Wetlands and Agriculture: Private Interests and Public Benefits. By Ralph E. Heimlich, Keith D. Wiebe, Roger Claassen, Dwight Gadsby, and Robert M. House, Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 765.

Abstract

Society has recently increased the value it places on the services that wetlands provide, including water quality improvement, flood control, wildlife habitat, and recreation. However, owners of wetlands are often unable to profit from these services because the benefits created are freely enjoyed by many. This report examines differences between public and private incentives regarding wetlands. Federal wetland policy has shifted in recent decades—from encouraging wetland conversion to encouraging wetland protection and restoration—in an effort to balance public and private objectives. The report assesses the need for continued wetlands protection policies as the United States approaches achieving the goal of "no net loss" of wetlands.

Keywords: Wetlands, "no net loss," Swampbuster, conservation, restoration

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Summary

The public and private interests in conserving wetlands have been the subject of some contentious debates in recent years. This report analyzes wetland policy questions in the context of competing interests of private landowners and the public. The report examines successes in reducing wetland losses and the prospects for keeping net losses at a low level.

Wetlands preserve water quality, provide habitat for fish and wildlife, prevent erosion, reduce flood damage, and provide aesthetically pleasing open spaces and recreational sites. Society values wetlands, but the private owners usually cannot benefit from them economically unless they are coverted to other uses, such as agriculture or urban development.

People are interested in wetlands because public benefits of wetlands extend well beyond their boundaries. The appropriate balance between society's interest in wetlands and the rights of individual landowners is heavily debated because the outcome determines how wetlands are used, and how the costs and benefits associated with wetland use are distributed. Government seeks to balance these competing claims through a combination of Federal and State regulatory programs and economic incentives.

Former direct and indirect economic incentives for wetland conversion have been eliminated. New incentive programs encourage landowners to make socially acceptable use of wetlands.

Wetland issues have been an important part of agricultural and environmental policy debates at Federal and State levels since the mid-1970’s. Over the last 25 years, Federal and State governments have acted to discourage wetland conversion by withdrawing direct and indirect incentives (such as farm program payments), regulating conversion through water quality and other legislation, and funding voluntary programs to restore wetlands. These policy changes are partly responsible for the decrease in wetland conversion, but falling commodity prices during 1982-92 also reduced pressure to convert wetlands, and it is difficult to statistically separate policy and market factors responsible for decreased conversion.

The rate of converting wetlands to other uses has dropped steadily over time. Between first settlement and 1954, more than 800,000 acres per year were converted, while the most recent statistics for 1982-92 show that less than 80,000 acres were converted annually. The share of wetlands converted to agricultural uses dropped from more than 80 percent in 1954-74 to 20 percent during 1982-92.

The United States appears to be reaching its goal of "no net loss" of wetland acreage in the 1990's, conserving and restoring at least as much wetland as is lost. However, eliminating current wetland programs would likely increase wetland conversion rates. Sustaining the "no net loss" goal will be difficult unless programs to conserve wetlands remain in place, greater efforts toward wetland restoration are undertaken, or both. Even if we can sustain "no net loss" of wetland acreage, the challenge of protecting the quality of remaining wetlands from changes in land and water use in upland areas remains.

If farm program payments are eliminated at the end of the 1996 Federal Agricultural Improvement and Reform Act in 2002, the Swampbuster sanction becomes ineffective, exposing remaining wetlands to agricultural conversion. We estimate that, in the short run, 5.8 to 13.2 million acres would be profitable to convert to agricultural production based on expected prices, increasing income for those farmers with wetlands to convert. In the long run, some marginal cropland would drop out of production, leaving a net cropland addition of 2.2 to 5.0 million acres. Increased commodity supplies from the added acreage would depress commodity prices for all farmers, resulting in reductions of farm income of $1.6 to $3.2 billion.

Proposals for compensating wetland owners for wetland regulation could cost from $30 to $180 billion. Costs would vary depending on the extent of wetlands compensated, the timing of compensation payments, and interactions between compensation and the rate of wetland conversion. Agricultural wetlands would require less compensation per acre, but are more extensive than wetlands near urbanizing areas.

Maintaining and improving the quality of remaining wetlands is an important goal because fully functioning wetlands provide services that are valued by society. Changes in soil erosion, irrigation, deforestation, and urbanization in watersheds with significant wetlands indicate that 75 percent of watersheds have most of these four wetland quality indicators degrading. More than 60 percent of wetland watersheds show improvements in water-caused soil erosion, 22 percent had decreases in irrigation, while 87 percent had decreases in forest cover and 96 percent had increased urbanization.

While the exact nature of the policy questions that will arise in coming years remains unclear, it is virtually certain that wetland issues will remain important, complex, and contentious, given the mix they represent between public and private benefits and interests. The analyses in this report provide a solid foundation for continued research and informed policy decisionmaking on wetlands and agriculture in the future.

Wetlands and Agriculture

Private Interests and Public Benefits

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Introduction

Wetlands are complex ecosystems that provide many ecological, biological, and hydrologic functions that society values. Greater scientific understanding of the roles wetlands play in the ecosystem has increased public appreciation for wetlands. As a result, society increasingly values conserving wetlands over converting them for private economic uses. Policies designed to balance public interests in wetlands with private benefits from conversion have been contentiously debated. This report analyzes emerging wetland policy questions in the context of success in reducing net wetland losses and the inherently competing interests of private landowners and public beneficiaries.

Ecological Functions

Wetlands preserve water quality, functioning as living filters by removing nutrients and sediments from surface and ground waters (Carter, 1996; Williams, 1996). Wetlands retain or remove nutrients through uptake by plant life, adsorption into sediments, deposition of detritus, such as organic matter, and chemical precipitation. Vegetation and flat topography in wetlands slow waters, causing sediments to be deposited in the wetland, reducing siltation of rivers, lakes, and streams.

Biological Functions

Wetlands are the most biologically productive ecosystems in the temperate regions, rivaling tropical rain forests (Mitsch and Gosselink, 1993). Their biological productivity derives from their ability to recycle nutrients and energy. Wetlands provide habitat for fish and wildlife. Some species spend their entire lives in wetlands, while others use them intermittently for feeding or rearing their young. Most freshwater fish depend on wetlands. Fresh and saltwater fish feed in wetlands, or on food produced in wetlands. Wetlands also serve as nursery grounds for many species (alewife, blueback herring) whose young take cover there, and many important sport fishes (pike, pickerel, muskellunge, large mouth bass, striped bass) spawn in or near wetlands. Amphibians and reptiles depend on wetlands, and are particularly sensitive to wetland quality. Over one-third of all bird species in North America rely on wetlands for migratory resting places, breeding or feeding grounds, or cover from predation (Kroodsma, 1979). Many fur-bearing animals, such as muskrat, beaver, otter, mink, and raccoon prefer wetlands as their habitat. Not surprisingly, wetland habitats are critical for the survival of species threatened or endangered with extinction, primarily because of habitat loss.

Hydrologic Functions

Wetlands are often found where the water table is close to the surface, resulting in fluctuating discharges or recharge of groundwater supplies. Wetlands also reduce waves and shoreline erosion, and store and convey floods because their interlocking root systems stabilize soil at the water's edge, enhance soil accumulation through sediment trapping, and reduce erosion by damping wave action and slowing water currents (Carter, 1996). Wetlands also act as a huge sponge, temporarily storing flood waters and releasing them slowly, thus reducing flood peaks and protecting downstream property owners from damage. Wetlands are often natural flood conveyances, channeling flood waters from upland areas into receiving waters and damping extreme flood events.

Wetland Values

Value is associated with goods and services that wetlands provide (Barbier, and others, 1997). Wetland functions are natural processes that exist regardless of their perceived value to society (Novitski, and others, 1996; Williams, 1996). Society does not necessarily attach value to all wetland functions, although greater scientific understanding of the roles wetlands play in ecosystems has increased our appreciation. The valuable functions wetlands provide and the aesthetically pleasing open space they create do enhance the quality of our lives. Many groups benefit from wetland functions: anglers, hunters, boaters, downstream property owners, public water supply and flood control authorities, and recreationists, among others. Protecting wetlands has become a recognized public interest. However, private owners of wetlands are not able to profit from these wetlands functions because the benefits created are diffuse and generally cannot be excluded from the wide variety of benefactors (Alvayay and Baen, 1990). This can create differences between public and private incentives regarding wetland protection.

In This Report

We analyze emerging wetland policy questions in the context of success in reducing net wetland losses and the inherently competing interests of wetland owners and society. First, we explore the public interest in wetland resources. Because economic incentives are the principal driver for wetland conversion, economic analysis is an essential tool in understanding the current state of wetland policy and examining potential future directions. We introduce a conceptual framework for thinking about wetland conversion, and analyze the economics of wetland conversion in the context of market and policy changes affecting agriculture.

The report presents a comprehensive view of wetland losses and gains over time, correlating statistics from various sources into a unified picture of wetland trends. In order to understand current and future policy issues, we examine the evolution of wetland policy through past eras of exploitation and transition, up to the current era of “no net loss.” Our main focus is on wetlands occurring on agricultural land and how agricultural and other programs have changed farmers’ incentives to conserve or convert wetlands.

In a series of analyses of future prospects for ongoing and emerging policy issues, the report also examines proposals for changes in wetland programs. We assess how far the United States has come toward achieving “no net loss” of wetland acreage, and look to broader goals for wetlands that involve “no net loss” of function and value, as well as simply balancing acreage gains and losses. Finally, prospects for maintaining wetland quality are investigated.

I. Wetland Economics

Public policy on wetlands, including the national goal of "no net loss" of wetlands, attempts to balance the public's interest in conserving wetlands for the benefits they provide, and landowners' interests in converting wetlands to economic uses that provide greater private benefits. While wetland economics can be understood in terms of balancing the marginal benefits of protecting and converting wetlands, in practice, difficulties with estimating those benefits limit public scrutiny to qualitative, case-by-case review of each conversion proposal.

Private and Public Roles in Wetland Economics

About 82 percent (92 million acres) of wetlands and former wetlands in the contiguous 48 States are privately owned. Historically, private owners converted wetlands to other uses to increase their productive value. For most of U.S. history, public incentives were offered to private owners to encourage wetland conversion to more productive uses in order to promote economic growth and westward expansion.

However, many interests in the remaining privately owned wetlands are public concerns. Appreciation of the public goods nature of wetland benefits and the costs associated with wetland loss or degradation has increased over the course of the 20th century. Society's interest in wetlands arises from the fact that the public benefits—providing fish and wildlife habitat, preserving water quality, storing flood waters, and so forth—extend well beyond the bounds of wetlands themselves. Wetlands perform a variety of functions that benefit the public, discussed in detail in Chapter II. What complicates wetlands as a policy issue is that many of these public goods benefits accrue to society at large or to individuals other than the wetland owners. For example, a wetland may provide habitat for migratory birds and reduce flooding on downstream properties, but fail to generate significant benefits for its owner. As a result, many private wetland owners may find it more profitable to convert wetlands to alternative uses, such as agriculture or urban development, even when such conversion is costly to society.

Wetland conversion or degradation deprives society of water quality, water quantity, fish and wildlife habitat, and recreation benefits, or increases the cost to society of replacing wetland services. Such wetland conversion or degradation in the process of development or agricultural production is said to generate "negative externalities," or unintended harmful effects on individuals other than the wetland owner.

The Private Conversion Decision: Private Gain and Public Disincentives

Private landowners decide to convert wetlands to alternative uses, like crop production or housing developments, by comparing the economic returns they expect to receive from these uses with what they would receive if the wetlands were left in their natural state. Throughout U.S. history, the Federal Government has influenced landowners by offering policies that increased returns from converting wetlands. For example, grants of wetlands to States during the 19th century paid for levees and drainage, allowing wetlands to be converted to agricultural production. Until 1985, farm program payments depended on crop base acreage, providing an incentive to create more cropland from wetlands.

More recently, public policies were enacted to decrease returns from conversion, by creating disincentives for wetland conversion or removing previous incentives. Public disincentives for wetland conversion range from regulatory review, through the dredge and fill permitting process under Section 404 of the Clean Water Act, to denying farm program payments under the Swampbuster sanctions of the 1985 Food Security Act.

The Public Restoration Decision: Public Cost and Private Gain

Beyond reducing expected returns from wetland conversion, recent policy efforts have also included efforts to enhance the returns that private landowners may receive from wetland protection and restoration. These voluntary programs offer owners of existing or former wetlands incentives to conserve or restore wetlands, thus seeking to secure the public goods threatened by or lost to conversion. The public's calculus includes the potential benefits to be gained from the wetland, balanced against the incentive needed to offset the landowner's opportunity cost of converting the wetland. The public interest in the protected or restored wetland varies from a limited agreement to repay restoration costs if wetlands are converted for programs, such as the Fish and Wildlife Service's Partners for Wildlife Program, to formal acquisition of the cropping and drainage rights for the Wetlands Reserve Program.

Socially Optimal Wetland Conversion: The Economics of "No Net Loss"

"No net loss" of wetlands is a policy goal that emerged in 1989 that has garnered bipartisan support. To date, the "no net loss" goal has been interpreted to mean wetlands should be conserved wherever possible, and that acres of wetlands converted to other uses must be offset through restoration and creation of wetlands, thus maintaining or increasing the wetland resource base.

The antecedent of the "no net loss" goal in Federal wetlands policy was the National Wetland Policy Forum. In 1987, Environmental Protection Agency Administrator Lee Thomas asked the Conservation Foundation, headed by its then-President William Reilly, to convene a blue-ribbon panel of environmental, agricultural, business, academic, and government leaders to consider ways to improve wetland regulation. The Forum concluded that "no net loss" was a reasonable goal (The Conservation Foundation, 1988):

> Although calling for a stable and eventually increasing inventory of wetlands, the goal does not imply that individual wetlands will in every instance be untouchable or that the "no net loss" standard should be applied on an individual permit basis—only that the nation's overall wetlands base reach equilibrium between losses and gains in the short run and increase in the long term. The public must share with the private sector the cost of restoring and creating wetlands to achieve this goal.

"No net loss" was subsequently adopted as a policy goal of both the Bush and Clinton administrations (White House, 1991; 1993). Vice-President Gore's Clean Water Action plan calls for achieving a net gain of 100,000 acres of wetlands by 2005 (Gore, 1997).

How do differing private and public incentives to preserve and convert wetlands translate into observed and optimal levels of wetland preservation and conversion? Is the "no net loss" goal consistent with an optimal allocation of wetlands between preservation and conversion? Figure 1 presents a stylized framework that helps us discuss the factors involved (Larson, 1994). The horizontal axis in each of the four diagrams represents the total initial stock of wetlands in the contiguous United States at the time of European settlement (221-224 million acres).[1] This initial stock has subsequently been allocated to one of two categories: remaining/protected wetland acreage P (measured from the left-hand side, about 124 million acres) and converted wetland acreage C (measured from the right-hand side, about 97 million acres). The vertical axis in each diagram represents an index of value, such as dollars per acre.

Figure 1-a represents the net marginal benefits individual landowners realize by protecting an incremental acre of wetlands (MB_p^i).[2] This curve is relatively low, since relatively few benefits of wetland protection exist that individual landowners can capture. Examples include private scenic, hunting and fishing, or recreational opportunities, and possibly economic returns from haying, grazing, or timber harvesting. MB_p^i would be expected to rise as the remaining acreage of protected wetlands decreases (moving from right to left).

Figure 1-b represents the net marginal benefit individual landowners realize by converting an incremental acre of wetlands (MB_c^i).[3] In contrast to individual benefits from wetland protection, MB_c^i may be relatively high, since conversion makes possible more intensive agricultural or developed uses that provide returns directly to the individual landowner. MB_c^i

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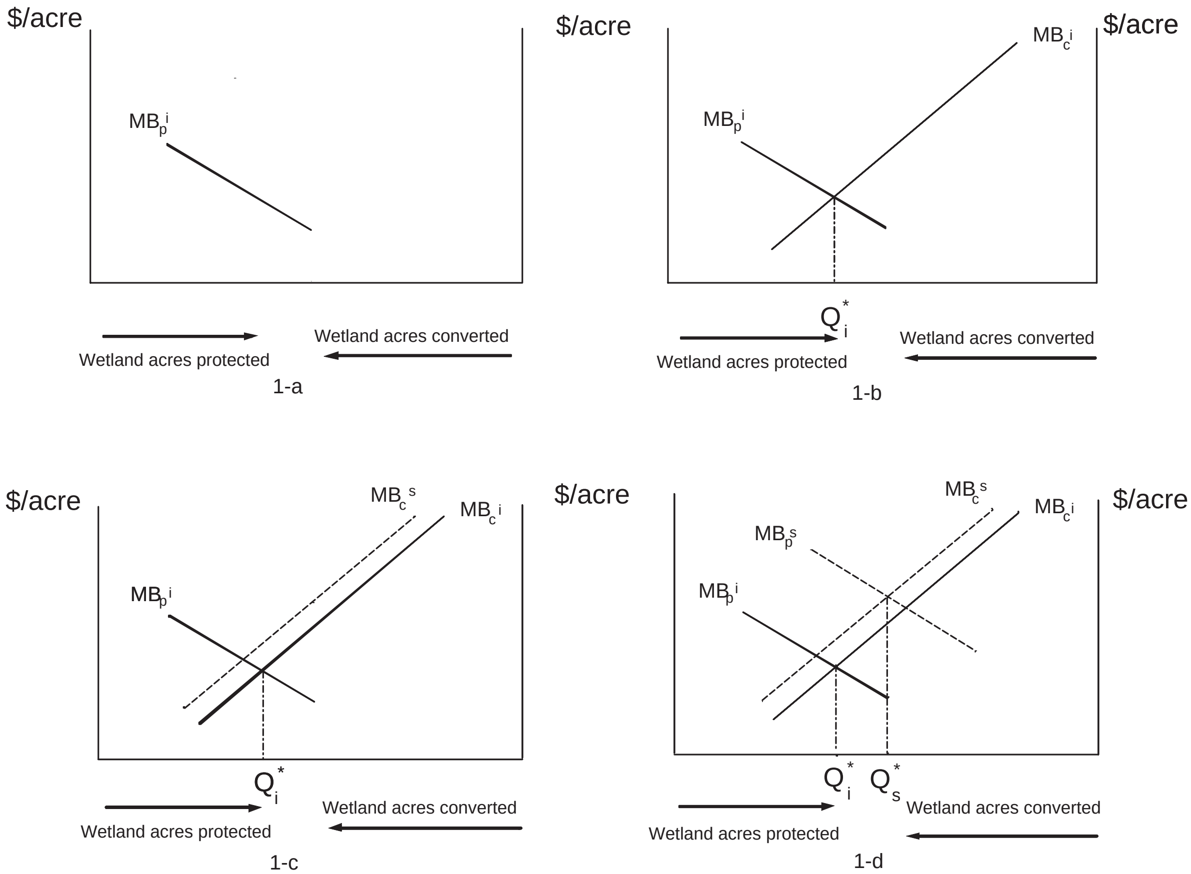
[1]This figure could also be constructed in terms of specific types of wetlands, such as prairie pothole wetlands or forested bottomland wetlands, or particular States or regions, such as Alaska or the Everglades. If functional assessment schemes such as the Wetland Evaluation Technique (WET; Adamus and Stockwell, 1983) or hydrogeomorphic (HGM; Brinson, 1993) rating methods could be agreed upon, the diagram could be couched in terms of wetland functions or services provided by remaining wetlands instead of acreage. The diagrams would be conceptually similar to those presented here for total wetland acreage.

[2]These are "net" benefits in the sense that they are adjusted for direct costs of wetland protection, such as monitoring and enforcement costs, but not for economic returns foregone, the indirect opportunity costs of not converting. Foregone economic returns are embodied in the marginal benefits to conversion, introduced next. Due to conceptual and measurement difficulties, the true level and shape of this curve is not known with precision. The same is true of the other curves introduced below.

[3]As with MB_p^i, these "net" benefits are adjusted for direct conversion costs, such as drainage costs, but not for indirect opportunity cost, such as the wetland benefits foregone. Foregone wetland benefits are embodied in the marginal benefits of protecting wetlands.

Figure 1
Optimal wetland conversion/protection



Source: Adapted from Larson (1994).

would be expected to decline as the acreage of converted wetland increases (moving from right to left). The privately optimal allocation of the stock of wetlands is represented by the point (Q_i^*) where the two marginal benefit curves cross. At this point, protecting an additional acre would cost more in terms of foregone benefits from conversion than would be gained in benefits from protection. Likewise, converting an additional acre would cost more in terms of foregone benefits from protection than would be gained in benefits from conversion. This simple framework can be extended to capture two important dimensions in wetland economics. First, we can use it to illustrate the differences between the public and private incentives to protect and convert wetlands. And second, we can use the resulting extension to illustrate changes in wetland policy and in conversion trends over the course of U.S. history.

Both conversion and protection generate public benefits as well as private benefits. In the case of wetland conversion, for example, these benefits may include increased agricultural output, lower consumer prices, and, in the 19th century, westward expansion and settlement. However, it is expected that public benefits to conversion are now small relative to private benefits since settlement has been accomplished and remaining wetlands are small relative to the cropland base. Adding these incremental public benefits to the individual benefits curve MB_c^i results in a social marginal benefit curve for conversion of MB_c^s in figure 1-c.

In the case of wetland protection, on the other hand, most benefits are public in nature. Examples include flood control, water quality improvement, fish and wildlife habitat, and recreational opportunities. Adding these public benefits to the individual marginal benefits curve MB_p^i results in the significantly higher social marginal benefit curve for protection of MB_p^s, as depicted in figure 1-d. The socially optimal allocation of the initial stock of wetlands (Q_s^*) thus occurs to the right of the privately optimal allocation

(Q_i^*), representing relatively more wetlands protected and less converted than under the privately optimal allocation.

Having distinguished public and private benefits from wetland conversion and protection, we can now use this graphical framework to characterize historic trends in wetland policy, conversion, and protection in the United States. The period from European settlement through the middle of the 20th century can be characterized as one in which the public benefits of wetland protection were not recognized. Even if benefits had been recognized, the initial stock of wetlands was sufficiently high that the marginal benefits of protecting the full initial stock were low. By contrast, the public benefits from conversion were recognized (in addition to the private benefits), and motivated the public incentives that were provided for wetland drainage and conversion. This set the country in motion towards an "optimum" allocation at the intersection of MB_p^i and MB_c^s, to the left of Q_i^* as depicted in figure1-c, representing a relatively high level of wetland conversion.

Over the course of the 20th century, as the public benefits of wetland protection came to be more fully appreciated, it became apparent that the socially optimal allocation of wetland resources lay further to the right, at Q_s^*(as depicted in figure 1-d at the intersection of social marginal benefit curves for preservation and conversion, MB_p^s and MB_c^s), representing a higher level of wetland protection. The various benefit curves may themselves shift over time. For example, increases in agricultural productivity over time shifted both MB_c^s and MB_c^i downwards as less land was required for a given level of production. These shifts also affect the optimal allocation of wetlands.

The problem in determining whether "no net loss" of wetlands is an appropriate policy goal in the United States today, or whether more wetlands or fewer wetlands would be socially superior, lies in the difficulty of determining how public benefits from wetlands change as more are converted (the location of the public marginal benefit curve, MB_p^s), and thus the optimal level of wetland resources remaining relative to the current allocation of the initial wetland stock (see Chapter II concerning wetland valuation). If we have already made it to Q_i^* or even farther to the left, then no net loss would be inadequate from a public policy perspective; a net *gain* of wetlands would be necessary to reach Q_s^*. If, in the course of historic wetland conversion, we have just made it to Q_s^*, then "no net loss" is an appropriate policy goal. On the other hand, if the current allocation still lies to the right of Q_s^*, some degree of net wetland loss would still be socially appropriate. Not surprisingly, given the difficulty in estimating public benefits and the different distributions of private costs that different wetland policies represent, there is considerable controversy over where the current allocation of wetlands lies relative to Q_s^*. The "no net loss" goal makes it clear that some think that enough (or even too many) acres of wetlands have been lost. Strong public support for wetland conservation validates this position.

Even in the absence of complete and accurate data about public benefits provided by wetlands, however, it is possible to estimate the level of public benefits required to justify "no net loss" in specific wetland contexts. Stavins (1990) develops theoretical models of privately optimal and socially optimal use of forested wetlands, and then links them in an econometric analysis of land-use data from 36 counties in the lower Mississippi alluvial plain during the period 1935-84. He then incorporates alternative estimates of environmental externality values (as indicators of public benefits) in a series of dynamic simulations to estimate changes in forested wetland acreage that would have occurred if private landowners had taken environmental consequences into account in their land-use decisions. Given historical levels of Federal construction and maintenance of flood-control and drainage projects, Stavins finds that $150 in annual environmental benefits per acre would have justified zero net depletion of forested wetlands in the lower Mississippi alluvial plain during this period. In the absence of such Federal projects, Stavins estimates that $80 in annual environmental benefits would have sufficed to make zero net depletion of wetlands optimal.

Stavins reports that benefits of such magnitude correspond to present values more than double the typical land prices in the study area. In terms of figure 1, the actual allocation of wetlands in the lower Mississippi alluvial plain (based on private optimization in the context of Federal flood-control and drainage projects) lies to the left of the socially optimal allocation (at Q_s^*). Stavins concludes that policymakers should consider ways of narrowing the gap between the actual and the socially optimal allocation of land between remaining and converted wetlands, including tax provisions, easements, and cross-compliance requirements.

Although Stavins' analysis indicates the type of estimation that can be done even in the absence of complete and accurate data about public benefits provided by wetlands, data constraints currently limit our ability to conduct a similar analysis on a national scale.

Wetland Economics and Technology

Benefits from wetlands are part of the equation, but costs for wetland drainage and wetland restoration enter into wetland economics as well by defining what conversion is physically possible. Drainage technology and drainage costs affect how far to the left (in terms of figure 1) we are able to encroach on remaining wetlands. Many of the major conversions undertaken in the 20th century, including those in South Florida and the Mississippi Delta, could not be undertaken until modern machinery and methods were developed.

The real cost of wetland drainage has declined unevenly over time, fluctuating from $225 per acre in 1900 to a low of $125 per acre in 1950. Costs rose to $210 per acre in 1970 and fell to $140 per acre by 1985. The real cost of subsurface drainage on farms was about $415 per acre in 1985, about half the cost of subsurface drainage in 1965. Significant technical advances that lowered the real cost of subsurface drainage include the development of continuous corrugated plastic tubing and improved installation equipment, notably laser beam grade control devices on trenching and other drainage equipment (Pavelis, 1987b). Further advances in drainage technology could make drainage profitable on additional wetlands, particularly in a period of high market prices, such as 1996. Some researchers speculate that wetland conversion has slowed in recent years in part because easily or cheaply converted wetlands have already been converted (Kramer and Shabman, 1993).

Beyond conservation, support for wetland restoration in such high-profile cases as restoring the natural course of Florida's Kissimmee River and efforts to rebuild vanishing Louisiana delta wetlands show that the public supports augmenting the remaining supply of wetlands. Although the public supports wetland restoration, some scientists are skeptical that these complex ecosystems can be rebuilt (Kusler and Kentula, 1990; Kentula, 1996; NRC, 1995). Success with wetland restoration varies from rapid and nearly complete in the case of resilient prairie pothole wetlands, through long-term and risky for bottomland hardwoods, to practically impossible for certain unique bog environments (NRC, 1992; Kentula, 1996).

Restoration costs and improvements in restoration technology play a part here in determining how far to the right of figure 1 the remaining stock of wetlands can be supplemented (King and Bohlen, 1994; King, 1992; NRC, 1992). For some wetlands, conversion is an irreversible decision not well reflected in figure 1. To the extent that restoration focuses on types that are relatively easy to restore and ignores or fails in more difficult situations, achieving "no net loss" of wetland acreage may mask changes to the mix of wetland types, and their unique functions and values, that comprise our stock of wetlands. Improving restoration technology for more difficult wetland types can lessen the need for conservation of these types because they can then be restored with some degree of certainty.

Policy Instruments To Equate Social and Private Incentives

Policymakers and society need to balance private rights to convert wetlands with public benefits from keeping wetlands intact (Kohn, 1994). For example, public policy can compensate a wetland owner to prevent converting a wetland and generating negative externalities. On the other hand, society can regulate conversion of wetlands to prevent damages to public interests in the wetland.

In fact, wetland policies are considerably more complex than these examples suggest, and thus far, there is no clear agreement between landowners and the public or consistency across public programs on which approach should prevail. At one end of the spectrum, Section 404 of the Clean Water Act regulates dredging and filling in wetlands (33 U.S.C. 1344). Section 404 implements the "no net loss" goal with a regulatory review process that handles small conversions through general permits, and conducts more thorough, qualitative reviews of the social costs and private benefits of major proposals affecting wetlands. The balance between private benefits and social costs is assessed for each permit. The Swampbuster provisions of the 1985 Food Security

Act (P.L. 99-198; 7 C.F.R. 12) deny most farm program benefits to farmers who choose to convert wetlands, but are not a regulation of wetlands, *per se*. Instead, Swampbuster provisions are a condition on continued receipt of payments from a voluntary program that reconciles society's interests in farm programs and in protecting wetlands. At the other end of the spectrum, the Natural Resources Conservation Service purchases interests in prior-converted (and subsequently restored and protected) wetlands from willing sellers through the Wetlands Reserve Program (P.L. 101-624; 7 C.F.R. 620).

Wetlands and Property Rights

Land ownership consists of a "bundle of rights," not all of which an individual landowner necessarily holds. Society generally reserves certain rights in each parcel of land, including the rights of eminent domain (the right to take property for public use, with compensation) and police power (the right to prevent actions that harm others). The appropriate balance between these rights and the rights of individual landowners is the subject of considerable debate, nowhere more vocal than in the case of wetlands, because it helps determine how wetlands are used and who benefits and loses from any use of wetlands (Kohn, 1994; Holtman, and others, 1996).

