THE WETLANDS INITIATIVE

Considering an ecological means to reduce flood damages in the Upper Mississippi River Basin

To truly solve the ecological problems facing the Upper Mississippi River Basin (UMRB), we need an ecological solution. Despite a century of massive capital investment in flood control structures across the basin's floodplain, flood damages have increased. Nearly 67% of the basin has been converted to an agro-ecosystem in which natural vegetation and drainage patterns have been highly altered to accomodate cultivated food and fiber crops (Audubon, 2000). These alterations and the accompanying loss of wetlands have contributed significantly to the ecological problems of flooding, degraded water quality, sediment and nutrient contamination, and loss of biodiversity.

The proposed ecological solution is to restore the natural hydrological functions within the unleveed 100-year flood zone and to reconnect much of the leveed flood zone to its parent river. In short, the bottomlands of the UMRB should be returned to their basic functions, that is, to hold floodwaters, improve water quality and support rich biodiverse systems.

> Despite a century of massive capital investment in flood control structures across the 18 million acres of floodplain, flood damages have increased. It is time to solve this problem with an ecological solution, rather than a structural one.

To promote this ecological solution, The Wetlands Initiative (TWI) and its partners conducted a study in 2003-04, funded by the McKnight Foundation, to determine how much of the 100-year flood zone had been altered to accommodate cultivated land in the bottomlands of five states and to project the impact that wetland restoration of this land would have on the flood damages, wildlife habitat, and the economy of the communities and regions of these restored areas. In addition, this study incorporated an estimate of the impact of restoration on economic activity in the region and on natural habitats in the bottomlands.

Within Iowa, Illinois, Minnesota, Missouri and Wisconsin, landscape data of 77 counties were analyzed in detail, incorporating approximately 24% of the total 100-year flood zone of the five states. These data were used to extrapolate the landscape characteristics for the entire 5-state UMRB, which are summarized here:

- The 100-year flood zone encompasses an estimated 18.4 million acres within the five-state region, of which about 6.9 million acres were once wetlands. An estimated 3 million acres (46%) of wetlands were converted to cropland and another 1 million acres (14%) is now managed grasslands.
- Today, federal levees protect approximately 2.4 million acres of bottomland in the five states. These levees were built to protect the agricultural areas, as well as growing urban areas.
- Wetland restoration of the 4 million acres of presettlement bottomland wetlands (land that now supports row crops and managed grass) would help alleviate flood problems in the basin. Restored wetlands, combined with present-day wetlands, could provide an estimated 5.5 million acres of wetlands outside of the federal levees in the bottomlands. These areas could store an estimated 40 million acre-feet of water. For comparison, most of the damage caused by the 1993 flood in the Upper Mississippi River system was due to an excess of 39 million acre-feet of water (as measured at St. Louis).
- Restoration of 4 million acres of wetland would increase bird habitat and biodiversity. Audubon scientists concluded that the restored wetlands would support an estimated 2.9 times more bird species than the cropland and pasture lands. These wetlands would support 7.5 times as many threatened and endangered species as cropland and pasture. Similar increases in other wildlife are likely.

This report is based on research funded by the McKnight Foundation and conducted by Donald L. Hey, Ph.D., Deanna L. Montgomery, and Laura S. Urban, The Wetlands Initiative; Tony Prato, University of Missouri-Columbia; Ric Zarwell, Andrew Forbes, Mark Martell, Judy Pollack, and Yoyi Steele, Audubon. John Tandarich, Ph.D., Becky Kerwin, and Tara Todd also contributed research assistance to this study.

- Alternatively, if the entire 7 million acres of cropland in the 100-year flood zone were managed to store floodwaters, 72 million acre-feet of water could be stored.

- Conversion of 7 million acres of cropland from the bottomlands to wetlands and flood storage areas would produce an estimated annual net benefit of $503 million. Benefit-cost analysis showed that cropland conversion would be socially efficieint for all counties except for St. Louis County, Missouri.[2] As computed by agricultural economist Tony Prato, social benefits included the annual reduction in flood-related crop damages, governmental crop subsidies, and non-flood related benefits. Social costs included the loss in cash from farm rentals and the cost of wetland construction and maintenance.

