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# **Impacts of Federal Policies and Programs on Wetlands**

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# Impacts of Federal Policies and Programs on Wetlands

Pierre Crosson and Kenneth Frederick

## Abstract

Human activities have resulted in the loss of about half of the original 221 million acres of wetlands in the conterminous 48 states. Federal laws, policies, and programs have had major impacts on the nation's wetland resources. Initially, they encouraged and subsidized the draining and filling of wetlands, the flooding of wetlands behind dams, and the diversion and alteration of streamflows to riparian wetlands. More recently, federal policies have been directed to conserving and preventing further net losses.

The focus of this study is on the impacts of federal policies on riparian wetlands, i.e., those formed at the interface of rivers and streams and uplands and that require occasional flooding to maintain the health of their ecosystems. The study identifies the trends in wetland acreage, describes the principal federal policies and programs impacting riparian wetlands, summarizes what is currently known or can be deduced from existing research about the impacts of these policies and programs on riparian wetlands, identifies key knowledge gaps, and suggests priorities for additional research.

The policies that once directly and indirectly encouraged drainage of wetlands as well as water use and development practices harmful to wetlands have for the most part been abandoned. In some cases they have been replaced by new policies designed to protect the remaining wetlands and to encourage wetland restoration and creation. From the mid-1950s to the early 1990s conversion of wetlands to agriculture accounted for some 70 percent of total conversions. From 1982 to 1992, however, agriculture actually contributed a small net increase in the number of wetland acres. Changes in federal agricultural policies played a major role in this turn around. Overall, net wetland losses have been slowed but not ended since a "no net loss" policy was established in 1989.

Several lines of research could contribute to the design and implementation of policies to achieve the "no net loss" goal. Research is needed to understand how farmers' incentives to convert wetlands to agricultural uses would be affected should Swampbuster become toothless as farm subsidies are eliminated or agricultural prices rise. And, if this analysis suggests wetland losses to agriculture would likely accelerate, alternative market-based and regulatory strategies for curbing these losses should be examined.

As wetlands are lost to development and other pressures, achieving the no net loss goal requires that these losses be compensated. Research on the physical characteristics and the ability of different wetlands to provide social values such as fish and wildlife habitat, retention of flood waters, and water quality improvements would provide a better basis for determining how much society should invest in protecting, enhancing, restoring, or creating wetlands and whether these investments adequately compensate for the functions of lost wetlands. Research also is needed to determine how mitigation banking might be made more efficient and effective in ensuring social values are adequately compensated when wetlands are lost.

Key Words: wetlands, land use, agricultural policy, water policy

JEL Classification Numbers: Q15, Q25, R14

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Sean Cash, who served as a summer intern at Resources for the Future from May through July, 1998, collected many of the source materials used in this report; helped educate the authors as to the federal laws, policies, and programs affecting wetlands; and provided valuable comments on earlier drafts of some sections. Eugene Stakhiv supplied many very helpful reports produced by the Institute for Water Resources, Corps of Engineers. Dennis King provided additional information and helped educate us on issues involving wetland mitigation. Robert Brumbaugh, Leonard Shabman, Eugene Stakhiv, and Michael Toman read and provided extensive comments on an earlier draft. The report has benefited greatly from their constructive criticisms and suggestions. Several others who also gave generously of their time and expertise are mentioned as sources of material in the text. We wish to thank all who contributed but, as always, the authors must bear responsibility for any remaining omissions and commissions.

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# IMPACTS OF FEDERAL POLICIES AND PROGRAMS ON WETLANDS

Pierre Crosson and Kenneth Frederick\*

## INTRODUCTION

Wetlands perform a variety of useful functions. They are among the earth's most productive ecosystems. Many fish and wildlife populations rely on wetlands for habitat and food. Nearly half of all federally listed threatened and endangered species depend upon wetlands for some part of their life cycle. They are also the source of harvestable resources such as timber, berries, fish, fur, rice, and peat. Wetlands purify water by filtering and settling sediments and pollutants, and they reduce flooding by dispersing high water flows over time and area. They are also the site for recreational activities such as hunting, canoeing, bird-watching, and fishing.

In spite of the varied and valuable services they can provide, human activities have resulted in the loss of about half of the original 221 million acres of wetlands in the conterminous 48 states. Federal laws, policies, and programs have had and continue to have major impacts on the quantity and quality of our wetland resources. Initially they encouraged and subsidized the draining and filling of wetlands and the damming and diversion of rivers and streams, contributing to the sizeable loss in the nation's wetland endowment. More recently, policy initiatives have been directed to conserving and preventing further net losses of wetlands. The long-term goal set by the Clinton administration is to increase the quantity and quality of the nation's wetlands.

The principal objectives of this study are to describe federal policies and programs impacting riparian wetlands, summarize what is currently known or can be deduced from existing research about the federal impacts, identify key knowledge gaps, and suggest priorities for additional research. Riparian wetlands, which are a subset of the floodplains, are formed at the interface of rivers and streams and uplands and require occasional flooding to maintain the health of their ecosystems. The quantity and quality of these wetlands are affected both by efforts to keep floodplains dry for agricultural and urban use and by water use and management practices that alter the timing and quantity of flood flows. The focus on riparian wetlands covers, at least indirectly, many of the policies affecting floodplain use while emphasizing federal policies and programs directed specifically to wetlands and the social services they provide that are not valued in the marketplace. Because of budget and time constraints, other types of wetlands are not part of our focus.

Wetlands vary widely in their characteristics and location. They include swamps that are common in the southern United States, prairie potholes in the northern plains states, playa lakes of Texas and elsewhere in the West, wet mountain meadows, freshwater marshes,

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coastal salt marshes, mangroves, fens, bogs, and bottomlands. Wetlands may be covered or saturated with water throughout the year or partially or completely dry for months. Indeed, the composition of the soil or the presence of characteristic plants may be the only indication that a given area is a wetland.

Since the federal government began regulating wetlands on a broad scale in the 1970s, controversy and confusion has existed over what is and is not a wetland. To help resolve the issue, the Congress asked the National Research Council (NRC) to study the scientific basis for characterizing wetlands. The NRC report, which has not resolved the regulatory controversy over what is a wetland, offers the following definition.

A wetland is an ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical, and biological features reflective of recurrent, sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physicochemical, biotic, or anthropogenic factors have removed them or prevented their development (National Research Council, 1995, p. 3).

Of the three factors that characterize a wetland--water, substrate, and biota--water has special significance; eliminating the characteristic hydrology of a wetland eliminates the wetland, even though the characteristic substrate and organisms can persist for some time after the change in hydrology (National Research Council, 1995).

The dual nature of wetlands--neither entirely land nor entirely water--accounts in part for the competing views of them. Left in its natural state a wetland is an important hydrological and biological component of a watershed. But when the same area is drained or protected from flooding, the proximity to water enhances its value as a residential, commercial, or recreational property.

While the social benefits of wetlands are sizeable, they are largely unmarketable and difficult to quantify in monetary terms. The benefits of improved fish and wildlife habitat, reduced flooding, and cleaner water are shared by society as a whole (in the case of habitat for endangered species) or groups removed from the wetland such as downstream residents of floodplains and cities using water filtered naturally by the wetland. On the other hand, dry land with proximity to a river for recreation, navigation, and scenic views can be worth thousands of dollars an acre. Consequently, individuals have little incentive to protect wetlands that can be developed for crops, homes, or factories through draining and flood protection.

Human activities affect wetlands in many ways. Draining and protecting lands from floods for farming, mining, forestry, urban development, and highway construction may



eliminate the water essential to the existence of a wetland. Changes in the landscape associated with these activities may result in erosion that degrades or destroys wetlands. Dam and reservoir construction, channelization and dredging for navigation, reservoir management, water diversions, drainage, and discharges of used water are likely to alter the quantity, quality, or timing of flows for wetlands. Finally, human activities are not necessarily detrimental to wetlands. They can preserve existing wetlands, restore those that have been damaged, and even create wetlands where none previously existed.

Numerous federal laws, policies, and programs influence activities that in turn affect wetlands. The U.S. General Accounting Office (1998) identified 36 federal agencies that, to varying degrees, undertook wetlands-related activities during fiscal years 1990 through 1997. These activities are regulated by over 25 federal statutes that have resulted in (1) regulation of activities in areas designated as wetlands, (2) acquisition of wetlands through purchase or protective easements, (3) restoration or creation of wetlands, and (4) incentives to protect wetlands. In addition, wetlands are impacted by a variety of federal laws and programs that affect the use and management of land and water resources by private interests and state and local governments. A comprehensive assessment of the impacts of all federal laws and programs on the nation's wetlands is well beyond the time and resources available for this study. Our focus is on the laws and programs that have had and continue to have the greatest impacts on the activities accounting for most of the past changes in the nation's wetlands.

This report draws on the Department of Interior study, *The Impact of Federal Programs on Wetlands* (U.S. Department of Interior, 1994), but it is not intended to be an update of that study. In addition to the areas considered in this report (agriculture, water development and management, and terrestrial transportation, which the wetlands data include as an urban activity), the Interior study also considers federal programs impacting resource use, extraction, and development. The Interior study concluded, however, that the areas covered in this report were the three most important areas in which federal policies and programs impacted wetlands. According to the data presented in the following section, these three areas account for virtually all changes in wetlands acreage.

The following section describes trends in the nation's wetlands over the past two hundred years. This is followed by sections devoted to federal impacts on each of three broad types of activities that affect wetlands: land use and management; water use and management; and measures to protect, enhance, restore, or create wetlands. The study concludes with a brief summary and conclusions about current federal impacts and future research needs.

## **TRENDS IN THE NATION'S WETLAND RESOURCES**

### **Sources of Data**

There are two sources of wetlands data that indicate trends over time: the Fish and Wildlife Service (FWS) of the U.S. Department of Interior, and the National Resources Inventory, managed by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture. Both agencies use the Cowardin system (Cowardin et al., 1979)

for identifying and measuring the extent of the nation's wetlands, but their techniques for actually collecting the data are different. FWS relies mainly on aerial photographs of randomly selected wetlands areas. The NRCS data are collected by agency personnel who visit randomly selected sites all across the country. The objective of the NRCS survey is to obtain data on land use, whatever the use may be, e.g., agriculture, forestry, urban. The amounts of land within these categories that are wetlands are identified as such.

The U.S. General Accounting Office (GAO) concluded that the two sets of estimates of the quantity of the nation's wetlands are not entirely consistent. In October, 1997 the Clinton administration announced plans to develop a single set of estimates by the year 2000 that would be used by all federal agencies. In the meantime, the FWS and NRCS estimates are all that are available. In commenting on the GAO report several federal agencies with responsibilities for wetlands pointed out that despite the differences between the estimates, both sets agree in showing a declining rate of wetlands loss since the mid 1950s (U.S. General Accounting Office, 1998).

### **The Cowardin System**

The Cowardin system identifies two main categories of wetlands, each of which includes a number of sub-categories. The main categories are estuarine, or coastal, wetlands, and palustrine, or inland freshwater, wetlands. According to FWS, 95 percent of the wetlands in the 48 states in the mid-1980s were palustrine. Fifty-three percent of the palustrine wetlands were forested, 25 percent were emergent marshes, 16 percent were dominated by shrubs, and the remainder had miscellaneous vegetative cover (Fish and Wildlife Service, 1991, pp. 8-9).

### **Wetland Definitions**

There is much controversy about the definition of wetlands. In general, environmentalists favor a more ample definition and developers a more narrow one. Since 1977 the U.S. Corps of Engineers, the federal agency with the authority to grant or withhold permits to convert wetlands to other uses, has defined wetlands as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated conditions" (Economic Research Service, 1997, p. 311).

The FWS has a similar but not identical definition: "In general terms, wetlands are lands where saturation with water is the dominate (sic) factor determining the nature of soil development and the types of plant and animal communities living in the soil and in its surface. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water" (Fish and Wildlife Service, 1991, p. 17).

As noted in the introduction to this report, the National Research Council (1995) has yet another similar, but not identical definition.

### **Estimates of Quantities of Wetlands**

The estimates of the Fish and Wildlife Service and of the Natural Resources Conservation Service of the amount of wetlands in the 48 states differ by about 20 percent. According to the FWS there were 103.2 million acres of wetlands in those states in the mid-1980s (Fish and Wildlife Service, 1991, p.9). The NRCS estimate for 1992 was 123.9 million acres (Economic Research Service, 1997, p. 311). Both estimates include wetlands on federal land, which, according to the NRCS, was about 12.5 million acres in 1992. The NRCS estimate thus implies that 90 percent of the wetlands in the 48 states were on non-federal land. Some 13 percent (14.6 million acres) of the 111.4 million acres of non-federal land was owned by states, counties and municipalities, with states having 80 percent of such land. The remaining 87 percent of non-federal wetlands--96.8 million acres--were in private ownership.

As noted above, the FWS and the NRCS do not use exactly the same definition of wetlands, nor do they use the same procedure for collecting the data. These differences may account for some of the differences in the two estimates. In a personal communication, Thomas Dahl, who prepared the estimates shown in FWS (1991, p. 9), expressed the view that the FWS estimates may be more conservative than those of the NRCS. For example, if a soil map used by the NRCS showed that a given plot of land had hydric soils, that plot was counted as a wetland by NRCS. FWS, on the other hand, would look for additional information about vegetative cover on the land and, depending on what that showed, the land might not be counted as a wetland.