The rights of private landowners are protected by the Fifth Amendment to the Constitution, which states that private property shall not be taken for public use without just compensation. In addition, the Fourteenth Amendment states that no State shall deprive any person of property without due process of law. However, determining when property is "taken" has never been simple. Before 1922, the courts generally found takings to have occurred only when property was physically occupied for public purposes, such as constructing a road or school. Then, in 1922, the Supreme Court ruled that regulations restricting land use might constitute takings as well, if they went "too far" (Pennsylvania Coal Co. v. Mahon, 260 U.S. 393, 415-416). Just how far is "too far" has been debated ever since, although the courts have generally held that a landowner must suffer near-complete loss of the economic use of an entire property before a regulation is judged to be a taking (Michelman, 1988; McElfish, 1994).

The stringency of this test has meant that takings challenges are rarely successful in the courts. According to the Congressional Research Service, of 135 Federal takings cases between 1990 and 1994, only 21 were found to be takings (Meltz, 1995). The ratio is similar with respect to wetlands cases. As of May 31, 1993, only 28 cases involving takings claims had been filed with the U.S. Court of Federal Claims as a result of regulatory actions under the Clean Water Act's Section 404 permit program (USGAO, 1993). Ten of these cases were decided in favor of the Federal Government, 3 were determined to involve takings, 1 was settled before a decision was rendered, and 14 were still pending as of May 31, 1993. Since 1993, over 30 new takings cases have been filed against the Federal Government under the 404 program (Rugiel, 1996). Five additional cases have been decided to date, only one of which was found to involve a taking (Meltz, 1994, 1995, and 1997).

Advocates of property rights reform have been frustrated with the uncertainty of case-by-case takings determinations by the courts, and with the pace and outcomes of takings cases. Even the well-known U.S. Supreme Court decision in *Lucas v. South Carolina Coastal Council* did little to change the direction of Federal court decisions. In that 1992 case, the Supreme Court ruled in favor of a South Carolina developer who was prohibited from building on beach front property. South Carolina eventually compensated Lucas for the full value of his property, but the impact of that decision as a precedent was limited by the special circumstances of the case, including the complete diminution in property value that it involved (Sugameli, 1994).

Because of their frustration with the judicial system's treatment of the takings issue, advocates of property rights reform have pressed Congress for legislation requiring compensation whenever Federal actions diminish property values by more than a threshold percentage, particularly those actions restricting the conversion of wetlands and endangered species habitat (Hunt and VandenBerg, forthcoming). Such a proposal, passed by the House in 1995, faltered in the face of concerns about fiscal and environmental costs. Twenty States have enacted takings laws in recent years, but most require takings impact assessments rather than compensation (American Resources Information Network, 1997). Chapter V further discusses legislative action at the State level.

II. What is a Wetland?

Before going any further, it is necessary to be more precise about what is meant by a "wetland." There is not a single definition of wetland that all agencies, scientists, policymakers, or landowners use for all purposes. Although there is a single definition that has evolved in Federal agencies regulating wetlands, the process of delineating wetlands on the ground and deciding what wetlands are subject to what policies is a matter of continuing controversy. By examining the different definitions used for different purposes, we find that three characteristics play a part in all definitions of wetlands: hydrology, soils, and vegetation.

Differences between *scientific* definitions of wetlands and *jurisdictional* definitions (those used in administering wetland programs) are discussed next, as well as differences between *defining* wetlands in general, and *delineating* wetlands on the ground.

Wetland Science and Wetland Jurisdiction

Federal agencies currently use several different definitions of "wetland." Wetland has been used as a term only since the beginning of the century (Wright, 1907), and only widely used by scientists, who prefer more specific terms such as mire, bog, fen, or swamp, since the 1950's (Mitsch and Gosselink, 1993). Despite recent controversies, concepts of wetland definition have been nearly constant since at least 1977, and slightly different definitions for scientific and jurisdictional purposes have evolved. Agency wetland definition attempts included efforts by the Fish and Wildlife Service in 1956, 1974, 1976, and 1979, the U.S. Army Corps of Engineers in 1975 and 1977, the Clean Water Act in 1977, and the Food Security Act in 1985 (NRC, 1995). The scientific definition developed by Lewis M. Cowardin in 1979 for the Fish and Wildlife Service has been approved by the Federal Geographic Data Committee as a standard for nonregulatory wetland classification and is used by the Fish and Wildlife Service for scientific classification of wetlands in the National Wetlands Inventory and by USDA in the National Resources Inventory (Cowardin, and others, 1979). For jurisdictional purposes, the Army Corps of Engineers uses their 1977 definition in the Section 404 permit program, and USDA uses the 1987 National Food Security Act Manual definition in administering the Swampbuster provision. All of these definitions include one or more of four essential factors: integration of physical, chemical, and biophysical aspects in the environment as an ecosystem; the central role of water as a defining feature; the presence of substrate or soils formed under saturated conditions (hydric soils); and the presence of vegetation adapted for saturated conditions (hydrophytic vegetation).

A National Research Council committee charged with investigating wetland definitions provided a reference definition (National Research Council, 1995 p. 55):

> 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 the 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.

A number of modifiers are used with "wetland" to describe various alterations or changes to wetlands that have policy relevance (see box: "Wetland Terminology"). Unfortunately, there is often disagreement or misunderstanding about what these terms and modifiers mean, which can create confusion in discussing the state of wetland resources and changes in wetland policy (Smith, 1997).

In this report, *wetlands* or *farmed wetlands* are generally considered to be in their natural state, or to have had the naturally occurring vegetation removed, but still have the soil and hydrologic conditions defining wetlands. *Prior converted* or *converted wetlands* have been cleared, drained, or filled so that wetland hydrology is no longer present. *Uplands* is the term usually applied to land that has never been wetland, while *created wetlands* or *artificial wetlands* are upland that has had wetland hydrology and vegetation artificially created or planted, usually to replace wetlands that are allowed to be converted. *Wetland restoration* is the process by which a former wetland that has been converted is made a wetland once again by restoring the wetland vegetation and hydrology necessary to meet the definition. Wetlands can be

Wetland Terminology

These definitions are based on the terms defined to implement wetland conservation (Swampbuster) provisions of the 1985 Food Security Act, as set forth in 7 C.F.R. Part 12, Section 12.2.

Creation (of a wetland)—The development of the hydrologic, geochemical, and biological components necessary to support and maintain a wetland where a wetland did not previously exist. Any wetland established on a nonhydric soil is considered a created wetland.

Degradation (of a wetland)—The alteration of an existing wetland to decrease its specific functions and values. Degradation can occur because of activities in the wetland itself, such as drainage or clearing, or because of activities around the wetland, such as soil erosion or hydrologic modifications.

Enhancement (of a wetland)—The alteration of an existing wetland to increase its specific functions and values. Enhancement actions include new capabilities, management options, structures, or other actions to influence one or several functions and values.

Hydric soils—Soils that, in an undrained condition, are saturated, flooded, or ponded long enough during a growing season to develop an anaerobic condition that supports the growth and regeneration of hydrophytic vegetation.

Hydrophytic vegetation—Plants growing in water or in a substrate that is at least periodically deficient in oxygen during a growing season as a result of excessive water content.

Restoration (of a wetland)—The re-establishment of wetland conditions, including hydrologic condition or native hydrophytic vegetation, to an area where a wetland had previously existed.

Wetland—Land that (1) has a predominance of hydric soils; (2) is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions; and (3) under normal circumstances does support a prevalence of such vegetation, except that this term does not include lands in Alaska identified as having a high potential for agricultural development and a predominance of permafrost soils.

Wetland determination—A decision regarding whether or not an area is a wetland, including identification of wetland type and size. A wetland determination may include identification of an area as one of the following types of wetland:

(1) Artificial wetland—An area that was formerly nonwetland, but now meets wetland criteria due to human activities, such as creation of an artificial lake or pond; temporary or incidental creation of a wetland as a result of adjacent development activity.

(2) Commenced-conversion wetland—A wetland, farmed wetland, farmed-wetland pasture, or converted wetland on which conversion began, but was not completed, prior to December 23, 1985.

(3) Converted wetland—A wetland that has been drained, dredged, filled, leveled, or otherwise manipulated (including the removal of woody vegetation or any activity that results in impairing or reducing the flow and circulation of water), making possible the production of an agricultural commodity.

(4) Farmed wetland—A wetland that prior to December 23, 1985, was manipulated and used to produce an agricultural commodity, and on December 23, 1985, did not support woody vegetation and met the wetland hydrologic criteria.

(5) Farmed-wetland pasture—Wetland that was manipulated and managed for pasture or hayland prior to December 23, 1985, and on December 23, 1985, met wetland hydrologic criteria.

(6) Prior-converted cropland—A converted wetland where the conversion occurred prior to December 23, 1985, an agricultural commodity had been produced at least once before December 23, 1985, and as of December 23, 1985, the converted wetland did not support woody vegetation and met wetland hydrologic criteria.

Wetland delineation—Outlining the boundaries of a wetland determination on aerial photography, digital imagery, other graphic representation of the area, or on the land.

degraded, but not converted or destroyed, by loss of wetland vegetation, impairment of wetland hydrology, or contamination by pollutants or sediments that reduce wetland functional characteristics, while still meeting the definition of a wetland. *Wetland enhancement* is the process of improving the vegetation or hydrology of a degraded wetland to fully functional status. While some controversy remains over our ability to reverse wetland conversion or degradation (Steinhart, 1987; Kusler and Kentula, 1990; NRC, 1992, p. 316; Kentula, 1996; Hunt, 1996), it is generally agreed that restoring or creating wetlands adds to total wetland resources. Wetland enhancement improves wetland function, but does not increase the total acreage of wetlands.

Delineating Wetlands

Although there has been considerable agreement on how to *define* jurisdictional wetlands, great controversy has surrounded the application of criteria and indicators of the essential factors in the reference definition (such as depth and duration of saturation or inundation) (NRC, 1995; EDF/WWF, 1992). Wetlands can be broadly *defined*, but administering wetland programs requires *delineating* a wetland's boundaries on the ground by applying specific criteria at a particular site.

Federal agencies responsible for wetland programs did not explicitly develop rules or manuals for wetland delineation until 1987. Since then, attempts have bogged down because of disagreements over requirements for direct evidence of wetland characteristics that resulted in including or excluding specific wetlands. Instead of agreeing on a standard manual, debate was conducted through a series of opposing manuals. An attempt to develop a common interagency manual was first attempted in 1989, but controversy erupted over exact delineation criteria. Another attempt in 1991 also failed to achieve consensus, leading to a National Research Council study of wetland delineation and a retreat to earlier manuals. (See box: "Wetland Delineation.")

Field tests of the 1989 and 1991 delineation manuals by Federal, joint Federal and State, and State field teams under a variety of conditions indicated that 30 to 80 percent of land delineated as wetlands in the 1989 manual were excluded by the 1991 manual (EDF/WWF, 1992). Areas that would have been excluded by the latter include cottonwood and willow wetlands in riparian areas of the Rocky Mountains and Southwest, most bogs in the Northeast and Midwest, and many prairie potholes in the Dakotas. Also excluded would be high coastal marsh along the Pacific coast, some of the Florida Everglades in the National Park and remaining on private land, and as much as 80 percent of the Great Dismal Swamp in Virginia and North Carolina. Similar results were obtained in comparisons of the 1987 Army Corps of Engineers manual and changes proposed to the Clean Water Act in 1995 (*National Wetlands Newsletter*, 1995).

Wetland definitions and delineation criteria used to administer programs differ from definitions and criteria used by scientists and for scientific inventories (NRC, 1995; Cowardin, and others, 1979). Estimates of national and regional wetland acreage and wetland losses and gains are based on scientific definitions (Frayer, and others, 1983; Dahl and Johnson, 1991). Programmatic or jurisdictional wetlands are not comprehensively inventoried but are delineated by the Army Corps of Engineers, USDA, or contractor technicians if and when permit or other regulatory action is pending. Although general writing treats "wetlands" as a homogeneous class of lands, the reality is a diverse set of landscapes with different hydrology, vegetation, and soil substrates that provide a widely varying set of natural functions (NRC, 1995; Cowardin, and others, 1979; Tiner, 1996).

Wetland Delineation

1987 U.S. Army Corps of Engineers Wetlands Delineation Manual (USACE, 1987)—Developed between 1978 and 1986 by the Environmental Laboratory at the Army Corps of Engineers Waterways Experiment Station, this manual used the three-parameter (hydrology, soils, and vegetation) definition. Congress directed the Army Corps of Engineers to resume use of the 1987 manual after a consensus failed to develop around interagency manuals proposed in 1989 and 1991.

1988 Environmental Protection Agency Wetland Identification and Delineation Manual (EPA, 1988)—Developed between 1980 and 1987, this manual also used the three-parameter definition, but distinguished between a "simple" approach for routine delineations and a more complex "detailed" approach for large or controversial situations. The Environmental Protection Agency acceded to the Army Corps of Engineers 1987 manual after interagency approaches failed.

1987 National Food Security Act Manual (NRCS, 1994)—Developed in 1987 to implement the 1985 Food Security Act conservation provisions, including the Swampbuster provision, this manual has been revised three times. The manual stressed cooperation and consultation with other wetland agencies, but differed from other manuals on delineation details.

1989 Interagency Wetland Delineation Manual (Interagency Manual, 1989)—Differences between the Army Corps of Engineers 1987 manual (USACE, 1987) and the National Food Security Act Manual led to this interagency attempt to develop a common manual.

1991 Interagency Wetland Delineation Manual—Critics argued that the 1989 interagency manual expanded the scope of wetland regulation and countered with this manual (56 Fed. Reg. 40,446, 1991).

1995 National Research Council Study (NRC, 1995)—By January 1992, the 1991 delineation manual received more than 80,000 formal comments. Attempts to revise the manual to account for the diverging views bogged down. A National Research Council committee was funded to study the delineation question, delaying any decision for 18 months. In the interim, the Army Corps of Engineers and the Environmental Protection Agency returned to using the 1987 delineation manual. The Administration's August 1993 wetland policy statement affirmed using the 1987 delineation manual pending completion of the National Research Council study. No further action on developing an interagency delineation manual has occurred since the National Research Council report was published in 1995. The National Research Council confirmed that wetlands are defined by hydrology, soils, and vegetation, and recommended that a new manual be developed based on 35 recommendations. Although administrative attempts to clarify delineation issues have not confirmed either the more expansive 1989 manual or the more restrictive 1991 manual, there is general agreement that the agencies have achieved greater uniformity in applying delineation criteria and indicators already present in earlier manuals. However, legislation to specify wetland delineation procedures to reduce the scope of wetlands regulatory jurisdiction was passed in the House version of the Clean Water Act reauthorization (104th Congress H.R. 961 and S. 851) and was discussed as a change to Swampbuster provisions in the 1996 farm bill debate. None of these provisions was enacted into law.

III. Wetland Functions: Physical Values and Economic Values

Public recognition of the value of wetlands has risen rapidly over the past 25 years. Today, scientists and environmental interest groups recognize how many different species and functions depend on wetlands and strive to increase public awareness of their importance in the natural order and to society. However, this increased recognition has not resulted in economic value that individual landowners can capture in the marketplace. Many now-recognized wetland benefits are nonmarketed goods, such as water quality and wildlife preservation. Although these wetland services are important to society, they have often been undervalued relative to converting wetlands to other land uses. Economists have developed nonmarket valuation techniques to estimate these values. However, variations in methods, physical properties of the wetlands, position of the wetland in the landscape, and socioeconomic context contribute to large variations in estimated wetland values.

Functions, Services, and Economic Values

There are bioeconomic linkages among wetland functions, services generated by those functions, and socially valued outcomes (fig. 2). A wetland performs a biologic, hydrologic, or geologic function that produces a good or supports an ecological service. Some wetlands perform many such functions, but some may perform only one or none. Many of the services provided are joint products, provided simultaneously in varying degrees by the same wetland function, based on the quality and characteristics of the wetland. For example, sediment and nutrient trapping in wetlands also makes the wetland a valuable habitat for fish nurseries and is associated with flood peak retention. Human populations value the flow of goods and services natural wetlands produce, some of which are traded in markets. Many other goods and services are not marketed, but economists have developed techniques for estimating the economic values of the nonmarket goods and services that account for complex bioeconomic linkages. In general, marketed goods and services provide mainly private benefits, while nonmarketed goods and services provide mainly public benefits.

An example of a marketed good that produces mostly separable, exclusive, private benefits is tree growth. The wetland may be a physical medium for tree growth that supports a service, such as commercial tree harvest. That service has an economic value, in this case the net value of the timber. Foresters can model and value linkages between site characteristics and tree growth, determining the types of trees that will grow on a site and the associated board-feet of timber that can be produced. Next, the good or service must be valued in economic terms. Forest economists use market valuation techniques that consider commercial prices of timber, transportation costs, production costs, and other factors to estimate the net economic value of the timber produced.

Another example is commercial fishing. Here, the linkages are less clear, particularly the relationship between fish habitat and commercial fish harvest. A wetland area functions as a nursery ground for young fish, and as a medium for further growth. The tonnage of fish and shellfish that can be harvested in an estuary, or offshore from the estuary, is related to this wetland habitat function. The economic value linkage is the relationship of the commercial fish harvest to the net value of the commercial fish species. That is, once the portion of the tonnage harvested related to the wetland is known, an economist can combine dock prices with estimates of production and harvesting costs to estimate the net economic value of the harvest attributable to wetlands.

Finally, the linkages that are least clear are those involving nonmarket valuation. For example, the wetland function could be wildlife habitat that provides a service of improving the recreational waterfowl experience for hunters. Estimating the relationship between wildlife habitat and waterfowl hunting quality is extremely complicated because of the many links between physical functions, services provided, and economic values served. The economic valuation linkage is the relationship between recreational waterfowl hunting and the net economic value of the hunting experience. Nonmarket valuation techniques can be used to establish the linkage between the service provided and the contribution of wetlands to that value. The relationships between habitat, waterfowl populations, hunting quality, and economic values involve biological, recreational, sociological, and economic considerations that interact in very complex ways.

Nonmarket Wetland Values

Although some values derived from wetlands can be determined using market transactions, or using

Figure 2
Wetland bioeconomic linkages

	Private values		Mixed values	Public values		
Wetland	**Forestry**	**Fisheries**	**Recreation**	**Flood control**	**Water quality**	**Endangered species**
Function	Tree growth medium	Fish habitat	Wildlife habitat	Flood retention	Water filtration	Wildlife habitat
Service	Commercial timber harvest	Commercial fish harvest	Recreational waterfowl harvest	Reduced flood flows/peaks	Cleaner water	Biodiversity
Economic value	Net economic value of timber	Net economic value of commercial catch	Net economic value of hunting experience	Net economic value of reduced damages	Net economic value of reduced damages	Net option and existence values

Source: Adapted from Bergstrom and Brazee (1991).

income attributable to each factor of production used to produce marketable commodities (for example, Lynne, and others, 1981), most economic values associated with wetland benefits must be estimated using nonmarket techniques. Eliciting use values with nonmarket techniques involves either revealed preference approaches, such as travel cost or hedonic methods, or expressed preference approaches, such as contingent valuation and conjoint analysis (Scodari, 1997; Anderson and Rockel, 1991; Braden and Kolstad, 1991; Freeman, 1979). Values of people who do not use wetlands reflect the importance of the continued existence of the resource, or the option of using the resource in the future. Travel cost methods are used for recreation sites where it is assumed that the cost of traveling to the site and foregoing income from working to use it are revealed measures of the value users place on the resource (Clawson and Knetsch, 1966). Hedonic methods decompose the observed values of goods, such as housing, into various attributes, including environmental amenities that might influence price (Farber, 1987). Contingent valuation directly elicits values through surveys, and can be used for both use and nonuse values (Bergstrom, and others, 1990; Loomis, and others, 1990). Finally, ecological functions provided by wetlands can be valued using replacement or avoided cost methods that price the service provided in terms of equivalent manmade services (for example, nutrient filtering), or in terms of avoided damages (for example, from flooding or hurricanes) (Folke, 1991).

Many authors have constructed classification schemes for wetland functions and values (NRC, 1995; Anderson and Rockel, 1991; Novitski, and others, 1996; Scodari, 1997; Leitch and Ekstrom, 1989; Leitch and Ludwig, 1995). Although these authors generally agree on the broad categories of functions and services, they do not agree on details or what to call specific functions and services. Not surprisingly, physical scientists characterize wetlands based on physical and biological functions, while economists make characterizations based on human uses and valuation of wetland resources. Available economic studies of wetland valuation from the United States and abroad are collected and organized in table 1 (see Appendix I for compilation details). Although the values vary greatly, even within a category, some generalizations about nonmarket wetland values are possible.

Agricultural vs. Nonagricultural Wetlands

Typical wetlands in agricultural landscapes have generally not been studied for economic values. Coastal marshes and wetlands in urbanizing areas have received more attention by economists. Perhaps this is because the functions and values associated with

Table 1—Economic values of wetland functions

Wetland function valued	Number of studies	Median	Mean	Range of means
	Number	---------Dollars per acre---------		
Marketed goods:				
Fish and shellfish support	8	702	6,132	7-43,928
Fur-bearing animals	2	na	137	13-261
Nonmarketed goods:				
General-nonusers	12	32,903	83,159	115-347,548
General-users	6	623	2,512	105-9,859
Fishing-users	7	362	6,571	95-28,845
Hunting-users	11	1,031	1,019	18-3,101
Recreation-users	8	244	1,139	91-4,287
Ecological functions:	17	2,428	32,149	1-200,994
Amenity and cultural	4	448	2,722	83-9,910

na = not available.
Sources: See Appendix I.

coastal wetlands are more obvious because these wetlands are near large populations or may have been perceived as more threatened, despite higher absolute rates of agricultural wetland conversion.

Marketed Goods

Values for marketed goods from wetlands, generally including fish and shellfish and fur-bearing animals, are lower than values for nonmarketed goods from wetlands. If the values of marketed goods were large relative to nonmarketed goods, wetland owners might be able to capture more of the value of services provided by the wetlands directly from anglers and others who benefit from them.

The values of marketed goods that might be produced by draining or filling a wetland are not considered in this section. These values are the opportunity costs of keeping the wetland as a wetland (we estimate opportunity costs of agricultural conversion in response to a proposed policy change in Chapter VI). The case of timber harvesting is an ambiguous one because harvesting timber, particularly from old-growth bottomland hardwood stands, may be tantamount to destroying the wetland, even though the trees are theoretically a renewable resource that can regenerate. Much of the acreage of wetlands listed as converted to "other" uses between 1974 and 1982 was forested wetlands that had been drained and harvested, but not put to an identifiable use at the end of the inventory period. This land may have been intended for agricultural use, but was not used for agricultural production at the end of the inventory period.

User and Nonuser Values

Values per acre elicited from people who do not use the wetland directly are generally higher than values elicited from wetland users. This apparent paradox is because the willingness to pay for wetland preservation by nonusers is actually lower per person than for users, but the number of nonusers willing to respond with a value is much greater than the number of wetland users. Evidence from some studies shows that willingness to pay declines with distance from the subject wetland (Hanley and Craig, 1991). This finding is complicated by certain nationally or internationally known wetlands (Florida's Everglades or Virginia's Great Dismal Swamp) that may have nonuse values for persons thousands of miles away. Another complication with nonuse valuation is that respondents may consciously or unconsciously be valuing wetlands generally, rather than any specific subject wetland.

Nonuse value estimates may be good relative measures of public support for environmental amenities, but may be suspect as absolute measures of benefits. In particular, nonuse values for relatively abundant, generic wetlands, versus a specific, clearly defined wetland subject to a development proposal, may not be useful. Comparisons between nonuse values and market values may also not be appropriate. Finally, the hypothetical nature of survey techniques to obtain nonuse values makes differentiation between "willingness to pay" and "ability to pay" difficult (Freeman, 1979; Anderson and Rockel, 1991; Barbier, and others, 1997).

Variations in Wetlands and Context

The range in values shown, even within specific functional categories, arises partly from the range in wetland characteristics that are almost unique from wetland to wetland, and, more importantly, from the social and economic context within which the valuation studies were conducted. It is easy to understand that coastal marshes, riparian wetlands, and prairie pothole wetlands may elicit different values based on variation in the functions and services they provide. What is more difficult to recognize is that the number of people living in the surrounding area and their wetland use, education, age, income, and other characteristics, and the range of alternative wetland and nonwetland opportunities available may contribute more to differences in valuation than the wetland characteristics themselves. That is, identical wetlands, providing identical functions and services, may be less valued in remote, isolated areas surrounded by other similar wetlands than in densely populated areas with few remaining wetlands.

Ecological Functions

Values of ecological services based on replacement costs of artificially supplied alternatives can be large. However, wetlands may not actually be used to provide such services, particularly water supply, and the artificial substitutes may seldom actually be built. In reality, areas undergoing wetland conversion often forego the services once provided by natural wetlands, risking increased flood damages and enduring periodic water shortages and reduced water quality.

Heterogeneity and Cumulative Impact

Economic valuation techniques attempt to estimate the marginal value of small losses or gains of wetlands. Valuation methods are based on the assumption that increments of wetland acres are identical, uniform substitutes for one another, and that a continuous, smoothly shaped supply function of wetland acres (or services) underlies the valuation problem. However, even within a given wetland complex, differences in hydrologic and landscape position mean that some wetland acres are more critical in providing functions and services than others. Conversion of these key wetlands can result in discontinuous changes that drastically affect the functions and services provided by the remaining wetlands. Threshold effects create other complications in which incremental conversion of wetlands causes no discernable diminution of services until a threshold is reached, dropping function and service flows to near zero. Examples include effects on flood storage and nutrient filtering dependent on discharge stage and minimum habitat size, shape, and connectedness requirements for fish and wildlife species.

Benefits Transfer

Policy analysts and decisionmakers are interested in using existing valuation studies to conduct cost/benefit analyses using benefits transfer methods (Scodari, 1990). Benefits transfer refers to the practice of using values estimated for an alternative policy context or site as a basis for estimating a value for the policy context or site in question (Barbier, and others, 1997, p. 43; Brookshire and Neill, 1992). Benefits transfer studies are often the only recourse where data are poor or funds are not sufficient for a full-scale valuation study. A number of problems with benefits transfer methods are discussed in the literature (Krupnick, 1993; WRR, 1992). This compilation of values indicates several limitations on possibilities for benefits transfer. First, wetland values in the interior of the United States and in agricultural areas generally are largely missing from the literature. Second, other than for users of fish and wildlife habitat services, most other functional categories are poorly represented. Third, there may be little opportunity to adjust wetland valuation estimates for differences in landscape and socioeconomic context. Finally, the geographic scope over which benefit estimates can be extrapolated is unclear, despite its critical role in determining the total and per acre level of benefits, particularly from nonusers.

The array of values displayed in table 1 is impressive and clearly indicates that wetlands are valued resources. However, it is not possible to estimate the full social value of the U.S. stock of wetlands based on the sparse and fragmentary data in this compilation. A much more comprehensive, consistent, and systematic effort will be needed to produce valuation estimates that could form the basis of a realistic benefits transfer scheme. A similar assessment was reached by Paul Scodari, who concluded that "Even the very best of the wetland value estimates produced to date do not shed much light on the welfare implications of wetland conversions beyond the specific wetland areas studied" (Scodari, 1997, p. 76). Although greater use of economics could improve estimates of private benefits subject to wetland regulation in specific cases (Barbier, and others, 1997), it is unlikely that economic valuation estimates could be deployed rapidly enough and with sufficient sensitivity to usefully inform cost/benefit considerations for any but the largest wetland conversion proposals (Holtman, and others, 1996; Shabman and Batie, 1987). By contrast, as we do below, it is possible to estimate, albeit crudely, the market value of the stock of remaining U.S. wetlands in their highest and best alternative use, an estimate with considerable policy interest in its own right.

IV. Wetland Status and Trends, Settlement to 1992

Although it is now commonly accepted that wetlands provide valuable environmental benefits, they were converted to other uses, altering and degrading wetland functions and values from the earliest colonial times. Wetlands were considered a health hazard, due to diseases such as yellow fever and malaria, a hindrance to settlement and land development, and a nuisance that needed to be eliminated (Wallace, 1985). Farmers recognized that many such "nuisances" were potential blessings in disguise, transforming over 28 million acres of wetlands into high-quality cropland in nine Midwestern States since settlement (Heimlich and Gadsby, 1994, p. 35). This chapter reviews historical and recent trends in wetland conversion and concludes with the status of the remaining wetland base.

Trends in Wetland Conversion

Discerning trends in wetland conversion is difficult because different agencies, using different definitions and methods, collect data useful for examining broad trends. Moreover, these data have only recently become available for dates beyond the mid-1970's. Improvements in data collection methods result in wetlands inventoried at the beginning of a succeeding inventory exceeding wetlands inventoried at the end of a previous inventory. A naive reading of these data can lead to the conclusion that wetland extent had actually *increased*; in reality, the adjusted estimates reveal that wetland conversion continued from a previously underestimated base. Rather than simply reporting published trend data from other agencies, we constructed a single, relatively consistent series proceeding backwards from, or controlled by, the total wetland acreage found in the most recent inventories, but preserving the wetland losses and gains found within each multi-period inventory. Ranges of estimates reflect differences in wetland extent between two recent inventories (Fish and Wildlife Service, National Wetland Status and Trends Analyses and USDA, National Resources Inventories). We summarize the findings here. Our methods and detailed tables are contained in Appendix II.[4]

[4]This data series does not include an inventory for 1985-95 reported after this manuscript was prepared for publication (see box: "Problems with Recent Wetland Status and Trends, pg. 23"). Differences in methodology between this latest inventory and others make comparisons questionable and could not be resolved prior to publication.

Original Wetland Extent

When colonists first set foot in America, there were 221-224 million acres of wetlands in what was to become the continental United States (Dahl, 1990). (There were another 170 million acres in Alaska and Hawaii, but this report focuses on the lower 48 States.) Most of those wetlands were in three regions: the Midwestern States (27 percent), the Southeastern States (24 percent), and the Delta and Gulf States (24 percent) (see fig. 3). As settlement spread, wetlands were converted for other uses, with the pace increasing as available nonwetlands decreased and drainage technology improved.