Background

Flooding and, more importantly, flood damages have increased over the past century. From 1904 to 1933 mean annual flood 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 nationwide 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.

As the Army Corps of Engineers expanded the use of levees, the cumulative effects became obvious and disastrous.

Over a few hundred years, European settlers altered the land surface and drainage patterns of the UMRB to such an extent that it bears little resemblance to presettlement conditions (Hey, 2002a). Drainage control in the form of ditches, drains and levees were constructed as farms, homes and cities were developed in flood prone land. The levees, which prevent seasonal inundation of flood prone lands, initially appeared to be the ideal solution. However, as the use of levees expanded throughout the basin, 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. Today more than 2.3 million acres of the UMRB flood zone are protected by levees.

On drained and leveed wetlands, farmers have built their homes and barns and grown their crops. Urban dwellers have constructed roads, factories and shopping centers. Because of the flood control structures, the inhabitants of the altered lands feel safe; they are not, as escalating flood damages so clearly illustrate. Even the cost of maintaining the structures is high: in 1993, the U.S. Army Corps of Engineers spent more than $55 million to repair damaged levees.

The current drainage structures, 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 flooding. 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.[3]

The second economic measure is the high cost of the sediment and contaminant load carried in the river. Outlet ditches and storm drains move water quickly off the land and into rivers. The levees direct the water through only a narrow section of the river's natural channel; no longer does the water travel slowly through the wide vegetated floodplain where sediments and contaminants can be removed. The result is poor water quality for humans who use the rivers as a source of their drinking water and for all 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 overabundance of nutrients carried downstream by the Mississippi River. It is estimated that approximately 50 to 75% 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).

In addition, the sediment load of the main channel carries its own direct cost, that of dredging the navigational channel where sediment has been deposited. The U. S. Army Corps of Engineers spent $100 million annually on dredging the main channel of unwanted sediments in the past decade.

The third economic consequence of lost wetlands and current drainage practices is one of lost opportunity. Well-vegetated, healthy wetlands within the flood zone can provide many vital functions: reducing flood peaks, removing excess nutrients and sediments, recharging groundwater supplies for urban and rural communities, supporting diversified and abundant wildlife populations, and providing recreation opportunities. Without wetlands, these benefits cannot be realized.

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[2] 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.

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

Landscape Analysis

This study was an unprecedented analysis of the data from many sources across five states. By finding and compiling disparate sets of geographic information within 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 UMRB region (Illinois, Iowa, Minnesota, Missouri, and Wisconsin);
- Estimate the potential flood storage capacity within the 100-year flood zone of the region, identifying both maximum and intermediate potential flood storage volumes;
- Approximate the distribution of wetland habitats that would naturally form once a more natural hydrologic function in the flood zone was restored.

The number of sampled counties, which varied from state to state, was determined by the availability of data and by the location of the county within the state (Figure 1). The counties were selected in blocks that included both upstream and downstream characteristics of the flood zone, ensuring that a variety of stream types would be incorporated in the analysis. For each county, TWI compiled Geographic Information System (GIS) data on five landscape variables: 100-year flood zone, hydric soil, wetlands (using National Wetlands Inventory (NWI) data), land cover, and leveed area. (Only levees in the 100-year flood zone that protect less than 10% urban development were included in the study.) Detailed results from the sampled counties are available in the full report (Hey et al., 2004).

Landscape Characteristics

The presence of NWI wetlands and mapped hydric soils within the 100-year flood zone were used to identify the areas on the landscape that could support wetland habitats. Recent land cover maps were used to determine whether or not these areas currently support wetlands, as well as how much of the land surface is now used for row crops.