The FWS and NRCS estimates also differ by states, and in some cases the differences are greater than the 20 percent difference at the national level. The trends over time in the two sets of data, however, both at the national and state levels, are generally consistent with one another. We do not believe that the differences between the FWS and NRCS estimates are significant for the purposes of this report.

### **Quantities of Wetlands in the Cowardin System**

As noted above, the Cowardin system classifies wetlands in two broad categories: palustrine and estuarine, with palustrine wetlands accounting for 95 percent of the combined total of 103.2 million acres in the mid-1980s. Table 1 shows the amounts of wetlands in sub-groups of the palustrine category as of the mid-1980s.

The focus of this report is on the effects of federal government policies on management of riparian wetlands in floodplains, which are included in the palustrine category. However, neither the FWS nor the NRCS show separate estimates of the amounts of wetlands in floodplains (personal communication, Thomas Dahl). We cannot, therefore, focus our discussion exclusively on those wetlands. However, we know that certain wetlands, e.g., the approximately 5 million acres in the prairie pothole region of the northern plains and part of Minnesota, are not in floodplains, nor are the wetland playas found in west Texas and in other western states. Our inability to identify wetlands in floodplains from the data inevitably means that our discussion is less focused than we would like it to be.

**Table 1. Palustrine Wetlands, by Type, in the mid-1980s**

	(millions of acres)
Vegetated palustrine	91.6
Palustrine emergent	24.5
Palustrine forested	51.7
Palustrine shrub	15.3
Palustrine nonvegetated	<u>6.1</u>
Total	97.7

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Source: Fish and Wildlife Service, 1991, p. 9 (p. 18 gives definitions of the palustrine wetlands).

### **Regional Changes in Wetlands**

Both FWS and NRCS show changes over time in the quantities of wetlands in the 48 states and in major regions. The two sources show similar trends. Since the NRCS data are more up-to-date (1992 compared to the mid-1980s), we use them in this discussion.

#### 1780s to 1992

According to both the NRCS and FWS there were 221 million acres of wetlands in the area now in the 48 states in the 1780s (Economic Research Service, 1997; Fish and Wildlife Service, 1991). Table 2 shows the NRCS estimates of the numbers of acres of wetlands by USDA producing region in the 1780s and in 1992.

The largest absolute and percentage losses were in the five Cornbelt states. Much of that area was in wetlands before settlement, and conversion to cropland (thus making the region the nation's cornbelt) required that the land be drained. The smallest absolute and percentage losses were in the Northeastern states. The reasons for this are speculative. However, drainage technology was not well developed at the time of rapid expansion of cropland in the Northeast. By the time that it was, the Cornbelt and Plains states had come to dominate production of row crops. The area in wetlands in the Northeast was small relative to the total area of the region, suggesting that farmers were able to satisfy their demands for land without much drainage of wetlands.

Table 2 shows that by 1992 the 48 states had lost 44 percent of their initial endowment of wetlands. The losses of riparian wetlands, however, which are of special interest in this report, were substantially greater--60 to 75 percent (U.S. Department of Interior, 1994, p. 16). In the west the riparian losses were greater, reaching 90 to 95 percent in some areas. Of the remaining wetlands, 58 percent are in three regions: the Southeast with 25.9 million acres (44 percent in Florida); the Lake States with 25.7 million acres (46 percent in Minnesota); and the Delta with 20 million acres (56 percent Louisiana).

**Table 2. Wetland Acres by USDA Producing Regions, 1780s and 1992\***

	Millions of Acres		Changes	
	1780s	1992	Acres	%
Northeast	16.0	14.4	1.6	10.0
Appalachia	16.5	8.3	8.2	49.7
Southeast	41.1	25.9	15.2	37.0
Lake States	41.1	25.7	15.4	37.5
Cornbelt	27.6	5.2	22.4	81.1
Delta	35.9	20.0	15.9	44.3
Northern Plains	11.3	8.0	3.3	29.2
Southern Plains	18.8	6.2	12.6	67.0
Mountain States	8.9	5.7	3.2	36.0
Pacific	8.6	4.4	4.3	50.0
48 states	221.1	123.9	97.2	44.0

Source: Economic Research Service, 1997, p. 311.

\*Northeast: New England, N. Y., Pa., N.J., Del., Md.; Appalachia: Va., W. Va, N. C., Ky., Tenn. ; Southeast: S.C., Ga., Fla., Ala.; Lake States: Mich., Wi., Minn.; Cornbelt: Oh., Ind., Ill., Ia., Mo.; Delta: Ark., Miss., La.; Northern Plains: Ka., Neb., S.D., N.D.; Southern Plains: Tx., Ok.; Mountain: N. M., Co., Wy., Mont., Id., Ut., Ar., Nev.; Pacific: Cal., Ore., Wa.

### 1954-1992

According to ERS (1997, p. 313), the first reliable estimates of wetlands acreage in the country date from the 1950s and were prepared by the FWS. The estimates from then until 1992 show a substantial fall in average annual rates of wetlands loss, as shown in Table 3. It is important to note that the data from 1954 through 1983 are from the FWS while those from 1982 to 1992 are from the NRCS. As noted above, the national and state totals from these sources are not in complete agreement. It is likely that the changes in quantities of wetlands from the two sources differ even more than the totals. Nonetheless, the decline in gross and net wetland losses from 1982 to 1992 shown in the NRCS data are generally consistent with the declines in losses shown in the FWS data from 1954-74 to 1974-83.

Perhaps the most notable feature of the pattern of declining losses over the three periods is the greatly diminished role of agriculture as a source of the losses. Agriculture was responsible for 87 percent of the gross losses from 1954 to 1974, for 56 percent from 1974 to 1983, and for 23 percent from 1982 to 1992.

The Fish and Wildlife Service estimates of gross and net changes in wetlands attributable to various activities are substantially different from those in Table 3, which are attributable to the National Resource Conservation Service. For example, the FWS estimate of average annual gross wetlands losses attributable to agriculture from 1985 to 1995 is 4.6

times greater than the annual agriculture-induced loss of 30.9 thousand acres from 1982 to 1992, as shown in Table 3 (U.S. General Accounting Office, 1998). Some small part of the difference in the two estimates may be attributable to the different time periods. Most of the difference, however, must reflect differences in wetland definitions and data collection techniques. According to the GAO, these differences at present cannot be totally reconciled.

**Table 3. Average Annual Changes in Quantities of Wetlands in the 48 States\***

	(thousands of acres)		
	1954-74	1974-83	1982-92
Wetlands converted to			
Agriculture	592.8	234.8	30.9
Urban	54.4	14.0	88.6
Other	<u>35.3</u>	<u>168.1</u>	<u>16.4</u>
Total	682.5	416.9	135.9
Converted to wetlands from			
Agriculture	na	81.5	41.8
Urban	na	0.4	1.5
Other	<u>na</u>	<u>53.4</u>	<u>28.8</u>
Total	247.8	135.3	72.1
Net Change in Wetlands			
Agriculture	na	-153.3	+10.9
Urban	na	-13.6	-87.1
Other	<u>na</u>	<u>-114.7</u>	<u>+12.4</u>
Total	-434.7	-281.6	-63.8

Source: Economic Research Service, 1997, p.313; na = not available; \*not including deepwater wetlands; "urban" includes all urban uses of land plus roads and inter-urban highways.

The difference in losses between the latter period and the earlier ones may be somewhat exaggerated by the difference in the two sources of the data. However, a significant decline in losses from agriculture between 1982 and 1992 would be expected in any case because the so-called Swampbuster provisions of the 1985 Farm Bill imposed penalties on farmers who drained protected wetlands. Farmers in violation of Swampbuster lost access to government price and income support programs. Since these programs contributed significantly to farm income from the mid-1980s to the early 1990s, it is plausible that the threat of loss of access to the programs would have reduced farmers' incentives to drain wetlands. And indeed, the Department of Interior (1994, p. 8) asserted that "Swampbuster has greatly diminished agricultural losses . . ." of wetlands. Heimlich et al.

(1998, p. 62) made the same argument citing a number of studies suggesting that the number of wetland acres not converted on account of Swampbuster "... is likely large . . . ."

The sharp changes in losses of wetlands to "other" uses also are notable, but the changes may not be significant. The Department of Interior (1994) points out that the large quantity of wetland losses in the other category in 1974-1983 included much land that had already been cleared and drained but had not yet been put to any alternative use. Some of that land may have subsequently been converted to urban uses, which would account for some of the sharp increase in losses in that category from 1982 to 1992. Heimlich et al. (1998) point out that compared to the experience in 1974-83, losses attributable to agriculture in 1982-92 declined significantly and those owed to urban uses rose.

## **FEDERAL POLICIES AFFECTING LAND USE AND WETLANDS**

Throughout the country's history until the 1970s federal government policies played a major role in promoting wetland losses. Since the 1970s these policies have been significantly changed, or entirely new policies adopted, to reduce wetland losses. Policies that mainly affected management of water resources are treated in a later section. Policies that mainly affected management of land resources are discussed in this section.

Policies affecting land management fall into three categories: agriculture, urbanization, and terrestrial transportation, which we treat as an urban activity. This treatment is consistent with Table 3 in which losses of wetlands because of roads and highways are included as part of urban losses. From Table 3 it can be calculated that agriculture and urban activities accounted for 87 percent of gross wetland losses from 1954 to 1992. From 1982 to 1992 these two activities accounted for 88 percent of the losses. Thus by concentrating on agriculture and urban activities we capture much the greater part of the wetlands impact of federal government policies affecting management of the land.

### **Agricultural Policies Affecting Land Use Prior to the 1970s**

Table 3 indicates that between the mid-1950s and 1983 agriculture was by far the major source of wetland losses in the 48 states. Comparable data for earlier periods are not available, but given the major role that agriculture played in the settlement of the country in that period, it is highly likely that agriculture was responsible for an even greater share of wetland losses prior to the mid-1950s.

Federal government policies throughout the country's history until the 1970s provided incentives to convert wetlands to crop and animal production by directly or indirectly making it profitable to do so. Until the 1930s the policies mainly reflected an overall thrust to promote the economic development of the country (Heimlich et al., 1998). Among these indirect policies major importance must be given to the building of a nationwide transport infrastructure that lowered costs to producers everywhere of buying production inputs and selling the resulting outputs. Farmers enjoyed these lower costs, which strengthened their

incentives to expand production by bringing more land under production. Some of that land was wetland.

The federal government also indirectly stimulated the conversion of wetlands to agricultural production by engaging in, or funding, research to develop new, more profitable farm technologies. The research program did not amount to much until after the beginning of the 20th century, but by the 1930s it had begun to pay off, most notably in the development of hybrid corn. This development greatly increased the profitability of corn production, and must have provided stimulus to drainage of wetlands in the extensive area we now call the Cornbelt.

In the early years of the country the federal government also adopted policies specifically designed to encourage farmers (and others) to drain wetlands, both to increase production and protect the public health (Economic Research Service, 1997, p. 319). A notable example is the Swamp Lands acts passed between 1849 and 1860. These Acts granted 64.9 million acres of federally owned wetlands to 15 states on condition that the proceeds of selling the land to private individuals be used to finance land reclamation projects. Many of the beneficiaries of this program must have been farmers.

Beginning in the Great Depression years of the 1930s the Federal Government, as part of the New Deal program, launched a series of policies to support agricultural prices and income, policies that strengthened farmer's incentives to drain wetlands. The economic benefits of these programs were capitalized in farmland prices. The increase in the price of the land provided incentive to farm more intensively; converting wetlands to crop production is one way to do that. This line of argument is consistent with the observed major role of agriculture in wetland losses from the mid-1950s to 1983, noted in Table 3.

Other post-1930s programs of the federal government also directly encouraged farmers to drain wetlands. Beginning in the 1940s and lasting into the 1970s, the Agricultural Conservation Program, the Great Plains Conservation Program, and the program for Conservation Technical Assistance provided cost-sharing and technical assistance for open ditch and tile drainage on some 57 million acres of wet farmland, much of it wetlands. Under the Small Watershed Program (1944-1977) the federal government provided farmers funds for flood control and drainage structures, which were used in some cases as outlets for water drained from wetlands (Economic Research Service, 1997). As in the case of the price and income support programs for agriculture, these programs are consistent with the observed losses of wetlands to agricultural uses from the mid-1950s to the mid-1970s.

### **Agricultural Policies Affecting Wetlands After the 1970s**

In the 1960s the country began to be increasingly concerned about protecting the environment against the various negative impacts of human activities. This concern definitely extended to agriculture in general, and to wetlands in particular.

A variety of federal government policies were developed in response to the concern. The first of these was the Water Bank Program, adopted in 1970. Under this program participating farmers received per-acre payments in exchange for 10-year contracts in which



they agreed not to burn, drain, fill, or otherwise destroy the character of wetlands enrolled in the program.

Section 404 of the 1972 Federal Water Pollution Control Act Amendments directly regulates the dredging and filling of wetlands. Regulatory authority is vested in the U.S. Army Corps of Engineers. Section 404 provides some, but not full, protection of wetlands. Excavation, drainage, clearing, flooding or construction of water supply systems can and do result in wetland losses, and none of those activities are covered by section 404. Farmers wishing to clear and drain a wetland do not need to obtain a 404 permit so long as those activities do not involve dredging and filling (U.S. Department of Interior, 1994).