Agricultural Wetland Conversion

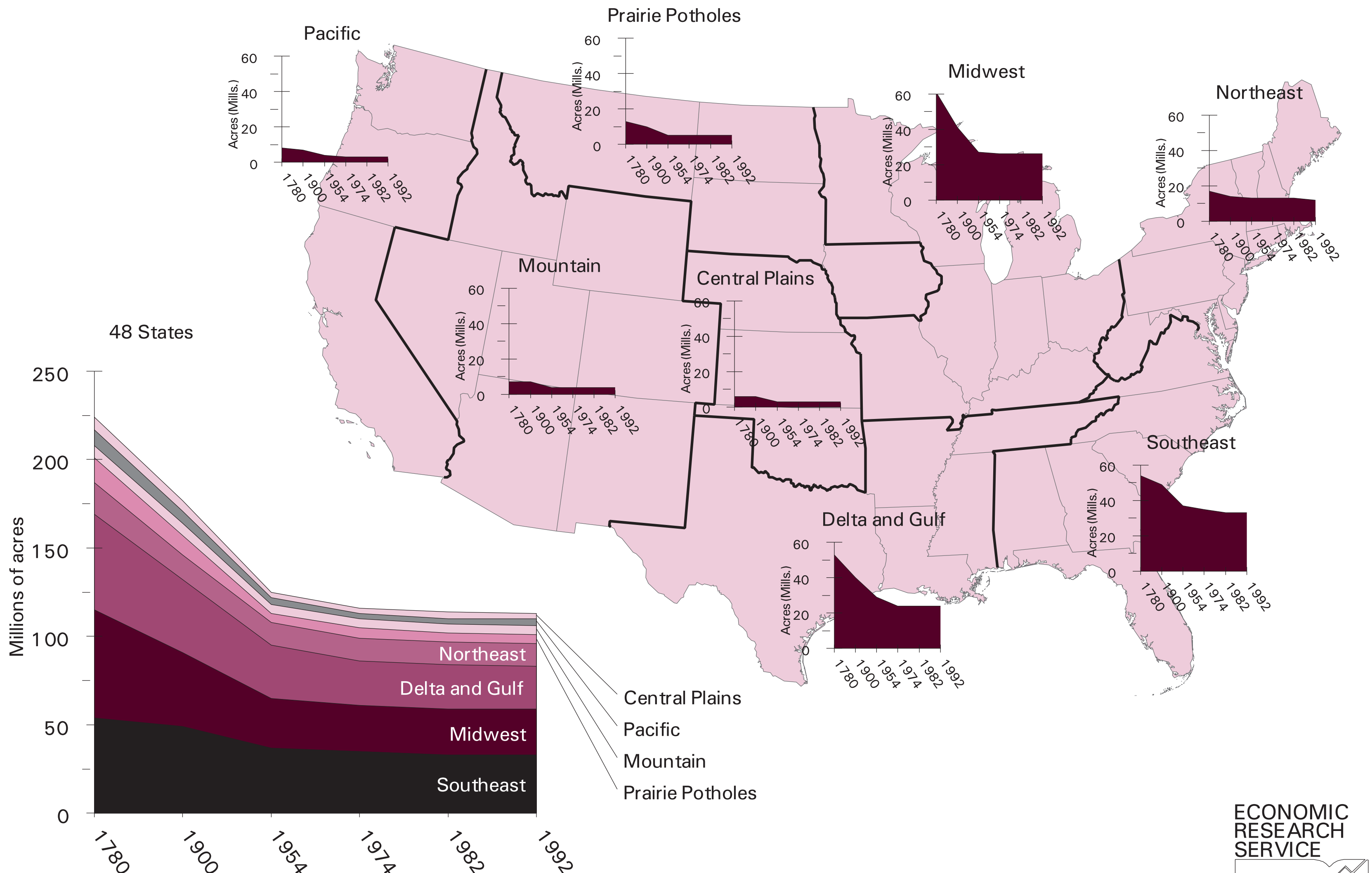
Most wetland conversion in the 19th century was originally done for agricultural purposes, although converted land subsequently was often used for urban development. Net rates of wetland conversion dropped from more than 800,000 acres per year between settlement and 1954 to less than 80,000 acres per year in 1982-92. Agriculture's share of gross conversion dropped from more than 80 percent in 1954-74 to 20 percent in 1982-92, while urban development's share rose from 8 percent to 57 percent (table 2). This long-term reduction in wetland conversion for agriculture coincided both with changing economic conditions that were less favorable for conversion and with enactment of Federal and State wetland regulatory programs (see Chapter V).

Wetland Exploitation: Settlement to 1954

Between first settlement[5] and 1954, 40-44 percent of original wetlands were drained or filled. Data on land area drained (not all wetlands) show that most of this activity probably occurred after 1885, with as much as 50 million acres drained by 1920, few acres drained during the Depression and World War II, and another 25-30 million acres drained between 1945 and 1955 (Pavelis, 1987). With the explicit encouragement of Federal Government policies and local cooperative efforts, wetlands were converted to agricultural and other uses at an average net rate between 814,000 and 887,000 acres per year between settlement and 1954 (table 2). The highest rates of conversion occurred in the Midwest, Delta, and Southeast wetland regions,

[5]Defined here as the date each State joined the Union.

Figure 3
Wetlands remaining, by year and wetland region, 1780 - 1992



Source: USDA, ERS, based on FWS Status and Trends data and 1992 Natural Resources Inventory data.

ECONOMIC RESEARCH SERVICE

Table 2—Average annual wetland conversion, contiguous States, settlement to 1992

Item	Settlement-1954		1954-74		1974-82		1982-92	
	Average annual change in wetland acreage							
	Thousand acres/year	Percent	Thousand acres/year	Percent	Thousand acres/year	Percent	Thousand acres/year	Percent
Wetlands converted to:								
Agriculture	na	na	593	81	235	53	31	20
Urban development	na	na	54	8	14	3	89	57
Other	na	na	35	5	168	38	16	10
Deepwater	na	na	48	6	29	6	20	13
Total	na	na	730	100	446	100	156	100
Converted to wetlands from:								
Agriculture	na	na	2,48[1]	91	82	53	42	54
Urban development	na	na			0	0	1	2
Other	na	na			53	34	29	38
Deepwater	na	na	25	9	20	13	5	6
Total	na	na	272	100	156	100	77	100
Net change in wetlands[2]								
Agriculture	na	na	4,35[1]	95	153	53	-11	-14
Urban development	na	na			14	5	87	110
Other	na	na			115	40	-12	-16
Deepwater	na	na	23	5	9	2	15	20
Total	814-887	100	458	100	290	100	79	100

na = not available.

[1]Conversion from agriculture, urban development, and other uses and net conversion not available as individual categories.

[2]Conversion of wetland to nonwetland uses, plus increases in wetlands due to restoration, abandonment, and flooding.

Source: Economic Research Service compilation of sources, including Dahl (1990); U.S. Department of the Interior, U.S. Fish and Wildlife Service, National Wetland Status and Trends Analysis, mid-1950's to mid-1970's and mid-1970's to mid-1980's, excluding Alaska and Hawaii and deepwater habitats; Soil Conservation Service, USDA, National Resources Inventories, 1982 and 1992, excluding Alaska, Hawaii and Caribbean and estimated acreage of deepwater habitats. See Appendix II for methods.

mostly for increased agricultural production (fig. 3). Almost 30 percent of net wetland conversion during this period was in the Midwest, 22-24 percent in the Delta and Gulf region, and 14-16 percent in the Southeast. Data are insufficient to reveal gross changes from dryland to wetland, but some wetlands were probably restored or created as lands once converted were abandoned, drainage failed, and reservoirs or other impoundments saturated formerly dry land.

Modern Wetland Conversion: 1954-74

The pace of net wetland conversion in 1954-74 was about half that of the long-term rate since settlement, dropping from as much as 887,000 acres to an average of 458,000 acres per year. Gross conversion to agriculture averaged 593,000 acres per year, while urban development, conversion to other uses, and water impoundments increased the total to 730,000 acres of wetlands converted per year. Conversion of dryland and deep water to wetlands averaged 272,000 acres per year, about 1 acre restored for every 3 acres converted.

During this period, the geographic focus of drainage shifted from the Midwest to the Delta and Gulf region (53 percent of all net conversion) and the Southeast (30 percent). In the Delta, expansion for agricultural production in Louisiana, Mississippi, and Arkansas was probably the largest contributor to wetland conversion, although changes to coastal wetlands on the Louisiana Gulf coast were also significant. In the Southeast, both urban and agricultural expansion in Florida and North Carolina were contributors. Net wetland acreage increased slightly in the Central Plains, Prairie Potholes, and Northeast, due to farmers abandoning some agricultural land, increased rainfall expanding wetland area, and farmers developing ponds and reservoirs with fringes of wetlands.

Wetland Policy Transition: 1974-82

Federal policy changes, such as the Clean Water Act's Section 404 and Executive Order 11990, and State wetland laws began to reduce wetland conversion from 1974 to 1982. Net wetland conversion dropped by 37 percent, from 458,000 acres per year to

290,000, despite greater economic incentives for agricultural conversion provided by higher market prices. Gross conversion for agriculture dropped to 235,000 acres per year, but a large increase in conversions to other uses kept total gross conversion at 446,000 acres. Gross increases in wetlands also fell to 156,000 acres per year, with agricultural lands accounting for more than half. Wetland was converted primarily in the Southeast, which had more than 60 percent of net conversion, and the Delta and Gulf region, which had 30 percent. Three-fourths of Southeast conversions were North Carolina wetlands converted to agricultural land, while changes in coastal wetlands in Louisiana and agricultural conversion in Mississippi and Texas contributed to net changes in the Delta region.

"No Net Loss": 1982-92

The Swampbuster provisions of the 1985 Food Security Act, more rigorous enforcement of Section 404 permitting, changes in preferential income tax treatment of conversion investments, and additional State wetland regulation, as well as falling agricultural prices, further reduced wetland conversion in 1982-92. Net wetland conversion dropped 72 percent to 79,000 acres per year. Gross conversion to agricultural uses was only 31,000 acres per year, amounting to only 20 percent of total gross conversion. The building boom of the 1980's may have increased urban conversion to 89,000 acres per year, or 57 percent of the total. The shift in proportion of wetland losses urbanized may be overstated since it seems so large relative to relatively constant proportions in earlier inventories. Differences in the "urban" category in National Wetland Status and Trends Analysis and National Resources Inventory may explain these differences (see Appendix II). Gross wetland increases also dropped to 77,000 acres per year, but the ratio of restored to converted acres increased from 1:3 to 1:2. More than half of wetland restored was from agricultural lands, while 38 percent was from "other" and 6 percent from deep water.

The Southeast again had more than half of the net conversion, but the Midwest had 22 percent, and the Northeast had 18 percent. Agricultural conversion in North Carolina dropped sharply, but conversion for urban development in Florida and the Northeast increased. There was a net gain in wetlands in the Prairie Pothole region, particularly Montana and South Dakota, and broadly across the Central Plains region, particularly Oklahoma.

By 1992, 45-50 percent of the original wetlands in the 48 States had been converted to other uses, with losses approaching 90 percent in Illinois, Indiana, Iowa, Missouri, and Ohio. The rate of wetland conversion dropped steadily from the mid-1950's on, to 10 percent of historic rates, and shifted away from agricultural uses to urban uses. These data show that, although the United States is still losing wetlands every year, we are moving toward the goal of "no net loss" of wetland acreage that has been Federal policy for the last 8 years.

Status of Wetlands

The wetland resource base remaining in the United States is a product of past conversion trends, much of which can be discerned from soil and water features observed today. Of the 224 million acres of wetlands and former wetlands in the 48 States, the 1992 land use of 195 million acres can be determined because they are wetlands or are known to be on hydric soils formed under wet conditions (table 3). More than 83 million acres of land no longer classified as wetlands on hydric soil was probably converted from wetlands since settlement. Two-thirds of this land (55.4 million acres) was in crop production in 1992, and another 15 percent (12.4 million acres) was in pasture and range uses. Urban, transportation, and water uses that may be on converted wetlands cannot be determined because no soils information is available. In addition, land in all uses that was converted from wetlands not on hydric soils also cannot be identified.

As outlined above, hydric soils and hydrology are two of the three most important criteria defining wetlands. Most wetlands (94.6 million acres; at least 85 percent) are on hydric soils, but not all hydric soils are wetlands. Wetland hydrology also varies, with remaining wetlands ranging from almost 50 million acres (45 percent) that have no likelihood of flooding to 22 million acres (20 percent) that are expected to flood 1 year in 2 and remain inundated for more than 7 days (table 4). Flood frequency and duration are not available for 17 million acres, more than 15 percent of 1992 wetlands.

Of the 111.5 million acres of remaining non-Federal wetlands inventoried in the 1992 National Resources Inventory, more than half (61.1 million acres) are forested. Miscellaneous uses, mostly marshes, barrens, flats and other nonuse categories, account for another 17 percent (18.8 million acres), and crop and pasture uses make up another 14 percent (18.5 million acres).

Nearly 12 million acres (10 percent) of remaining wetlands are not on hydric soils, mostly in forest cover. We estimate that 12.5 million acres of wetlands are on Federal land, mostly in natural cover types, such as forest, range, and water.

Private owners hold more than 82 percent (92 million acres) of the remaining non-Federal wetlands in the 48 States inventoried in the 1992 National Resources Inventory (table 5). State, county, and local governments own another 14.7 million acres (13 percent). In addition, the Federal Government controls an estimated 12.5 million acres of wetlands, only a fraction of which are in the National Resources Inventory. Of the privately owned wetlands, 77.5 million acres (84 percent) are farmed and naturally farmed wetlands subject to the 1985 Food Security Act Swampbuster provisions. Forty-six percent of the 195 million acres of identifiable wetlands and former wetlands were converted to nonwetland, either before 1985 (PC) or after (CW). Another 13.7 million acres of wetlands (7 percent) are identified scientifically under the Fish and Wildlife Service's Cowardin classification, but are not considered wetlands for Food Security Act purposes. There is no reliable way to estimate the extent of wetlands subject to the Clean Water Act 's Section 404 dredge and fill permits, although both Food Security Act and Cowardin wetlands are likely included.

Table 3—Wetlands and former wetlands by land use, 1992

1992 land use	Wetlands				Nonwetland	
	Hydric	Not hydric	Not known[1]	Subtotal	Hydric	Total
	Thousand acres					
Cropland	9,080	1,471	0	10,551	55,424	65,975
Pastureland	6,629	1,357	0	7,986	6,452	14,438
Rangeland	6,159	1,605	0	7,764	5,995	13,759
Forest land	55,817	5,297	0	61,114	9,461	70,575
Miscellaneous	16,923	1,841	0	18,764	3,040	21,804
Urban	0	0	952	952	0	952
Rural transportation	0	0	559	559	0	559
Water	0	0	3,826	3,826	0	3,826
Federal	0	0	0	0	3,140	3,140
Total	94,607	11,571	5,336	111,513	83,513	195,026

[1]Soils information not known because of land cover.
Source: Economic Research Service compilation of 1992 National Resources Inventory data.

Table 4—Wetlands by flooding frequency and duration, 1992

Expected flooding frequency (chance of flooding in any year)		Average duration of inundation per flood: Not applicable	Very brief (< 2 days)	Brief (2 - 7 days)	Long (7 - 30 days)	Very long (> 30 days)	Total
None	Not likely	49,962	0	0	0	0	49,962
Rare	0-5%	7,041	0	0	0	0	7,041
Occasionally	5-50%	0	507	3,212	3,415	832	7,967
Frequently	>50%	9	2,151	5,257	13,235	8,986	29,638
Not recorded		16,906	0	0	0	0	16,906
Total		73,918	2,658	8,469	16,650	9,818	111,513

Source: Economic Research Service compilation of 1992 National Resources Inventory data.

Table 5—Remaining wetlands by ownership and Food Security Act status, 1992

Food Security Act status	Private	Municipal	County	State	Federal	Indian/tribal	Water	Total
				Thousand acres				
Farmed wetlands (FW)	3,768	1	2	54	0	37	0	3,862
Wetlands (W)	73,702	277	1,869	11,012	0	873	13	87,746
Wetlands subtotal	77,470	278	1,870	11,066	0	910	13	91,608
Converted wetlands (CW)	160	0	2	0	0	0	0	162
Converted prior to 1985 (PC)	83,384	143	260	1,327	3,140	376	5	88,635
Former wetlands subtotal	83,544	143	262	1,327	3,140	376	5	88,797
Artificial wetlands (AW)	757	3	5	99	0	14	0	878
Non-Food Security Act wetlands	8,506	143	125	1,048	0	97	3,825	13,743
Total wetlands	91,985	428	2,013	12,229	0	1,021	3,838	111,513
Wetlands/former wetlands	170,277	567	2,262	13,539	3,140	1,397	3,843	195,026

Source: Economic Research Service compilation of 1992 National Resources Inventory data.

Problems with Recent Wetland Status and Trends

According to a report released by the U.S. Fish and Wildlife Service in September 1997, U.S. wetland losses continued in the 1985-95 period, but at a rate 60 percent below that recorded in 1974-83 (Opheim, 1997). The report estimated that 100.9 million acres of wetlands remained in the conterminous United States. Ninety-five percent of the remaining wetlands were estimated to be inland freshwater wetlands, and 5 percent were coastal or estuarine wetlands. Freshwater forested wetlands made up the single largest category of remaining wetlands.

The rate of wetland losses between 1985 and 1995 was estimated to be 117,000 acres per year, 60 percent lower than the loss rate reported for the mid-1970's to mid-1980's. However, 79 percent of the lost wetlands were projected to have been converted to agricultural uses. Urban development and other types of land use were estimated to be responsible for 6 percent and 15 percent of losses, respectively. Although loss rates to agricultural uses in 1985-95 were estimated to be 93,900 acres per year, 40 percent less than the 156,600 acres per year estimated for 1974-83, the proportion of losses due to agriculture in this report is higher than that estimated using the 1982-92 National Resources Inventory data.

Like previous U.S. Fish and Wildlife Service analyses (Dahl and Johnson, 1991; Frayer, and others, 1983), this study was based on aerial photography of 3,726 four-square-mile plots chosen using a weighted, stratified random sample. For this study, 2,682 plots were analyzed using photography with dates ranging from 1981 to 1991. Mathematical projection was used to estimate (1) the total area of the sample plot in each wetland type in 1985 and 1995, and (2) the changes in wetland type area between these dates. The projection technique was used to estimate 1985-95 losses for 2,682 plots with photography dating up to 1991, and for the 1,044 plots for which only data from the mid-1970's to mid-1980's were available. The projection technique depends on a fairly constant rate of change between dates, and makes no adjustment for policy changes after the photography was taken. The use of projection from earlier photography in this inventory makes comparisons with former inventories difficult. Because policy changes in the late-1980's were not taken into account, particularly those related to agricultural losses, losses projected from earlier photography are not likely to be accurate. These methodological differences were not resolved in time to include the new inventory in the data presented in this publication. The National Resources Inventory will serve as the basis for a single inventory of wetland resources beginning in 2000 (*National Wetland Newsletter*, 1998).

V. Federal Wetland Policies and National Trends

Federal wetland policy has evolved over our Nation's history. During the period of settlement and national expansion, incentives for converting wetlands to other uses hastened wetland loss. Direct incentives for conversion remained until late in this century. Gradually, direct and indirect incentives were eliminated and policies to conserve wetlands were adopted. With the adoption of the "no net loss" goal, efforts to conserve and restore wetlands accelerated.

The Era of Wetland Exploitation

In the earliest stages of settlement, farmers bypassed wetlands in favor of dry land with good water and trees. Only toward the end of the 19th century, when easily accessible farmland grew scarce, did farmers turn to the previously bypassed wetlands in earnest.

> By a strange quirk of fate those who blazed the first trails and developed the first farms in Iowa found [...] that their timber-prairie farms near the rivers were often less valuable than the farms developed by those who came much later and took the land they had avoided. To be sure, the wet lands required considerable drainage expense, but even so these wet lands were eventually a better bargain (Peterson, 1967, pp. 448-449).

To encourage farmers to convert wetlands, Congress gave 64.9 million acres of wetlands to 15 States in the Swampland Acts of 1849, 1850, and 1860. Congress wanted the States to reclaim wetlands by constructing levees and drains to reduce flooding and eliminate mosquito breeding areas. States transferred nearly all of the granted lands to private owners who converted large acreages to other uses (Shaw and Fredine, 1971). Since then, many Federal programs have provided incentives for wetland conversion, including those that subsidize agriculture, support reservoir construction for flood control, irrigation, and hydroelectric power, support highway projects, provide flood disaster relief and flood insurance, subsidize and provide tax incentives to forestry, and establish grazing policies on Federal land (USDI, 1994).

Agricultural subsidies are an indirect incentive that has accelerated wetland conversion over the past 60 years. Hoover questioned the expense and overall public efficiency of these subsidies (Hoover, 1969). The U.S. Department of the Interior conducted a series of studies that exhaustively explored the subsidies' role in wetland conversion, finding that the subsidies did promote wetland conversion (USDI, 1988 and 1994). The Swampbuster provisions of the 1985 Food Security Act and changes in the 1986 Tax Reform Act largely eliminated indirect government assistance in the form of farm program benefits and income tax deductions for wetland conversion (Heimlich and Langner, 1986; Heimlich, 1994).

Drainage and Flood Control

Federal involvement in drainage programs dates back to 1902 when the Bureau of Reclamation was established to develop irrigation in the West. Drainage was required to fully use the new irrigation capacity, providing new Federal involvement in agricultural drainage programs (USDI, 1988). Farmers using Bureau irrigation encountered drainage problems while developing irrigation systems in such areas as the Newlands Project in Nevada, the Modesto Irrigation District in California, the Mesilla Valley of New Mexico, and the marsh lands of Western Oregon. Large-scale agricultural drainage solved irrigation problems in the Imperial Valley of California. Other drainage projects included the Columbia Basin (Washington), Grand Valley (Nebraska), Big Horn Basin (Montana and Wyoming), Oahe (South Dakota), Weber Basin (Utah), Garrison (North Dakota), and Big Thompson (Colorado).

The U.S. Army Corps of Engineers began rechanneling work on the Mississippi River in the 1870's (Beauchamp, 1987). Flooding in the 1940's motivated Congress to enact the Flood Control Act of 1944, which further authorized the Corps of Engineers to construct major drainage and flood control channels. Many dormant drainage districts in the Mississippi Valley were reactivated to exploit the benefits of the newly enhanced flood control infrastructure for agricultural drainage. Additional flood control work provided drainage outlets in response to floods in both the Mississippi and the Missouri Valleys in the early 1950's, and additional farm drainage exploited the new outlets. Between 1929 and 1974, Army Corps of Engineers flood control projects were authorized affecting 5.5 million acres in the Lower Mississippi alluvial plain. Construction was completed on 4.5 million acres (USDI, 1988).

The U.S. Department of Agriculture (USDA) helped farmers drain wetlands from an early date. Drainage inventories in 1906 and 1922 identified 75-79 million acres of wetlands with potential for drainage to accommodate agricultural production (Gray, and others, 1923; Wright, 1907). Beginning in 1936, USDA provided cost-sharing for wetland drainage, a practice that continued into the late 1970's (USDI, 1988 and 1994; Holmes, 1980; National Audubon Society, 1996). The Civilian Conservation Corps and other Federal relief agencies conducted drainage activities in the 1930's. In 1953, Congress explicitly linked flood control and agricultural drainage when the Federal Watershed Protection and Flood Prevention Act (P.L. 83-566) directed the Army Corps of Engineers and USDA to create a formal partnership for constructing drainage outlet channels in cooperation with State and local governments. The Army Corps worked primarily in main stems of major rivers, while USDA undertook upstream projects in tributaries.

P.L. 566 authorized USDA to plan and construct watershed improvements. USDA's Soil Conservation Service (now the Natural Resources Conservation Service) provided technical assistance and cost sharing for ditches, subsurface drains, conduits to convey water from fields without causing erosion, protection devices for tile outlets, and surface field drainage (Beauchamp, p. 19; Gadsby, and others, 1976). The Agricultural Stabilization and Conservation Service's (now the Farm Service Agency) role in financing new drainage on farms has been relatively minor and declined over time (Pavelis, 1987b, p. 161). By the mid-1980's, less than 10 percent of all existing surface or subsurface drainage improvements could be attributed to Federal financing provided under the Agricultural Conservation Program.

However, a major impact of small watershed programs under P.L. 566 was construction of outlet channels into which landowners could drain their wetlands (USDI, 1988, p. 19). Most channelizing work under P.L. 566 was in four Southeastern States: Georgia, Louisiana, Mississippi, and North Carolina. A 1972 study by Arthur D. Little concluded that, "On balance, the weight of evidence is marginally in favor of channeling both untouched natural streams and man-altered channels in terms of ...economic effects." Conflicts with environmentalists concerned about preservation of wetlands began when the Soil Conservation Service began straightening stream channels to provide more efficient outlets for drainage and flood waters (Gillette, 1972).

Drainage and Cropland Expansion

Cooperative efforts between farmers and Federal and State agencies expanded the supply of land for farming. Mattson concluded that in the Mississippi Delta "Land clearing was common and appeared to be linked to better control of water regimes and flooding. In these circumstances it would seem inevitable that improved drainage linked to an arterial channel system being installed by the Corps of Engineers and other projects, would hasten the conversion of remaining hardwood forests to highly productive, generally large, crop fields" (Mattson, 1975, p. 31).

Federal assistance to drain wetlands for production of subsidized crops expanded agricultural production in order to expand crop base acreage in high-price years. This often led to underuse or abandonment of cropland as long-term retirement and annual set-aside supply control measures focused on marginally productive land in low-price years. For example, the North Carolina Conservation Needs Committee in 1962 extrapolated a gain of over 45 percent (144,800 acres) of cropland for the nine major crops in the 10-county Albemarle area (Hoover, 1969). Large-scale conversion in the area in the 1970's affected thousands more acres as commodity prices rose (Carter, 1975). By the mid-1980's, however, problems with drainage permits, conversion feasibility, and commodity economics forced abandonment of large acreages of unconverted and partially converted land that were donated to the Fish and Wildlife Service to expand the existing Alligator River National Wildlife Refuge.

The Era of Policy Transition

Even as the conversion of wetlands to other uses continued at a rapid pace throughout the early part of this century, scientists, conservationists, and the public were beginning to recognize the unique and important functions and values of wetlands. Gradually, the supply of remaining wetlands decreased (moving to the right in fig. 1) and wetland benefits became more widely known. Public attitudes and public policy began to shift from supporting and subsidizing wetland conversion to encouraging wetland conservation and restoration (Carey, and others, 1990; Dahl and Allord, 1996).

Part of the persistence of wetlands in the landscape traces back to a public regard for them as something beyond crop fields and building sites. This regard grew from the perceptions of early naturalists like William Bartram and John James Audubon, the activism of conservationists from Teddy Roosevelt to J.N. "Ding" Darling, and the ordinary appreciation of millions of hunters, anglers, and birdwatchers (Wallace, 1985). Economic measures of this regard are reflected in the willingness-to-pay measures for use, nonuse, and amenity values reported in the literature (see Appendix I). Public opinion polls have found that 58 percent of respondents thought the government was not doing enough to protect wetlands, and 59 percent stated a willingness to pay additional taxes to protect them (EOS, 1991; NWF, 1989). Public policy on wetlands has responded to the changing values and views, moving from whether they should be protected, to how best to protect them.

Early Wetland Preservation Efforts

Wetland preservation efforts began early this century out of concern for waterfowl habitat. President Theodore Roosevelt established the first National Wildlife Refuge in 1903 to protect Pelican Island, Florida, a nesting site for colonial nesting water birds. The Migratory Bird Hunting Stamp Act of 1934 established a special fund to finance wetland acquisitions for duck habitat. In 1961, the Wetlands Loan Act allowed advance appropriations for the purchase of wildlife refuges and waterfowl production areas (National Audubon Society, 1996). Today, the National Wildlife Refuge system contains over 500 refuges and nearly 200 Waterfowl Protection Acres, the latter primarily in the Prairie Pothole region (Stewart, 1996).

In 1970, the Water Bank program created the first agricultural program to temporarily protect wetlands. Water Bank provided annual per acre payments to the owners of eligible wetlands and adjacent uplands who agreed not to burn, drain, fill, or otherwise destroy the character of enrolled areas for the life of the contract. Ten-year contracts provided cost-sharing to install conservation practices designed to maintain vegetative cover, control erosion, improve wildlife habitat, conserve surface water, or manage bottomland hardwoods (USDA-ASCS, 1988; Heimlich, and others, 1989; Higgins and Woodward, 1986). At the program's peak in 1993, more than 1,000 Water Bank contracts in 11 States covered 73,831 acres of wetlands and 46,121 acres of associated upland at an average rental cost of $12.28 per acre per year (USDA-ASCS, 1994). The last Water Bank contracts will expire when their 10-year terms run out, but the land is eligible to compete for enrollment in the more recent Wetlands Reserve Program.

However, early wetland preservation efforts were at cross-purposes with continuing Federal policies that directly or indirectly subsidized wetland conversion. Farm commodity program benefits were available for crops grown on converted wetland acres. Tax breaks allowed significant writeoff of conversion costs and opportunities to shelter income from taxation through wetland conversion for agriculture (Whitaker, 1976, p. 172). Nearly $170 million in deductions for conservation and land clearing, including wetlands and nonwetlands, were claimed on 4 percent of returns in 1982, reducing farmers' taxes by an estimated $27-$37 million (Daugherty, 1987).