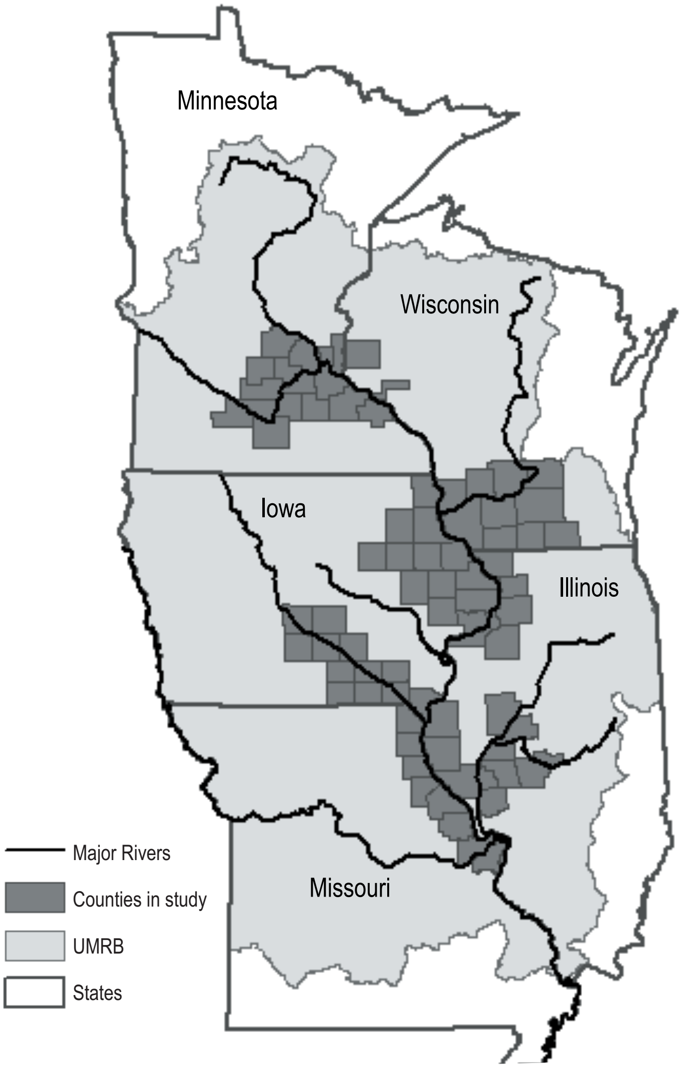
With this data, a variety of statements can be made regarding the 100-year flood zone within the study area, a total 4.4 million acres:

- 1.7 million acres (38%) could support wetland habitats. Nearly one-half of these once-or-current wetland areas have been artificially drained and now support row crops.
- 0.6 million acres are behind federal levees. Nearly 70% of the leveed land (0.5 million acres) supports row crops.

Flood Storage Capacity

The landscape within the sampled 100-year flood zone has the potential to store more than 9.6 million acre-feet of excess floodwaters. This number was computed by the following method: within the unleveed reaches of the flood zone it was assumed that the existing or drained wetland areas (1.3 million acres) could be managed to store floodwaters 3 feet deep; within the leveed reaches of the flood zone it was assumed that the entire levee district (0.6 million acres) could hold floodwaters 10 feet deep, regardless of the distribution of existing or drained wetlands. An estimate by the US Army Corps of Engineers suggests that an average 12 feet of water could be stored behind the levees along the Illinois River (Landwehr, 2003).