In recent years farmers' requests for 404 permits have declined, and in 1994 they accounted for only 7.1 percent of the requests received by the Corps of Engineers. An important reason for the lack of farmer interest in 404 permits is a series of federal government policies adopted since the mid-1980s (Heimlich et al., 1998). One of the most important of these was the 1985 Farm Bill, which included the Swampbuster provision. As noted above, farmers who drained protected wetlands were denied access to government price and income support programs, a penalty that significantly weakened farmers' incentives to convert wetlands.

The Tax Reform Act of 1986 also contained provisions that weakened farmers' incentives to drain wetlands. Those provisions ". . . eliminated preferential tax treatment of conversion costs and preferential capital gains treatment from selling land that had appreciated in value due to drainage" (Heimlich et al., 1998, p. 61). Studies suggest that the eliminated tax benefits did not provide strong incentive to drain wetlands in the Prairie Pothole region, but their effects in other regions may have been significant (Heimlich et al., 1998).

The Emergency Wetland Resources Act of 1986 called for the formulation by the federal government of a National Wetland Priority Conservation Plan. The Plan was to emphasize both conservation and restoration approaches to wetland protection. One of the outcomes of the Act was the North American Waterfowl Management Plan, involving the U.S., Canada and Mexico. This Plan called for restoration of former waterfowl habitat, prominently including former wetlands. In 1989 the North American Wetlands Conservation Act (NAWCA) established a Wetland Trust Fund, and also established the North American Wetlands Conservation Council to approve wetlands restoration projects (Heimlich et al., 1998).

Activities under these various programs received \$233 million in federal funds between 1991 and 1997, plus another \$487 million from non-federal government sources. In the 9 years since the establishment of NAWCA more than 447 wetlands conservation projects have been initiated and/or completed in Canada, Mexico, and 45 states in the U.S., and more than 20 million acres of wetland and waterfowl habitat have been conserved, restored, and enhanced.

In addition to Swampbuster, the 1985 Farm Bill also included the Conservation Reserve Program (CRP). Under the CRP farmers bid to take land out of production in

exchange for annual per-acre payments from the federal government. Most of the land was put into trees or grass. The contracts setting out these terms are for 10 years. Initially the CRP was designed only for highly erodible cropland. In 1989, however, the decision was made to include wetlands as well, and in time 410,000 acres of such land was in the CRP, most of it in the Northern Plains and Mississippi Delta states (Heimlich et al., 1998).

When the Water Bank Program was ended in 1990, farmers could enroll in the Wetland Reserve Program, which was authorized in the Farm Bill of 1990. Under the Wetland Reserve Program farmers enter into permanent or long-term easement agreements with the federal government to restrict agricultural use of restored wetland. The original goal under the Wetland Reserve Program was restoration of one million acres of wetlands previously converted by farmers to agricultural production. Subsequently the goal was reduced to 975 thousand acres.

Heimlich et al. (1998, p. 99) assert that, "In the last ten years, wetland restoration has emerged as a tool of equal importance with wetland preservation" and that the "... Wetland Reserve Program and Emergency Wetland Reserve Program have mounted the largest wetland restoration program in history." By the middle of 1997, over 533 thousand acres of land in the Wetland Reserve Program and Emergency Wetland Reserve Program were "... moving through the process toward permanent easements. . . ." (Heimlich et al., 1998, p.100).

The effects of six federal government programs designed to restore or enhance wetlands in the years from 1987 to 1995 are summarized in Table 4. Not all of these programs dealt exclusively with farmers, but most of the land affected was farmland. The U.S. Department of Agriculture's Conservation Reserve Program also contributed some uncertain number of restored or enhanced wetland acres. Thus, the 1,045 thousand acre total shown in Table 4 is an underestimate of the actual number of acres restored or enhanced under federal programs.

**Table 4. Acres of Wetlands Restored or Enhanced Under Five Federal Government Programs, 1987-1995**

	thousands of acres
Partners for Wildlife (a Fish and Wildlife Service program)	243
N. American Waterfowl Management Plan	390
Wetland Reserve Program	302
Emergency Wetland Reserve Program	57
Section 404	<u>53</u>
Total	1,045

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Source: Economic Research Service, 1997, p. 320

These data indicate that the number of acres of farmland wetlands restored or enhanced over the last decade is significant. Note in Table 3 above, that between 1982 and 1992 agriculture contributed a net increase of 110 thousand acres to the stock of the nation's wetlands. Although no information is available indicating the gross annual rate at which farmers may have been converting wetlands since 1992, the continued restraining effects of Swampbuster suggest that the rate is unlikely to be much, if any, greater than the 31 thousand acres experienced in 1982-92 (Table 3). In this case, the 1,455 thousand acres of wetlands restored or enhanced between 1987 and 1995 suggest that since 1992 agriculture may have been adding acres to the nation's stock of wetlands at an even faster rate than in 1982-92.

It is important to recognize that wetlands vary widely in the functions they perform, and, therefore, in the social services they provide. As noted in the introduction to this report, wetlands provide wildlife habitat, filter toxics, help to ameliorate floods, and provide other services as well. But not all wetlands provide all of these services, and those that do provide all, provide them in different proportions. Beyond those differences, the per acre social value of wetland services can vary widely, even among wetlands for which the proportions of services provided are identical. The demand for services of wetlands close to population centers typically will be greater than for distant wetlands, and this difference in demand will be reflected in higher per acre values of close-in wetlands than of those farther away (King and Herbert, 1997).

These points are made here to give perspective to the point made above about the possibility that in the 1990s agriculture has been stepping up its contribution to increasing the number of wetland acres. The differences among wetlands with respect to the functions they perform mean that an acre-for-acre accounting of changes in wetland numbers does not necessarily reflect a comparable change in the social values of wetlands. These points are discussed more fully below in the section on restoration and enhancement of wetlands.

### **Effects of Terrestrial Transportation Policies on Wetlands**

The terrestrial transportation policies of the federal government that have the greatest impact on wetlands are those of the Federal Highway Administration (FHWA), an agency of the Department of Transportation. The FHWA oversees one of the largest federally-aided construction programs in the country, providing financial support to the states and other agencies to develop and maintain the nation's highway system. In its survey of the impacts of federal government policies and programs on wetlands, the Department of Interior (1994, p. 90) concluded that next to agricultural programs and multipurpose water projects, the federal highway program was most responsible for wetland losses.

From 1982 to 1992 urban activities, which include transportation, accounted for almost two-thirds of the gross number of wetland losses (see Table 3). If the Department of Interior study (1994) is right about the relative importance of transportation in wetland losses, then that sector must have been responsible for a significant share of the losses attributable to urban activities. Over this period, wetland losses because of agriculture dropped substantially, and, on a net basis, agriculture contributed an increase in the stock of wetlands.

It is likely, therefore, that over the last decade, FHWA policies contributed substantially more wetland losses than agricultural policies.

For reasons discussed above, the comparison of gains in acres of agricultural wetlands with the likely losses of acres attributable to transportation must take account of the probable per acre differences in social value among different wetlands. Because urban wetlands are closer than rural wetlands to people demanding their services, the gain in social value from an additional acre of agricultural wetlands may not totally offset the loss of social value resulting from the loss of an acre of urban wetlands.

The FHWA Administrator, in accordance with the recently established national policy, issued an environmental policy statement in 1990 that committed the agency to a policy of "no net loss of wetlands" and to the adoption of all practicable measures needed to implement that policy. Subsequent actions of the agency carried through on this commitment, at least to some extent. For example, in 1991 the FHWA changed its policy with respect to mitigating the impacts of its programs on privately owned wetlands. Before that date the agency would replace such wetlands that it destroyed, but only on an acre-for-acre basis. No attention was given to wetland function. But since wetlands can differ substantially in the functions they perform, the acre-for-acre policy often did not fully compensate the owner of the destroyed wetland. The 1991 policy change adopted by the agency committed it to replacement of equivalent wetland functions. The agency also reached agreements with the EPA and the Corps of Engineers which clarified its obligations with respect to section 404 permits for alteration of wetlands (U.S. Department of Interior, 1994).

### Flood insurance

Until the National Flood Insurance Act of 1968 (NFIP) it was practically impossible for property owners to buy flood insurance in the United States (U.S. Department of Interior, 1994). The NFIP changed this.

Since under the NFIP emergency relief payments to flood victims were financed out of the federal budget, taxpayers generally were in effect compensating people who located in floodplains and suffered flooding losses as a consequence. Under the NFIP the federal government provides flood insurance, but to qualify for the program communities must adopt and enforce floodplain management regulations that meet NFIP standards. The regulations are designed to promote measures to protect against damage to floodplain properties, or to encourage avoidance of floodplain development in the first place. As the Department of Interior (1994, pp. 95-96) put it:

With the NFIP Congress gave notice that: it would no longer offer a blank check in the form of flood disaster insurance; it wanted people to self-insure; and for properties in which the Federal Government had a financial interest, it wanted the property owner to indemnify the Federal Government against loss from flooding. Communities without flood insurance are ineligible for disaster relief in the event of floods and prospective lenders must be notified.

The Federal Emergency Management Agency (FEMA) has responsibility for administering the National Flood Insurance Program. FEMA seeks to limit floodplain development by identifying flood hazard areas, assessing risk, establishing floodplain management criteria, and overseeing local management compliance. FEMA is involved in development of floodplain maps that make it possible to distinguish among areas in the floodplain according to the risk of flooding. The maps are then used by states and local jurisdictions to restrict development of high risk areas, guide development away from plains, and in general to improve management of the floodplain.

The Department of Interior (1994) concluded that the measures taken under the National Flood Insurance Program have helped to protect wetlands against loss or degradation. The Department cites an estimate by FEMA that measures taken under the Act had discouraged encroachment on some 9,000 square miles of floodways, many parts of which are in wetlands. The Department's report on this issue concludes, however, that ". . . the NFIP remains effective only as long as (1) the program is actuarially sound and insurance rates reflect the true risks of locating in flood-prone areas, (2) mapping is accurate, and (3) development restrictions and requirements under the program are aggressively enforced" (U.S. Department of Interior, 1994, p. 79).

#### Other urbanization policies

The Department of Interior (1994) also reviews the effects on wetlands of a number of other federal government urbanization programs. The Urban Development Action Grants Program, a program for community development block grants, programs of the Economic Development Administration, and programs to promote private housing were all found to encourage losses of wetlands in some areas and to some uncertain extent. For example it was concluded that the Urban Development Action Grants program had induced wetland losses in Louisiana, North Carolina, New Jersey, and Michigan, and some losses attributable to the community development block grants occurred in Michigan. Economic Development Administration programs were judged to have encouraged wetland losses in Michigan and North Carolina. But in all of these cases, the Department of Interior study (1994) found the effects of the various government programs to be so intertwined with other factors bearing on wetland losses that no estimates of the losses specifically attributable to the programs were possible.

## **FEDERAL POLICIES AFFECTING WATER USE AND WETLANDS**

### **Water Management and Wetlands**

Riparian wetlands are created by and depend on seasonal and annual streamflow variations. Consequently, their ecosystems are altered and possibly destroyed by activities that change streamflows. Reservoirs inundate wetlands while dam operations and water diversions for irrigation and urban use or hydroelectric power production alter historic flooding patterns and downstream flows. Changes in the quantity, timing, or location of flow

can alter or eliminate indigenous vegetation and aquatic communities; valuable wetland functions are likely to be diminished in the process. Dredging and channeling streams for flood control or navigation and constructing levees and dikes to control flows also adversely impact wetlands.

### **The Evolving Federal Role in Water Resource Development**

The federal government has had and continues to have a major impact on water resource use and development and, consequently, on the status and future prospects of riparian wetlands in the United States. Federal impacts on wetlands are the product of current policies and programs specifically directed at wetlands, the indirect effects of many other laws and programs, and past activities that continue to shape how water is managed and allocated.

The federal government's impact on wetlands during the nineteenth century stemmed from their policies to facilitate trade and encourage settlement of the interior of the country. The Corps of Engineers (COE) activities to improve harbors and clear channels on major rivers undoubtedly disturbed some riparian wetlands. But the government's primary impact during this period is attributable to the Swamp Lands Acts of 1849 and 1850 (that encouraged building levees and developing floodprone areas in the Lower Mississippi River basin) and legislation such as the Desert Land Law of 1877 and the Carey Land Act of 1894 (that encouraged settlement of the arid and semiarid West). By 1900 large numbers of people had been attracted by the lure of inexpensive land to areas where their welfare and even survival depended on benign precipitation patterns. Policies and programs introduced in the twentieth century to help these people adapt to variable and uncertain precipitation had major impacts on wetlands.

The plight of these people along with the challenges of providing safer drinking water, developing hydroelectric power, and improving understanding of the underlying hydrology of the nation's water resources led to the adoption of an activist federal role in developing the nation's water resources. The view that it is wasteful to leave water resources unused that could be developed for cities, factories, or the production of crops and power dominated federal water policy from about 1900 to 1970. Highlights of the growing federal role are described below (Frederick, 1991).