Recent Wetland Preservation Efforts

In the 1970's and 1980's, a shift from conversion to conservation policies became clearer. The first changes eliminated economic incentives for wetland conversion and provided a public review process for private wetland conversion decisions. Section 404 of the Federal Water Pollution Control Act Amendments of 1972 established a permit program regulating discharges of dredged and fill materials. Although initial rules limited the scope of regulation to navigable waterways, a Federal district court directed the Army Corps of Engineers to include "isolated waters," consistent with what Congress intended in the law. Final rules, issued in 1977, explicitly included "isolated wetlands and lakes, intermittent streams, prairie potholes, and other waters...." Attempts to narrow the scope of regulation were rejected in the debate over the Clean Water Act of 1977 (USEPA, 1993). Executive Order 11990, issued by President Carter in May 1977, directed Federal agencies to minimize destruction, loss or degradation of wetlands and to preserve and enhance the natural beneficial values of wetlands in all actions involving Federal lands, federally financed or assisted construction projects, and other Federal activities affecting land use.

The succeeding wave of wetland policies was voluntary programs providing incentives to landowners to conserve and restore wetlands. Under the Small Wetland Acquisition Program, the Fish and Wildlife

Service can either purchase a wetland and surrounding upland acreage outright or enter into a permanent easement agreement restricting wetland use. Compensation is made on a one-time basis, with the payment varying according to land values in the immediate area and the development potential of the wetland. The Small Wetland Acquisition Program currently has 1.2 million acres of wetlands under perpetual easement in Montana, Nebraska, North Dakota, and South Dakota, at a cost of $46.7 million, or $38 per acre. The program also holds an additional 76,300 acres in associated grassland easements at $4.9 million or $64 per acre (Hartmann, 1993).

The Section 404 Permit Program

Section 404 of the Clean Water Act directs the Army Corps of Engineers and the Environmental Protection Agency to regulate discharge of dredged and fill material into "waters of the United States," which are defined to include wetlands, even when they are isolated from navigable bodies of water. A landowner must obtain a permit from the Army Corps of Engineers before beginning work in wetlands, which almost always involves discharging dredged or fill materials into U.S. waters. Section 404 regulation is not a narrow, technical regulatory process, but a public review procedure that allows all interested parties to comment on potential adverse impacts from the proposed wetland conversion (Alvayay and Baen, 1990). In this regard, the Section 404 process acknowledges the public-good aspects of wetlands and allows the affected public to weigh potential negative effects against the private (or competing public) interests of the permit seeker.

Regulated activities cannot be permitted if a practical alternative is less damaging to the aquatic environment, or if the Nation's waters would be significantly degraded. Permit applicants must show that a sequence of all practical steps has been taken to avoid, minimize, and as a last resort, compensate for unavoidable losses by restoring or creating replacement wetlands. The Army Corps of Engineers has authority to issue general nationwide permits for any category of activities involving discharges of dredged or fill material if the activities are similar in nature and will impose minimal individual and cumulative effects. If an activity fits into the category of activities authorized under a nationwide general permit, it does not require a case-specific review; it is automatically authorized. Some nationwide general permits are being phased out, to be replaced with activity-specific permits.

In recent years, relatively few permits for agricultural conversion have been requested. In fiscal year (FY) 1994, for example, agricultural activities accounted for only 7.1 percent (3,430) of total Section 404 permit applications (USACE, 1995). Moreover, most agricultural permit applications (87.5 percent) were approved under nationwide general permits. A wide variety of agricultural activities are either covered by nationwide general permits or entirely exempted from regulation under Section 404(f). Specific agricultural activities covered by nationwide general permits include cranberry production, discharges due to construction of farm building foundations, and federally approved or funded wetland restoration or creation activities. Agriculture-related exemptions include normal farming, silviculture, or ranching activities, such as tillage, seeding, and harvesting; and constructing or maintaining farm ponds, irrigation ditches and drainage ditches, and farm or forest roads, as long as wetland hydrology is not further impaired.

Finally, the role of Section 404 as a deterrent to wetland conversion is often asserted but difficult to assess. In FY 1994, the Army Corps of Engineers received 48,292 permit applications. Of these, 43,753 (91 percent, affecting 17,200 acres) were approved through general permits, standard permits (which require case-by-case review), or letters of permission. Another 4,184 (9 percent) were withdrawn, about half of which qualified for general permits and administrative adjustments, or did not require permits. Only 358 permits applied for (less than 1 percent) were denied, including only 30 agricultural permits (0.9 percent). The Army Corps of Engineers estimates that an additional 50,000 activities each year are authorized under nationwide general permits that do not require the public to notify the Army Corps of Engineers (USACE, 1995). Converted wetland acreage permitted rose from 11,600 in FY 1993 to 24,987 in FY 1996 (USACE, 1995; Robertson, 1997).

Although permit denials are few, denials are a function of both Army Corps of Engineers policy in assessing applications and private decisions to submit permit applications. The Swampbuster provisions, discussed in the next section, and State wetland regulations discourage wetland conversion, thus reducing Section 404 permit applications over what they would have been in the absence of these policies (Zinn and

Copeland, 1996). Moreover, evidence suggests that as the requirements of the permit process itself have become widely known, they have deterred individuals from applying under conditions which are not likely to pass Army Corps of Engineers review without substantial and costly revision (Albrecht and Goode, 1994; Alvayay and Baen, 1990).

Swampbuster and Tax Reform

Conflicts between Federal farm policy and wetland protection were eliminated with passage of the wetland conservation provisions (popularly known as the "Swampbuster" provisions) of the 1985 Food Security Act. Although not specifically directed at wetland conservation, provisions of the Tax Reform Act of 1986 also eliminated preferential tax treatment of conversion costs and preferential capital gains treatment from selling land that had appreciated in value due to drainage.

The Swampbuster provision directs the Secretary of Agriculture to deny farm program benefits to farmers or landowners who drain protected wetlands. Benefits at risk include direct payments (for example, production flexibility contract payments), price support loans, agricultural disaster payments, loans for farm storage facilities, and certain federally insured or guaranteed loans. Benefits may be denied on all fields and all farms in which the violator has a financial interest (16 U.S.C. 3801 *et seq*; 7 C.F.R. Part 12).

The 1985 Food Security Act also shifted emphasis from price support to income support in commodity subsidy programs. Price support programs, operated through nonrecourse commodity loans, are designed to bolster market prices. Price support programs tend to encourage "free riding," because all producers benefit from higher prices caused by acreage reductions and government purchase of commodity stocks from participating farmers. Income support is paid directly to participants as deficiency payments, discouraging free riders and significantly increasing the potential Swampbuster penalty during periods of low market returns and high support payments.

The Swampbuster provision, like the Section 404 permit program, deters wetland conversion beyond the actual violations processed. USDA's Farm Service Agency reports that over $11 million in benefits were denied to producers on 351 tracts representing over 15,000 acres between 1987 through 1996. There is debate about whether the small number of violations indicates a successful deterrent or inadequate enforcement of the Swampbuster provisions (USGAO, 1994b; EWG, 1995). According to simulation studies, wetland acreage not converted during this period because of potential loss of farm program benefits is likely large, although estimating it in aggregate is impossible (Heimlich and Langner, 1986; Kramer and Shabman, 1993; see next section). Dependence on farm program payments during the latter half of the 1980's and low agricultural conversion rates in the 1982-92 National Resources Inventory support this conclusion (Carey, and others, 1990).

The Tax Reform Act eliminated provisions allowing capital investment in drainage and land clearing to be treated as annual expenses and preferential tax treatment for capital gains. Although the value of tax incentives varies significantly with producers' incomes, these changes significantly increased the after-tax cost of wetland conversion for agriculture and largely eliminated opportunities to shelter nonfarm income from taxation through investment in wetland conversion for agriculture in some areas of the country (Heimlich and Langner, 1986; USDI, 1994).

Prior to the Tax Reform Act, drainage costs were treated as conservation expenses and could be immediately deducted, up to 25 percent of *gross* farm income. Land clearing expenses were deductible up to the lesser of $5,000 or 25 percent of net farm income. Any unused deductions could be carried forward to subsequent years. For farmers and landowners with income that could be offset, deductibility amounted to a Federal Government cost share on wetland conversion activity.

Investment in wetland conversion for agriculture provided an opportunity to shelter regular income from taxation by converting it to a capital gain, reducing the tax rate, and delaying taxation until the land was sold. The increase in the value of the land due to drainage and clearing (the capital gain) was taxed only when the land was sold and only 40 percent of the gain was taxed at the rate of regular income (if the land was held for at least 10 years following conversion). For example, $20,000 in conservation expenses to drain 100 acres of bottomland hardwood wetlands for cropland use could offset other income in the year in which drainage was done. If the undrained land cost $400 per acre and sold for $1,000 after drainage, only $16,000 of $40,000 in total capital gains (40 percent x [$100,000 - $40,000 - $20,000]) in the year the land was sold would be taxed at ordinary income tax rates. The economic context of the 1970's was particularly conducive to the use of these tax mechanisms. Agricultural returns were relatively high (including capital gains through land value inflation) and real interest rates were low, holding down the *annualized* cost of conversion. Favorable tax treatment further enhanced the value of investing in the conversion of wetland for agricultural production (Ward, and others, 1989; Daugherty, 1987; Heimlich, 1986).

Wetland Economics and Policy Effectiveness

Have wetland policy changes slowed the rate of wetland conversion for agriculture? Although Swampbuster reduces returns to conversion, is the reduction large enough to make the difference between conversion and conservation of wetlands? How important are regional differences in the kinds of crops grown, size and structure of farms, and prevailing economic conditions over time as factors affecting the importance of Swampbuster's sanction? As noted in Chapter III, inventories of wetland acreage conducted over the past 40 years show that the rate of wetland conversion has slowed and that wetland conversion for agriculture has been reduced. Although Federal wetland policies likely played a role in reducing the rate of wetland conversion for agriculture, their enactment in the mid-1980's coincided with a deep recession in the agricultural economy, which also reduced economic incentives for wetland conversion (Heimlich and Melanson, 1995). Moreover, inventory data show that the downward trend in wetland conversion began before wetland conservation and restoration policies were implemented. In the sections that follow, we review previous research and other evidence on the effectiveness of these policies.

The bulk of previous research assessing the role of Swampbuster and the Tax Reform Act in changing economic incentives for wetland conversion employed simulation models developed for specific locations. For example, models for both the Delta and Prairie Pothole regions, using 1975-84 as a baseline for prices and yields, are reported in *The Impact of Federal Programs on Wetlands, Volume I* (USDI, 1988). In the Prairie Pothole region, six representative farms were simulated. Results indicate that ending tax breaks on wetland conversion would have virtually no impact on the (whole farm) net present value (NPV) of returns to farms that drain wetlands (McColloch and Wissman, 1985). The withdrawal of other Federal benefits, including price and income support, was simulated to reduce NPV by 6 to 66 percent, with an average reduction of 14 percent for the six representative farms studied. Even so, NPV of the "drained without price and income supports" scenario exceeded that of the "undrained with price and income supports" scenario for all six representative farms. The authors conclude that farm program payments were not important in inducing drainage, but stopped short of concluding that Swampbuster provisions would be ineffective at retarding drainage.

In the Delta region, loss of tax benefits and farm program support was more significant. Eliminating tax breaks would reduce the per acre NPV of wetland conversion by between 6 and 46 percent, averaging 14 percent over the four representative farms simulated. Withdrawal of farm program benefits would reduce NPV of wetland conversion by between 17 and 35 percent, averaging 26 percent. Although the authors of the Delta study conclude that Swampbuster and tax reform have significant potential to reduce returns to wetland conversion, they also argue that including additional, per acre general farm overhead costs would render wetland conversion only marginally profitable in any case (Kramer and Shabman, 1986).

Danielson (1989) simulated wetland conversion economics in the pocosin wetlands of eastern North Carolina, also using data from 1975-85. His work showed that removing tax breaks and agricultural support programs would reduce returns attributable to overhead, management, risk, and land from 22.4 percent to 17.2 percent. He concluded that estimated returns would not be sufficient to prompt large-scale conversion of pocosin wetlands.

Heimlich and Langner (1986) simulated representative farms in North Carolina and North Dakota for economic and policy conditions projected to exist in 1986-91. They found that Swampbuster sanctions would reduce the net cash income in both cases, by 26 percent for the North Carolina farm and by 145 percent for the North Dakota farm. Tax incentives reduced taxes by 36 percent for the North Carolina farm, but with conversion, taxes increased 6 percent for the North Dakota farm.

Kramer and Shabman (1993) simulated per acre returns to wetland conversion for representative counties in Louisiana, Arkansas, and Mississippi for 1985 (before Swampbuster or tax reform) and 1987 (after implementation of Swampbuster and tax reform). Under 1987 conditions, in two of the three counties, returns to wetland conversion were positive, but low, even without the loss of farm program benefits on nonwetland acres. In the third county (Arkansas), wetland conversion could be profitable, but the loss of program benefits on as little as 1.03 nonwetland acres would fully offset returns to wetland conversion. That is, wetland conversion without program benefits would net $266 per wetland acre, but Swampbuster provisions would deny $264 in program benefits on all nonwetland acres. In each of the three counties, loss of farm program payments due to Swampbuster—not counting the nonwetlands penalty–was 150 to 275 percent greater than the increase in tax liability due to tax reform.

The simulation studies provide estimates of the effect of Swampbuster on returns to wetland conversion over a range of economic, policy, and geographic circumstances and configurations. Based on the results from these studies, Swampbuster significantly reduced returns to wetland conversion after 1985. A more difficult question is whether Swampbuster makes the critical difference between conversion and conservation of wetlands with agricultural potential, especially when commodity prices rise above prices seen in the latter half of the 1980's.

U.S. Department of Interior studies, using data from 1975-84, when market returns to crop production were relatively high and farm program benefits were a smaller share of farm income, show that Swampbuster would not have been effective, particularly for the Prairie Pothole region. Changes in economic conditions by the late 1980's led Heimlich and Langner to conclude that Swampbuster would significantly deter wetland conversion, especially in the Prairie Pothole region. Kramer and Shabman (1993) argued that, by the late 1980's, returns were unfavorable to wetland conversion, even without Swampbuster and the Tax Reform Act. However, their results suggest that Swampbuster penalties were severe. Even if returns to wetland conversion were high, Swampbuster sanctions easily drove returns to negative levels, indicating that the deterrent potential of Swampbuster was high.

Finally, the Tax Reform Act had a smaller overall impact on returns to wetland conversion than did Swampbuster provisions. Simulation studies of the Prairie Pothole region, carried out for different time periods and circumstances, show that tax incentives were never an important factor in wetland conversion. For other regions, however, tax reform may have reduced overall incentives for wetland conversion. Differences between States in the value of tax breaks in wetland conversion are due at least in part to variation in the capital intensity of conversion activities (Heimlich, 1986). In the Prairie Pothole region, conversion costs are low and conversion can often be accomplished using farm machinery during slack seasons. Differences in the level and composition of farm operators' incomes are also important in understanding the effects of tax reform on wetlands.

Army Corps of Engineers officials argue that the Swampbuster provisions have significantly reduced agriculture-related Section 404 permit applications (Zinn and Copeland, 1996). However, the extent to which Swampbuster or unfavorable economic conditions for wetland conversion contributed to the slowdown in permit activity cannot be decisively determined. Whether or not Swampbuster has slowed agriculture-related permit applications, its enactment may also have served to focus greater Army Corps of Engineers attention on agricultural wetlands because producer actions that may have escaped Army Corps of Engineers notice prior to Swampbuster were now identified by USDA officials as wetland conversions.

By the latter half of the 1980's, policies and programs were enacted to conserve existing wetland resources. Policies in place included eliminating direct and indirect incentives for conversion in Federal programs, directly regulating dredge and fill activity under Section 404, and increasing the number of State and local wetland regulation and conservation laws. A broader vision of wetland conservation, including an overall goal and interest in restoring former wetlands, was the next step in the evolution of wetland policy.

The Era of "No Net Loss"

"No net loss" was adopted as a policy goal of both the Bush and Clinton administrations (White House, 1991; 1993). As the discussions of the National Wetland Policy Forum reveal, achieving "no net loss" was never envisioned solely as a matter of conservation; wetland restoration was a necessary tool to enable land use adjustments needed with growth (The Conservation Foundation, 1988). The "no net loss" goal can be pursued by conserving existing wetlands, restoring former wetlands that were converted, or by some combination. Should we put relatively more effort into conserving our existing wetland resources than restoring wetlands that have previously been converted? Conservation avoids adding the cost of restoration to the original costs of converting wetlands that ultimately prove marginal in their converted use. Critics of wetland restoration argue that the functions and values of wetlands lost are never totally recovered in restorations (Steinhart, 1987; NRC, 1992, p. 316; Kentula, 1996; Hunt, 1996). The policy response embodied in the "no net loss" goal is that conservation alone will not be enough (White House, 1991; 1993; Gore, 1997). In many areas, wetland conversion has destroyed so much of the original wetland base that restoration is required for functioning wetland ecosystems. Future wetland conversion where public and private benefits exceed costs is unavoidable. Wetland restoration is the only way to make up for truly unavoidable losses.

Although wetland conservation programs, including Section 404 permits, Small Wetland Acquisition Program, Water Bank, and the Swampbuster provisions, were in place by the mid-1980's, Federal programs for wetland restoration were just emerging. Some restoration developments preceded the formal statement of the "no net loss" goal. The National Wetland Priority Conservation Plan, required under the Emergency Wetland Resources Act of 1986 (P.L. 99-645 100 Stat. 3582), emphasized conserving and restoring wetlands, required States to include wetlands in their Comprehensive Outdoor Recreation Plans, and transferred to the Migratory Bird Conservation Fund amounts equal to the import duties on arms and ammunition for acquisition and restoration work. The Emergency Wetland Resources Act extended the Wetlands Loan Act authorization through 1988, and forgave previous advances under the Act and authorized purchase and restoration of wetlands from Land and Water Conservation Fund moneys, removing a prior prohibition on such acquisitions. Other provisions included establishing entrance fees at National Wildlife Refuges, with fee receipts to be allocated 70 percent into the Migratory Bird Conservation Fund for acquisition and restoration and 30 percent for operations and maintenance at the refuges, and increasing the price of duck stamps funding restoration work from $7.50 to $15.00, to be phased in through 1991.

The North American Waterfowl Management Plan, a joint agreement and treaty between the United States, Canada, and Mexico, also called for restoring former waterfowl habitat. The North American Wetlands Conservation Act (P.L. 101-233 103 Stat. 1968; 16 U.S.C. 4401-4412) established a Wetland Trust Fund in 1989, and established the North American Wetlands Conservation Council to approve wetland restoration projects. The Act identified several sources of Federal revenue for the fund, including sums received under section 6 of the Migratory Bird Treaty Act of 1918 from fines, penalties, and forfeitures of property, interest accrued on the fund established under section 3 of the Federal Aid in Wildlife Restoration Act of 1937, and Congressional appropriations. In 1990, amendments to the Federal Aid in Sport Fish Restoration Act directed that a portion of the moneys collected from Federal fuel excise taxes on small gasoline engines be allocated for use under the Act for coastal wetlands projects. In October 1994, Federal appropriations under the North American Wetlands Conservation Act were reauthorized for FY's 1995 through 1998. Up to $20 million was authorized in FY's 1995 and 1996, of which Congress appropriated $9 million in 1995 and $6.75 million in 1996. Up to $30 million was authorized in each of FY's 1997 and 1998. In 1991-97, 544 projects in Canada, Mexico, and the United States, involving over 700 partners, received $233 million under the Act, while partners have contributed $487 million. Approximately 3.7 million acres of wetlands and associated uplands have been acquired, restored, or enhanced in the United States and Canada, while conservation education and management plan projects in Mexico affected nearly 20 million acres.

Two agricultural programs have demonstrably affected wetland restoration more than any other. The Conservation Reserve Program, enacted in the 1985 Food Security Act, made cropped wetlands eligible to be retired from crop production for 10 years. Beginning in 1989, 410,053 acres of wetlands were enrolled, mostly in the Northern Plains and Delta States (Osborn, and others, 1995). In the 1990 Food, Agriculture, Conservation, and Trade Act, Congress created the Wetlands Reserve Program to purchase permanent easements on former wetlands that had been converted to crop production and restore them as wetlands (Carey, and others, 1990; USDA-ERS, 1994). Beginning in 1992 as a pilot program in nine States, the Wetlands Reserve Program expanded to include the entire Nation. In 1993, the Emergency

Wetlands Reserve Program, authorized in emergency supplemental appropriations (P.L. 103-75, 107 Stat. 739), was added to the existing Wetlands Reserve Program in order to buy out flood-damaged croplands converted from wetlands that would be too expensive to protect through levee repairs.

Other programs contributing to wetland restoration include the Fish and Wildlife Service Partners for Wildlife Program, joint venture projects between public and private organizations under the North American Waterfowl Management Plan, onsite mitigation for wetland impacts under Section 404, and wetland mitigation banks being developed to offset future permits, for which data are presented in the next chapter. Data covering many of these activities are difficult to interpret because how many acres of existing wetlands are being conserved and how many are being created or restored is not clear. Also, most projects include upland buffers around conserved or restored wetlands that, while critical to wetland function, do not offset wetland conversion.

VI. Wetland Future: Ongoing and Emerging Issues in Wetland Policy

Even if achieving "no net loss" in wetland acreage is attainable in the near future, once achieved, can it be sustained? Challenges to Section 404 regulation and the Swampbuster program during the 104th Congress, uncertainty about the future of Federal farm policy, and continuing budget constraints bring into question how sustainable "no net loss" would be if conservation and restoration programs were substantially weakened. Voluntary, compensatory programs have been proposed to replace or supplant the existing framework of regulatory and quasi-regulatory programs, but will they be affordable? And, can these programs be designed to prevent perverse claims for compensation (ERP, 1995, p. 149; Innes, 1995)? More broadly, if "no net loss" of wetland acreage is sustainable, is it a sufficient goal? What threats to the *quality* of the wetland resource base go beyond issues of wetland *acreage* gained and lost?

The Outlook for Wetland Conversion

The 104th Congress proposed changes in wetland policy for both Section 404 regulation and the Swampbuster provisions. A focal point was wetland delineation; that is, the extent of wetlands subject to these programs. The so-called *21-day exemption* was included in the House-passed legislation reauthorizing the Clean Water Act (H.R. 961) and was discussed in the context of the 1996 farm bill debate to make Swampbuster consistent with that legislation. Changes in either 404 or Swampbuster, without changes in the other legislation, would leave landowners subject to inconsistencies in policy jurisdiction. The 21-day exemption would restrict Food Security Act wetlands (that is, wetlands subject to Swampbuster) to areas that are typically inundated (ponded or flooded) for at least 21 consecutive days during the growing season. Under the current Swampbuster provision, wetland delineation requires the soil to be inundated for 15 days during the growing season, except for prairie pothole, playa, or pocosin wetlands, which must be inundated for 7 days (NRC, 1995). The 21-day language would have exempted roughly 85 percent of wetlands currently subject to Swampbuster (Wiebe, and others, 1996a). The 104th Congress did not enact these exemptions and other proposals to exempt farmed wetlands.

Previous farm legislation required producers to set aside some acreage from production to control commodity supplies and, since 1985, placed restrictions on adding highly erodible land and wetlands to their crop acreage base. The Federal Agricultural Improvement and Reform Act of 1996 allows agricultural producers to make cropping and land allocation decisions based on market signals without affecting eligibility for farm program payments. The new law continues Swampbuster, but also provides additional flexibility to landowners in complying with Swampbuster (Moore, 1996). Actions that result in minimal effects on wetlands are excluded from Swampbuster sanctions and wetland drainage is allowed where wetland losses are fully mitigated by wetland restoration. Sanctions triggered by inadvertent actions are waived so long as wetlands are fully restored within 1 year.

The payments authorized by the Federal Agricultural Improvement and Reform Act are scheduled to expire after the 2002 season. Subtitle G of the Act establishes a "Commission on 21st Century Production Agriculture" that is charged with "Identification of the appropriate future relationship of the Federal Government with production agriculture after 2002" (H.R. 2854, Subtitle G, Section 183(b)(2)). Unless Congress acts to suspend it, agricultural policy will revert back to the permanent law (the 1949 Agriculture Act) when the 1996 Federal Agricultural Improvement and Reform Act expires. Thus, ending farm program payments cannot be accomplished by simply allowing the 1996 Federal Agricultural Improvement and Reform Act to expire. If commodity prices are relatively high when the Act expires in 2002, however, the Commission could recommend that Congress reduce direct payment support to agriculture or actually end farm program payments. Although Swampbuster remains intact under the Act, an eventual end to farm program payments could render it meaningless for lack of an effective sanction.

Analyzing Wetland Conversion Without Swampbuster

To develop a sense of Swampbuster's role in maintaining “no net loss,” we estimate wetland conversion for crop production in the absence of the Swampbuster program and economic consequences associated with such conversion. As discussed above, previous research on agricultural wetland conversion used site-specific simulation models (Kramer and Shabman, 1986 and 1993; Heimlich and Langner, 1986; USDI, 1988). These models generally contained significant detail on local resource conditions (such as, productivity) and farm structure (such as, the size and crop mix for farms), providing conclusions regarding economic incentives affecting wetland conversion (with and without Swampbuster) for a generalized farm on a specific site.

In our model, we analyze data on wetland hydrology and potential agricultural productivity for nearly 50,000 wetland sample points, which are aggregated to make regional and national estimates of wetland area that may be profitably drained for crop production in the absence of Swampbuster. The site-specific nature of the data allows us to draw regional and national conclusions based on the potential agricultural productivity of a representative sample of actual wetlands rather than using county average productivity or other assumptions that may obscure important variations in resource quality. The national scope of our study allows us to (1) quantify potential wetland losses and assess policy proposals in terms of consequences for achieving and maintaining “no net loss” and (2) estimate potential equilibrium adjustments in crop acreage, commodity prices, farm income, and the regional distribution of farm income. Our methodology has two steps:

- First, we estimate wetland acreage that could be profitably farmed at expected (baseline) crop prices and production and conversion costs immediately after Swampbuster provisions end. We specify **high wetland conversion** and **low wetland conversion** scenarios to place upper and lower bounds on the range of conversion possibilities.[6] The wetland conversion decision depends partly on the expected profits from conversion, which we calculate as expected value of returns from conversion less expected costs of conversion, assuming no feedback effects on prices and costs from increased production due to the wetland conversion (Appendix III). For expected price in the profitability calculation, we assume commodity prices for 2001 from the *Agricultural Baseline Projections to 2005, Reflecting the 1996 Farm Act*, the latest long-term projection produced by USDA-WAOB (1997). Baseline commodity prices are expected to be strong, a relatively favorable situation for land conversion. The low conversion scenario assumes conversion of only those wetlands that Natural Resources Conservation Service field technicians judge have some likelihood of conversion and that are profitable to convert. The high conversion scenario expands on this by including lands that Natural Resources Conservation Service field technicians do not judge likely to convert based on physical features, evidence from similar land, and economic conditions at the time of the inventory, but which expected economic conditions indicate would be profitable if converted to crop production in the future.

- Second, we simulate the economic effects of wetland conversion including crop acreage planted, crop production, commodity prices, and farm income in the long run, after equilibrium adjustment to the shortrun wetland conversion. Wetland acreage expected to be converted from step one is used to augment land supply in the U.S. Agriculture Sector Mathematical Programming Model (USMP), a national/interregional model of U.S. agriculture (see Appendix III for details). Economic effects of wetland conversion on the farm sector depend on how much acreage is converted, which crops are planted on that acreage and consequent crop acreage shifts on other acreage, and the cost and net return effects of all these changes on farm income across the country. Producers respond to price changes due to increased production on the converted wetlands: If prices decline, then some land may subsequently be removed from crop production. Price effects are factored back into producer response and crop acreage decisions are allowed to equilibrate with reduced market prices.

[6]We did not include so-called "nuisance" wetlands in the conversion estimates presented here. "Nuisance" wetlands are cropped wetlands where improved drainage would not be profitable based on the yield effect for the wetland area itself but may be undertaken to avoid problems in the farming operation (Danielson and Leitch, 1986; Leitch, 1981). For example, a small wetland in the middle of a field may be drained to avoid driving around it or becoming mired in it in wet seasons. Some "nuisance" wetlands are likely to be drained if Swampbuster is ended, although how much cropped wetland falls in the "nuisance" category is difficult to predict.

Potential Wetland Conversion

In the **high conversion** case, wetland conversion or improved drainage for crop production would be profitable on an estimated 13.2 million acres (table 6). For the **low conversion** case, we are left with 5.8 million acres after screening out acreage judged by Natural Resources Conservation Service technicians as unlikely to be converted. Cropped wetlands account for 15 percent of low conversion wetlands, while forested wetlands make up more than 60 percent (fig. 4). In the high conversion case, forested wetlands increase to 75 percent of all convertible wetlands, while the proportion of cropped wetlands shrinks to 7 percent.

These results are consistent with simulation results reported earlier for periods in which commodity prices were strong enough to provide an incentive for wetland conversion, but government payments remained at levels high enough to make the Swampbuster sanction effective (Heimlich and Langner, 1986). During 1975-84, farm program payments were not high enough that their loss would provide a significant disincentive against wetland conversion. Because farm program payments continue regardless of commodity price levels under the 1996 FAIR Act, high prices and high payments can occur simultaneously, as they are projected to do in the baseline.

Longrun Effects

Longrun economic effects are reported as changes from the crop acreages, crop production, prices and farm income anticipated by the USDA baseline, after adjustment to the shortrun increase in acreage from wetland conversion (table 6). In terms of overall cropland acreage, the low conversion scenario would result in a 2.2-million-acre increase in cropland acreage, 0.7 percent higher than the baseline acreage of 328.3 million acres. In the high conversion scenario, total crop acreage would rise by 5.0 million acres from the baseline, a 1.5-percent increase. In both scenarios, the longrun acreage increase is about 38 percent of the potentially convertible wetland acreage provided to the USMP model.