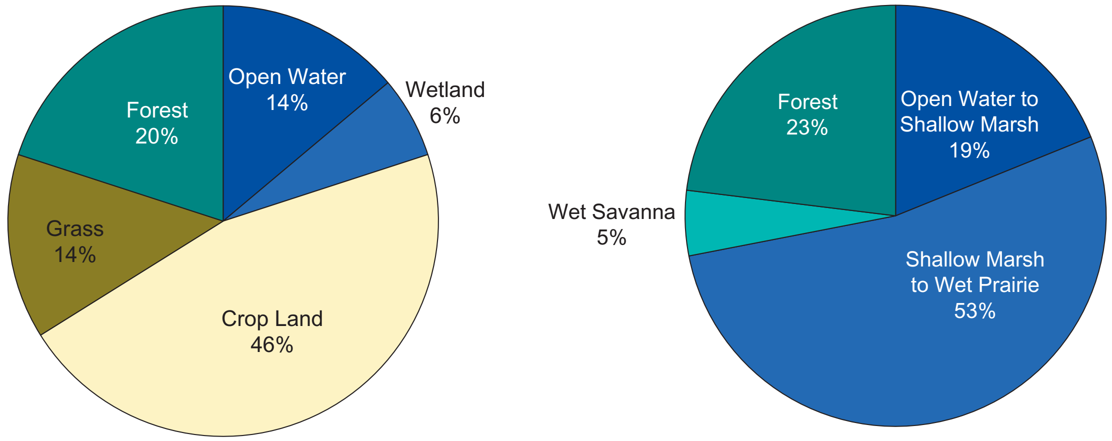
Figure 1. Counties included in study analysis



Potential Restored Habitats

Current landcover maps indicate that the 1.7 million acres of drained or existing wetlands presently support a variety of habitats, although the dominant habitat is row crops (Figure 2). If a more natural hydrologic function was restored to the region, and the artificial drainage removed, these 1.7 million acres would support a variety of wetland habitats, dominated by shallow marshes and wet prairies (as suggested by the characteristics of the hydric soil and the NWI wetlands).

Figure 2. Comparison of current land cover to potential wetland habitats



Current land cover

Potential wetland hbitats

This conversion of the landscape from row crop to shallow marsh would be accompanied by a remarkable change in the bird population. Audubon identified 53 bird species which typically use the cropland in the study counties, most of these only sporadically. If this same land was wetland, it would support an estimated 145 species of birds, birds which breed in or migrate through wetland habitats. Only eight of the bird species which use cropland are ranked as "high conservation priority" species, whereas 62 of the bird species using wetlands are so ranked. It is likely that this increase in bird diversity and population density would be accompanied by a similar increase in the diversity of all wildlife populations, from insects to mammals.

Looking Basin-wide

Using data from the sample counties, TWI estimated the flood storage and wetland restoration potential at a grand scale—a scale that would be large enough to impact the ecological health of the UMR basin and beyond. TWI extrapolated the results to the entire 100-year flood zone (estimated to be 18.4 million acres) in the five-state basin. This extrapolation provides an estimate of both the floodwater storage capacity and the wetland restoration potential in the flood zone of the basin.

Based on our extrapolation, two flood storage scenarios were created, called "maximum" and "wetland," described below. 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 caused $16 billion in flood damage. That flood generated 39 million acre-feet of floodwaters at St. Louis (Hey and Phillipi, 1995). To avoid the flood damages of '93, this volume of water would need to be stored for the duration of the flood.

Maximum Flood Storage Strategy. If the entire 100-year floodplain were managed to hold floodwater, 72 million acre-feet of water could be stored (assuming leveed areas could hold floodwaters 10 feet deep and unleveed reaches were managed to hold floodwaters 3 ft deep). This is 1.8 times more than the flood volume that caused the flood damage during the 1993 catastrophic flood (Figure 3, "Maximum flood storage").

Wetland Flood Storage Strategy. If, however, excess floodwaters were stored only in (1) areas that are drained or existing wetlands and (2) areas that are behind levees , an estimated 40 million acre-feet of water could be stored in the 100-year flood zone of the five-state basin (Figures 3 and 4).

Approximately 46% of this potential flood storage area (nearly 3 million acres basin wide) is used for agriculture. Generally, this means the land has been modified for quick drainage, using buried tiles or ditches, and or protected from flooding by levees. In order to use this land to store water, these modifications would have to be reversed. Ideally, this would mean converting the cropland back to wetland. In addition to providing needed floodwater storage, this conversion would remove the costs of agricultural flood insurance subsidies as well as lessen the costs of agricultural flood damage.