- The Reclamation Act of 1902 established the Reclamation Service (currently the Bureau of Reclamation) to assist in developing the West through irrigation. Federal projects now supply, under highly subsidized terms, about 25 percent of the West's irrigation water.
- The purview of the Corps of Engineers was broadened in 1913 to include power development and again in 1917 to plan and construct flood control works in the Lower Mississippi and Sacramento basins.

- The Federal Power Commission was established in 1920 to sell surplus power from federal dams, to license nonfederal power developments on navigable waters, and to survey future water power opportunities. More than 2,300 hydroelectric plants now operate under federally granted licenses.
- In the 1930s, water development projects became a vehicle for creating jobs during the depression as well as gaining control over a highly variable and uncertain resource. New Deal legislation--which gave the president extraordinary powers to initiate and finance public works, including municipal water supplies, sewage plants, irrigation, flood control and hydropower--led to construction of some of the nation's largest water projects.
- The 1936 Flood Control Act, which declared that flood control on navigable rivers and their tributaries is a proper activity of the federal government, initiated a national flood control program. The Corps of Engineers built more than 300 reservoirs primarily for flood control. Other federal agencies, including the Soil Conservation Service (renamed the Natural Resources Conservation Service), Tennessee Valley Authority, and the Bureau of Reclamation developed urban or rural flood damage reduction programs.
- The pace of dam construction accelerated after World War II as large multipurpose dams were viewed as symbols of farseeing humane management of natural resources. More than 35,000 dams were completed between 1945 and 1969, or nearly 3.9 per day for 25 years. Although less than 5 percent of the dams in the COE's 1982 dam inventory were federally owned, federal agencies planned and constructed most of the large dams.

Due in part to federal programs and policies, water use as well as the capacity to control the resource for human purposes increased rapidly from 1900 to 1970. For instance,

- water withdrawals rose from 40 to 370 billion gallons per day;
- the number of completed dams rose from 2,661 to 50,589\*;
- reservoir storage capacity behind these dams rose from 10 to 753 million acre feet.

The magnitude of these changes was attributable in part to a willingness to ignore their impacts on streamflows, wetlands, and water quality. Although the environmental impacts are not as readily quantifiable, they include:

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\* This only includes dams at least 6 feet high with at least 25 acre-feet of storage, or at least 25 feet high with at least 15 acre-feet of storage.

- the loss of tens of thousands of miles of free flowing streams;
- the destruction or deterioration of millions of acres of riparian wetlands that were either inundated by reservoirs or damaged by altered streamflows;
- the contamination and deterioration of the ecosystem of countless streams and lakes such that they were unable to support most human uses.

Mounting concerns over these impacts contributed to a major shift in federal water policies. Federal support for water development projects has declined sharply since the passage of a series of environmental laws to protect and restore the nation's water resources. The National Environmental Policy Act of 1969 (NEPA) established the Environmental Protection Agency (EPA) with responsibility for setting and enforcing water quality standards. NEPA made it national policy to minimize damage to the environment; federal agencies were now required to assess the environmental impacts of their actions.

The Clean Water Act of 1972 established ambitious and unattainable goals of restoring all navigable waters to a "fishable and swimmable" condition by 1983 and eliminating all pollutant discharges to these waters by 1985. Section 404 required a permit for the discharge of any dredged or fill material into navigable waters of the United States. The COE had responsibility for issuing wetland permits while the EPA could intervene in and even override a permit action by the Corps. Subsequent court decisions and the 1977 Clean Water Act Amendments extended the COE's permitting authority to include wetlands. The criteria for issuing permits as well as the definition of a wetland remain controversial.

In May 1977 President Carter ordered all executive agencies to conduct their business in ways that would protect the environmental values of floodplains and wetlands. Executive Order 11988 (Floodplain Management) ordered each agency "to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative." Executive Order 11990 (Protection of Wetlands) requires agencies to "take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities . . . ." President Bush established a "no net loss" policy for wetlands in February 1989. The Water Resources Development Act of 1990 set an interim goal of "no net loss of the Nation's remaining wetland base" and a "long-term goal to increase the quality and quantity of the Nation's wetlands" (U.S. Department of Interior, 1994, p. 72). The Clean Water Action Plan issued February 19, 1998 calls for a net gain of up to 100,000 acres of wetlands each year beginning in the year 2005 (U.S. General Accounting Office, 1998).

These are just a few of the laws and policies that have shifted federal water policy from a construction and development emphasis to one more concerned with protecting and restoring environmental and recreational values. Despite the change in focus, the impact of federal water policies, programs, and management practices on riparian wetlands is complex



and inconsistent. While measures have been adopted to protect and restore wetlands, enormous quantities of subsidized water continue to be diverted for irrigation. In addition, federal dams are managed for flood control, hydropower, and navigation with little concern for their impacts on wetlands. Currently water use and management often involves a struggle between traditional users with rights established under laws that treat water as a free resource and encourage depletion of natural ecosystems and environmental and recreational interests armed with legislation designed to protect and restore environmental water values. Federal policies commonly support both sides of this struggle.

Inconsistencies in the federal role may be inevitable in view of the multitude of agencies and legislative committees, each of which has somewhat different agendas and goals, that are involved in formulating and carrying out water policies and programs. The complexity of the policy process has changed little from the situation in 1988, described by Foster and Rogers.

"... eighteen federal agencies, in seven departments and seven independent agencies, currently exercise responsibility for water programs and projects. They operate under policies enshrined in individual legislative acts. At least twenty-five separate water programs, and some seventy separate Congressional appropriations accounts, have been identified. These programs are governed by more than two hundred federal rules, regulations, and laws" (Foster and Rogers, 1988, p. 9).

Research undertaken for this study identified about 50 federal policies and programs that, either directly or indirectly, affect wetlands. Federal impacts on activities that affect water use and management are described below.

### **Water Resource Infrastructure**

Federal agencies continue to support construction of water development infrastructure such as dams, reservoirs, levees, and navigation locks. And, as is noted below, some federal regulations and operating procedures continue to be biased in favor of structural approaches for resolving water issues. Nevertheless, the federal impact on water resource use has shifted dramatically in recent decades from its virtual unmitigated support of structural projects to control and divert streamflows and its willingness to overlook the environmental impacts. Policies and programs are now oriented as much to local protection works that avoid or mitigate wetlands impacts and to restoration as they are to development activities detrimental to wetlands. Financial support for federal water projects has declined sharply, and agencies are now required to give special consideration to the impacts of their activities on wetlands and other environmental resources. Moreover, environmental laws are now commonly used to delay, alter, or even eliminate federal and private water projects.

### Federal funding

For fifty years after passage of the Flood Control Act of 1936 the federal government paid the great majority of the costs of federal projects. The contribution of local beneficiaries of these projects was generally limited to lands, easements, and rights-of-way unless the project had reimbursable purposes such as hydropower and water supply. As long as the federal government paid most of the costs, water projects were often sought by local communities for the jobs and lucrative contracts they would bring regardless of their impacts on the environment and alternative uses of the resource.

Federal funding for COE projects changed with the Water Resources Development Act (WRDA) of 1986. Local cost sharing was set at 100 percent of the construction and operation and maintenance costs for hydropower, municipal, and industrial uses; between 25 and 50 percent of the construction costs and 100 percent of the operation and maintenance costs for flood control; and 25 percent of all costs associated with water quality and fish and wildlife purposes. The nonfederal cost share for flood control and most environmental restoration was increased to 35 percent by the 1996 WRDA. Inland navigation projects are financed 50 percent from the Inland Waterways Trust Fund (financed by a 20 cent per gallon tax on barge fuel) and 50 percent from the federal treasury. The treasury pays 100 percent of the operation and maintenance costs.

Section 1135 of the 1986 WRDA authorized the Corps to review the water resources projects it had already constructed to determine the need for modifications that would improve the quality of the environment. Projects to address environmental degradation caused by the Corps could be undertaken if nonfederal parties paid 25 percent of the project costs and usually 100 percent of the operation, maintenance, replacement, and rehabilitation costs (U.S. General Accounting Office, 1998).

Under section 206 of the 1996 WRDA, the Corps may carry out aquatic ecosystem restoration projects that improve the environment, are in the public interest, and are cost effective. Individual projects are limited to \$5 million in federal cost; nonfederal parties must contribute 35 percent of the construction and 100 percent of the operation, maintenance, replacement, and rehabilitation costs (U.S. General Accounting Office, 1998).

The Bureau of Reclamation was not covered by the 1986 WRDA provision mandating increased local cost sharing. Although the agency has resisted standardized cost sharing percentages for its irrigation and flood control works, it has negotiated increased local cost shares for several projects. With its original mission of reclaiming and settling the arid west complete, the agency is being transformed from a construction to a water management agency. Few, if any, additional large water projects are anticipated. Thus, cost sharing on BOR projects is now largely an issue of recovering the costs for past construction projects and future operation and maintenance.

The International Boundary and Water Commission (IBWC) within the Department of State manages, cooperatively with Mexico, the Rio Grande river from El Paso, Texas to the river's mouth. The commission's Rio Grande Channelization Project completed in 1943 destroyed riparian wetlands along a 100 mile reach of the river. The flood control project

allowed urban development in the floodplain that is now protected at federal expense. The cost sharing and environmental principles of the recent WRDAs have not been applied to the commission's activities (U.S. Department of Interior, 1994).

The Public Utility Regulatory Policies Act (PURPA) of 1978 reflects the nation's concerns over the availability of energy supplies during the mid to late 1970s. This act provided generous incentives for developing small hydro projects that, by their very nature, alter stream habitat and wetlands. PURPA requires utilities to purchase energy from small hydro plants at the utilities' avoided cost. In addition to a guaranteed market, PURPA provided a 21 percent investment tax credit, 5-year depreciation of capital investment costs, and loans for as much as 90 percent of the costs of feasibility studies and 75 percent of project costs. Subsequently, these subsidies were curtailed in part because of concerns over the projects' impacts on aquatic ecosystems. Only the buy-back requirement remains. And even this benefit can be denied for "new dams and diversions unless: the project complies with specific fish and wildlife recommendations; FERC finds that the project will not have substantial, adverse effects on the environment; and the project is not located on a State or national wild and scenic river system or a river designated by a State as having important attributes which may be affected. Few proposed projects meet these criteria" (U.S. Department of Interior, 1994, p. 85).

The Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service) has helped local communities plan and construct small watershed reservoirs since the 1950s. Under the PL-566 watershed program authorized in 1953, the agency provides financial and technical assistance to local sponsors to develop and implement watershed plans for flood prevention, watershed protection, water management, and groundwater recharge. The program has supported construction of small dams to retard flood waters and drainage channels. The watershed program has been modified in recent years to reflect environmental concerns. In 1990 the agency was authorized to assist local sponsors acquire perpetual conservation easements on wetlands and floodplains to improve water quality, reduce flood damages, and provide habitat for fish and wildlife. However, in 1994 none of the \$1.3 billion in authorized projects had wetlands components (U.S. Department of Interior, 1994). As of this writing, NRCS has not used its authority to purchase wetland easements under PL-566 (personal communication, Ron Page, NRCS). This is due in part to a 50 percent cost sharing requirement for the purchase of wetland easements while providing full federal funding for other flood prevention measures such as dams and levees.

NRCS's Emergency Watershed Protection (EWP) program, established in 1978, provides technical and financial assistance to preserve life and property threatened by excessive erosion and flooding. Under this program the agency provides up to 75 percent of the financing to restore the natural functions of a watershed through projects such as clearing debris from clogged waterways, restoring vegetation, and stabilizing river banks. The 1996 Farm Bill provides farmers the option of offering land for a floodplain easement. To date, NRCS has spent approximately \$15 million to secure easements for 19,000 acres of wetlands under this program (personal communication, Ron Page, NRCS).

There are over 12,000 miles of commercially navigable inland waterways in the United States with over 200 locks and dams. Public and private investments in the system were estimated at nearly \$60 billion as of 1987. The COE is responsible for operating and maintaining nearly all of the waterway segments operated for commercial navigation (Schilling et al, 1987). Federal expenditures in recent decades have been directed to operating and maintaining the existing system and repairing and replacing locks rather than expanding the system.

Federal support of inland navigation impacts riparian wetlands directly and indirectly. Direct impacts include construction of locks and dams which can destroy wetlands by flooding and channelization. Operation of the dams and locks for navigation can damage wetlands by altering river flows. On the other hand, sediment dredged to maintain channel depths can be, and often is, used to create wetlands.

The indirect effects on wetlands of federal support of navigation likely have been strongly negative. Boat traffic produces waves that cause erosion, and fuel spills and dumping waste can adversely impact riparian ecosystems. But the principal impact of navigation probably comes from the encouragement it provides for development of the floodplains. Access to low cost transportation to distant domestic and international markets has encouraged major industrial development along the nation's inland waterways. In some cases these developments have resulted in the loss of riparian wetlands.

#### Distortions in project evaluation

For more than two decades the Corps' planning and evaluation process for reducing flood damages has included non-structural approaches such as watershed restoration and permanent evacuation (relocation) of floodplain structures. And since the 1990 WRDA, environmental protection has been a primary mission of COE planning, constructing, operating, and maintaining water projects (U.S. Department of Interior, 1994). However, under the project evaluation procedures of the Principles and Guidelines (U.S. Water Resources Council, 1983) that have been adopted by the Corps of Engineers, non-structural approaches are rarely competitive with structural measures such as flood control dams, levees, floodwalls, channel enlargement, diversion channels, and pumping stations.