Regionally, the largest differences in potential wetland conversion between the **low** and **high** conversion scenarios are for forested wetlands in Appalachia and the Southeast (table 6). There is little or no change in wetland acreage likely to convert in the Northern Plains, Mountain States, or Pacific Coast States. In the Southeast for the high conversion case, 4.1 million acres of wetland are estimated to be potentially profitable in crop production—a large pool of land when compared with a total cropland base of roughly 18 million acres (Daugherty, 1987). In the Appalachian farm production region, the high conversion estimate of 2.1 million acres of potentially convertible wetland is a

Table 6—Wetland acreage and farm income changes from USDA baseline levels by farm production region and low and high wetland conversion scenarios

	Low wetland conversion			High wetland conversion		
Farm production region	Potential wetland conversion	Longrun change in crop acreage	Longrun change in farm income	Potential wetland conversion	Longrun change in crop acreage	Longrun change in farm income
	Million acres		Million $	Million acres		Million $
Northeast	0.5	0.4	-17.9	0.9	0.6	-27.3
Lake States	0.6	0.1	-209.3	1.4	0.2	-402.5
Corn Belt	0.4	-0.3	-835.5	0.5	-1.3	-2,072.3
Northern Plains	0.8	0.0	-371.8	0.8	-0.7	-870.6
Appalachia	0.7	0.5	8.8	2.1	1.7	162.3
Southeast	1.0	0.8	150.6	4.1	3.3	722.7
Delta States	1.5	1.1	76.1	2.8	1.9	3.2
Southern Plains	0.2	-0.2	-236.4	0.4	-0.5	-452.8
Mountain States	**	0.0	-74.8	**	-0.1	-115.7
Pacific Coast	0.1	0.0	-104.8	0.1	-0.1	-153.1
U.S.	5.8	2.2	-1,614.9	13.2	5.0	-3,206.3

** Fewer than 50,000 acres.
Source: Economic Research Service, USDA.

somewhat smaller proportion of the roughly 29-million-acre cropland base in that region.

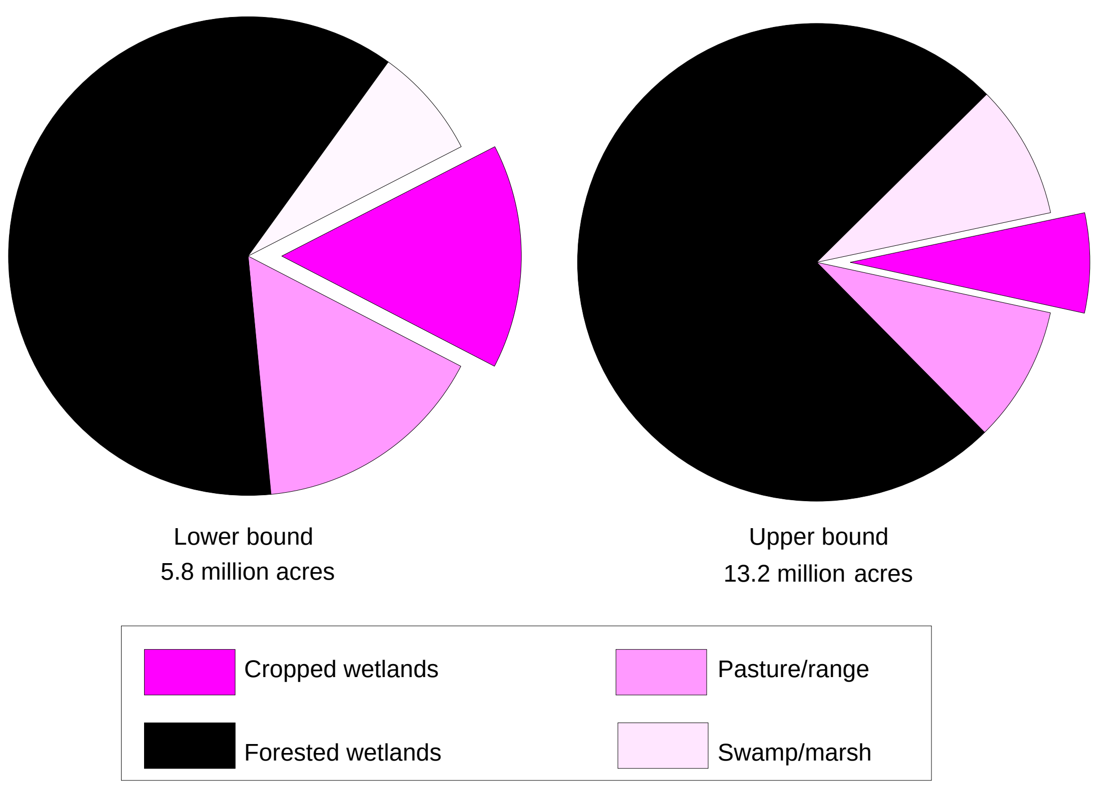
However, gross conversion of wetlands to crop production may not be limited to the longrun increase in crop acreage. Wetlands may be initially converted and then removed from production as prices fall, or other marginal land that had been in production may be removed from production as prices fall. At lower longrun equilibrium prices, little of the wetland acreage estimated to be profitable to convert becomes unprofitable, suggesting that converted wetlands are likely to remain in production while other marginal land is pushed out. For the low conversion scenario, 5.1 million wetland acres are still profitable at longrun equilibrium prices, 88 percent of the 5.8 million acres profitable at baseline prices. For the high conversion scenario, 9.4 million acres remain profitable at longrun equilibrium prices, 71 percent of the 13.2 million acres profitable at shortrun baseline prices. Even if converted wetlands were removed from production, there is little reason to believe that they would be effectively restored to wetland condition.

Production increases for all major commodities except for sorghum[7] (table 7). The largest percentage increases in production are for cotton and rice, while the largest absolute increases are for corn and soybeans. Increased production leads to reduced crop prices for all eight commodities (table 7). In the low conversion scenario, percentage reductions are lowest for wheat (-0.6 percent) and barley (-0.8 percent) and largest for rice (-5.9 percent), soybeans (-3.2 percent), and cotton (-3.2 percent). These results are not surprising given that convertible wetlands are concentrat-

[7]Relatively few wetland acres are converted to sorghum production because there are few convertible wetlands in sorghum growing regions. However, increased production of other feed grains leads to lower feed grain prices, led by lower corn prices, reducing sorghum production.

Figure 4

Former use of wetlands potentially convertible after FAIR



Source: ERS analysis of 1992 National Resources Inventory data.

Table 7—Longrun production and price changes from USDA baseline, high and low wetland conversion scenarios

Crop	Baseline[1] Price	Baseline[1] Production	Low wetland conversion: Change in production	Low wetland conversion: Change in price	High wetland conversion: Change in production	High wetland conversion: Change in price
	Dollars/ bushel	Million bushels	Percent			
Corn	2.80	10,010.9	0.8	-2.6	2.1	-7.4
Sorghum	2.50	659.9	-0.10	-2.9	-3.2	-7.7
Barley	2.60	455.0	0.5	-0.8	0.3	-2.3
Oats	1.70	318.2	1.3	-2.6	2.6	-10.6
Wheat	4.30	2,489.6	0.7	-0.6	1.6	-1.4
Soybeans	6.45	2,533.1	1.8	-3.2	4.5	-8.3
	Dollars/cwt	Million cwt				
Rice	10.31	173.7	6.6	-5.9	12.8	-11.5
	Dollars/pound	Million pounds				
Cotton	[2]	9,750.0	2.6	-3.2	6.2	-7.5

[1]Baseline production and prices for 2001 from *Long-term Agricultural Baseline Projections, 1998-2008*, February 1997.
[2]USDA is prohibited from publishing cotton price projections.
Source: Economic Research Service, USDA.

ed in the South, where rice, soybeans, and cotton are major crops. Wheat and barley are grown in regions with comparatively few convertible wetlands.

Nationally, reduced prices lead to declines in longrun aggregate net farm income of more than $1.6 billion in the low conversion scenario and $3.2 billion in the high conversion scenario, reductions of 2.2 percent and 4.9 percent, respectively (table 6). Note that deficiency payment, supply control, export promotion, and other features of pre-FAIR farm legislation, which served to mitigate the magnitude of income declines, are no longer authorized. The fact that farm income declines as production expands and prices fall reflects the relatively inelastic demand and supply responses in the model.

In both scenarios, aggregate farm income also declines in most farm production regions, as it does nationally. However, the Southeast, Delta, and Appalachian regions enjoy small increases in aggregate net farm income. These regions have large amounts of convertible wetland but have relatively small existing cropland bases on which to suffer losses due to the price effect. The largest aggregate reduction in income is in the Corn Belt, where few unconverted wetlands remain and the existing cropland base is large and highly productive. Farm income also declines substantially in the Northern Plains, Southern Plains, and Lake States.

Environmentally, even the longrun, low conversion case—in which 2.2 million wetland acres are converted—would be a serious blow to achieving and maintaining "no net loss" of wetlands. Between 1982 and 1992, gross conversion of wetlands for crop production was about 310,000 acres (USDA-NRCS, 1996, p. 52; Heimlich and Melanson, 1995). Conversion of 2.2 million acres over a 10-year period would represent a sevenfold increase in the rate of wetland conversion for agriculture, although it would be less than half of the 5.6 million acres converted each decade between the mid-1950's and mid-1970's. That level of conversion would also far exceed current efforts to restore wetlands previously converted to agricultural production. The Wetlands Reserve Program is capped at a maximum enrollment of 975,000 acres, with just over 400,000 acres enrolled as of January 1997. Thus, remaining Wetlands Reserve Program authority represents one-fourth of the 2.2 million acres expected to be converted without Swampbuster.

Ending Swampbuster would have the largest impact on bottomland hardwood forests in the Delta, Appalachian, and the Southeast regions. These wetlands provide flood storage, water quality maintenance, and winter waterfowl habitat. In the lower Mississippi delta, about 80 percent of forested wetlands have already been lost, mostly to crop production (Dahl, 1990). Although the acreage of cropped wetland that would be converted is small, much of it is located in the Prairie Pothole region, North America's most valuable waterfowl breeding ground. In some years, the Prairie Pothole wetlands produce up to one-half of U.S. production of waterfowl (Kantrud, and others, 1989; Stewart, 1996). About 50 percent of these wetlands have already been lost, mostly to crop production (Dahl, 1990).

Phasing out commodity program payments would not end Conservation Reserve Program or Wetlands Reserve Program payments or other smaller programs from which benefits could be denied under Swampbuster. However, the level of payments from these programs is small (about 7 percent of total agricultural payments) compared with income support payments under the FAIR Act, and far less uniformly distributed across farms. Most farms likely would not receive payments under these programs and, hence, would not be subject to sanctions under Swampbuster provisions.

A potential decline in farm income of 2.5 to 4.9 percent demonstrates that farmers and landowners who do not drain wetlands have a significant economic stake in the fate of wetlands.[8] Farmers who actually drain wetlands for crop production are likely to see their incomes rise. However, these individuals are a minority of agricultural landowners. Other producers would suffer reduced incomes due to lower commodity prices. Although land use restrictions, whether as a pre-condition to receiving farm program payments or otherwise, have never been popular among farmers or landowners, our analysis shows that lifting Swampbuster restrictions would be contrary to the economic interests of most farmers and landowners. Farm-level analyses of the effects of wetland policies on farm income do not account for the restrictions faced by other farms. National analysis shows that wetland conservation policies can create increases in aggregate returns to producers because farms without wetlands to convert gain more than farms with wetlands to convert lose. Lichtenberg and Zilberman (1986) show why farm price support programs buffer farm income from price decreases caused by eliminating environmental programs.

[8]To put these declines in context, net farm income, excluding government payments, has increased 3.5 percent in real terms and 6.9 percent in nominal terms on average over the 1985-95 period.

Section 404's Post-Swampbuster Role

If Swampbuster provisions were eliminated or made ineffective through changes in farm legislation that remove the leverage provided by farm program payments, agricultural wetlands would still be subject to requirements for Section 404 permits. However, the Section 404 permit program has been criticized in the past as ineffective in reducing wetland conversion, including agricultural conversions (USGAO, 1988; Theis, 1991). In the past, Section 404 has had limited impact on agricultural wetland conversion because many activities are exempted under Section 404 (f) or covered under nationwide general permits, Section 404 did not explicitly regulate drainage, and Army Corps of Engineers offices are located far from agricultural areas, making enforcement difficult. According to the General Accounting Office (GAO, 1988, p. 4):

> Because neither the Corps nor EPA has systematic surveillance programs to detect unauthorized activities, undetected violations of Section 404 permit requirements may be occurring. Also, some suspected unauthorized activities reported to the Corps may not be investigated for months after they are reported, and many projects are not inspected by the Corps for compliance with permit conditions.

Whether Section 404 will be more effective in limiting future conversion of wetlands for agricultural production remains to be demonstrated. Recent changes to Nationwide General Permit 26, which formerly permitted substantial agricultural conversion, may indicate that Section 404 will more effectively deal with agricultural conversion.

Section 404 regulates discharge of dredge and fill material in wetlands, but does not specifically regulate wetland drainage or clearing. Regulation of wetland drainage under Section 404 has been incidental to discharge of dredged or fill materials into a wetland during drainage installation. As a result of a settlement to a lawsuit brought against the Army Corps of Engineers (*North Carolina Wildlife Federation v. Tulloch*, Civil number c90-713-CIV-5-BO, EDNC 1992), regulations expanding Section 404 to cover activities, such as drainage, land clearing, and construction on pilings that damage wetlands but were previously exempted as *de minimis* fills were proposed in rule making on June 16, 1992 (33 C.F.R. 323.2(d), 40 C.F.R. 232.2(3)), and included in the Clinton wetland plan (White House, 1993, p. 22). In January 1997, the Tulloch ruling was invalidated in a decision allowing landowners to drain wetlands without a permit so long as any dredged material produced by drainage installation is removed from the wetland site (*American Mining Congress v. U.S. Army Corps of Engineers*, 951 F. Supp. 261). The court cited Congressional failure to expand Section 404's scope, which indicates that the issue is still alive legislatively. Most of the wetland regulatory reform bills considered in the 104th Congress, but not passed, included drainage provisions reflecting the Tulloch decision. The Army Corps of Engineers appealed to have the Tulloch decision restored, and won a stay of the District Court decision in June 1997. In July 1998, the Circuit Court issued an order that effectively vacated the stay, meaning that the injunction against enforcement of the Tulloch rule is in effect. The Corps of Engineers is expected to appeal.

Using general permits that provide blanket coverage for whole classes of activities streamlines much of the Army Corps of Engineers permit activity. Thus time-consuming individual permit review is avoided. The nationwide permit program has been controversial because regulators and landowners do not agree on what constitutes a "minimal impact." Nationwide Permit 26, used for small agricultural conversions, allowed fill of up to 10 acres of isolated and headwater wetlands with a pre-discharge notification to the Army Corps of Engineers, and up to 1 acre without notification (Davis, 1997, p. 14; *Federal Register* 1996). In FY 1995, 13,837 activities were conducted under Nationwide General Permit 26, accounting for 5,020 acres of wetland loss, which were offset by 5,809 acres of wetland mitigation (*National Wetlands Newsletter*, 1997). During FY 1995, a total of 43,775 activities were authorized by nationwide general permits (including Nationwide General Permit 26), adversely affecting 6,500 acres for which the Army Corps of Engineers received approximately 7,800 acres of mitigation in return (*Federal Register*, 1996). Environmentalists viewed Nationwide General Permit 26 as a major threat to protection of small, isolated wetlands, which, they argue, provide important wildlife habitat and other important ecological services (National Audubon Society, 1996).

In response to these concerns, the Army Corps of Engineers is phasing out Nationwide General Permit 26 over a period of 2 years (beginning February 11, 1997), replacing it with multiple, activity-specific, nationwide general permits to be proposed during 1998. In the meantime, the size of activities authorized under Nationwide General Permit 26 is reduced from 10 to 3 acres. Only those activities which affect one-third acre or less may proceed without pre-discharge notification to the Army Corps of Engineers (*Federal Register*, 1996).

State Wetland Responsibilities

States have had a major role in wetland conversion since colonial times. For example, South Carolina authorized drainage in the Cacaw Swamp in 1754, and Virginia surveyed areas of the Great Dismal Swamp for drainage in 1763 (Dahl and Allord, 1996). Moreover, the Swampland Acts of 1849, 1850, and 1860 allowed States to reclaim overflow lands in the Federal domain.

State policies concerning wetlands evolved similar to those of Federal policies, moving from exploitation to conservation as remaining wetlands disappeared and wetland functions and values became appreciated. In 1963, Massachusetts was the first State to pass regulations governing the circumstances under which wetlands could be drained, dredged, or otherwise converted (Council on Environmental Quality, 1978, p. 53). Other States followed, particularly after Section 404 was passed in 1972. By 1978, 15 States had legislation specifically regulating wetlands. As of 1984, the Office of Technology Assessment found that all 30 coastal States (including the Great Lakes) had programs that directly or indirectly regulated coastal wetlands, although usually not inland wetlands (OTA, 1984, chapter 9).

The Association of State Wetland Managers polled States in 1992 to learn more about State laws applying to wetlands. In 1996, the States were surveyed again about changes to their wetland laws and 16 of the 50 States responded. Table 8 summarizes the results. Forty-four States have wetland statutes or laws, including 18 that regulate both coastal and freshwater wetlands, 7 that regulate only coastal wetlands, and 4 that regulate coastal and part of their freshwater wetlands. Forty-six States relate wetland policies to water quality policies, such as Clean Water Act Section 401 water quality certification programs or

Table 8—State wetland laws and programs, 1996

Item	Number of State laws with provision			
	Yes	No	Not listed	Total
1. State Wetland laws	44	4	2	50
2. Wetlands and water quality	46	4	0	50
Regulates only coastal wetlands	7	0	43	50
Regulates coastal and some freshwater wetlands	4	0	46	50
Regulates both coastal and freshwater wetlands	18	0	32	50
3. Staffing	40	0	10	50
4. Definitions/delineation comparable with Federal definitions	46	2	2	50
5. Regulated and exempted activities	44	0	6	50
6. Special provisions (if any) for agriculture and forestry	25	9	16	50
7. Wetland classification (if any)	28	9	13	50
8. Mapping	44	1	5	50
9. Mitigation policy (if any)	39	6	5	50
10. Mitigation banks (if any)	37	9	4	50
11. Role of local governments	34	5	11	50
12. Evaluation methodology (if any)	21	9	20	50
13. State general permit (if any) for 404	17	12	21	50
14. Investigated assumption of Section 404 powers	21	21	8	50
15. Joint permitting	30	6	14	50
16. Penalties	26	5	19	50
17. Permit tracking and enforcement	33	5	12	50
18. Special area management and advanced identification	32	5	13	50
19. State wetland conservation plan	30	6	14	50
20. No net loss goal	33	8	9	50
21. Wetland training and education	31	5	14	50
22. Nonregulatory incentives for private landowners	29	4	17	50
23. Special problem	23	3	24	50
24. Contacts	50	0	0	50
25. Guidebooks, brochures, other educational materials	37	0	13	50

Source: Kusler, and others (1994) and personal communication for 1996 update.

other State water quality standards. Forty-six States have wetland definitions that are comparable with those used in Federal programs. However, enforcement of these policies is less widespread: 40 States staff their programs, 33 States track and enforce wetland permits, and only 26 States penalize violators of their wetland laws.

The Association of State Wetland Managers identified key issues and trends in State wetland program adoption (Kusler, and others, 1994). The following issues are important for agricultural wetlands:

- States are shifting attention from coastal wetlands that are now well-protected to freshwater wetlands, including those subject to agricultural conversion.

- States are recognizing a need to move beyond dredge and fill to regulate drainage and removal of vegetation, activities related to agricultural conversion.

- States are recognizing needs for special standards applying to altered and managed wetlands, including those used in agricultural production.

- States recognize that wetland regulation must be carried out in the context of broad State wetland plans and in a watershed context.

- States see a need to establish minimum, uniform standards, such as the "no net loss" goal.

- States seek better definition and coordination of Federal, State, and local roles in wetland protection.

- Twenty-one States have investigated assumption of direct Section 404 permitting authority under the Clean Water Act, although only two have actually assumed full responsibility for the program.

A U.S. Geological Survey (USGS) report shows important Federal, State, and private organizational ties in State programs (USDI-USGS, 1996). Participation by State agencies in wetland-related management, regulation, restoration and creation, and delineation and inventory is detailed. More difficult to obtain is insight as to what powers of coordination are exercised and what financial resources are available to carry out concerted programs with Federal agencies and, within the State, with local governments. One of the most important avenues for State involvement in wetlands policy is through joint participation with Federal agencies, particularly through programmatic general permits developed in conjunction with the Army Corps of Engineers based on strong State, local, or regional programs (Studt, 1995, p. 77).

State Participation in Administering the Section 404 Permit Program

Sections 404(g) and (h) give States the authority to assume administration of the Section 404 program in lieu of the Army Corps of Engineers where the States have, among other things, instituted wetland permitting programs that are at least as stringent as the Federal wetlands program. Many of the tensions that develop in administering a wetland regulatory program would likely be ameliorated if States assumed the program, returning control to more local authority. To date, only two States—Michigan and New Jersey—have assumed responsibility for the Section 404 program. States may take responsibility for parts of the Section 404 program without assuming complete responsibility. Twenty-one States have investigated assuming some Section 404 powers in operating their own regulatory programs, and 13 have carried out detailed technical reviews (Kusler, 1994).

States can also participate in Federal wetlands permitting by exercising their authority under Clean Water Act Section 401 to grant or deny water quality certification for individual or general Federal Section 404 permits (Kusler, 1994, p. 45; Studt, 1995). States adopt surface water quality standards and wetlands water quality standards to protect their waters, and are free to make these standards as stringent as they wish. States can review and approve, deny, or put conditions on all Federal permits or licenses that might result in discharges to State waters, including wetlands under any Section 404 permit, that would fail to meet State water quality standards (USEPA, 1993).

Finally, some States participate in Federal wetlands regulation through State program general permits (SPGP's; Kusler, 1994, p. 50). The Clean Water Act does not specifically authorize the Army Corps of Engineers to issue SPGP's. However, the Army Corps of Engineers relies upon its general permit authority in Section 404(e) to issue statewide permits that are "piggy-backed" onto the existing State wetlands permitting programs. The Army Corps of Engineers has also issued programmatic permits on a local basis. At present, the Army Corps of Engineers has issued approximately 60 SPGP's and local programmatic permits, including permits in New Hampshire, Maine, Wisconsin, North Carolina, and Maryland.

Determining the appropriate roles of Federal, State and local governments in regulating wetlands and water resources is difficult (Kusler, 1994, p. i). Federal, State, and local governments, acting in concert, have the potential to articulate the ideal market for public goods demanded of wetlands in a "no net loss" environment.

The Outlook for Wetland Restoration

In the last decade, wetland restoration has become as important as wetland conservation. While controlling wetland conversion to other uses is essential to attaining the "no net loss" goal, not all existing wetlands can be conserved. Weighing the costs and benefits of a particular wetland conversion may show that society is better off because of the conversion. Wetland restoration programs are needed to replace wetland functions and values lost at the margin through these kinds of conversions.

There are four aspects of wetland restoration. First, one of the most important restoration programs for agriculture is the Wetlands Reserve Program, which was considerably revised in the 1996 FAIR Act. Second, mitigation for permitted wetland conversion under Section 404 of the Clean Water Act attempts to replace lost wetlands. Mitigation can be done either through creating or restoring similar wetlands on the development site, carried out by the permit applicant, or through granting wetland mitigation banking credits for wetland restoration done in advance of development at another location. Third, private groups are restoring wetlands, either on their own or in partnership with Federal or State programs. Finally, floodplain management questions raised by the major floods in 1993 have raised issues of wetland restoration.

Completing the Wetlands Reserve Program

Begun as a nine-State pilot program, the Wetlands Reserve and Emergency Wetlands Reserve Programs have mounted the largest wetland restoration effort in history. By the middle of 1997, 533,026 acres of wetlands were enrolled in 3,200 contracts under the Wetlands Reserve and Emergency Wetlands Reserve Programs (table 9). Wetlands Reserve Program enrollment is highest in the Delta and Gulf regions (40 percent) and the Midwest region (21percent).

The 1996 FAIR Act included several changes for the Wetlands Reserve Program. The Act requires that, to the extent practicable, new enrollments in the Wetlands Reserve Program will consist equally of permanent easements, 30-year easements, and restoration cost-share agreements without easements. Payments for 30-year easements will be limited to 50-75 percent of the amount that would have been paid for permanent easements. Furthermore, the Federal share of restoration costs will be 75-100 percent in the case of permanent easements, and 50-75 percent in the case of 30-year easements or cost-share agreements without easements. The 1996 Act also capped Wetlands Reserve Program enrollment at 975,000 acres.

These changes reflect three sets of pressures that will affect any Federal wetland restoration program. First, the cost of acquiring property rights is high, even the rights for a limited easement. In the prevailing era of budget austerity, many interests compete for the dollars that must be allocated to acquire cropping rights and restore wetlands. Second, environmental critics charge that restoring prior converted wetlands is needlessly expensive, and may not be effective because of the limitations of restoration science (Kusler and Kentula, 1990). Efficiency and equity issues are also raised by restoration programs that reward landowners who previously converted wetlands for crop production, while not providing sufficient regulatory or compensatory incentives to current wetland owners for conserving wetlands. Finally, other critics warn that permanent easements on wetlands are not acceptable to landowners because they remove land from crop production, limit flexibility for future land use changes, and reduce the U.S. competitive advantage in international commodity markets. These arguments helped motivate 1996 changes to the Wetlands Reserve Program, despite the widespread acceptance of permanent easements by Wetlands Reserve Program landowners and a relatively successful restoration track record for the program. By mid-July 1997, permanent and 30-year easements had been fully enrolled at more than 50,000 acres each, but cost-share agreement acreage lagged at about 13,000 acres.

Mitigating Conversion and Wetland Mitigation Banking

Mitigation involves the compensatory creation or restoration of substitute land with particular environmental characteristics, such as wetlands, to make up for unavoidable conversion of environmentally sensitive land. Some regulatory programs, such as Section 404 of the Clean Water Act, require compensatory mitigation if wetland conversion cannot be avoided or sufficiently minimized. The Swampbuster provisions of the 1985 Food Security Act did not allow wetland mitigation. Gradually, pressure from producers who wanted to find some way to accommodate necessary conversions, and pressure for consistency with Section 404 brought amendments in 1990 and 1996 farm legislation to allow continued program participation if the wetland conversion is mitigated through restoration of a prior-converted wetland in the same general area of the local watershed (16 U.S.C. 3822).

Compensatory wetland mitigation has historically required creation, restoration, or enhancement of replacement wetlands of the same type on or adjacent to the site of the wetland conversion (ELI, 1993). This onsite, project-specific focus has resulted in small-scale, high-cost compensatory wetlands yielding poor ecological benefits in areas that may not reflect broader wetland priorities. For example, a one-quarter acre wetland restoration enclosed by chain-link fence, and surrounded by a shopping mall parking lot clearly does not provide the wetland functions and values, including nonmarket values, that the undeveloped wetland site provided, even if "no net loss" of acreage goals are met. Concern about these results has led to an alternative mitigation approach over the last decade: wetland mitigation banking (USACE, 1994).

Wetland mitigation banking attempts to provide greater flexibility in meeting the wetland mitigation requirements of the Section 404 permit program. Rather than creating or restoring wetlands at the site of wetland losses, public works agencies, private developers, or other parties involved in wetland conversion can mitigate those losses by purchasing "compensation credits" in larger, centralized wetland mitigation projects. Credits are issued to those who seek to convert wetlands based on the acreage of wetlands they pay to create or restore. Mitigation ratios typically require more than 1 acre of wetlands to be created or restored for each wetland acre converted, and may be further adjusted to account for differences in the type and timing of wetland restoration. The wetland mitigation bank itself may be operated for the exclusive use of a particular developer or public agency, or it may also serve other parties, or it may be altogether independent of conversion activities (ELI, 1993).

In a traditional mitigation scenario, for example, Developer A might be required to create a 2-acre wetland near the site of a 1-acre wetland that is being converted for development. Under mitigation banking, by contrast, Developer A might pay Mitigation Bank B to create or restore 2 acres of wetlands at an offsite location providing greater wetland benefits. Bank B would then issue Developer A a mitigation credit that could be used to permit the planned wetland conversion and development to proceed.

The Environmental Law Institute identified 46 existing wetland mitigation banks in the United States as of July 31, 1992 (ELI, 1993). Banks were located in 17 States, but concentrated in California (with 11 banks) and Florida (with 8). State highway departments, port authorities, or local governments operated nearly 75 percent of the 46 banks to provide mitigation for public works projects. Private developers controlled six more banks for advance mitigation of their own projects. Only four banks offered compensation credits for commercial sale to the general public—one of them a privately owned bank and the other three owned by public agencies or nonprofit organizations.

The Environmental Law Institute also identified 64 proposed mitigation banks at various stages of review and authorization. Of the 64, 32 proposed to offer credits for commercial sale to the general public, in contrast with 9 percent of existing banks. By 1995, private sector entrepreneurs had established 12 banks for sale of credits to the general public (Scodari and Brumbaugh, 1996). By February 1997, another U.S. Army Corps of Engineers survey identified 108 operating wetland mitigation banks, with 43 established for general sale of credits. The latest survey identified 100 more banks in various stages of development (Brumbaugh, 1997).

On November 28, 1995, USDA's Natural Resources Conservation Service and other Federal agencies published final policy guidance for the establishment, use, and operation of mitigation banks to satisfy the wetland mitigation requirements of the Clean Water Act's Section 404 permit program and the "Swampbuster" provisions of the 1985 Food Security Act (*Federal Register*, 1995a). The guidelines state that banks may be sited on public or private lands, but that mitigation credits may not be generated by federally funded wetland conservation projects, such as the Wetlands Reserve Program or the Fish and Wildlife Service's Partners for Wildlife Program. Mitigation requires restoring or creating wetlands; preservation of existing wetlands may not generally be used as the sole basis for generating credits, except under unusual circumstances. The guidelines express the agencies' preference for mitigation within the same geographic area and of the same kind of wetland as that being degraded or lost. The guidelines require that wetlands be restored, or that restoration be contracted for, prior to any debiting of mitigation credits from the bank, with preference for advance restoration. Finally, wetlands created, restored, or enhanced by the mitigation bank are to be protected in perpetuity with appropriate real estate arrangements, such as conservation easements or transfer of title to an appropriate Federal or State agency or to a nonprofit conservation organization. Wetlands and other aquatic resources restored under the Conservation Reserve Program or similar programs requiring only temporary conservation easements may be eligible for banking credit upon termination of the original easement if the wetlands are provided permanent protection and it would otherwise be expected that the resources would be converted upon termination of the easement (*Federal Register*, 1995a).