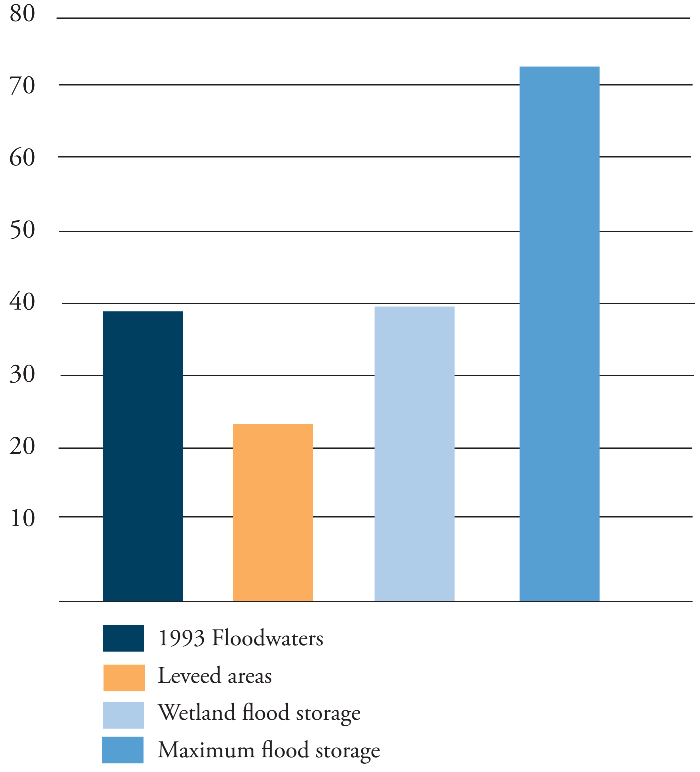
Economic Benefits

An aggressive restoration strategy in the UMRB might include converting all 7 million acres of cropland in the 100-year flood zone to wetlands. The total annual net social benefit of this conversion is estimated to be $494 million. This benefit was calculated by adding together:

- savings in crop damage payments;
- savings in crop subsidy payments, and;
- income from hunting, fishing, or recreation in the new wetlands.

Figure 3. Potential flood storage volumes compared to 1993 Floodwaters

(Millions of acre-feet)



Then, the following were subtracted:

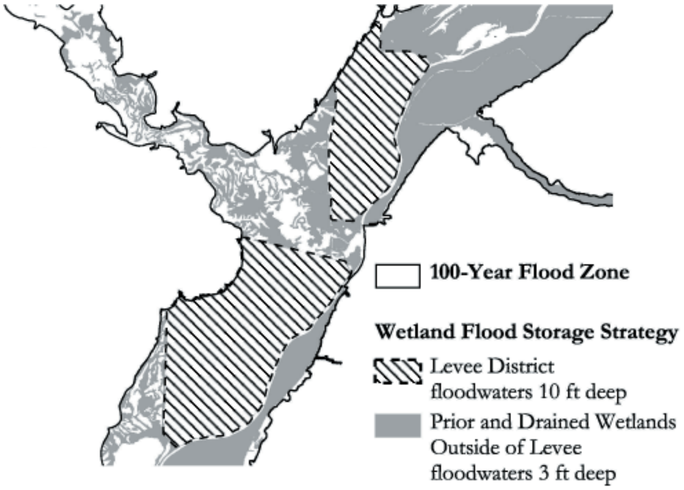
- costs of constructing and operating wetlands, and
- net income earned on cropland that would be lost due to wetland restoration.

On average, only 7% 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.

Conclusions

Currently, about 40% of the 100-year flood zone in the five-state UMRB is used for row crops, about 7.1 million acres extrapolated to the five-state watershed. The hydrologic modifications made to support row crops, including levees for flood protection and drain tiles and ditches for rapid drainage, have contributed to the substantial flood damages experienced throughout the basin. By restoring the natural hydrologic functions to these areas, and managing them to store excess floodwaters, we could reduce the level of peak flood flow, in turn, reducing the cost of flood damages. In addition, we would reap the benefits of additional wetland habitats, which include both a more diverse wildlife population and an increase in water quality.