The Principles and Guidelines (P&G) states: "The Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements" (U.S. Water Resources Council, 1983, p. 1). Although the guidelines recognize environmental and social considerations in the planning process, final recommendations are based primarily on maximizing national economic development (NED) benefits consistent with environmental constraints. Because the NED maximization principle does not provide for environmental restoration as a project purpose, non-structural measures are at a disadvantage in the evaluation process. However, wetlands are considered an environmental constraint subject to the 404 permit process, and the Corps no longer builds projects in wetlands.

The accounting rules used to estimate the relative benefits and costs of reducing flood damages through permanent evacuation also understate the potential benefits of relocation as an alternative to structural measures. The acquisition costs of a relocation project are based on market values which incorporate factors such as insurance subsidies and the amenities of being located next to a river. In contrast, the reduction in flood damages, which is the primary project benefit, is based on the cost of physical replacement less depreciation. Leonard Shabman (personal communication, 1998) argues that other justifications such as riparian zone restoration might be used to evaluate the merits of evacuation. Recent studies by the Corps indicate that the differing bases for the calculation of benefits and costs distorts the benefit-cost ratio of evacuation projects and significantly overstates their economic inefficiency relative to structural alternatives (Institute for Water Resources, 1998).

Federal subsidies such as relief and recovery payments and subsidized flood insurance transfer some of the costs of floodplain occupancy from the occupants to the public. These subsidies increase residents' incentives to remain in the floodplain. And since these subsidies are capitalized into the market value of the floodplain structures, they increase the cost of undertaking a permanent evacuation program (Institute for Water Resources, 1998).

Partly in response to the Institute for Water Resources analysis of the current distortions in the criteria for evaluating non-structural approaches for mitigating flood damages, section 119 of Senate Bill S.2131 (introduced June 4, 1998) would modify the Water Resources Development Act of 1990 to instruct the Secretary of the Army to "include primary flood damages avoided in the benefit base for justifying Federal non-structural flood damage reduction projects." However, for reasons unrelated to this provision, this bill did not pass during the 105th Congress.

Correcting the distortions in the evaluation process and eliminating the influence of the subsidies would make little difference in the advantages of structural protection relative to evacuation projects in areas that are already heavily developed and urbanized. The costs of evacuating urbanized areas are too high to be feasible. On the other hand, structural protection is more expensive and more likely to be inefficient in sparsely developed areas or where houses are spread out in narrow strips along a stream (Institute for Water Resources, 1998). Distortions in the evaluation process might alter the outcome in favor of structural approaches in intermediate situations.

#### Impacts of environmental legislation

The nation's environmental laws have had major impacts on water projects. The NEPA requirement that all federal agencies include an environmental impact statement (EIS) as part of a project's analysis provides a legal tool for challenging an agency's analysis of the environmental impacts and proposing alternative uses of water resources that might be impacted by the project. Environmentalists have used NEPA citizen suit provisions to delay, alter, and even terminate projects to dam and divert streams. But, as noted above, this is only one of the environmental laws that have altered the course of water development. Examples

of the past and potential impacts of other environmental legislation on water planning and project implementation are described below.

- In 1990 EPA used its authority under section 404 of the Clean Water Act to veto the Two Forks dam and reservoir project which would have added 1.1 million acre-feet (maf) of storage on the South Platte River in Colorado and increased Denver's water supply by 98,000 af. The veto came after nearly a decade of planning, numerous modifications to mitigate adverse environmental impacts, the expenditure of more than \$40 million on an EIS, and issuance of a permit by the COE.
- The Wild and Scenic Rivers Act has designated more than 100 rivers and stretches of rivers as wild and scenic, precluding any water projects that would excessively damage the natural amenities of the designated areas. In California, flows in federal and state designated wild and scenic rivers constitute the largest environmental water use (California Department of Water Resources, 1998).
- The Endangered Species Act (ESA) prohibits federal agencies from undertaking actions that threaten the survival or critical habitat of a species officially designated as endangered. Water development agencies must await the results of biological studies of a project's impacts on endangered species before undertaking any actions that might result in irreversible or irretrievable damage. When a threat is identified, the project must be altered or abandoned. This act halted completion of the Tellico Dam project on the Little Tennessee River until Congress passed legislation exempting the project from the ESA. In 1990 the ESA was used to halt the Animas-La Plata Project, one of the few remaining large water projects planned by the BOR, on the San Juan River system in southwestern Colorado. The fate of this project, which has been modified to mitigate its environmental impacts, remains uncertain.
- The Electric Consumers Protection Act of 1986 (ECPA) requires the Federal Energy Regulatory Commission (FERC) to give power and nonpower benefits, including wetlands and fish and wildlife habitat, equal consideration in the licensing and relicensing of hydropower dams. From the utilities' perspective, ECPA increases the costs and reduces the benefits of their hydropower developments.

Environmental legislation and reduced federal financial support contributed to a sharp decline in the pace of dam and reservoir construction. The average annual number of dams completed declined from 1,909 during the 1960s, to 1,059 in the 1970s, 480 from 1980-84, 439 from 1985-89, and 255 from 1990-1995 (Frederick, 1991, and personal communication, Bruce Carlson, COE).

## **Reservoir Management**

More than 75,000 dams and reservoirs with storage capacity of about 860 million acre-feet have transformed the nation's rivers and streams. Depending on how they are managed, these facilities can help control floods, provide farms and cities more reliable water supplies, produce power, facilitate navigation, and influence a variety of recreational and environmental benefits. Management of these dams and reservoirs determines the timing and magnitude of downstream flows which in turn affects the ecological health of the remaining riparian wetlands. As noted below, managers of private as well as federal facilities are now required to give greater emphasis to the environmental implications, including the impacts on wetlands, of their actions.

The United States has more than 2,300 hydroelectric power plants with a total capacity of 73,500 megawatts (Richard Hunt Associates, 1994). They account for about 9 percent of U.S. electric power generation. Most of these plants operate under federal licenses issued as many as fifty years ago when few questions were raised about the implications for wetlands and fish and wildlife habitat. Consequently, the plants generally were operated to maximize the value of the power produced with little concern for the impacts on other values. As these licenses expire, the relicensing process under ECPA is likely to require a detailed environmental assessment of the plant's impacts on fish and wildlife habitat, water quality, recreation, land use, local communities, and cultural resources. If a new license is issued, it is likely to be encumbered by restrictions that increase the environmental and recreational benefits at the expense of hydropower production. The impacts of the changes in dam operations on riparian wetlands are unknown. It is likely, however, that wetlands benefit from changes designed to improve fish and wildlife habitat and to reduce the artificial fluctuations in reservoir levels and downstream flows associated with operating the dams for peaking power.

Management of many of the large federal dams also has been modified in recent years to reflect changing social values and to repair some of the damage caused by past management practices. For example, the Bureau of Reclamation has released hundreds of thousands of acre-feet of water around the turbines at Shasta Dam on the Sacramento River in California to provide colder water for the spawning of the endangered winter-run Chinook salmon. The various efforts to save and rebuild salmon stocks in the Columbia River Basin include creation of a 4.5 million acre-feet water budget to be available for supplementing flows for fish during critical periods. In 1996 the Bureau of Reclamation released an estimated 117 billion gallons (about 360,000 af) from Glen Canyon Dam on the Colorado River to create a week-long controlled flood designed to restore natural beaches and wildlife habitat in the Grand Canyon. The impacts on wetlands from these ad hoc changes in dam operations were probably small. But to the extent that environmental values receive greater weight in the operation of federal dams, wetlands are likely to benefit.

Regulation of the six large Corps dams on the mainstem of the Missouri River has been contentious and the subject of a major review of the guidelines used to manage the river. While the Corps and the eight basin states have yet to agree on the criteria for managing the dams and reservoirs, some changes have already been made in response to the mandates of

the Endangered Species Act. Designation of the least tern as an endangered species and the piping plover as a threatened species in 1985 has constrained management of the river on several occasions. These birds nest on the low lying sandbars and islands downstream from several of the dams. Water released for navigation, flood control, and hydropower production frequently floods these sites. To comply with the Endangered Species Act, dam releases have been modified during the May 1 through mid-August nesting season of these birds.

The broad issue as to how federal water management criteria should be modified in response to changing social values such as the heightened appreciation of wetlands remains largely unresolved. In the absence of any consensus and basinwide perspective, the water management agencies are required to make ad hoc adjustments to the mandates of legislation such as the ESA. These adjustments often involve spending large sums and foregoing millions of dollars of hydropower revenues with little analysis of the relative benefits and costs or the alternative uses of the water and related infrastructure.

### **Water Diversions**

In 1995 freshwater withdrawals from the nation's surface waters averaged an estimated 263 billion gallons per day (Solley, Pierce, and Perlman, 1998). These withdrawal rates are a legacy of past laws and policies that favored offstream over instream uses and encouraged development of the infrastructure that made it possible. Federal policies promoting irrigated agriculture, which accounts for nearly 40 percent of all withdrawals, were an important determinant of past water development and use, especially in the West. These policies continue to have major impacts on water use and, thereby, on riparian wetlands.

The Bureau of Reclamation supplies about 30 million acre-feet of water annually, about 86 percent of which is provided under highly subsidized terms for irrigation. The federal subsidy for irrigation water has risen dramatically--from about 14 percent early in this century (when repayment had to be made within 10 years) to more than 90 percent of construction costs (when repayment was stretched to 50 years or more) (Wahl, 1989). Few of these irrigation projects would have been commercially viable in the absence of the subsidies. The fact that they were built and continue to provide farmers with highly subsidized water has persistent impacts on western water use.

Other federal agricultural subsidies also have contributed to the expansion of irrigation and, thus, to the depletion of streamflows. The complex of agricultural subsidies discussed earlier increase the profitability of agriculture and encourage the spread of irrigation. The Bureau of Land Management and the Forest Service provide easements for small diversion projects that cross their lands. These projects, which reduce the flow to riparian vegetation, may be eligible for Agricultural Stabilization and Conservation Service funds on a cost-sharing basis. The percentage paid by the federal government varies by county and can reach 70 percent in some areas (U.S. Department of Interior, 1994).

The Bureau of Reclamation's salinity control program for the Colorado River Basin also provides generous subsidies that largely benefit irrigators. Irrigators contribute about 37 percent of the river's salinity but contribute less than 6 percent of the costs of the multi-billion



dollar program to reduce salt levels. In the absence of the federal program, it might have been necessary to retire some irrigated lands to reduce salinity levels in the Lower Colorado River (U.S. Department of Interior, 1994). Moreover, retiring some of the lands that contribute the largest quantities of salts would be a less costly means of reducing salinity.

The federal impact on irrigation diversions is in large part a product of past policies that resulted in construction of the infrastructure and established the high priority rights to divert water in perpetuity. In recent years some changes in policy reflect the growing concerns over irrigation's impacts on environmental values and instream flows. Most notable is the Central Valley Project Improvement Act of 1992 (CVPIA) which authorized major changes in the Bureau of Reclamation's management of the Central Valley Project, California's largest water storage and delivery system. The CVPIA authorized the marketing of federally-supplied water outside the project area and required the annual dedication of up to 800,000 acre-feet of project water for fish and wildlife habitat. A principal purpose of the dedicated water is to double the natural production of anadromous fish populations by the year 2002. The act prohibited the BOR from executing new water service contracts (with minor exceptions), except for fish and wildlife purposes, until all of the environmental restoration actions specified in the statute had been completed. Only interim renewal (not more than three years) of irrigation contracts are allowed until the programmatic EIS is completed. Contract renewals would incorporate new provisions mandated by the act, such as tiered water pricing. And as of October 1997 most existing contracts were subject to monetary penalties designed to encourage early renewal (California Department of Water Resources, 1998). Five years after passage of the CVPIA the Department of Interior released its adaptive management approach in which the amount of instream water for fish will vary given hydrological conditions and fish demands. Interior's proposal has been criticized by both environmentalists and CVP water users and is now the subject of ongoing negotiations and a lawsuit (McClurg, 1998). An increase in water allocations for fish and wildlife would benefit wetlands. But there is no way to quantify the implications for wetlands of Interior's or any other proposal to carry out the mandates of the 1992 act.

The federal government, as well as some states, has been purchasing water for environmental purposes, such as preservation of endangered species, in recent years. Federal water acquisitions for environmental purposes have been made in three regions, the central valley of California, the Columbia River Basin, and the Truckee-Carson river basins near Reno, Nevada (Simon, 1997).