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. Given the relatively recent emergence of wetland mitigation banking, whether the bank concept will prove a viable market

Table 9—Acreage under the Wetlands Reserve Program (WRP) and Emergency Wetlands Reserve Program (EWRP), 1992-97[1]

State/wetland region	1992 WRP	1993 EWRP	1994 WRP	1995 WRP	1995 EWRP	1996 WRP	1996 EWRP	1997 WRP Permanent	1997 WRP 30-Year	1997 WRP Cost-share	1997 EWRP	Total
						Acres						
Kansas	0	142	1,166	2,243	0	1,770	0	1,578	0	0	0	6,899
Nebraska	0	55	1,408	5,634	0	0	0	1,076	64	0	0	8,237
Oklahoma	0	0	0	12,590	0	0	0	2,344	1,184	0	0	16,118
Central Plains	**0**	**197**	**2,574**	**20,467**	**0**	**1,770**	**0**	**4,998**	**1,248**	**0**	**0**	**31,254**
Arkansas	0	0	16,081	15,424	0	3,867	0	6,014	5,199	1,856	0	48,441
Louisiana	12,663	0	28,183	25,705	0	0	0	6,934	5,467	125	0	79,077
Mississippi	11,751	0	26,705	20,451	0	0	0	3,732	5,621	0	0	68,260
Tennessee	0	0	1,876	4,166	0	0	0	576	200	0	0	6,818
Texas	0	0	2,440	6,731	0	0	0	447	409	500	0	10,527
Delta and Gulf	**24,414**	**0**	**75,285**	**72,477**	**0**	**3,867**	**0**	**17,703**	**16,896**	**2,481**	**0**	**213,123**
Arizona	0	0	0	0	0	0	0	0	0	0	0	0
Colorado	0	0	0	503	0	0	0	838	203	0	0	1,544
Idaho	0	0	0	102	0	0	0	972	787	0	0	1,861
Nevada	0	0	0	0	0	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0	0	0	0	0	0
Utah	0	0	0	0	0	0	0	0	0	0	0	0
Wyoming	0	0	0	37	0	0	0	0	0	100	0	137
Mountain	**0**	**0**	**0**	**642**	**0**	**0**	**0**	**1,810**	**990**	**100**	**0**	**3,542**
Illinois	0	197	2,470	2,473	4,453	2,643	3,326	2,394	847	0	0	18,803
Indiana	0	0	1,675	476	0	1,306	0	1,096	2,548	500	0	7,601
Kentucky	0	0	0	1,905	0	0	0	836	0	99	0	2,840
Michigan	0	0	0	1,460	0	535	0	2,948	836	0	0	5,779
Minnesota	453	672	1,751	2,125	1,569	535	0	1,856	66	0	0	9,027
Missouri	1,696	11,172	4,699	1,869	7,067	12,206	0	2,779	1,420	0	5,900	48,808
Ohio	0	0	0	2,450	0	652	0	2,677	714	8	0	6,501
Wisconsin	1,560	0	1,465	3,917	0	1,750	0	1,649	165	1,104	0	11,610
Midwest	**3,709**	**12,041**	**12,060**	**16,675**	**13,089**	**19,627**	**3,326**	**16,235**	**6,596**	**1,711**	**5,900**	**110,969**
Connecticut	0	0	0	112	0	0	0	0	0	0	0	112
Delaware	0	0	0	52	0	0	0	0	0	0	0	52
Maine	0	0	0	500	0	0	0	189	0	3,428	0	4,117
Maryland	0	0	0	1,177	0	0	0	105	0	0	0	1,282
Massachusetts	0	0	0	30	0	0	0	0	0	0	0	30

See notes at end of table.

—Continued

Table 9—Acreage under the Wetlands Reserve Program (WRP) and Emergency Wetlands Reserve Program (EWRP), 1992-97[1]—Continued

State/wetland region	1992 WRP	1993 EWRP	1994 WRP	1995 WRP	1995 EWRP	1996 WRP	1996 EWRP	1997 WRP Permanent	1997 WRP 30-Year	1997 WRP Cost-share	1997 EWRP	Total
	Acres											
New Hampshire	0	0	0	103	0	0	0	0	0	70	0	173
New Jersey	0	0	0	195	0	0	0	198	0	0	0	393
New York	45	0	401	951	0	1,528	0	4,217	2,892	75	0	10,109
Pennsylvania	0	0	0	485	0	0	0	552	0	0	0	1,037
Rhode Island	0	0	0	0	0	0	0	0	0	0	0	0
Vermont	0	0	0	200	0	0	0	0	0	0	0	200
West Virginia	0	0	0	0	0	0	0	190	0	66	0	256
Northeast	**45**	**0**	**401**	**3,805**	**0**	**1,528**	**0**	**5,451**	**2,892**	**3,639**	**0**	**17,761**
California	4,410	0	2,556	5,495	0	4,674	0	4,057	1,787	2,356	0	25,335
Oregon	0	0	0	770	0	0	0	1,081	646	6	0	2,503
Washington	0	0	626	2,289	0	0	0	1,982	1,033	35	0	5,965
Pacific	**4,410**	**0**	**3,182**	**8,554**	**0**	**4,674**	**0**	**7,120**	**3,466**	**2,397**	**0**	**33,803**
Iowa	5,073	29,759	5,858	928	5,733	4,039	9,811	2,653	208	0	0	64,062
Montana	0	0	0	859	0	0	0	615	480	40	0	1,994
North Dakota	0	0	0	0	0	0	215	0	2,910	0	0	3,125
South Dakota	0	4,260	3,411	2,394	5,139	0	0	1,330	1,295	0	0	17,829
Prairie Pothole	**5,073**	**34,019**	**9,269**	**4,181**	**10,872**	**4,039**	**10,026**	**4,598**	**4,893**	**40**	**0**	**87,010**
Alabama	0	0	0	858	0	0	0	0	381	0	0	1,239
Florida	0	0	0	0	0	0	0	0	13,000	2,800	0	15,800
Georgia	0	0	0	2,005	0	0	0	0	0	0	0	2,005
North Carolina	5,703	0	2,802	1,340	0	0	0	131	455	0	0	10,431
South Carolina	0	0	0	4,142	0	0	0	442	602	18	0	5,204
Virginia	0	0	161	462	0	0	0	160	102	0	0	885
Southeast	**5,703**	**0**	**2,963**	**8,807**	**0**	**0**	**0**	**733**	**14,540**	**2,818**	**0**	**35,564**
Alaska	0	0	0	0	0	0	0	0	0	0	0	0
Hawaii	0	0	0	0	0	0	0	0	0	0	0	0
United States	**43,354**	**46,257**	**105,734**	**135,608**	**23,961**	**35,505**	**13,352**	**58,648**	**51,521**	**13,186**	**5,900**	**533,026**

[1]Data current as of July 14, 1997.
Source: WRP and EWRP program data, Natural Resources Conservation Service, USDA.

institution over time, and whether it might eventually prove promising in other conservation contexts remains to be seen.

Although embracing mitigation banking as a "market-based" solution to replacing wetlands lost to conversion is fashionable, regulatory agencies need to recognize the extent to which they create the market for mitigation banks (see fig. 5). The supply of wetland "commodities" created by banks must satisfy two customers, the ultimate demand from permit seekers who want to acquire credits to offset wetland conversion (shown in the right column), and the regulatory authority that must approve the credits (shown in the center column). Abrupt changes in standards or practices by the regulatory authority will likely upset investment decisions made by the bank on the basis of previous rules and can be a source of disruption with which other markets do not have to contend. Key trading rules set by the regulators include standards for design and construction, performance, monitoring and maintenance, long-term management, time to market, and liability for failure. For example, if the regulatory authority abruptly changes a previously established standard mitigation ratio from 3 acres of wetland restoration to 1 acre of wetland conversion permitted to 2:1, the mitigation bank's market is arbitrarily cut by a third with no other underlying change in development demand.

The mitigation bank's supply of mitigation credits is subject to risky investment decisions. These include risks in anticipating the kind and location of wetlands that will be in demand and that will provide acceptable credits for wetlands converted; risks in producing successful restorations that are of sufficiently high quality to garner low mitigation ratios, thus reducing fixed costs (land); and the normal financial risks attending any long-term capital investment. Regulatory agencies must recognize that their rules for mitigation banking can increase or lower many of these risks, raising or lowering the potential return for mitigation banks, and increasing or decreasing the supply of bank credits developed (USACE, 1994-c, p. 18). The interagency guidance on mitigation banking issued in 1995 provides a good basis for creating mitigation banking markets (*Federal Register*, 1995a).

Private Efforts to Protect Wetlands

In addition to public programs to protect remaining wetlands and restore converted wetlands, private nonprofit conservation organizations have similar goals. A 1994 survey found that 73 percent of nearly 1,100 land trusts nationwide reported wetland protection among their priorities (Doran, 1997). The National Wildlife Federation's Wildlife Habitat Enhancement Council, founded in 1988, now includes 80 corporate members and 15 national conservation groups, which have enhanced and restored over 200,000 acres of wetlands at 225 sites (USACE, 1994-e). Since its establishment in 1951, The Nature Conservancy (TNC) has purchased nearly 475,000 acres of wetlands from willing landowners in the United States. Ownership of most of this acreage has since been transferred to other public and private conservation organizations. As of August 1996, TNC owned about 170,000 wetland acres, and protected another 210,000 wetland acres through management agreements, conservation easements, and leases (TNC, 1996). Because of difficulties in accounting for these activities, there is likely considerable overlap in the reported achievements and acreage from these efforts.

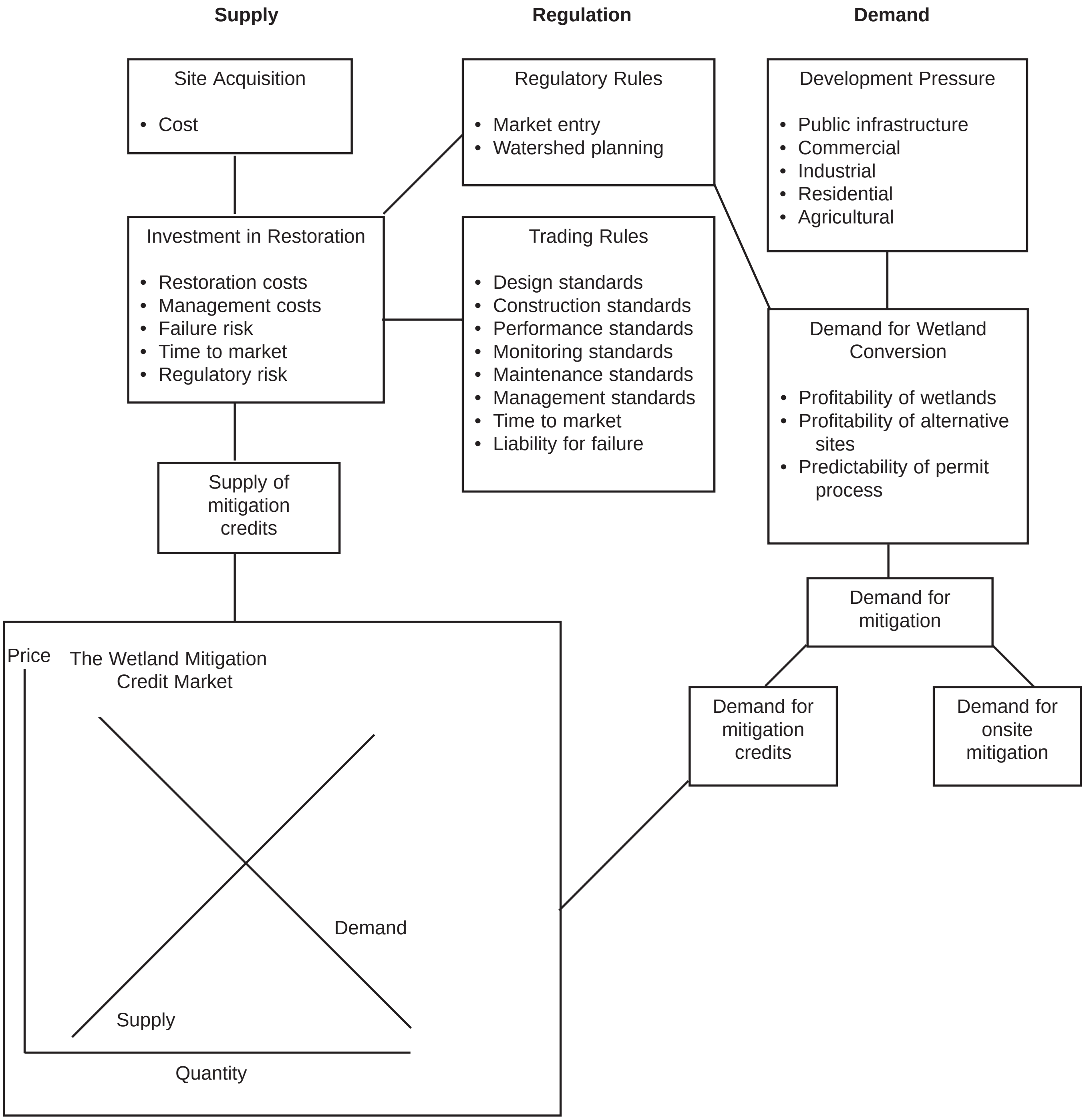
Public-private Partnerships

Federal, State, and local government agencies may be able to reduce the transaction costs associated with wetland preservation by enlisting nonprofit conservation groups as partners in acquiring, managing, and monitoring easements. (As specified in Wetlands Reserve Program regulations, however, the responsibilities and costs of enforcing easements must remain with delegated Federal or State agencies (7 C.F.R. 720 and 1467, Section 1467.2(f)).) Nonprofit groups, such as land trusts, offer flexibility and agility, the ability to mobilize private financial and political support, and the capacity to provide local knowledge and insights (Wiebe, and others, 1996b). Local knowledge and support may also be acquired through participating organizations, such as soil and water conservation districts. A survey found 20 Federal wetland enhancement and restoration efforts that invite varying degrees of partnership, 34 programs in 24 States, and 14 nonprofit organization programs (USACE, 1994-e).

Public and private nonprofit organizations working in partnership also offer access to a larger pool of landowners potentially willing to convey conservation easements. Public easement-acquisition programs reach a wide range of landowners, but such programs are limited by the availability of public funding. Although qualified nonprofit organizations can offer

Figure 5

Regulatory policies influence wetland mitigation credit markets



Supply—The quantity of credits supplied at any given price.
Demand—The quantity of credits demanded at any given price.
Regulation—The conditions established by government to create and link the market for credits with the market for permits.

Source: USACE, 1994-c.

tax advantages in exchange for easement donations, public programs generally require that easements be acquired at fair market value (or at least, as in the case of the Wetlands Reserve Program, that landowners be *offered* fair market value). For example, the implementing regulations (49 C.F.R. 14.102(2)(d)) of the Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970 require Federal agencies to offer not less than fair market value when they seek to acquire land (USGAO, 1994a, p. 4). Neither the Conservation Reserve Program nor the Wetlands Reserve Program is required to *pay* full fair market value for the partial interests they acquire, however, and landowners may increase their chances of selection by offering to accept less than fair market value (USDA, 1997). Nonprofit programs surmount the funding constraint by emphasizing the tax advantages of easement donation or bargain sale, but may be unable to attract landowners for whom tax benefits are insufficient. Public and private approaches together may attract a larger pool of interested landowners than either approach can alone.

These two potential advantages—cost savings and an expanded pool of interested landowners—justify a closer look at the role of partnerships between Federal agencies and nonprofit organizations in resource conservation policy. Nonprofit organizations play an active role in acquiring land and partial interests in land for the Forest Service, Bureau of Land Management, Fish and Wildlife Service, and National Park Service. Land trusts and other nonprofit groups increasingly perform a brokerage function with regard to conservation easements, both in transactions between private parties and in transactions involving private parties and government agencies. The Forest Service and the Fish and Wildlife Service, for example, often rely on nonprofit organizations to help negotiate or acquire and transfer interests in land for conservation purposes. In the Wetlands Reserve Program, land trusts may participate in easement monitoring and management, and landowners may sell other partial interests, such as easements beyond the 10-year term and hunting, fishing, and timber rights allowed under the Wetlands Reserve Program easement agreement, to private conservation organizations (7 C.F.R. 720 and 1467, Section 1467.2(f)).

Partnerships between Federal agencies and conservation organizations have also been successful in a variety of other contexts. For example, partnerships under the North American Wetlands Conservation Fund include projects totaling 940,723 acres of wetlands acquired, restored, and/or enhanced as of September 1996, at a combined Federal and non-Federal cost of $359 million ($382 per acre). The Fish and Wildlife Service Partners for Wildlife program has initiated voluntary restoration projects totaling approximately 400,000 acres for little more than the cost of the restoration work. No property interests are acquired, but the landowner agrees to maintain the restoration for some years or repay the cost of the work. Wetlands Reserve Program regulations provide that USDA's Natural Resources Conservation Service can delegate specified administrative functions, including wetland management, and monitoring responsibilities (but not enforcement), to qualified Federal or State agencies or private organizations (Arnold, 1993; *Federal Register*, 1995b). To date, such delegation has occurred only in cases where residual interests (that is, the owner sold residual fee simple title to a Federal agency) in Wetlands Reserve Program land have subsequently been acquired by other State or Federal agencies—as in the case of the Iowa River Corridor Project discussed below—but not in cases where the land has remained in private ownership (Misso, 1997). The Farm Service Agency (FSA) seeks land trusts' help in educating farmers about FmHA's program to reduce debts in exchange for conservation easements, and in monitoring those easements (Land Trust Alliance, 1994). The White House noted the achievements of land trusts in the *1996 Economic Report of the President* (Council of Economic Advisers, 1996). The Forest Service and the Bureau of Land Management are also seeking to work more closely with land trusts in activities relating to land acquisition and management (USDA-FS, 1994; Land Trust Alliance, 1993).

Federal officials caution that land trusts must be well-informed of Federal standards and practices regarding appraisal and land acquisition, such as the guidelines in *Uniform Appraisal Standards for Federal Land Acquisitions* (Interagency Land Acquisition Conference, 1992), and must work closely with the Federal Government from the beginning of any easement acquisition process if such partnerships are to be successful (Sherman, 1995). In addition, as mentioned above, although Federal agencies can pay less to landowners willing to accept it, they are required to offer not less than fair market value when they seek to acquire land (USGAO, 1994a).

Two recent reports have examined the role of nonprofit organizations in Federal land acquisition. An audit in May 1992 by the Office of Inspector General at the U.S. Department of the Interior found that between 1986 and 1991 the Fish and Wildlife Service, National Park Service, and Bureau of Land Management spent $222 million (about 22 percent of their land acquisition expenditures) on properties involving nonprofit organizations (USDI, 1992, as summarized in GAO, 1994a). That report found that U.S. Department of the Interior agencies generally paid nonprofit organizations the appraised fair market value of the land acquired, resulting in financial gains to the nonprofit organizations in some cases (for example, when the latter had originally acquired the land for less than fair market value through bargain sale with tax deductions under Section 170(h)). U.S. Department of the Interior's Assistant Secretaries for Land and Minerals Management and for Fish and Wildlife and Parks disagreed with the Office of Inspector General's conclusion that these gains were unduly large, prompting debate about the appropriate role of nonprofit organizations in Federal land acquisition.

In 1994, the General Accounting Office issued a second report on the role of nonprofit organizations, which focused on land acquisitions by the Forest Service and the Department of Energy (USGAO, 1994a). In contrast to the U.S. Department of the Interior study, the General Accounting Office found that the Government's interests were adequately safeguarded in both cases. Between 1988 and 1992, the Forest Service's land acquisitions totaled about $337 million, of which about 41 percent was spent on acquisitions involving nonprofit organizations (USGAO, 1994a). In most transactions, the Federal agencies based their offers on fair market value as determined by timely appraisals, as required. Even in cases where nonprofit organizations sold land to the Government for more than they paid for it (as when nonprofit organizations acquired land at less than fair market value), the nonprofit organizations were found to incur net losses when all direct and indirect costs associated with land acquisition and transfer were considered. The General Accounting Office report concluded that Forest Service and Department of Energy relationships with nonprofit organizations have been positive, allowing the Federal Government to take advantage of opportunities to acquire desirable properties that might otherwise have been missed due to landowner unwillingness to deal directly with Federal agencies or to agencies' inability to act quickly.

Restoring Wetlands To Manage Floodplains

Rainfall that was unusual in both extent and duration resulted in ground saturation and flooding in the Midwest in 1993, causing widespread damage and raising questions about the appropriate use of watersheds and floodplains. Subsequent flooding in Georgia (in 1994), California (in 1995), and the mid-Atlantic States and Pacific Northwest (1996) further demonstrated the importance of floodplain management. The White House Interagency Floodplain Management Review Committee (IFMRC, 1994) found that loss of wetlands and upland cover (primarily to agricultural uses) had significantly increased runoff over the past century and a half, but that restoring converted wetlands along the floodplain to provide additional out-of-bank storage would have had little impact on conditions in 1993 (IFMRC, 1994). Economic damage estimates ranged from $12 to $16 billion, of which agriculture accounted for over half. As of June 1994, USDA emergency assistance paid to the nine Midwestern States most severely affected totaled $2.9 billion, most of it for disaster assistance and crop insurance (USDA Flood Information Center, 1994).

Despite the magnitude of damages in 1993, the IFMRC found that reservoirs and levees built by the Army Corps of Engineers worked essentially as designed, preventing more than $19 billion in potential damages. Watershed projects built by the Natural Resources Conservation Service were estimated to have prevented potential damages totaling an additional $400 million. However, they also found that nonstructural solutions, such as permanent evacuation of floodprone areas, flood warning, flood proofing of structures, and creation of additional natural and artificial flood storage, need greater emphasis. The IFMRC concluded that, although wetland conversion dramatically increased runoff, wetland restoration would have had only a minimal effect on the 1993 flood's unprecedented magnitude (IFMRC, 1994). Floodplain wetland restoration under the Wetlands Reserve and Emergency Wetlands Reserve Programs since 1993 will likely reduce future flood damages from more typical floods.

Based on its findings, the IFMRC recommended a variety of administrative and legislative steps, improved coordination of Federal acquisition of environmentally related interests in land from willing sellers, and recommended reforms to enhance the efficiency and effectiveness of the National Flood Insurance Program. The National Flood Insurance Reform Act of 1994 (Title V of P.L. 103-325, 42 U.S.C. 4001) restricts lending secured by uninsured or underinsured property located in floodplains, extends the waiting period before new flood insurance policies become effective from 5 to 30 days, and denies Federal disaster assistance to individuals who failed to obtain and maintain flood insurance when required to do so as a condition for receiving disaster assistance.

Wetland's role in floodplain management remains relevant today. Not just the Midwest is affected; California, the Ohio Valley, and the Upper Mississippi, Missouri, and Red River basins had flooding in 1996 and 1997. A variety of public and private efforts are conserving and restoring wetlands in floodplains. Nonprofit conservation organizations played a significant role in acquiring land interests after the Midwestern floods of 1993 (IFMRC, 1994). The Nature Conservancy, for example, helped negotiate floodplain easements and even acquired residual rights from Missouri farmers who had placed their farms in the Wetlands Reserve Program (Tenenbaum, 1994).

Examples of how public-private partnerships can accomplish floodplain management are the Iowa River Corridor Project (IRCP) and the Levee District 8. Numerous Federal, State, local, and private organizations are working together to restore wetlands and encourage a mix of floodplain-sensitive land uses in these areas. The IRCP focuses on a 50-mile stretch of the Iowa River's floodplain above the Coralville Reservoir in eastern Iowa (IRCP, undated; USDI-FWS, 1995). Of a total of about 50,000 acres within the project area, about 30,000 acres were cropland at the time of the 1993 floods, much of it on prior-converted wetlands. Since 1993, about one-third of project-area landowners have enrolled nearly 12,000 acres of this cropland in the Wetlands Reserve Program or the Emergency Wetlands Reserve Program. In addition, many participating landowners have agreed to sell their remaining interests in about 8,000 acres of enrolled land to the Fish and Wildlife Service, which will turn over management responsibilities on that acreage to the Iowa Department of Natural Resources. In addition to these property acquisition activities, numerous other public and private agencies are working in the project area to monitor water quality and other ecological changes, and to help landowners explore new floodplain-sensitive uses for lands not enrolled in the Wetlands Reserve Program or the Emergency Wetlands Reserve Program.

Partnerships in floodplain wetland restoration and preservation are also evident in Levee District 8, which covers 3,000 acres of Iowa River floodplain in southeastern Iowa's Louisa County. Prior to 1993, the district had received Federal funds to repair flood-damaged levees 14 times, at a cost of nearly $4 million (in 1993 dollars). The 1993 floods caused a further $757,000 in levee damage (Dettman, 1994). Rather than repair the levees again, the district's Board voted in March 1994 to discontinue agricultural operations and disband the district, returning riparian land to wetland condition.

Landowners, State and Federal agencies, and private conservation organizations agreed to return the land to wetlands. As a result, most of the land formerly protected by the district's levees is being reclaimed as part of the Iowa River's natural floodplain and restored to bottomland hardwood forest. Most of the district's landowners sold permanent easements to the Federal Government under the Emergency Wetlands Reserve Program. Private conservation organizations are purchasing interests in other land not enrolled in WRP. In all, more than a dozen Federal, State, local, and private agencies contributed to the effort, including the Natural Resources Conservation Service, the Fish and Wildlife Service, the Environmental Protection Agency, the Federal Emergency Management Agency, the Iowa Department of Natural Resources, the Iowa Natural Heritage Foundation, the Conservation Fund, The Nature Conservancy, Pheasants Forever, Ducks Unlimited, the Fish and Wildlife Foundation, and the Louisa County Soil and Water Conservation District (Mountain, 1995). The Fish and Wildlife Service will maintain the area as part of its Mark Twain Wildlife Refuge. In addition to providing wildlife habitat, recreation, and educational opportunities, the restoration will ease flooding downstream.

These public and private approaches to restoring wetlands formerly converted to other uses are thus beginning to make headway toward the long-term goal of increasing wetland resources. However, continued appropriations are needed because all of the restoration programs are voluntary and landowners must be compensated for the loss of income foregone when the wetland is restored. Compensation for restoring wetlands, along with concerns about regulatory and quasi-regulatory wetland conservation programs, has led to interest in compensating landowners for conserving wetlands. This is a more expensive task because of the large acreage of existing wetlands, lack of a way to ration compensation among claimants, and the higher cost of some wetlands subject to pressure for conversion to developed uses.

The Outlook for Wetland Compensation

Property rights have received unprecedented attention in recent years. When the Government takes property for public use, called a "taking," the Constitution requires that it pay the owner just compensation. Legislation considered in the 104th Congress would have required the Federal Government to compensate landowners whenever Federal agency actions diminished the value of even a portion of a property by a threshold percentage varying from 20 to 33 percent (H.R. 961 passed in the House on May 16, 1995; H.R. 925, S. 352). Federal agency actions included the Endangered Species Act, the Clean Water Act, the Swampbuster provisions of the 1985 Food Security Act, and others. This requirement would have established diminution in value as a sufficient criterion by which takings could be determined, regardless of other economic and legal criteria (see section I). However, the proposal was not enacted into law. Takings-related activity has fallen off considerably in the 105th Congress.

Most States have also considered takings legislation in recent years, and 20 States have now enacted takings laws. Most of the State laws require takings impact assessments rather than compensation for diminished property values, but four States have enacted compensation laws. Florida authorizes compensation for real property owners whose property has been "inordinately burdened" by government actions, Louisiana and Mississippi provide for compensation when government actions diminish the value of agricultural or timber land by 20 percent and 40 percent, respectively, and Texas has a takings threshold of 25 percent diminution in property value, including water rights (American Resources Information Network, 1997).

Strictly voluntary public and private programs such as the Conservation Reserve Program, the Wetlands Reserve Program, and State and local farmland protection efforts provide insights into the difficulties inherent in identifying and valuing partial interests in land—difficulties that public agencies will confront when conducting takings impact assessments. Experience with existing voluntary programs suggests that the analysis necessary to determine whether takings resulted from government actions and what compensation is due will ultimately have to be conducted on a costly, case-by-case basis (Wiebe, and others 1996b; USDA-ASCS, 1993). Ironically, this is an objection critics raise with reference to the approach traditionally employed by the courts (Goldstein, 1996; Innes, 1995; Hunt and VandenBerg, 1998).

Estimating Compensation Costs for Wetlands

Even though local appraisal will have to determine actual compensation amounts, if required compensation measures are enacted, the Federal Government's potential liability under proposed compensation requirements for some restrictions on the use of privately owned wetlands can be estimated (Zinn, 1992). These estimates are useful in illustrating the size of the fiscal commitment implied by compensation requirements, and to show how the total cost varies depending on the scope and timing of compensation. Estimated compensation liability will vary depending on the location of land affected (metropolitan versus nonmetro), the prevented use claimed (for example, urban development versus agriculture), and degree of conversion potential that will be compensated (for example, compensating all wetlands affected versus wetlands for which a *bone fide* development proposal is pending). Although estimates derived from varying these assumptions vary widely, they all imply significant public outlays.