Figure 4. Illustration of wetland flood storage strategy



Restoring natural hydrologic functions in the flood zone requires disabling the drain tiles and drainage ditches that move excess water rapidly off the land. By retaining precipitation where it falls and storing floodwaters on the floodplain upstream, flood damages will be reduced downstream. This strategy provides a cost effective and environmentally sensitive solution to curbing flood damages. If the entire floodplain were managed in this way, an estimated 72 million acre-feet of water could be stored in the 5-state floodplain. A scenario like this could have drastically reduced the amount of flood damage experienced during the 1993 flood when an excess 39 million acre-feet of water caused most of the damage near St. Louis.

A more conservative strategy in the basin would be to restore the estimated 3 million acres of cropland that are situated on drained wetlands within the 5-state floodplain. Managing these areas to store excess floodwaters could provide more than 40 million acre-feet of floodwater storage. In addition, restoration of this cropland to its natural wetland habitat would nearly double the extent of the existing wetlands. These wetlands act as a natural buffer to the landscape, they trap sediments and sequester and recycle excess nutri-

Summary of Flood Storage Volume

(State totals extrapolated from sample)

State	Total 100-year Flood zone (acres)	Leveed (acres)	Current or drained wetlands, unleveed (acres)	Potential Flood Storage Volume (acre-feet)	Annual Net Social Benefit ($)[1]
IA	6,949,000	380,000	2,069,000	10,008,000	$238,893,000
IL	2,361,000	550,000	621,000	7,362,000	$81,067,000
MN	2,305,000	396,000	1,057,000	7,070,000	$30,578,000
MO	4,821,000	1,040,000	879,000	13,037,000	$82,604,000
WI	2,012,000	2,000	915,000	2,765,000	$60,970,000
Total	18,449,000	2,362,000	5,541,000	40,242,000	$494,113,000

[1] Based on conversion of all crop land (7 million acres) to wetlands in the 100-year flood zone.

ents carried from the upland agricultural land toward the river system. Cycling surface water through wetland areas enables us to provide cleaner water to those downstream.

What's Next?

Several recommendations follow from this study. The first is that the economic benefits to the individual landowner should be carefully quantified. 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," that is, restored wetlands managed to optimize nutrient removal. Nutrient "credits" generated from the nutrient farm could be sold to those who emit high levels of nitrogen, phosphorus or carbon (Hey, 2002b).

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 in the basin, included such a strategy as one of its recommendations (IFMRC, 1994). Yet details need to be considered: How and where would spillways and flood gates be constructed in levees to allow floodwaters to enter and recede? At what cost and at what scale would these structures need to be constructed?

The third is to implement pilot projects in several of the sample areas of this study. Each pilot project should encompass approximately 10,000 to 20,000 acres of land and 15 miles of stream channel, following, for example, a stream corridor from the watershed boundary down to its discharge to a major river or encompassing a large tract of flood zone on the main stem of the Mississippi or major tributary. Within the pilot project, varying land uses should be evaluated and the actual cost to restore wetlands, provide flood storage, process nutrients and attract recreational use should be 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 projects will help confirm the efficacy of this approach to flood control as well as help develop design, management and operations criteria.

An ideal example site for a pilot project is the Wapsipinicon River valley in Iowa. In Buchanan, Cedar, Clinton, Jones, Linn and Scott counties combined, nearly 34% of the agricultural land in the 100-year flood zone is on drained wetland. This area could provide more than 180,000 acre-feet of floodwater storage. The Nature Conservancy has identified the Wapsipinicon River system as an "ecologically significant area" (TNC, 2001).

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 these sites will reduce flood damage costs by converting cropland that would be damaged and by providing storage for floodwaters. In addition, these wetlands will increase water quality throughout the watershed and ensure the long-term survival of the native wildlife and natural communities currently existing within the upper Mississippi River basin.

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