### **Regulation of Returnflows and Waste Discharges**

Wetlands are affected by the quality as well as by the timing and quantity of flow. Waterways have long been viewed as convenient and inexpensive vehicles for disposing of a society's wastes. Despite the adoption of increasingly strict standards and federal support for treatment plants, the quality of the nation's waters continued to decline until passage of the Federal Water Pollution Control Amendments of 1972, commonly known as the Clean Water Act. This act initiated a major commitment to improving the quality of the nation's waters. In

1972 large quantities of conventional pollutants such as fecal coliform bacteria and organics which create biochemical oxygen demands (BOD) were being dumped directly into the nation's waters through municipal and industrial pipes and ditches. Concentrations of these pollutants reached levels that threatened human health and impaired or destroyed aquatic life and the recreational value of the receiving water resource. Curbing and treating these point-source discharges through technology-based effluent standards and federal construction grants has produced important water-quality benefits, albeit at a very high cost. Federal expenditures for municipal waste treatment plants totaled \$37 billion from 1972 to 1985 and at its peak covered 75 percent of their construction costs (U.S. General Accounting Office, 1986). The maximum construction grant was reduced to 55 percent in 1985, and the Clean Water Act Amendments of 1987 authorized an addition \$18 billion to construct sewage treatment facilities and establish a revolving fund to assist in financing future projects.

Municipal and industrial wastes continue to be significant contributors of BOD, bacteria, nutrients, toxics, and other pollutants. However, investments to control these point-source pollutants are encountering diminishing returns in their ability to restore the quality of the waters that are still unable to fully support their designated uses. Nonpoint sources such as runoff from farms, urban areas, and construction sites and seepage from landfills and septic systems are now the principal sources of pollutants reaching the nation's waters. Agriculture is the biggest polluter of the nation's rivers and streams, contaminating more than 173,000 miles of waterways with chemicals, sediment, and animal wastes (Cook, 1998).

### **Vegetation Management**

Riparian vegetation has been managed to conserve water for irrigation and municipal use and to improve water transport. Vegetation management, which might involve mowing, burning, bulldozing, and using herbicides to eliminate plants, has been part of the construction and operation and maintenance process of the BOR, COE, and IBWC water projects. The federal government pays the full cost of vegetation removal on floodways. And the Agricultural Stabilization and Conservation Service provides cost sharing for vegetation removal on private lands.

Although vegetation management continues to be a regular part of maintaining the water-transport capacity of floodways, its use has diminished in recent years because of doubts about its water-conserving benefits, adverse environmental impacts, and a decline in new construction by the water development agencies. Some studies suggest the water-conserving benefits may have been overstated. But the more important objection to vegetation management is that the destruction of the riparian vegetation reduces the ability of these areas to assimilate wastes, control erosion, slow floodwaters, moderate temperatures, and provide food for fish and wildlife (U.S. Department of Interior, 1994).

## **RESTORATION, ENHANCEMENT, AND CREATION OF WETLANDS**

### **Introduction**

The discussion above indicated that by the 1990s federal policies affecting wetlands had moved strongly to protection and restoration. The impacts of the Wetlands Reserve Program and Emergency Wetlands Reserve Program in wetlands restoration were noted in particular. But the policy shift has not been limited to those affecting farmers. Federal transportation and urban land use policies also shifted to give more emphasis to wetland protection. And policies influencing water development and management have become more sensitive to their environmental impacts, including those on wetlands. Indeed, the shift in policy with respect to wetlands now is quite general throughout the federal government. It is useful, therefore, to consider the policy shift without regard to any particular sector or any particular government agency.

The Bush administration adopted a policy of "no net loss" of wetlands, and the policy subsequently was endorsed by the Clinton administration. In 1993 the administration set an interim goal of no overall net loss of the nation's remaining wetlands and a long-term goal of increasing their quality and quantity. The Clinton administration's Clean Water Action Plan issued on February 19, 1998 includes a strategy to achieve a net gain of up to 100,000 acres of wetlands each year, beginning in the year 2005 (U.S. General Accounting Office, 1998).

A report by the National Research Council (1992) argued that the nation should adopt a goal of a net 10 million acre increase in wetlands by 2010. The NRC did not present an argument in support of this goal, but a case can be made for some net increase in wetlands acreage. For example, it might be argued that the past destruction of wetlands failed to give adequate consideration to the social benefits they provide, and that social welfare would be improved by increasing the wetland resource. As we look to the future, it is likely that demand for outdoor recreational services in the U.S. will continue to rise over the next several decades, as it has been doing for the last 20 or 30 years. The rise in demand is driven both by increasing population and increasing per capita income. The demand by hunters and bird watchers for direct contact with wildlife, and the interest of many other people who value the knowledge that wildlife numbers are maintained or increased, translates into rising demand for wildlife habitat, of which wetlands are a particularly rich source.

Since some amount of wetland conversion can be expected to continue more or less indefinitely despite continued government efforts to hold it in check, a policy of no net loss, or more challengingly, some net increase, requires a capacity to not only protect wetlands but also to restore a destroyed wetland, enhance the quality of a damaged wetland, or create an entirely new wetland.

The discussion above credited the Swampbuster provision in the 1985 and subsequent farm bills and section 404 in the Clean Water Act of 1972 with being mainly responsible for the sharp decline in wetland losses to agriculture from 1982 to 1992. Changes in policy with respect to water resource development and management also have helped to increase protection for wetlands. The effectiveness of Swampbuster depends on the strength of the

incentives farmers have to qualify for access to government price and income support programs. Under the farm bill of 1996 those programs are supposed to phase out by 2002. There still is some question whether, as that date approaches, the Congress will in fact permit the programs to disappear. But, if they do, Swampbuster will be de-fanged and farmers will no longer be penalized for drainage of wetlands. If agricultural markets are strong, some additional drainage will be likely.

In this discussion we take no position on the future of Swampbuster or of other wetland protection policies of the federal government. We assume that at least for the next several years wetlands will continue to receive reasonably strong protection. Accordingly, we focus our attention here on issues of wetland restoration, enhancement, and creation.

### **Federal Government Restoration, Enhancement, and Creation Policies**

The federal government, through the Fish and Wildlife Service, has been engaged in efforts to restore, enhance or create wetlands for over 50 years (Foster and Rogers, 1991, pp. 27-31). More recently, the Service has conducted wetlands programs under the North American Wetlands Conservation Act (1989) and the National Coastal Wetlands Conservation Grant Program (authorized under legislation passed in 1990). The Bureau of Land Management, also a part of the Department of Interior has an ambitious program to restore and maintain 23.7 million acres of riparian wetlands, mostly in the western states.

The Department of Agriculture, through its Wetland Reserve Program and the Emergency Wetland Reserve Program, also has been a major player in government efforts to restore and enhance wetlands.

The Corps of Engineers also has undertaken a number of wetland restoration and creation activities. Under section 1135 of the Water Resources Development Act of 1986 the Corps considers how modifications to its earlier water projects might provide environmental benefits. Under section 307 of the Water Resources Development Act of 1990, the Corps, in consultation with other agencies, was directed to prepare a national action plan for no net loss of wetlands and a national wetlands restoration and enhancement demonstration program to evaluate the long-term technical and scientific feasibility of such an approach. And section 206 of the WRDA of 1996 authorizes the Corps to undertake aquatic ecosystem restoration projects that improve the environment, are in the public interest, and are cost effective. Non-federal cost sharing is required for projects undertaken under sections 1135 or 206.

Table 5 summarizes wetland acreage restored under four federal programs from 1992-1996. The adjusted figures in Table 5 indicate that the USDA's Wetland Reserve and Emergency Reserve programs accounted for 70 percent of total wetlands restored under these government programs. The Corps of Engineers, through the 404 permitting process, accounted for 19 percent of the total. In addition to the acres restored under these government programs, 1,144 acres were restored through mitigation banking during the year 1992. As is noted below, mitigation banking has become more important in recent years although it still only accounts for a small percentage of wetlands restoration.

**Table 5. Average Annual Restoration of Wetlands Under Four Federal Programs, 1992-1996**

	(Thousands of acres)	
	<u>Unadjusted</u>	<u>Adjusted*</u>
USDA Wetland Reserve and Emergency Wetland Reserve	80.1	76.1
Fish and Wildlife Partners for Wildlife	46.6	2.3
Fish and Wildlife No. Am. Waterfowl Management Plan	37.8	9.5
Corps of Engineers Section 404	<u>21.8</u>	<u>20.7</u>
Totals	186.3	108.6

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\* The adjusted figures eliminate double counting and other anomalies in the unadjusted figures.

Source: Heimlich, et al., 1998, p. 54.

## **Policy Issues**

Policies to ensure the success of efforts to restore, enhance and create wetlands must confront and make headway in overcoming a number of difficult problems. The problems are technical, institutional and economic.

### Technical problems

The fundamental technical problem is that wetlands are so heterogeneous in their characteristics of soils, hydrology, flora, fauna and climate that the functions they perform and the ways in which they perform them are highly complex and different across the whole range of wetlands. Consequently, exact restoration of a wetland is difficult and probably impossible. Recognizing this, the National Research Council (1992, p.2) takes a pragmatic approach, arguing that while exact restoration may not be feasible, ". . . in certain situations partial ecological restoration may be the operant management goal and may provide significant ecological benefits even though full restoration is not achieved". The NRC notes that techniques for restoring wetlands fall into three broad categories: (1) reestablishing or managing wetland hydrology; (2) eliminating or controlling any chemical or other contaminants affecting the wetland; (3) and reestablishing and managing the biota native to the wetland. Research on the use of these techniques ". . . has focused primarily on techniques of species establishment and on development of species composition and wetland community structure. The functional values of wetlands, although widely recognized, are seldom evaluated" (National Research Council, 1992, p. 289).

While fully cognizant of the obstacles to wetland restoration, the NRC study (p. 5) asserts that: "Although restoration ecology applied to aquatic ecosystems is in a very early stage of development, the prospect for substantive improvement in damaged aquatic

ecosystems is excellent." This suggests that although the technical problems are not fully understood, enough is known about the problems to make wetland restoration and creation feasible approaches to maintaining or expanding the supply of wetland services.

### Institutional issues

The problems here are how to create or modify institutions that give people incentive to restore or create wetlands. The principal institutions to date used for this purpose are the Fish and Wildlife Coordination Act of 1958 (FWCA); Executive Order 11990, Protection of Wetlands; and the section 404 permitting process managed by the Corp of Engineers (Reppert, 1992). Under these authorities wetland mitigation (restoration, enhancement or creation) is achieved, in principle, by requiring developers or anyone else who wants to convert a wetland to show (1) that they have designed their project so as to minimize the wetland impact and (2) that the impacts that remain will be "mitigated" by restoring, enhancing or creating an equivalent wetland in the same area where conversion occurs.

The critical question that emerges is what constitutes an "equivalent" wetland. In administering section 404 the Corps of Engineers answers the question by relying on a memorandum of understanding (MOA) with the Environmental Protection Agency. According to King and Bohlen (1994, p.1) the MOA

"... specifically requires that mitigation requirements should be based 'solely on the values and functions of the aquatic resources impacted' and not on economic or other considerations. Compensation requirements under the federal program therefore, at least in principle, should be established on the basis of a comparison of the wetland functions and values expected from the compensation wetland and those lost with the destruction of the original wetland."

In practice, implementation of this principle of wetland mitigation has run into the hard fact emphasized above: wetlands are highly heterogeneous in the functions they perform and in the proportions in which they perform them. In consequence, it is not at all clear that wetland mitigation under the 404 permitting procedure has in fact compensated for wetlands by the restoration or creation of functionally equivalent wetlands.

In most cases permitting for wetland mitigation under section 404 requires that wetland restoration or creation occur in or close to the site where wetland conversion occurs. By the early 1990s a conviction had emerged that on-site mitigation too often had failed, and the concept of the mitigation bank developed as an institution that would permit off-site mitigation, with a greater chance of success (Leonard Shabman, personal communication, 1998).

According to Reppert (1992),

Wetland mitigation banks are normally relatively large blocks of wetlands whose estimated tangible and intangible values, termed credits, are similar to cash deposits in a regular checking account. As anticipated development takes place,

credits equivalent to the estimated unavoidable wetland losses are withdrawn or debited from the bank to compensate for the losses incurred. As development continues . . . , the credits of banks, *which are qualitatively similar and scaled in size to the magnitude of anticipated wetland losses*, are progressively exhausted (p. 1, emphasis added).

Reppert adds,

The objective of wetlands mitigation banking is to replace the physical and biological functions and *human-use values* of the wetlands which are unavoidably lost due to development (p. 1, emphasis added).

Heimlich et al. (1998, p. 43) state the rationale for mitigation banking as follows:

Mitigation banking essentially makes transferable a developer's obligation to mitigate when wetland losses are unavoidable. In so doing, it offers potential advantages of a wider market in conservation interests. Specifically, mitigation banking offers economies of scale in wetland creation, restoration, or enhancement, as well as flexibility in locating compensatory wetlands in sites that offer greater or higher priority ecological benefits.

Wetland mitigation banks operate under guidelines issued by the Natural Resource Conservation Service, the Corps of Engineers, and the Environmental Protection Agency. The Corps, operating under section 404 of the Clean Water Act, is the major actor in granting permits to establish mitigation banks. The guidelines are intended to assure that the performance of the banks in promoting wetland mitigation is in compliance with section 404 and Swampbuster (Heimlich et al., 1998). By February, 1997 there were 108 mitigation banks operating around the country, some three-quarters of them being managed by state highway departments, port authorities and local governments. Private developers and land owners were responsible for most of the rest. The banks were widely scattered around the country, with some tendency to concentrate in Florida and California (Heimlich et al., 1998). A more recent survey by the Corps of Engineers indicates that another 100 banks were in various stages of development (Heimlich et al., 1998).