One estimate of the total value of wetlands subject to Swampbuster and Section 404 provisions is based on recent State-average cropland values from Economic Research Service surveys, differentiated by metro and nonmetro location (table 10). The cropland values reflect both potential for agricultural production and an expectation of future development value. Metropolitan values are more than twice those in nonmetropolitan areas, where development is less likely and land is less valuable. The estimate of $181.6 billion is probably high for three reasons. First, the value implicitly assumed for the wetland in its natural state, before clearing and drainage to make it equivalent to average agricultural land, is zero. Natural wetlands do have some intrinsic market value for hunters, groups concerned with preserving natural areas, and people who just want natural surroundings in rural settings. These values, however low, should be subtracted from the gross agricultural valuation. Second, many wetlands are already used for crop production or grazing, and thus have some intrinsic agricultural value in their undrained or partially drained state. These values should also be subtracted. More fundamentally, it is unlikely that any compensation scheme would offer to compensate all wetland owners, regardless of how remote the expectation of conversion.

A second estimate is based on market values actually paid by public and private organizations that currently acquire easements or fee title rights to wetlands. Examples include The Nature Conservancy, the North American Waterfowl and Wetlands Office of the U.S. Fish and Wildlife Service, and USDA's Wetlands Reserve Program. As an illustration, the second estimate in table 10 values all wetlands in metro and nonmetro areas based on the average market value of wetland parcels acquired in such areas by The Nature Conservancy between 1955 and 1996, adjusted to 1996 constant dollars. Average wetlands market values are only slightly lower than average agricultural land values ($1,459 versus $1,629 per acre), resulting in similar aggregate estimates of compensation costs ($162.6 billion versus $181.6 billion).

A third estimate was developed by modifying the first approach based on expected rates of wetland conversion to different uses and using estimates of values for land that is ready to develop, rather than values for raw land with expectations for future development. As we saw in Chapter III, rates of wetland conversion

Table 10—Alternative estimates of compensation for wetland regulation

Item	Wetlands	Value per acre	Total value
	Million acres	Dollars	Billion dollars
Valuing all wetlands at agricultural land prices:[1]			
Metro	31.7	2,676	84.7
Nonmetro	79.8	1,214	96.8
Total	111.5	1,629	181.6
Valuing all wetlands at wetland market prices:[2]			
Metro	31.7	2,611	82.7
Nonmetro	79.8	1,002	79.9
Total	111.5	1,459	162.6
Valuing wetlands converted at 1982-92 rates, by converted use:[3]			
Urban	0.9	100,000	89.0
Agriculture	0.3	1,200	0.4
Total	1.2	74,477	89.4
Valuing wetlands converted at 1954-74 rates, by converted use:[3]			
Urban	0.5	100,000	54.0
Agriculture	5.9	1,200	7.1
Total	6.4	9,446	61.1
Valuing wetlands profitable to convert to agricultural use:[4]			
Preconversion use	13.2	145	1.9
Agricultural use	13.2	2,360	31.1
Total	13.2	2,215	29.2

[1]Raw agricultural land values are from National Agricultural Statistics Service/Economic Research Service cropland value survey data for 1996.
[2]Market values for wetlands acquired by The Nature Conservancy, 1955-96, in 1996 constant dollars, Christen Comstock, personal communication, 1997.
[3]Urban land values are from Urban Land Institute *Market Profiles, 1993* housing, retail, and office prices for selected cities.
[4]Values are for agricultural use and preconversion use of wetlands from profitability analysis in Section VI.
Source: Economic Research Service compilation of 1992 National Resources Inventory and Fish and Wildlife Service Status and Trends data.

for all uses have declined since the mid-1950's due to enactment of regulatory programs, and have shifted from primarily agricultural conversion to primarily urban conversion (table 2). If these regulatory programs are eliminated in favor of a compensation program, landowners will face few restrictions on conversion and will have additional economic incentives to pursue development projects (ERP, 1995, p. 149; Innes, 1995). Thus, compensation cost estimates can vary from $89.3 billion, assuming the current (1982-92) rates and mix of conversions, to $61.1 billion, assuming reversion to the higher conversion rates and agricultural emphasis of the 1950's to 1970's (table 10). Returning to the older pattern of conversion in which five times more wetland acres were lost would cost less than more recent patterns of wetland conversion because of the higher proportion of lower cost agricultural land converted in earlier periods.

A fourth estimate of compensation for agricultural conversion foregone was constructed based on an assessment of the potential profitability of wetland conversion. The estimate of $29.2 billion is solely for agricultural land, but it has the virtues of focusing directly on wetlands profitable to convert, accounting for the production potential of those wetlands and the cost of converting the wetlands to production, and subtracting an estimate of the market value of the wetlands in the absence of conversion. This estimate does not account for the price effects caused by regulation, or by removing regulation. For a complete estimate of wetland compensation required, a similar effort would have to be undertaken for wetland conversion for urban development, which would likely result in much higher values.

Achieving "No Net Loss"

Progress toward the "no net loss" goal has been more rapid than many anticipated when it was first enunciated in the late 1980's. The achievement is partly illusory because high net conversion rates debated in the late 1980's were based on trend data from 1954-74, the latest available at the time. Since then, estimates from 1974-84 and 1982-92 show that wetland conversions, particularly to agricultural uses, have been reduced. While wetland conversion is lower, since 1990 wetlands that had been drained are also now being restored by Federal, State, and private programs. On the basis of partial data, Tolman (1995; 1997) claims that wetland restoration in 1994 exceeded the rate of wetland conversion. Problems in accounting for restoration activity make confirming Tolman's hypothesis difficult, but there is little doubt that the United States is moving closer towards "no net loss," at least in acreage terms (Smith, 1997; Wilen, 1995).

In table 11, the most recent estimates of gross wetland losses and gains are compared with estimates of restoration activity. If the rate of gross wetland conversion to all uses observed over 1982-92 continued during the first half of the 1990's, 156,000 acres of wetlands would have been converted, requiring double the rate of restoration or replacement observed in 1982-92. Based on available data, restoration activity in 1992-96 accomplished that doubling, rising from 77,000 acres per year in 1982-92 to an average of 187,343 acres per year in 1992-96. When adjustments for upland acres, restoration versus enhancement, and double counting between the Partners for Wildlife and North American Waterfowl Management Plan are made, it appears that the United States is within 47,000 acres per year of achieving "no net loss" of wetland acreage. None of these estimates include purely private efforts at restoration, such as those of Ducks Unlimited, the Izaak Walton League, The Nature Conservancy, and other groups and individuals, nor efforts by State and local governments.

Whether the low rate of gross wetland conversion, the high rate of wetland restoration, or both, can be sustained over the long term remains unclear. Improvements in the agricultural and nonagricultural economy, proposals to exempt wetlands from current conservation and regulatory programs, phasing out of farm program benefits that motivate the Swampbuster provisions, and continuing budgeting issues could increase wetland conversion from the low rates observed in 1982-92, reduce restoration activity, or both, moving us away from the "no net loss" target.

Costs and Benefits of "No Net Loss"

Based on the analyses and data presented above, a rough picture of the costs incurred in preventing wetland conversion and conserving or restoring wetlands to achieve "no net loss" emerges. Mean costs of acquiring property rights in wetlands range from several hundred dollars per acre for wetlands in their natural state that have little potential for conversion up to hundreds of thousands of dollars per acre for wetlands with potential value for urban development sites (table 12). Acquiring rights to former wetlands and restor-

Table 11—Average annual wetland losses and gains compared with recent restoration activity, 1992-96

Program	1982-92 average annual gross wetland Losses	Gains	1992	1993	1994	1995	1996	Total	Average annual restoration 1992-96	Adjusted[1]
					Acres					
USDA-WRP/EWRP[2]	na	na	43,438	0	159,634		197,313	400,385	80,077	76,073
FWS-PFP[3]	na	na	38,000	34,528	54,739	54,146	51,407	232,820	46,564	2,328
FWS-NAWMP[4]	na	na	88,000	51,000	50,000			189,000	37,800	9,450
ACE-Section 404[5]	na	na	na	na	15,000	45,925	47,864	108,789	21,758	20,670
Mitigation banks[6]	na	na	1,144	1,144	1,144	1,144	1,144	5,720	1,144	1,087
Total	156,000	77,000	170,582	86,672	280,517	101,215	297,728	936,714	187,343	109,608

na = not available.
[1]Adjusted for the proportion of wetland versus upland acres, restoration versus enhancement, and for double counting.
[2]Wetland Reserve and Emergency Wetlands Reserve Programs, assumes 95 percent is actual restoration.
[3]Fish and Wildlife Service-Partners for Wildlife Program, assumes 20 percent not reported in North American Waterfowl Management Plan and 25 percent is actual restoration.
[4]Fish and Wildlife Service-North American Waterfowl Management Plan, assumes 25 percent is actual restoration.
[5]Robertson (1997), assumes 95 percent is restoration.
[6]Forty-six existing wetland mitigation banks inventoried in 1992, assumes 95 percent is restoration.
Source: Economic Research Service, USDA, analysis of U.S. Fish and Wildlife Service, Army Corps of Engineers and other data.

ing them to wetland condition can be less expensive than wetland conservation because there is a large supply of former wetlands that are marginally suited to economic uses and relatively easily restored. Wetlands that are profitable to develop have good agricultural productivity, or are well located with respect to urban development, increasing their market value. For both conservation and restoration purposes, costs range widely depending on the potential for economic uses, location, and the difficulty of converting from or restoring to wetland condition.

Summarizing the wetland valuation studies presented in Chapter III, mean values per acre generally match or exceed conservation or restoration costs (table 12). Nonuse benefits may greatly exceed wetland costs because relatively low values per acre are shared by millions of individuals who appreciate the environmental values represented in wetlands. However, the extremely wide range of benefit estimates causes some concern. Such variation can be caused by flaws in estimation methods (Anderson and Rockel, 1991; Shaman and Batie, 1985; Scodari, 1997), by instability in respondents underlying perceptions of the functions, services, and values of wetlands (Novitski, and others, 1996), or by real variation in the physical attributes and locational characteristics of wetlands that underlie the valuations. Whatever the cause, wetland benefits could justify the costs of forgoing conversion and/or restoring wetlands in a "no net loss" policy. Because both the costs and the benefits vary to such a large degree and on such a site-specific basis, however, it is not possible to make an aggregate assessment based on the current information.

Present policy combines an overarching goal of "no net loss" with a regulatory review process that deals with minimal impacts through general permits and conducts more thorough, qualitative reviews of the environmental costs and private benefits of major proposals impacting wetlands. Unnecessary impacts are avoided, minimized, and, as a last resort, mitigated through wetland restoration or creation to replace lost values. Although greater use of economics could improve estimates of private benefits subject to wetland regulation, it is unlikely that economic valuation estimates could be deployed rapidly enough and with sufficient sensitivity to usefully inform cost/benefit considerations for any but the largest wetland conversion proposals.

Wetlands After "No Net Loss"

Once "no net loss" of wetland acreage is achieved, what remains? The "no net loss" goal is often thought of solely in terms of reducing acres of wetland converted and increasing acres restored. However, the National Wetlands Policy Forum concluded that the balance must be struck in terms of wetland functions and values, not merely acreage (The Conservation Foundation, 1988; NRC, 1992; NRC, 1995). Attention will now focus on ensuring that the quality

Table 12—Costs and benefits of wetlands

Program	Costs of conserving or restoring wetlands: Number	Acres	Cost	Range of values	Wetland function valued	Economic values of wetland functions: Number of studies	Mean	Range of values
			Dollars per acre				Dollars per acre	
Acquisition of property rights for wetland conservation:					**Marketed goods:**			
Water bank (capitalized @ 6%)	6,000 (contracts)	671,446	250	na	Fish and shellfish support	8	6,132	7-43,928
					Fur bearing animals	2	137	13-261
The Nature Conservancy	1,343	501,504	1,306	1-968,423	**Nonmarketed goods:**			
Swampbuster	na	13,165,800	2,215	519-4,136	General-nonusers	12	83,159	115-347,548
					General-users	6	2,512	105-9,859
Acquisition of property rights for wetland restoration:					Fishing-users	7	6,571	95-28,845
North American Wetlands Conservation Fund	202 (projects)	940,723	382	40-422	Hunting-users	11	1,019	18-3,101
Wetlands Reserve Program	2,139	341,259	620	97-2,313	Recreation-users	8	1,139	91-4,287
Emergency Wetlands Reserve Program	719	94,181	799	598-1,283	Ecological functions	17	32,149	1-200,994
					Amenity and cultural	4	2,722	83-9,910

na = not available.
Sources: Table 1 and Appendix I, Table 10, Table 9 and unpublished FSA data, North American Wetlands Conservation Fund data.

of wetland resources is protected and restored, as well as their quantity.

Wetland quality issues concern the level of function that conserved and restored areas can attain and the ecological and human values they generate. Wetland conservation requires attention to quality because activities surrounding wetlands can degrade or improve wetland functioning, even when no direct conversion of wetland acreage occurs. Changing hydrologic regimes, altering sediment and nutrient flows, and changing surrounding vegetation can harm or help the level of functioning in an existing wetland and there are many human activities that can affect these watershed characteristics that are not affected by existing wetland protection programs.

Wetland quality or function is determined by the hydrologic functions, nutrient supply functions, plant community characteristics and dynamics, and faunal community characteristics discussed in Chapter III, relative to optimal levels in a fully functioning wetland of each type (NRC, 1992). Methods have been developed to analyze wetland function, but they have not been systematically employed to indicate trends in wetland quality (Brinson, 1993; Adamus and Stockwell, 1983). However, four factors can be used as indicators of potential change in wetland quality: soil erosion, irrigation, forest cover, and urbanization. All four indicators are related to important causes of wetland degradation (NRC, 1992; Kusler and Kentula, 1990) and are assessed here with data available in the 1992 National Resources Inventory. If watersheds surrounding wetlands are experiencing changes in these indicators, wetland quality is likely changing as well. Indicators of other factors that potentially affect wetland quality, such as livestock grazing, confined animal concentrations, and nutrient and pesticide use, may be significant, but data are not consistently available at the national level to construct indicators of these factors.

We examined watersheds that have at least 5 percent of their land area in wetlands, the same percentage as for the United States overall. There are 677 such wetland watersheds, encompassing 95.5 million acres of wetlands, about 85 percent of total non-Federal wetlands in the United States outside of Alaska. Findings of this national-scale analysis should be viewed as providing information on targeting regional- or local-scale efforts to monitor wetland quality changes, but cannot determine whether some or all wetlands in the indicated watersheds are actually being degraded or improved by changes in the activities taking place in those watersheds. In 1982-92, net reductions in sheet and rill erosion and irrigation in wetland watersheds probably contributed to improvements in wetland quality, while deforestation and urbanization had negative effects (table 13).

Sediment from Soil Erosion

Sediment can clog wetland vegetation and impair water holding capacity. In 1982-92, decreases in all sources of sheet and rill erosion were widespread, occurring in one-third of all watersheds and 63 percent of wetland watersheds (watersheds with at least 5 percent of area in wetlands, fig. 6). Erosion declines in wetland watersheds were 98 million tons, 29 percent of the total decline in U.S. sheet and rill erosion. Watersheds with erosion decreases contained 61 million wetland acres in 1992, while those with erosion increases contained 14.4 million wetland acres. Widespread changes in agricultural production practices caused by less intensive rotations, adoption of conservation tillage, and implementation of conservation compliance provisions in the 1985 Food Security Act accounted for the erosion reductions. NRI data show that the Conservation Reserve Program was responsible for 28 percent of the decrease in erosion in wetland watersheds.

Irrigation

Irrigation can degrade wetlands, where diversions from natural watercourses rob wetlands and other instream uses of water or where groundwater pumping lowers water tables and dries out wetlands. Thus, increases in irrigated acreage could impair wetlands, while decreases could improve wetlands. More wetland watersheds experienced net decreases in irrigated acreage between 1982 and 1992 than had net increases (fig. 7). Decreased irrigated acres in central Nebraska, and southern Georgia and Florida mitigated long-term problems for wetlands. Wetland watersheds with net declines lost 800,000 irrigated acres between 1982 and 1992, while irrigated acreage increased 1.3 million acres in watersheds with net gains. Some 23 million acres of wetlands were located in watersheds that had decreases in irrigated acres, and 15.8 million acres of wetlands were in watersheds where irrigated acreage increased. These changes mirror decreases in irrigated acreage in the Northern and Southern Plains States, Mountain region, and the Pacific region during this period (USDA-ERS, 1994, p. 50). Watersheds with increases in irrigated acres are largely in humid areas where irrigation supplements natural precipitation. Supplemental irrigation may cause short-term stress on affected wetlands, but long-term damage is less likely.

Loss of Tree Cover

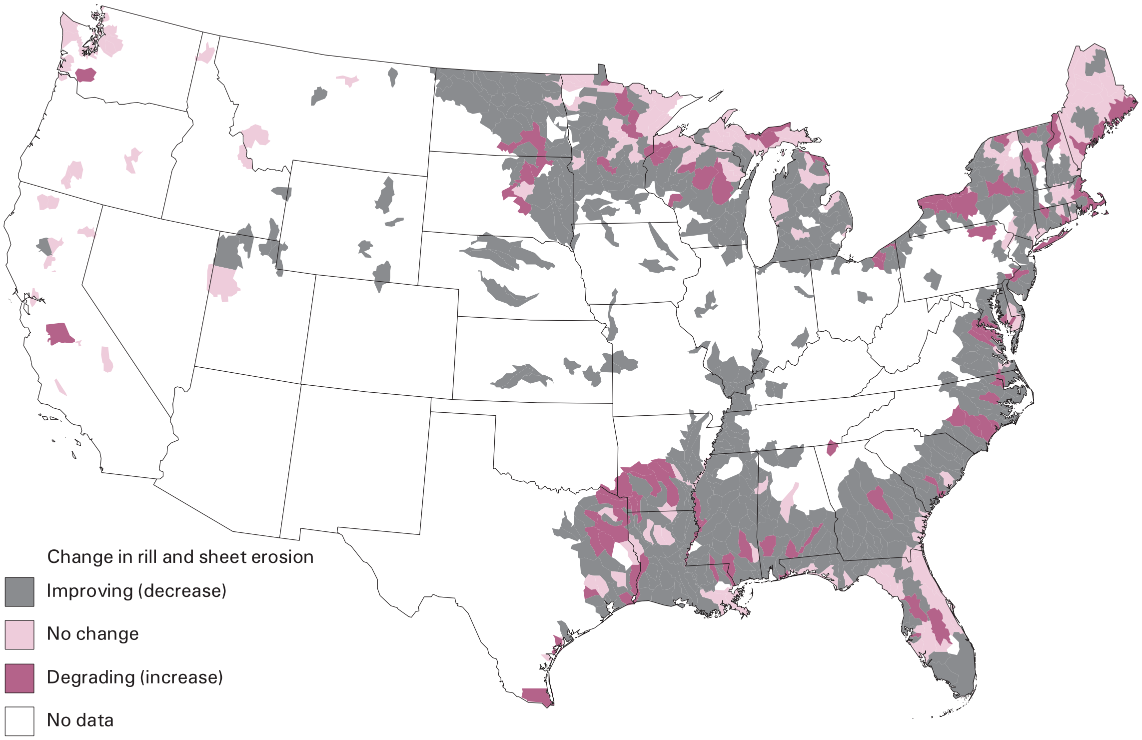
Deforestation, both from permanent land use change and from normal harvesting of mature tree crops, can stress wetlands. Tree canopy protects watersheds from runoff and erosion and shades watercourses, lowering water temperatures for sensitive aquatic species. Although some areas were planted to trees in 1982-92, development of tree canopy in a decade is usually insufficient to replace loss of mature tree cover. Watersheds with more than 5-percent wetlands lost 5.3 million forested acres between 1982 and 1992. These watersheds contained 87.1 million acres of wetlands (fig. 8). Deforestation in wetland watersheds represented about 36 percent of deforestation in the United States. Some 90 wetland watersheds, containing 8.4 million acres of wetlands, did not suffer deforestation. The loss of tree cover reflects both purposeful harvest and incidental clearing of trees associated with changes such as urban and agricultural development. Forest harvest is likely the major cause of deforestation in the Southeast, northern New England, Minnesota and Wisconsin, and the Pacific.

Table 13—Indicators of change in wetland quality, contiguous States, 1982-92

Indicator (impact on wetland quality)	Wetland watersheds[1]		Wetland area		Change in: Erosion	Change in: Irrigated area	Change in: Forest cover	Change in: Urbanization
	Number	Percent	1,000 acres	Percent	Million tons	Million acres	Million acres	Million acres
Water erosion:								
Degrading (increase)	88	13	14.4	15	3.8	0.1	-1.0	-1.0
Improving (decrease)	429	63	61.0	64	-98.0	0.3	-3.1	-4.9
No change	160	24	20.1	21	0.0	0.1	-1.2	-1.1
Irrigated area:								
Degrading (increase)	93	14	15.8	17	-17.6	1.3	-1.0	-1.4
Improving (decrease)	149	22	23.0	24	-21.4	-0.8	-1.3	-2.4
No change	435	64	56.7	59	-55.2	0.0	-2.9	-3.1
Forest cover:								
Degrading (decrease)	587	87	87.1	91	-86.9	0.5	-5.3	-6.7
No change	90	13	8.4	9	-7.3	0.0	0.0	-0.3
Urbanization:								
Degrading (increase)	647	96	92.3	97	-92.8	0.4	-5.2	-7.0
No change	30	4	3.2	3	-1.4	0.0	0.0	0.0
All indicators degrading	19	3	3.6	4	0.6	0.2	-0.3	-0.4
Most indicators degrading/ some with no change	187	28	25.0	26	2.1	0.2	-1.5	-1.2
Most indicators degrading/ some improving	300	44	42.8	45	-68.8	0.7	-2.5	-3.3
No change in indicators	9	1	1.0	1	0.0	0.0	0.0	0.0
Indicators degrading = indicators improving	142	21	21.1	22	-25.5	-0.6	-0.9	-2.0
Most indicators improving/ some degrading	18	3	1.8	2	-2.5	-0.1	0.0	-0.1
All indicators improving	2	0	0.1	0	-0.1	0.0	0.0	0.0
Total wetland watersheds	677	100	95.5	100	-94.1	0.5	-5.3	-7.0

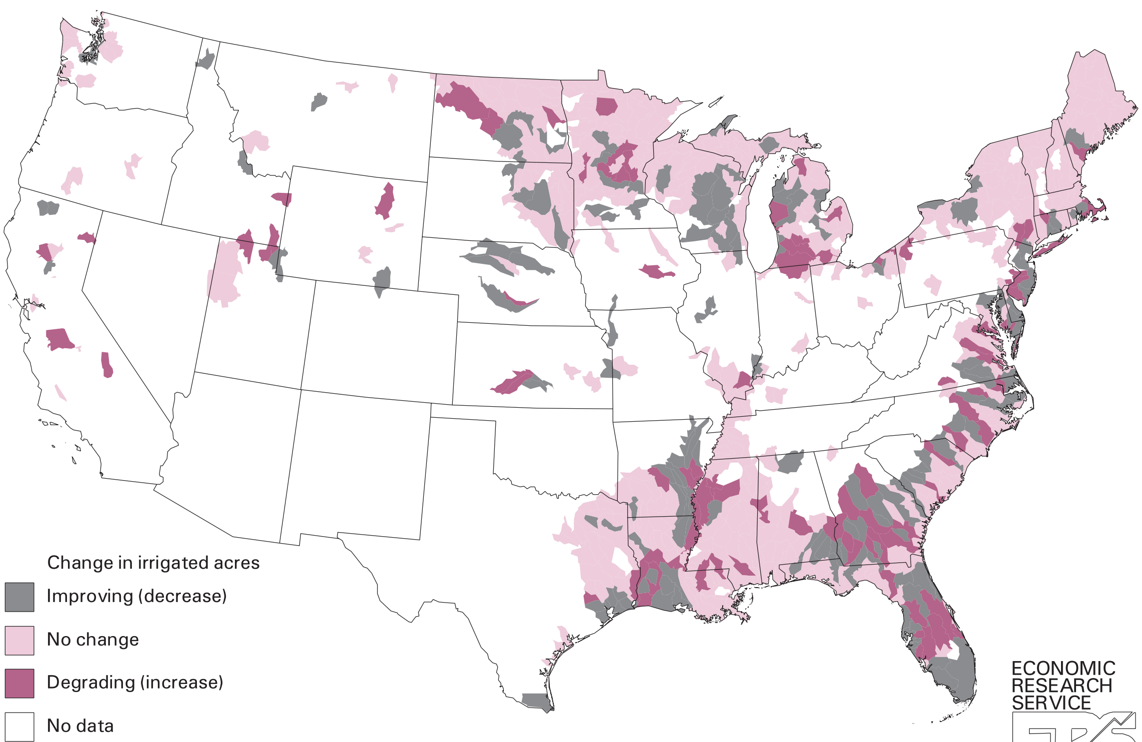
[1]Watersheds with 5 percent or more of total area in wetlands.
Source: USDA, Economic Research Service, based on 1992 National Resources Inventory data.

Figure 6
Change in sheet and rill erosion of wetland watersheds,* 1982-92



* Watersheds with at least 5 percent of land area classified as wetlands in 1992.
Source: USDA, ERS, based on NRCS 1992 National Resources Inventory data.

Figure 7
Change in irrigated acres of wetland watersheds,* 1982-92



* Watersheds with at least 5 percent of land area classified as wetlands in 1992.
Source: USDA, ERS, based on NRCS 1992 National Resources Inventory data.

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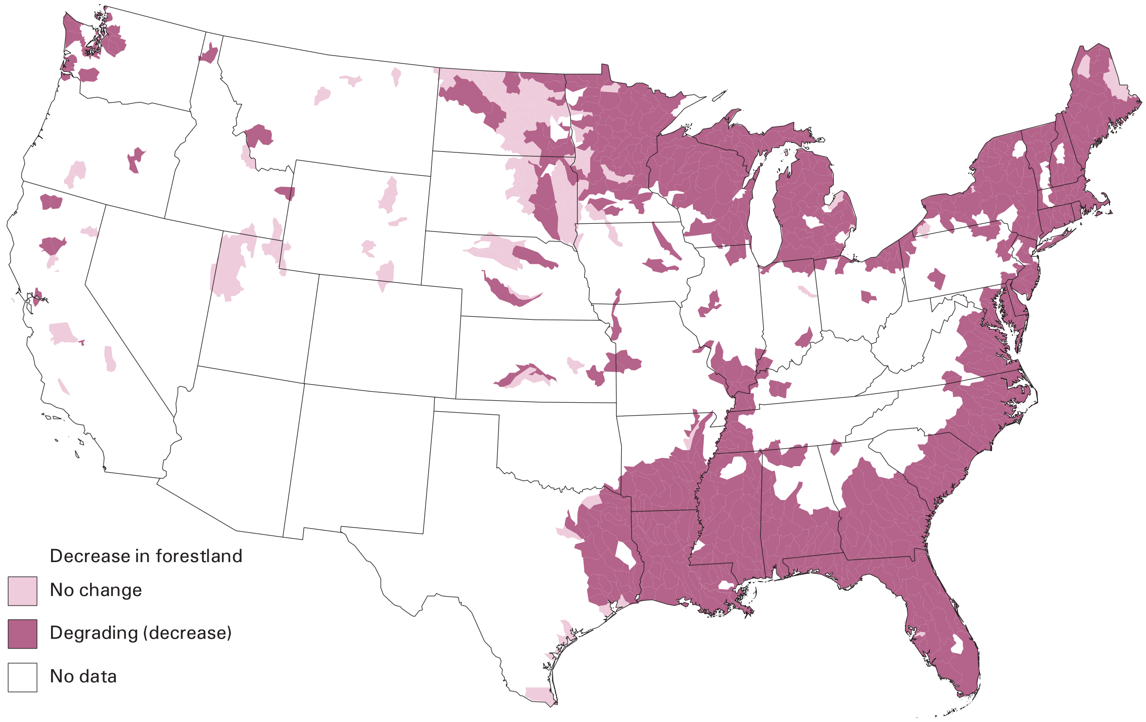
Figure 8

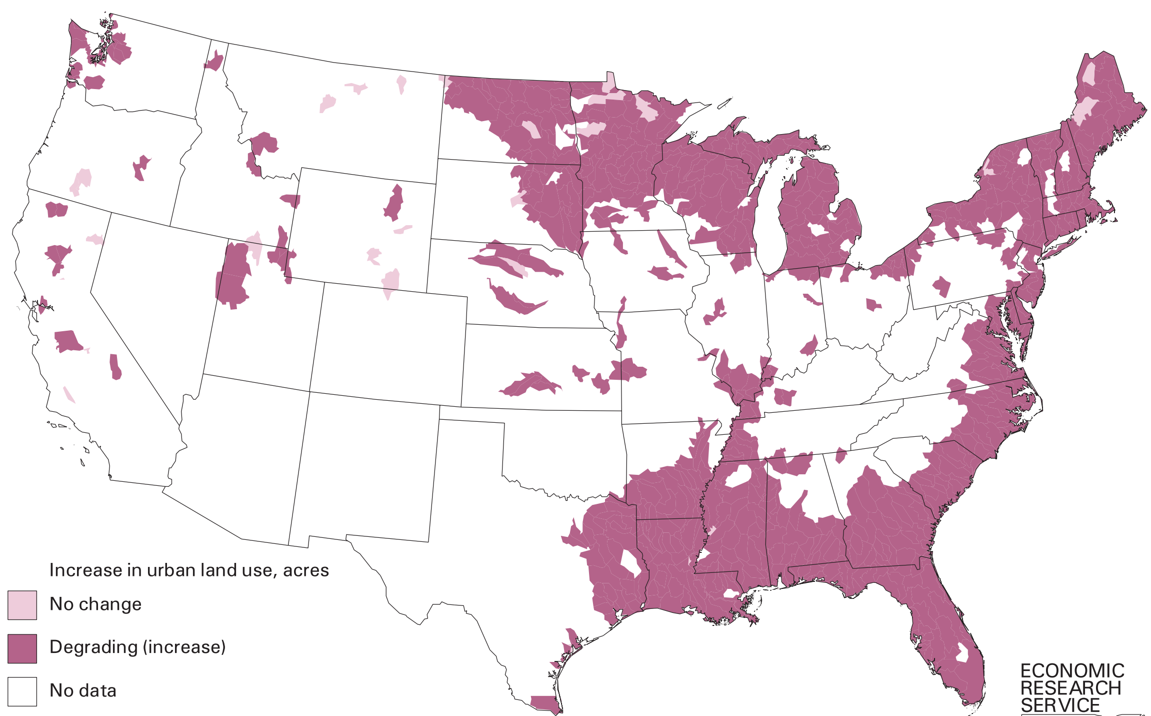
Loss of forestland and tree cover in wetland watersheds,* 1982-92



* Watersheds with at least 5 percent of land area classified as wetlands in 1992.
Source: USDA, ERS, based on NRCS 1992 National Resources Inventory data.

