan & Howell, 2001).

All technical evidence points to higher densities of birds of various species within good quality wetland habitats than those found in monoculture areas such as cropland. Wetland communities of various types also perform completely different and much more valuable hydrologic functions than do monoculture cropland areas. Thus the relative number of species of birds and the density of those bird populations can be a direct indicator of how well a unit of property provides valuable hydrological functions to the citizens of the nation such as flood reduction, removal of excessive nutrients, and other important and very inexpensive services.

CONCLUSIONS AND RECOMMENDATIONS

Currently, 41 percent of the 100-year flood zone in the five-state Upper Mississippi River basin is used for row crops, that is, 1.8 million acres of cropland in the sampled counties and 7.8 million acres extrapolated to the five-state watershed. This land use has contributed to the substantial flood losses experienced throughout the basin because the hydrology has been altered to support row crops. By restoring the hydrology of these areas, we could decrease flood peaks and flood damage costs, increase the wildlife biodiversity, and reduce the sediment and nutrient loads in the adjacent rivers and streams.

Restoring the hydrology in the system means disabling the drain tiles and drainage ditches that move excess water rapidly off the land. By retaining rainwater where it falls and storing floodwaters on the floodplain upstream, flood peaks will be reduced downstream. In addition, the wetland areas and levee districts could be managed for maximum floodwater storage when necessary. This strategy offers a more cost effective and a more environmentally sensitive solution to curbing flood damages.

If the entire 100-year flood zone in the five-state UMR watershed was used for flood storage, more than 72 million acre-feet of floodwaters could be stored. This estimate is based on an average column of water 10 feet deep in the levees and 3 feet deep outside the levees. This is a substantial volume of flood storage, 1.8 times more than the volume of water that caused the damage during the 1993 flood on the Upper Mississippi.

A second estimate of the flood storage capacity in this region can be done using only the existing and drained wetlands, as well as the levee districts within the 100-year flood zone. Using these lands, nearly 40 million acre-feet of floodwaters could be stored. This represents approximately 1.1 times the excess flood volume that occurred in 1993. In either case, storage of the floodwaters within the basin would result in a substantial decrease in the flood peaks and flood water volume in the river system at points near and far downstream. This decrease in flood peak and floodwater volume would also correspond to a decrease in flood damage costs.

In addition, conversion of the cropland within the 100-year flood zone of the five-state region could also result in a net annual social benefit savings of nearly $494 million related to crop damages. This includes savings in crop damage payments and crop subsidies.

Approximately 3.1 million acres, 40 percent of the cropland present in the 100-year flood zone of the five-state watershed, is situated on drainedwetlands, as determined by the areal extend of NWI wetlands and hydric soil. If this region was restored to its natural wetland habitat, it would provide a buffer between the existing agricultural lands and the river system. Since these flood corridors drain intensively used agricultural lands which net large aqueous loads of nitrogen and phosphorus, these restored wetlands could provide sites for trapping, sequestering and recycling these nutrients in a safe and beneficial manner. In the end, these nutrients would not find their way into downstream lakes or drinking water or ultimately to the Gulf of Mexico. This would be a substantial benefit for the fishing industry in the Gulf of Mexico, where large-scale areas of the Gulf are now considered dead, as well as improving fish habitat in the reaches of rivers between the point of emission and the Gulf and all of the interconnected lakes.

Conversion of the monotypic cropland cover of corn and beans (and pasture) to a more diverse system of prairie and marsh would also result in an increase in the regional wildlife habitat and diversity. An analysis of the change in bird population with this conversion suggests that 2.9 times more bird species would inhabit the marsh habitats than the crop land habitat. It is assumed that the population densities would increase as well. This increase in bird diversity and population density suggests a similar increase in diversity of all wildlife populations, from insects to mammals.

Several recommendations follow from this study. The first is that the economic benefits to the individual landowner who would convert the land use of the flood zone should be carefully considered. These benefits should include the potential for recreational income from the restored wetlands or converted agricultural lands as well as the potential for developing nutrient farms and selling nutrient credits to those who emit high levels of nitrogen, phosphorus or carbon.

Second, consideration needs to be given to the use of levees as flood control devices. The concept of using levees to permit passive flooding of protected areas during major flood events is not new. The 1994 "Blueprint for Change" report, prepared in response to the massive 1993 flood damage events in the basin, included such a strategy as one of its recommendations.[6] Yet details need to be considered. How and where would spillways be constructed in levees to allow floodwaters to enter the floodplain? At what cost and at what scale would these spillways need to be designed and constructed? What would be the most effective spatial distribution?

The third is to implement pilot projects in some of the sample areas of this study. The pilot projects should be at least as large as a county and should probably involve two or three counties, following a stream corridor from the watershed boundary down to its discharge with a major stream. Each pilot project should encompass approximately 10,000 to 20,000 acres of land and 15 miles of stream channel. Within the pilot project, varying land uses should be evaluated and the actual cost of restoring wetlands, providing flood storage, processing nutrients and attracting recreational uses should be explicitly explored. These pilot projects should track both the economic response as well as the environmental changes (e.g., water quality improvements as well as plant and wildlife changes). The results of the pilot project will help confirm the efficacy of this approach to flood control as well as help develop design, management and operations of such large scale environmental controls of flood damage and, ultimately, water quality and wildlife enhancement.

An example site for a pilot project is the Wapsipinicon River valley in Iowa, which offers both existing biological diversity and a great potential for restoration. In Buchanan, Cedar, Clinton, Jones, Linn and Scott counties, the 100-year flood zone along the Wapsipinicon River includes 244,000 acres. Approximately 74 percent of the flood zone is managed agricultural land, 132,000 acres of corn and beans and 49,000 acres of grass and hay. In addition, nearly 34 percent of the existing agricultural land is on drainedwetland (46,000 acres of corn and beans and 14,000 acres of grass and hay) and could provide more than 180,000 acre-feet of flood water storage. The Wapsipinicon

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6 Report of the Interagency Floodplain Management Review Committee to the Administration Floodplain Management Task Force. 1994. Sharing the challenge: Floodplain management into the 21st century. Part V. Washington, D. C., p. 170.

River system has also been identified as a high priority site by The Nature Conservancy, indicating that it captures the biological diversity of the region.

Other good candidates for early pilot projects include Pike or Greene counties, Illinois; Clark, Lincoln, or St. Charles counties, Missouri; Brown or Dakota counties, Minnesota; and Dane or Rock counties, Wisconsin. These counties each offer relatively high amounts of available flood storage volume and high levels of net social benefit from the cropland conversion.

Restoration and proper management of the Wapsipinicon River system, and other sites similar to it, will ensure the long-term survival of the native life and natural communities currently existing within the upper Mississippi River basin; provide additional sites for the native communities to return to and expand within; reduce flood damage costs by removing crop land that could be damaged and by providing storage for flood waters; and help increase water quality throughout the watershed.

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