Foster and Rogers (1991, pp. 35-36) make a strong argument, in principle, for the value of mitigation banks as an institution to compensate for losses of wetlands:

". . . at its best, wetland banking represents an imaginative, incentive-based form of mitigation; it helps streamline the development process, yet still provides regulators critical control; it allows developers to plan in advance and obtain a better handle on a project's economic viability; it prompts a fuller understanding of wetland values; it allows regulators and developers to work in a proactive

rather than a crisis mode; and by hooking many small mitigations together into a single project economies of scale and chances of success are heightened."

As indicated above, mitigation banking is designed to permit "mitigation" of wetland losses outside the immediate area where the losses occur, and the banks seek to put together big enough mitigation sites to generate economies of scale in creating the mitigating wetlands. The goal of increased size, however, has created some problems in the evolution of mitigation banks and some interesting institutional responses to the problem. Shabman and Scodari (1998, pp. 2-3) explain:

. . . few applicants [for permits to drain wetlands] can justify or afford their own large-scale wetlands restoration--that is, their own mitigation bank. Recognizing that single user mitigation banks would be impractical for many permit applicants, some agencies began charging a *fee in-lieu of on-site compensation* before issuing a permit. The in-lieu fees were held until accumulated funds were sufficient for a wetlands restoration project intended to offset the effects of multiple fills. Some in-lieu fees programs suffered from a lack of up-front planning and incomplete cost accounting. Often charges were not made for donated land, labor or project management. Insufficient attention to costs meant that the fee revenues might not cover the costs of producing ecologically successful credits. And, even if mitigation projects proved ecologically successful, under-priced fees were a subsidy to recipients of fill permits.

At this same time private firms began producing and selling credits to permit recipients. These private *credit sales ventures* assumed the legal and financial responsibility for the credits' ecological success.

Shabman and Scodari go on to point out that these private credit sales ventures were at first viewed skeptically by regulatory agencies, and to operate were required to post performance bonds and to meet protocols defining ecological success and requiring assurances of long-term site protection. Then Shabman and Scodari (1998, p. 3) write:

Motivated by the cost of bond forfeiture and by the desire to maintain professional and business credibility, private ventures wetlands credits have been created with the best available science and restoration technology. And because private sales ventures seek a competitive return on invested capital, credit prices must at least recover all costs of production--there can be no implicit subsidy to wetlands fill recipients.

The U.S. Army Corps of Engineers has published a number of studies under the general title National Wetland Mitigation Banking Study (Reppert, 1992; Shabman, Scodari, and King, 1994; Brumbaugh and Reppert, 1994; Scodari, Shabman, and White, 1995; Scodari



and Brumbaugh, 1996). The studies do a good job of covering a range of issues related to mitigation banking. None of the studies, however, includes a judgment of how well the banking activity has worked, or may work, in actually compensating the functions and social values of wetlands lost to some form of development. Among the Corps sponsored studies, that by Brumbaugh and Reppert (1994, p. x) comes closest to such a judgment:

When properly planned and executed, wetland mitigation banks may provide an effective means to mitigate the unavoidable loss of wetlands. Taken together, they can assist in our attempts to contribute to no net loss of wetlands by providing practicable mitigation alternatives.

Actual results among existing banks are inconsistent and the overall record is marred by a significant number of failures.

Bohlen and King (1995, p. 1) are more skeptical about the success to date of mitigation generally and of mitigation banking in particular. They note that since the 1970s when the concept of wetland mitigation was first introduced most environmentalists have objected to the principle underlying the concept ". . . because mitigation was not only frequently ineffective, but also often resulted in greater impacts to existing wetlands than would have been allowed in the absence of mitigation". Bohlen and King go on to say that mitigation remains controversial in part because of a poor compliance record, high failure rates, and ". . . low environmental value even of superficially successful projects." Although limitations in restoration science are partly responsible for the low success rate of mitigation projects, ". . . considerable evidence suggests that wetland mitigation's poor record is more a result of institutional and regulatory failures" (Bohlen and King, 1995, p. 1).

A major problem of mitigation generally and mitigation banking in particular is the highly heterogeneous nature of wetland functions. Lack of knowledge of how to deal with that heterogeneity has led to vagueness about what actually constitutes proper mitigation. In many states where mitigation banking has developed the principle of equivalency of wetland function has been espoused, but in practice mitigation has been based on compensation ratios, which are stated in acres, i.e., so many wetland acres must be restored or created for each wetland acre destroyed (Bohlen and King, 1995). Except under unusual circumstances, there is no way of knowing whether the compensation ratios lead to compensation of wetland function.

While not denying that the heterogeneity of wetlands presents a difficult technical problem for mitigation banking, Shabman, Stephenson and Scodari (1998) argue that ". . . limited technical knowledge may not be the primary barrier to ecological success [of mitigation banking projects]. Instead failed wetlands restoration or creation is often the result of poor site planning and limited regulatory oversight. Wetlands restoration and creation can be ecologically successful if regulators impose quality controls to assure that replacement wetlands will be constructed, monitored, maintained and protected in perpetuity." Clearly, in this statement, Shabman, Stephenson and Scodari see institutional failure as a major problem

of mitigation banking. On this point they seem to be in agreement with Bohlen and King (1995, p. 1), quoted above.

### Economic issues

The key economic issue is to establish the social value of an acre of wetland restored, enhanced or created relative to the social value of an acre converted. In accepting the "no net loss" policy the Bush and Clinton administrations have implicitly concluded that across the country as a whole the social value of an additional wetland acre is greater than its social value converted to some other use.

But to establish criteria for wetland mitigation in specific situations, information is needed about the social value of wetlands in those situations. In general, such information is not available. The reason is that most wetland functions, and the social services they provide, are not priced in markets. The only exception is where farmers, or other wetland owners, in exchange for a fee, permit access to their wetlands by hunters and birdwatchers. The fee is a quantitative measure of those groups' willingness to pay for the wildlife habitat services of the wetland, and is comparable to the prices paid for any good or service traded in markets. However, this market for habitat services of wetlands does not exist everywhere that the service is provided, and no markets of any kind exist for other important wetland services, such as melioration of floods, detoxification of chemicals, and capture of sediment. Thus, in general, quantitative measures of the social value of wetlands are not available.

Economists have sought to deal with this valuation problem by undertaking surveys in which people are asked how much they would be willing to pay for differing amounts of wetland services. In principle, the responses give estimates of wetland values that are comparable to the prices of goods and services traded in markets. But since the responses of these contingent valuation surveys do not rely on observed behavior the results are likely to be controversial. Heimlich et al. (1998) did an analysis of the results of over 30 such studies. Some of the studies estimated the marginal value of wetlands for commercial coastal fisheries; others focused on wetlands as the source of general recreational values, for recreational fishing and hunting; and others estimated the existence and option values of wetlands to people who do not actually use wetlands directly but who value the knowledge that they exist, or who value the maintenance of wetlands so that they or others will have the option of using them at some time in the future.

The studies varied widely in geographical scope, in the particular characteristics of the wetlands considered, in the time period covered, and, to a lesser extent, in the way the results of the studies were presented. Heimlich et al. put the estimates of wetland values in the studies on a comparable basis by calculating their present value over a 50 year period discounted at 6 percent, then converting these values to an annual basis. Heimlich et al. found enormous variation among the different studies in the per acre values of wetland services, with the greatest variation among the studies of recreational and hunting values. For general recreation the range of per acre estimates was from \$105 to \$9,859; for recreational fishing it was \$95 to \$28,845; and for waterfowl hunting it was from \$108 to \$3,101.

The wide variation in the estimates of wetland values found in the studies considered by Heimlich et al. strongly suggests, at a minimum, that the kinds of wetlands included in the studies varied widely in quality, in location with respect to urban areas, and/or, in the kinds of services they provided. This source of variation in the estimates would simply reflect the heterogeneous physical characteristics of wetlands and hence of the services they provide. Differences in methodology could also explain some of the differences in results among the various studies.

The problems of establishing quantitative measures of the values of wetland services are fundamental. Scodari (1992, pp. 63-64) states the sources of the problems as follows:

The two greatest obstacles [to quantitative measurement of wetland values] concern limitations in scientific and economic assessment. Wetland services are produced by complex hydrological and biological functions that are not fully understood, and generalized methods for quantifying functions and their production of wetland services are poorly developed. This limits the ability to quantify wetland outputs and how they are affected by protection activities.

A further complication for scientific and economic assessment involves the extreme diversity in wetlands systems and their uses and values in both their preserved state and developed states. These differences preclude generalizations about wetlands preservation and development outputs and values. Even the very best of wetland value estimates produced to date do not shed much light on the welfare implications of wetland conversion beyond the specific wetland areas studied.

The problems in the way of achieving quantitative measures of wetland values described by Scodari are not likely to be overcome in the foreseeable future. In the meantime, however, the American people, through their representatives at all levels of government, are insistent that the nation's stock of wetlands be protected against further net loss, or increased. Although the search for quantitative measures of wetland values likely will prove challenging for quite some time, something nonetheless can be said today about wetland values that should be useful in devising a strategy to meet the public's demand for constant if not rising wetland services.

Two characteristics of the economic benefits and costs of wetland restoration and creation are well established: (1) In general, demand for wetland services and, consequently, the per acre values of wetland services are higher in urban than in rural areas because of the greater density of people in urban areas. There are exceptions, however. For example, the demand of hunters for services of wetlands rich in habitat for ducks and other wildlife will be greater in rural than in urban areas. While the general proposition that demand for wetland services is greater in urban than in rural areas is useful for thinking about wetland restoration and enhancement issues, measures to deal with these issues must consider the demand

situation as it exists in specific locations. (2) The per acre cost of restoring or creating wetlands generally is much lower in rural areas than in urban areas, for two reasons. Most of the former wetlands in rural regions are on farms. Farmers drained much of those lands by putting in drainage tiles and drainage ditches. In many, if not most instances, the land can be restored to wetland by the relatively low cost procedure of breaking up the drainage tiles and plugging the drainage ditches (National Research Council, 1992). Moreover, according to the NRC (1992, p. 284),

"Many of the larger, altered wetland complexes consist of relatively flat, poorly drained lands . . . These lands constitute the largest area of potential wetland restoration sites, not only because of their large acreage but also because wetland restoration may be less expensive and may be achieved through the filling of drainage ditches or installation of minor water-control structures".

In contrast, wetlands in urban areas generally were drained so that the land could be used for buildings, roads, or some other "built-up" purpose. Restoring such land to wetland would require removing these structures, a far more expensive undertaking than restoring wetlands drained by farmers.

The second reason why restoration of rural wetlands tends to be much cheaper than restoration of such lands in urban areas is that in the latter the opportunity costs of the land are far higher. The opportunity cost of restoring an acre of farmland to wetland--that is, the value of that acre in crop production--might be \$2,000 or \$3,000. The opportunity cost of restoring an acre of wetland in an urban area, or, say, on the Chesapeake Bay, could easily be in the tens of thousands of dollars. The NRC (1992) gives a couple of examples of this. The city of San Diego paid \$3.5 million for a 20 acre semi-tidal wetland - or \$175,000 per acre. Restoring a 250 acre wetland near the Los Angeles airport may cost some \$50 million (\$200,000 per acre), in part because a major roadway through the wetland would have to be elevated. Foster and Rogers (1991, p. 30) make the same point that restoration costs are generally much higher in urban than in rural areas.

These demand and supply conditions for wetland services indicate that demand generally is lower in rural than in urban areas, but so are the costs of restoration or creation. A critical question for wetland restoration policy, then, is what do these differences in demand and supply conditions imply for differences in the cost-benefit ratios in the two regions?

There is no explicit information about the differences in urban-rural cost-benefit ratios. Such evidence as is available with respect to the location of wetland restoration or creation activity suggests that in the eyes of those making these location decisions, the cost-benefit ratios are more favorable in rural areas. The results of mitigation banking indicate that, at least in Florida where mitigation banking is relatively highly developed, wetland losses in urban areas are being compensated mainly by wetland restoration and creation in rural areas (King and Herbert, 1997). But this evidence is misleading (Dennis King, personal communication). King and Herbert found that in Florida the demand for permits to drain

wetlands was much higher in urban than in rural areas, reflecting the difference in population densities mentioned above. Although much the greater part of the wetlands restored or created to "mitigate" the urban losses were located in rural areas, this was not because those making these location decisions--the mitigation "bankers"--had concluded that the social benefit-cost ratio was more favorable in rural areas. The decisions were based on the fact that the out-of-pocket costs to the bankers of restoring or creating wetlands were much lower in rural than in urban areas. This is to say that the mitigation banking system works in such a way that the bankers have no incentive to take into account the social costs incurred by locating the mitigation wetlands relatively far from high population density areas, the areas where the demand for wetland services is highest.

In thinking about this locational issue for mitigation banking it is important to keep in mind differences in the risks of failure between rural and urban locations. Although the demand for wetland services generally is higher in urban areas, the risk of failure also is higher (King and Herbert, 1997). The higher urban-area risk arises fundamentally because of the proximity of urban area wetlands to a greater range of potentially damaging pollution sources, all of them stemming from the greater concentration of population in urban areas: toxics in urban runoff, overuse of the wetlands by urban people, and so on. In considering the social benefits and costs of rural vs. urban areas for wetland mitigation, the higher risks in urban areas would have to be taken into account.

The information about the general differences in demand and supply conditions for wetlands in urban and rural areas is useful for thinking about the economics of mitigation banking. But, as noted above, there will be exceptions that should be considered. In any case, the detailed information needed to calculate cost/benefit ratios for rural and urban areas is not now available. Absent that cost-benefit information, there is no way to judge whether the urban-rural distribution of wetland mitigation is in the social interest. The argument made by King and Herbert, however, strongly suggests that the way the current process works is socially inefficient. The material reviewed for this report turned up no evidence that anyone involved in mitigation banking is doing anything to improve the process.

## **SUMMARY AND CONCLUSIONS**

### **The Policy Issues**

It is clear that the American people and their representatives at all levels of government believe that losses of wetlands impose important costs in foregone social values, and that steps should be taken to halt the losses. Indeed, as noted above, an argument can be made that the stock of the nation's wetlands should be increased to compensate for past neglect and abuse and to accommodate growing demand for their various services. The goal of the administration's 1998 Clean Water Action Plan to achieve a net gain of up to 100,000 acres of each year starting in the year 2005 reflects this view.

It is also clear that through much of the nation's history, in the interest of economic development, federal government policies directly and indirectly encouraged drainage of

wetlands as well as water use and development practices harmful to wetlands. But in the last 25 years those policies for the most part have been abandoned, and the federal government now endorses a policy of "no net loss" of wetlands. That general policy was expressed in President Carter's May 1977 Executive Order 11990 requiring agencies in fulfilling their responsibilities to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance their beneficial values. Developing and implementing a strategy to achieve "no net loss" and the more difficult long-term challenge of increasing the quantity and quality of the nation's wetlands raises difficult issues. A key question is how well current policies aimed at reducing losses can be successfully maintained or strengthened. There are also questions pertaining to the quality of wetlands preserved or restored, as discussed below.

Enforcement of section 404 of the Clean Water Act and legislation such as the Swampbuster provisions of the 1985 and subsequent farm bills have helped curb, but have not ended, further wetland losses by farmers and others in the private sector. Phasing out farm price and income support programs as scheduled by 2002 would disarm Swampbuster because its effectiveness depends on the threat to deny farmers who drain wetlands access to the support programs. Should Swampbuster thus become toothless and agricultural markets be reasonably strong, farmers could again have incentive to convert wetlands to agricultural uses. In these circumstances achieving no net loss would become much more difficult than it is now. A heavier weight would be placed on policies to promote wetland restoration, enhancement, and creation and on the regulatory authority provided by section 404 of the Clean Water Act. In addition, a policy to substitute for the preservation incentives now provided by Swampbuster likely would need consideration.

Whatever may be the eventual fate of Swampbuster, the overall thrust of federal government policies with respect to wetlands has been reversed. But policies to protect, restore, enhance, or create wetlands face two intractable problems. First, wetlands are highly heterogeneous in their physical characteristics, including their location, that determine the functions they perform, e.g. as wildlife habitat, flood mitigation, sediment retention, and detoxification of dangerous chemicals. Second, many of the services that wetlands provide to people are not traded in markets, which means that there are no quantitative measures of the social value of their services.

The first problem means that it is very difficult to know whether a wetland restored, enhanced, or created to compensate for loss of another wetland in fact compensates all the various functions of the lost wetland. The second problem means that, even if we could be reasonably sure that we had done a good job of compensating the lost functions, we could not be sure that we had compensated the social value of the lost wetland unless the compensatory wetland were in the same area as the one lost and its services were enjoyed by the same people and to the same extent. Since with mitigation banking the mitigating wetland usually is not in the same area as the lost wetland, this valuation problem is severe.

## **Future Research Needs**

### The Swampbuster issue

Both the Department of Interior study (1994) and Heimlich et al. (1998) assert that Swampbuster was a major reason for the sharp decline in wetland losses attributable to agriculture from 1982 to 1992. Research is needed to gain insights to what might happen to wetlands if Swampbuster becomes ineffective after 2002, as now seems likely. One line of such research might focus on the likely future strength of markets for U.S. agricultural production. The stronger those markets, the stronger would be farmer incentives to drain wetlands in the absence of Swampbuster.

If analysis suggests that wetland losses to agriculture would likely accelerate, alternative strategies for curbing these losses should be examined. These strategies might include alternative market-based incentives (e.g., a wetland reserve similar to the conservation reserve for erodible lands) and regulatory measures (e.g., stricter application of the section 404 permitting process to farmlands).

### Restoration, enhancement, and creation

Recall from the previous discussion that the major obstacles to achieving the enhancement, restoration, or creation of wetland functions and social values are the great physical heterogeneity of wetlands and difficulty of valuing wetland services. Research to help achieve greater success in restoration, etc., therefore, should focus on overcoming these obstacles. Three lines of research are indicated.

(1) Research is needed to better understand the physical characteristics of wetlands so that better policies could be devised to assure that compensatory wetlands in fact do a reasonably good job of replacing lost wetland functions. The National Research Council (1992) study noted that while knowledge of the physical characteristics of wetlands is far from complete, useful information nonetheless is available. Research in this area would not start from ground zero.

(2) Research is needed to clarify and deal with obstacles to estimating the net social values of wetlands likely to be lost and of those that might be restored, enhanced, or created as compensation. Research along this line also would begin with some useful economic information at hand. It is reasonably clear that the demand for most wetland services is higher in urban than in rural areas, suggesting that, other things the same, the per acre value of the services is likely to be higher in urban than in rural areas. But other things are not the same. It also is reasonably clear that the costs of restoring, enhancing, or creating wetlands is much higher in urban than in rural areas. A major issue in wetlands policy is where to locate mitigating wetlands. Research designed to use these two kinds of economic information to shed light on the cost-benefit ratios of rural wetland mitigation relative to mitigation in urban areas could make an important contribution to sorting out this policy issue.

There is evidence, some of it anecdotal, of the benefits of wetlands for purposes such as water quality improvement and retention of flood waters that could be systematically

collected, evaluated, and perhaps expanded. Wetlands have long been valued for their ability to treat wastewater. Only recently, however, have constructed treatment wetlands been viewed as possible substitutes for expensive wastewater treatment plants. Since the 1980s, wetlands have been constructed to treat a variety of water pollution problems, including acid mine drainage, nitrate-contaminated groundwater, industrial wastewater, agricultural and storm water runoff, and effluent from livestock operations. A constructed wetland is a relatively inexpensive, low-maintenance technology that is now employed at more than 1,100 sites in Europe and North America and is reportedly in wide demand in some developing areas of the world. The technology has received a mixed reception in the United States and has yet to gain national regulatory acceptance. In some states and EPA regions it is readily accepted. But others are skeptical because the technology is not fully understood. The performance of constructed wetlands varies depending on the seasons and vegetative cycles, and ecosystems exposed to toxic compounds pose potential threats to wildlife. A better understanding of how these wetlands work is needed to provide engineers with detailed predictive models for waste treatment. Research on how the wetlands work and might be best designed to treat wastes is underway (Cole, 1998). As the technology becomes better understood, additional research will be needed to evaluate the potential economic benefits of constructed treatment wetlands for treating specific contaminants under various conditions.

Foster and Rogers (1991) suggest that treatment of nonpoint source pollution, which is now the principal reason many of the nation's surface waters fail to meet the quality standards required to fulfill their designated purposes, is a promising use of treatment wetlands. While a treatment wetland can be either newly constructed or restored, Foster and Rogers note that under current regulations, constructed wetlands have an advantage of not being considered "waters of the United States." Consequently, discharges into a newly constructed wetland would not be subject to federal regulations. A restored wetland, on the other hand, may be considered as "US waters," making its use as a wastewater treatment facility potentially subject to federal regulation under section 404 of the Clean Water Act. Yet, the probability of success may be higher with a restored than with a constructed wetland because the restored site should possess the geomorphological and hydrological characteristics needed for wetland persistence (Foster and Rogers, 1991). This dilemma suggests the need for research on the institutional arrangements that would best facilitate adoption of wetland treatment systems while protecting the broader social interests.

Retention of floodwaters is another well recognized benefit of wetlands, and wetlands should be considered as an alternative to structural approaches to reducing flood damages. Valuing these benefits in monetary terms, however, is difficult and location specific. For example, Minnesota has reportedly determined that for the same cost required to construct facilities to hold flood water, a wetland could be restored that would retain five times as much flood water (Taylor, 1991). If the state has predetermined that increased floodwater retention would be socially beneficial, wetland restoration would appear to be the least cost way of achieving this objective. But if the state wants to evaluate how much to invest in wetland restoration and the net benefits of that investment (assuming, for simplification, that this is a



single purpose wetland), this would require estimating the expected impacts on downstream flood damages. Such an evaluation involves estimating the impacts of increased floodwater retention on downstream flood levels under various hydrological conditions, valuing the reduction in flood damages associated with each hydrologic condition that is attributable to the wetland, and weighting these values by the probability of each hydrological event actually occurring. The expected net benefits of the wetland would depend on, among other things, assumptions as to the future hydrology in the basin. The results of any such analysis would be subject to considerable uncertainty and very site specific.

In spite of the difficulties of estimating the net social values of wetlands and the location-dependence of these values, a systematic assessment of existing studies estimating wetland values might provide insights as to their potential benefits under various conditions and suggest areas for more detailed evaluation. At a minimum, such an assessment should provide a better understanding of the social benefits of wetlands and the basis for protecting, restoring, or creating them.

(3) Research is needed on the institutional problems that now plague successful implementation of mitigation to restore, enhance, and create wetlands to offset losses. The rapidly growing importance of mitigation banking suggests that research designed to improve the efficiency of that institution could have high payoff. It was pointed out above that a problem with mitigation banking is that as presently structured the institution gives incentive to the "bankers" to minimize out-of-pocket costs of mitigation, which has led to a preponderance of mitigation wetlands being located in rural areas. Since the demand for wetland services generally is higher in urban and other built-up areas than in rural areas, the tendency of mitigation banking to favor rural areas raises questions about the efficiency, from a social standpoint, of the way the system works.

Aside from the locational issue, the account by Shabman and Scodari (1998, pp. 2-3), noted above, of the performance of private credit sales ventures in providing mitigation banking services suggests that these ventures have promise for "getting the incentives right" for those involved in mitigation banking. The private ventures described by Shabman and Scodari, unlike the mitigation banks managed by public agencies, are in business to make money. Within the framework of regulations designed to assure the restoration of ecologically sound wetlands, the private ventures have incentive to do the job at prices permit seekers can afford, and at minimum cost. It appears that the performance of these private venture mitigation banks deserve a closer look to determine if their performance is as promising as so far it appears to be.

In any event, the practice of mitigation banking is spreading, and has caught the attention of Congress. In June, 1998 a panel of a House Transportation and Infrastructure Committee approved legislation "enshrining 'mitigation banking' as a method of obviating wetlands loss" (*Environment and Energy Weekly*, June 8, 1998, p. 1). The proposed legislation, which failed to pass during the 105th Congress, would establish the Corps of Engineers as the agency responsible for issuing charters for mitigation projects. If such legislation is passed in the future, the Corps would have to set regulations that specify:

"...objective criteria to determine how many credits a mitigation project is due. The criteria should take into account the wetlands functions restored, enhanced, or preserved, and must establish a preference for preservation of high quality wetlands if they provide demonstrable benefits to their watersheds". (*Environment and Energy Weekly*, June 8, 1998, p. 2)

Although the proposed legislation might result in improved quality of wetlands restored, enhanced, or preserved, it is not clear from the account in *Environment and Energy Weekly* that the problem of locational bias in mitigation banking projects would be addressed.

As noted above, the Corps of Engineers has funded a number of studies of wetland mitigation banking, seeking to better understand how the institution works and how its workings could be improved (Reppert, 1992; Shabman, Scodari, and King, 1994; Brumbaugh and Reppert, 1994; Scodari, Shabman, and White, 1995; Scodari and Brumbaugh, 1996). These studies are a rich source of information about the performance of mitigation banking, citing examples where banking has been successful in some places both in compensating the lost functions of wetlands and being profitable for the mitigation bankers, and where in other places the banks have been unsuccessful in one or both of these mitigation objectives. The studies make it clear that mitigation banking is a rapidly evolving institution, that the forms that the banks take are variable (i.e., some public, some private, and some hybrids), and that a major factor in performance of the banks is the clarity and consistency of the regulations set by the federal and state agencies that define the rules under which the banks operate and the performance criteria they must meet.

The material covered by the studies is too far-reaching and complex for analysis and summary in this report. It is noteworthy, however, that in our review of the studies we found no attention paid to the locational bias in mitigation banking, i.e., the tendency for mitigation projects to be placed in rural areas where costs of mitigation generally are much less than in urban areas, but where demand for wetland services also is generally lower. This statement is not intended as a criticism of the studies cited above. In our judgement they are technically sound and, as just noted, sources of much valuable information about how to achieve wetland mitigation. Our point is that the important policy issue raised by the locational bias in mitigation banking as it has performed so far has not been systematically addressed. The issue should have high priority in designing a research program to improve the performance of wetland mitigation banking.

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