Figure 9

Increase of urban land use in wetland watersheds,* 1982-92



* Watersheds with at least 5 percent of land area classified as wetlands in 1992.
Source: USDA, ERS, based on NRCS 1992 National Resources Inventory data.

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Tree clearing for urban development is likely a major cause in southern New England, the mid-Atlantic, and Florida.

Urban Development

Measured by the change in urban land uses between 1982 and 1992, urbanization can stress wetlands because of hydrologic modifications caused by increased runoff from paved areas, toxic runoff from industrial pollutants and chemicals and oils deposited on roadways, and from trash and garbage dumped in wetland areas. Nearly all watersheds (96 percent) with more than 5 percent wetlands had urban land increases, adding 7 million acres of developed land over the decade (fig. 9). Urbanization in wetland watersheds represented 48 percent of total U.S. urbanization. Wetland watersheds that experienced urban development include 92.3 million acres of wetlands (table 13). More extensive suburban development patterns may have less impact on wetlands than intensive development, particularly where zoning and floodplain management avoid wetlands and riparian areas. No increase in developed land was recorded in 30 wetland watersheds with 3.1 million acres of wetlands.

Overall, 19 watersheds experienced declines in all 4 indicators, while 9 watersheds experienced no change in any of the indicators. Most of the indicators were negative in 487 watersheds, although most of these did have decreased erosion. Decreases in erosion and irrigated acreage in 160 watersheds offset or equaled losses in forest cover and increases in urbanization. Only two watersheds (in Wyoming and Montana) experienced improvements in all four of the quality indicators.

The relative importance of these indicators on wetland quality is difficult to judge. Urbanization and sedimentation may have longer lasting effects on wetlands than irrigation and deforestation. However, if the trees are being removed in bottomland hardwood wetlands with no provision for reforestation, there may be long-term changes in the nature and quality of the wetlands affected. Urbanization within wetland watersheds, combined with increased wetland conversion for urban development, is emerging as an important force impacting wetlands.

Wetlands and Global Climate Change

Another future indirect threat to wetlands comes from sea level changes that may accompany global climate change (USDI-USGS, 1997a). The 1992 National Resources Inventory classifies just under 10 percent of U.S. wetlands as marine or estuarine. Including associated freshwater marshes and forested wetlands, the National Oceanic and Atmospheric Administration identifies a total of 26 million acres of coastal wetlands in the continental United States, most of them along the Gulf and Atlantic coasts (Watzin and Gosselink, 1992). Coastal wetland losses threaten these regions' commercial and recreational fisheries, tourism, and habitat for threatened and endangered species.

Through surface sediment deposition, subsurface accumulation of plant material, and inland "migration" to formerly upland sites, many coastal wetlands have maintained their relative elevation and persisted despite gradual increases in sea level of 1-2 mm per year over the past several centuries. Based on predictions by the Intergovernmental Panel on Climate Change (IPCC), however, these rates of sea-level rise are projected to increase two- to fourfold over the next century as global mean temperatures rise (USDI-USGS, 1997a). Simulation modeling of the St. Marks National Wildlife Refuge area in northwestern Florida indicates that projected sea-level rise would result in permanent inundation of large portions of that area’s coastal zone over the next century. Coastal marsh area would actually increase slightly in the study area, with losses to open water offset by inland migration of coastal marsh and resulting replacement of existing forest habitat (USDI-USGS, 1997b). In other areas, coastal development and population growth would be expected to play a greater role in constraining the natural processes by which coastal wetlands migrate inland in response to increases in sea level.

VII. Conclusions

Socially optimal use of wetlands occurs when the marginal public benefits from conserving an acre of wetland equal the marginal public benefits of converting that acre. Unfortunately, neither the marginal benefits nor the marginal costs are well understood and quantified. Because of these uncertainties, the "no net loss" goal may not be optimal, but it does reflect public sentiment that wetland conversion should be reduced. Although the "no net loss" goal was a convenient formula when wetland conversion rates were relatively high, as conversion rates fall it becomes increasingly less useful as a guide to public wetland policy. More systematic research is needed to estimate wetland benefits and social costs of greater wetland conversion in order to formulate a more precise goal for remaining and potentially restorable wetlands.

Public recognition of wetland values has increased rapidly over the past 25 years. Wetlands functions affect wildlife, water quality, and flooding. Humans value the flow of goods and services produced by natural wetlands, only some of which are traded in markets. Our survey of the economic literature on valuing wetlands shows that, in general, estimated nonuse values (that is, valuing the continued existence of the resource or the option to use the resource in the future or pass it on to future generations) are higher than estimated values from using wetlands for recreation, wildlife habitat, or ecological services. Values of marketed goods and services produced by existing wetlands are lower still. The replacement values of ecological services provided by wetlands are high, but these services are seldom replaced when wetlands are lost, resulting in losses of ecological services to affected populations. Values of agricultural wetlands have been studied less than coastal wetlands or wetlands associated with other land uses. The wide range of wetland values in the literature reflects the wide range of functions and services provided by wetlands of different types and the widely differing socioeconomic contexts in which wetlands occur.

People are interested in wetlands because public benefits of wetlands extend well beyond their boundaries. The appropriate balance between society's interest in wetlands and the rights of individual landowners is heavily debated because the outcome determines how wetlands are used, and how the costs and benefits associated with wetland use are distributed. Government seeks to balance these competing claims through a combination of Federal and State regulatory programs and economic incentives. Former direct and indirect economic incentives for wetlands conversion have been eliminated. New incentive programs encourage landowners to make socially acceptable use of wetlands.

Although it is now commonly accepted that wetlands provide valuable environmental benefits, they have been converted to other uses, altering and degrading wetland functions and values since colonial times, often with explicit public incentives for conversion. In the latter half of the 20th century, attitudes and public policy began to shift from supporting and subsidizing wetland conversion to encouraging wetland conservation and restoration. Federal and State wetlands policies have evolved from active encouragement of wetland conversion, through prohibitions on assistance with conversion, to support of regulatory and voluntary incentive programs to conserve and restore wetlands in pursuit of the "no net loss" goal. These policy changes are responsible, at least in part, for reducing wetland conversion, especially agriculture's share since the mid-1980's.

Net rates of wetland conversion have decreased over time, from more than 800,000 acres per year between settlement and 1954 to less than 80,000 acres per year in 1982-92. Agriculture's share of gross conversion dropped from more than 80 percent in 1954-74 to 20 percent in 1982-92, while urban development's share rose. This long-term reduction in wetland conversion for agriculture is partly due to changing economic conditions, and partly the result of regulatory and quasi-regulatory programs like Section 404, State laws, and the Swampbuster provisions, combined with Federal, State, and private efforts to restore formerly converted wetlands. In the absence of these policies, sufficient economic incentives for agricultural wetland conversion remain, especially in periods of favorable commodity prices, that substantial additional wetland conversion for crop production would occur.

Reductions in the rate of wetland conversion moved us closer toward "no net loss" of wetland acreage in the early 1990's. Because this achievement depends on these public and private efforts, however, "no net loss" may not be sustained if economic conditions spur additional wetland conversion, if Section 404 is weakened, if Swampbuster's leverage from farm program payments is eliminated, or if continued funding for wetland restoration programs is not forthcoming.

If farm program payments are eliminated at the end of the 1996 Federal Agricultural Improvement and Reform Act in 2002, the Swampbuster sanction becomes ineffective, exposing remaining wetlands to agricultural conversion. We estimate that, in the short run, 5.8 to 13.2 million acres would be profitable to convert to agricultural production based on expected prices, increasing income for those farmers with wetlands to convert. In the long run, some marginal cropland would drop out of production, leaving a net cropland addition of 2.2 to 5.0 million acres. Increased commodity supplies from the added acreage would depress commodity prices for all farmers, resulting in reductions of farm income of $1.6 to $3.2 billion. Landowners with wetlands to convert, primarily located in the Southeast, Delta, and Appalachian farm production regions, would have minor increases in farm incomes, while farmers with no wetlands to convert and marginal land that comes out of production would have reduced farm income.

After the 1996 Federal Agricultural Improvement and Reform Act, wetland owners will still have to comply with Section 404 of the Clean Water Act, which regulates wetland conversion. However, experience with Section 404 from 1972 to 1985, before Swampbuster was enacted, indicates that it may not be as effective at limiting agricultural wetland conversion as the Swampbuster provisions. Wetland conservation and restoration programs could help maintain the wetland resource base, but may not receive adequate funding to offset the loss of the Swampbuster provision.

Proposals for compensating wetland owners for wetland regulation could cost from $30 to $180 billion. Costs would vary depending on the extent of wetlands compensated, the timing of compensation payments, and interactions between compensation and the rate of wetland conversion. Agricultural wetlands would require less compensation per acre, but are more extensive than wetlands near urbanizing areas.

Even if "no net loss" of wetland acreage can be sustained in the future, maintaining and improving the quality of remaining wetlands is an important goal because fully functioning wetlands provide services that are valued by society. Changes in soil erosion, irrigation, deforestation, and urbanization in watersheds with significant wetlands indicate that 75 percent of watersheds have most of these four wetland quality indicators degrading. More than 60 percent of wetland watersheds show improvements in water-caused soil erosion, 22 percent had decreases in irrigation, while 87 percent had decreases in forest cover and 96 percent had increased urbanization.

Future Research Needs

Changes in wetland policy over the last 25 years are an example of how public policy and institutions respond to greater scientific and public understanding and appreciation for the functions performed by environmentally sensitive lands. Significant progress has been made in designing institutions to conserve and restore wetlands, much of it based on understanding private economic incentives and disincentives for conversion. Issues of the relationships between agricultural production and wetlands have periodically risen to importance over the last quarter century, and are unlikely to completely recede in the future. Thus, there will likely always be an agenda of unmet research needs awaiting attention. Over the next several years, the following research topics are likely to receive policy attention and would benefit from objective, economic analysis.

First, the perceived acceptance and success of the Wetlands Reserve Program, coupled with interest in providing flexibility for producers to expand productive capacity within the "no net loss" guidelines means that an expansion of restoration programs is likely. This has recently gotten attention in the Clinton administration's water quality initiative, which called for a net increase in wetland acreage of 100,000 acres per year by 2005 (Clean Water Action Plan, 1998). Further research is needed on the potential for expansion of WRP under alternative assumptions about the distribution of enrollment across regions, the relative importance of replacing different wetland types, and the fiscal resources available for wetland restoration. Policymakers need more information about the efficiency of permanent versus shorter-term land retirement instruments, and their acceptance by landowners in different parts of the country.

Achievement of a net gain in wetland acreage may be complicated by some emerging problems that will need further research attention. As we have indicated above, the potential impact of climate change on wetlands, at least in coastal areas, may become as significant as more directly human-induced sources of wetland loss. Can we generalize about the magnitude and location of impacts from the limited case-study estimates of the effects of a rise in sea level on wetlands along the Gulf coast to gain a better understanding of this phenomena? Wetlands are also thought to be a potential source of carbon sequestration. Can we estimate the cost-effectiveness of expanding wetland acreage to mitigate climate change through increased carbon sequestration?

Even without increased wetland losses due to climate change, loss of important policy tools such as the Swampbuster provisions and development of an activity-specific nationwide general permit for agriculture may increase potential wetland losses. Better estimates of the potential impacts of these changes will be needed as the next farm bill debate approaches. Continued analysis of the evolving relationship between the Clean Water Act and other wetland programs regarding agricultural land will also be needed, particularly with respect to livestock waste management's impacts on water quality and potential mitigation of those impacts through wetland-based treatment measures.

We also need to investigate the potential of alternative programs to conserve and restore wetlands. For example, existing data on wetland mitigation banks focus on older, single-client banks, but indicate that there has been a recent increase in the number of banks that cater to multiple clients on a market basis. How successful are such banks proving to be in economic and environmental terms? What is the potential for other market-based incentives such as wetland conservation tax credits, and alternatives for traditional crop and flood insurance related to floodplain and wetland easements?

While the exact nature of the policy questions that will arise in coming years remains unclear, it is virtually certain that wetland issues will remain important, complex, and contentious, given the mix they represent between public and private benefits and interests. The analyses presented in this report, as well as the longer research record on which they are based, indicate the complexity and variety of research and policy issues on wetlands and agriculture that will require continued attention. The analyses in this report provide a solid foundation for continued research and informed policy decisionmaking on wetlands and agriculture in the future.

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Appendix I—Valuation Studies Summary

Thirty-three studies from the literature on wetland valuation were reviewed and classified according to the wetland function, goods or services provided, and economic value represented (appendix table 1). Where possible, estimates of mean willingness to pay, any statistical or other range in willingness to pay values, and values per acre of wetlands were recorded. In many cases, this process involved estimating the total value placed on wetlands for that function or service and dividing by the number of acres of wetlands recorded in the study or estimated from other sources. All estimates were standardized using a 6-percent discount rate and a 50-year accounting period. Estimates in foreign currencies were converted to U.S. nominal dollar equivalents using appropriate exchange rates. Nominal dollar values were adjusted to 1992 constant dollar terms using the Gross Domestic Product implicit price deflator for the year to which the information in the study related.

Appendix table 1—Illustrative wetland functions and estimated values

Wetland function	Good or service	Economic value	Willingness to pay Dollars/respondent/year				Real value per acre[1] 1992 dollars/acre			Location and wetland type	Year	Deflator	Source
			Mean	Low	High	Interval	Mean	Low	High				
Marketed goods													
Shellfish life support	Blue crabs	VAMP[2]	na	na	na	na	$7	na	na	Florida, Gulf coastal wetlands	1981	1.517	Lynne, and others, 1981
Shellfish life support	Blue crabs	Change in surplus	na	na	na	na	$22	$16	$30	Florida, Gulf coastal wetlands	1986	1.241	Fischer, and others, 1986
Fish/shellfish life support	Fish/shellfish	VAMP[2]	na	na	na	na	$547	na	na	Louisiana, coastal wetlands	1983	1.368	Farber and Costanza, 1987
Fish/shellfish life support	Fish/shellfish	VAMP[2]	na	na	na	na	$702	$651	$702	Louisiana, coastal wetlands	1990	1.068	Farber, 1995
Shellfish life support	Oysters	VAMP[2]	na	na	na	na	$1,205	$35	$4,372	Virginia, coastal wetlands	1978	1.961	Batie and Wilson, 1979
Fish/shellfish life support	Fish/shellfish	VAMP[2]	na	na	na	na	$1,259	na	na	Florida, Gulf coastal wetlands	1976	2.242	Bell, 1989
Fish life support	Fish	VAMP[2]	na	na	na	na	$1,390	$696	$2,783	Lake St. Clair, Michigan	1986	1.241	Amacher, and others, 1989
Fish life support	Fish	Fish harvest	na	na	na	na	$43,928	na	na	Morton Bay, Queensland, Australia	1990	1.068	Morton, 1990
Marketed goods-fish/shellfish life support (number, mean, median)						8	$6,132	$702					
Furs	Fur trapping	Fur harvest	na	na	na	na	$13	na	na	United States	1975	2.370	Chabreck, 1979
Furs	Fur trapping	VAMP[2]	na	na	na	na	$261	na	na	Louisiana, coastal wetlands	1983	1.368	Farber and Costanza, 1987
Marketed goods-furs (number, mean, median)						2	$137	na					
Human life support	Crops, fuelwood, fishing	VAMP[2]	na	na	na	na	$99	na	na	Nigeria, floodplain wetlands	1989	1.115	Barbier, 1994
Nonmarketed goods													
Fish and wildlife habitat-nonuser values													
General	Habitat	WTP[3]	$21	$16	$29	95%	$115	$88	$154	Caithness flow, Scotland, forested peats	1991	1.028	Hanley and Craig, 1991
General	Habitat	WTP[3]	$114	na	na	na	$1,155	na	na	New England	1995	0.929	Stevens, and others, 1995
General	Habitat	WTP[3]	na	$175	$298	model	$1,248	$865	$1,632	Alberta, Canada	1993	0.975	Phillips, and others, 1993
General	Habitat	WTP[3]	$24	$10	$39	95%	$2,850	$1,165	$4,536	Nebraska, Rainwater Basin	1996	0.929	Poor, 1997
General	Habitat	WTP[3]	$127	$64	$190	95%	$14,916	$7,487	$22,345	Nebraska, Rainwater Basin	1996	0.929	Poor, 1997
General	Habitat	WTP[3]	$3	$2	$5	95%	$15,956	$10,079	$21,857	Austria Donau-Auen Danube, riparian wetlands	1993	0.975	Kosz, 1996
General	Habitat	WTP[3]	$11	$7	$14	95%	$49,850	$31,489	$68,286	Austria Donau-Auen Danube, riparian wetlands	1993	0.975	Kosz, 1996
General	Recreation	WTP[3]	$11	$5	$17	na	$52,848	$24,679	$80,532	Western Kentucky	1989	1.115	Whitehead and Blomquist, 1991

See notes at end of table.

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Appendix table 1—Illustrative wetland functions and estimated values—Continued

Wetland function	Good or service	Economic value	Willingness to pay (Dollars/respondent/year) Mean	Low	High	Interval	Real value per acre[1] (1992 dollars/acre) Mean	Low	High	Location and wetland type	Year	Deflator	Source
General	Habitat	WTP[3]	$14	$9	$20	95%	$68,055	$42,989	$93,223	Austria Donau-Auen Danube, riparian wetlands	1993	0.975	Kosz, 1996
General	Habitat	WTP[3]	$28	$18	$39	95%	$133,860	$84,558	$183,366	Austria Donau-Auen Danube, riparian wetlands	1993	0.975	Kosz, 1996
General	Habitat	WTP[3]	$152	$123	$188	90%	$309,511	$250,459	$382,816	San Joaquin Valley, California	1989	1.115	Hannemann, and others, 1990; Loomis, and others, 1990
General	Habitat	WTP[3]	$251	$235	$268	90%	$347,548	$325,394	$371,087	San Joaquin Valley, California	1989	1.115	Hannemann, and others, 1990; Loomis, and others, 1990
Nonmarketed-fish and wildlife-nonuser-general (number, mean, median)						12	$83,159	$32,903					
Nonmarketed-fish and wildlife-user values													
General	Habitat	WTP[3]	$103	na	na	na	$105	na	na	Louisiana, coastal wetlands	1983	1.368	Farber and Costanza, 1987
General	Various values	Rep[4]/Dam[5]	na	na	na	na	$286	$93	$479	North Dakota, prairie potholes	1993	0.975	Leitch and Hovde, 1996
General	User/owner values	Rep[4]/Dam[5]	na	na	na	na	$591	$168	$1,013	North Dakota, prairie potholes	1993	0.975	Leitch and Hovde, 1996
General	Habitat	WTP[3]	na	$174	$201	model	$655	$302	$1,008	Alberta, Canada	1993	0.975	Phillips, and others, 1993
General	Habitat	WTP[3]	na	$5	$7	na	$3,578	$3,067	$4,089	Austria Donau-Auen Danube, riparian wetlands	1993	0.975	Kosz, 1996
General	Various values	MVP,[6] WTP,[3] Rep[4]	na	na	na	na	$9,859	$9,142	$9,859	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Nonmarketed-fish and wildlife-user-general (number, mean, median)						6	$2,512	$623					
Freshwater fishing	Fishing	WTP[3]	decrease	$15	na	1986$	$95	na	na	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Saltwater fishing	Fishing	WTP[3]	decrease	$56	na	1986$	$356	na	na	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Fishing	Fishing	TC[7]	na	na	na	na	$273	$224	$323	Lake St. Clair, Michigan	1986	1.241	Amacher, and others, 1989
Fishing	Fishing	UDV[8]	na	$257	$353	na	$362	$280	$444	Massachusetts, riverine wetlands	1977	2.110	Thibodeau and Ostro, 1981

See notes at end of table.

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Appendix table 1—Illustrative wetland functions and estimated values—Continued

Wetland function	Good or service	Economic value	Willingness to pay (Dollars/respondent/year) Mean	Low	High	Interval	Real value per acre[1] (1992 dollars/acre) Mean	Low	High	Location and wetland type	Year	Deflator	Source
Fishing	Fishing	WTP[3]	$47	na	na	na	$942	na	na	Lake St. Clair, Canada	1985	1.276	van Vuuren and Roy, 1993
Fishing	Fishing	WTP[3]	na	na	na	na	$15,126	$3,725	$26,528	Florida, coastal wetlands	1976	2.242	Bell, 1989
Fishing	Fishing	WTP[3]	na	na	na	na	$28,845	$14,413	$43,257	Lake St. Clair, Michigan	1986	1.241	Amacher, and and others
Nonmarketed-fish and wildlife-user-fishing (number, mean, median)						7	$6,571	$362					
Waterfowl hunting	Hunting	UDV[8] per bird, drought	na	$0	$2 pair/brood		$18	$7	$28	Saskatchewan, Canada	1993	0.975	Van Cooten, 1993
Trapping	Trapping	WTP[3]	$5	na	na	na	$108	na	na	Lake St. Clair, Canada	1985	1.276	van Vuuren and Roy, 1993
Waterfowl hunting	Hunting	WTP[3]	decrease	$25	na	1986$	$156	$145	$156	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Waterfowl hunting	Hunting	UDV[8] per bird, nondrought	na	$11	$16 pair/brood		$209	$173	$246	Saskatchewan, Canada	1993	0.975	Van Cooten, 1993
Waterfowl hunting	Public hunting	WTP[3]	$11	na	na	na	$215	na	na	Lake St. Clair, Canada	1985	1.276	van Vuuren and Roy, 1993
Hunting and fishing	Hunting	WTP[3]	na	$262	$265	model	$1,031	$542	$1,519	Alberta, Canada	1993	0.975	Phillips, and others, 1993
Waterfowl hunting	Hunting	UDV[8]	$575	na	na	na	$1,060	na	na	Massachusetts, riverine wetlands	1977	2.110	Thibodeau and Ostro, 1981
Small game hunting	Hunting	UDV[8]	$316	na	na	na	$1,066	na	na	Massachusetts, riverine wetlands	1977	2.110	Thibodeau and Ostro, 1981
Waterfowl hunting	Hunting clubs	WTP[3]	$97	$21	$115	size	$1,960	$414	$2,316	Lake St. Clair, Canada	1985	1.276	van Vuuren and Roy, 1993
Hunting,fishing, and trapping	Hunting/fishing	WTP[3]	$114	$84	$131	size	$2,283	$1,680	$2,639	Lake St. Clair, Canada	1985	1.276	van Vuuren and Roy, 1993
Waterfowl hunting	Hunting	Hunting experience/ existence value	na	na	na	na	$3,101	$2,190	$4,013	Massachusetts, marshes	1970	3.268	Gupta and Foster, 1975
Nonmarketed-fish and wildlife-user-hunting (number, mean, median)						11	$1,019	$1,031					
Recreation	Recreation	WTP,[3] TC[7]	na	na	na	na	$91	$40	$129	Louisiana, coastal wetlands	1983	1.368	Farber and Costanza, 1987
Recreation	Recreation	WTP[3]	$24	$19	$29	95%	$115	$90	$140	Western Kentucky	1990	1.068	Whitehead, 1992
Birds	Habitat	WTP[3]	$43	$29	$61	95%	$131	$86	$183	Caithness flow Scotland, forested peats	1991	1.028	Hanley and Craig, 1991

See notes at end of table.

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Appendix table 1—Illustrative wetland functions and estimated values—Continued

Wetland function	Good or service	Economic value	Willingness to pay: Dollars/respondent/year				Real value per acre[1]: 1992 dollars/acre			Location and wetland type	Year	Deflator	Source
			Mean	Low	High	Interval	Mean	Low	High				
Recreation	Recreation	WTP[3]	$360	na	na	na	$160	na	na	Louisiana delta, 7 parishes	1987	1.203	Bergstrom, and others, 1990
Recreation	Recreation	WTP[3]	$323	na	na	na	$327	na	na	Louisiana, coastal wetlands	1983	1.368	Farber and Costanza, 1987
Recreation	Coastal recreation, total	WTP[3]	decrease	$96	na	1986$	$607	$563	$607	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Nature study	Recreation	UDV[8]	$316	na	na	na	$3,393	na	na	Massachusetts, riverine wetlands	1977	2.110	Thibodeau and Ostro, 1981
Recreation	Recreation	WTP[3]	$37	$31	$42	wq improvements	$4,287	$2,428	$5,501	Cornbelt, riparian wetlands	1987	1.203	Lant and Roberts, 1990
Nonmarketed-fish and wildlife-user-recreation (number, mean, median)						8	$1,139	$244					
Nonmarketed-ecological functions													
Wastewater treatment	Nutrient filtering/retention	Rep[4]	na	na	na	na	$1	$0.46	$1	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Life support-Biologic	Various functions	Rep[4]	na	na	na	na	$2	$2	$2	Sweden, freshwater wetlands	1989	1.115	Folke, 1991
Life support-Hydrologic	Various functions	Rep[4]	na	na	na	na	$6	$1	$11	Sweden, freshwater wetlands	1989	1.115	Folke, 1991
Storm protection	Storm damage	Dam[5]	na	na	na	na	$17	$15	$19	Louisiana, coastal wetlands	1980	1.656	Farber, 1987
Life support-Biogeochemical	Various functions	Rep[4]	na	na	na	na	$20	$14	$27	Sweden, freshwater wetlands	1989	1.115	Folke, 1991
Aquifer recharge	Water supply	Rep[4]	na	na	na	na	$37	$34	$37	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Storm protection	Storm damage	Rep[4]	na	na	na	na	$74	$72	$77	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Life support-Total	Various functions	Rep[4]	na	na	na	na	$1,659	$882	$2,435	Sweden, freshwater wetlands	1989	1.115	Folke, 1991
Water quality improvement	Riparian filtering	WTP[3]	$43	$38	$47	wq improvements	$2,428	$835	$5,671	Cornbelt, riparian wetlands, outer 10 meters	1987	1.203	Lant and Roberts, 1990
Flood control	Short-term flood storage	Dam[5]	na	na	na	na	$3,916	na	na	Massachusetts, riverine wetlands	1971	3.106	USACE, 1971
Water quality improvement	Riparian filtering	WTP[3]	$43	$38	$47	wq improvements	$5,501	$1,688	$13,694	Cornbelt, riparian wetlands,	1987	1.203	Lant and Roberts, 1990
Property buffering	Property protection	Reduced service flows	na	na	na	na	$8,435	$7,822	$8,435	Louisiana, coastal wetlands	1990	1.068	Farber, 1996
Waste assimilation	Nutrient filtering/retention	Rep[4]	na	na	na	na	$51,874	na	na	Massachusetts, riverine wetlands	1977	2.110	Thibodeau and Ostro, 1981
Flood control	Short-term flood storage	Dam[5]	na	na	na	na	$66,233	na	na	Massachusetts, riverine wetlands	1977	2.110	Thibodeau and Ostro, 1981

See notes at end of table.

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Appendix table 1—Illustrative wetland functions and estimated values—Continued

Wetland function	Good or service	Economic value	Willingness to pay (Dollars/respondent/year)				Real value per acre[1] (1992 dollars/acre)			Location and wetland type	Year	Deflator	Source
			Mean	Low	High	Interval	Mean	Low	High				
Nitrogen assimilation	Nutrient filtering/ retention	Rep[4]	$4,044	$2,696	$6,269	na	$68,091	$45,394	$105,568	Gotland, Sweden	1990	1.068	Gren, 1995
Water supply	Water quantity and quality	Rep[4]	na	na	na	na	$137,247	na	na	Massachusetts, marshes	1970	3.268	Gupta and Foster, 1975
Water supply	Water quantity and quality	Rep[4]	na	na	na	na	$200,994	na	na	Massachusetts, riverine wetlands	1977	2.110	Thibodeau and Ostro, 1981
Nonmarketed-ecological functions (number, mean, median)						17	$32,149	$2,428					
Nonmarketed-amenity/cultural functions													
Visual amenity	Scenic/open space	MHV[9]	na	na	na	na	$83	$26	$109	Lake St. Clair, Michigan	1986	1.241	Amacher, and others, 1989
Visual amenity	Scenic/open space	MHV[9]	na	na	na	na	$323	na	na	Massachusetts, riverine wetlands	1977	2.110	Thibodeau and Ostro, 1981
Visual amenity	Scenic/open space	MHV[9]	na	na	na	na	$573	($886)	$2,306	Ramsey County, Minnesota	1990	1.068	Doss and Taff, 1993, 1996
Visual/cultural	Scenic/cultural	WTP[3]	na	$3,684	$5,769	na	$9,910	$4,500	$15,320	Massachusetts, marshes	1970	3.268	Gupta and Foster, 1975
Recreation and amenity	Scenic/recreation	WTP[3]	$119	$105	$132	95%	na	na	na	Broadland fens, U.K.	1991	1.028	Bateman, and others, 1995
Recreation and amenity	Scenic/recreation	WTP[3]	$152	$140	$142	95%	na	na	na	Broadland fens, U.K.	1991	1.028	Bateman, and others, 1995
Recreation and amenity	Scenic/recreation	WTP[3]	$248	$133	$462	95%	na	na	na	Broadland fens, U.K.	1991	1.028	Bateman, and others, 1995
Recreation and amenity	Scenic/recreation	WTP[3]	$22	na	na	na	na	na	na	Broadland fens, U.K.	1991	1.028	Gren, and others, 1994
Recreation and amenity	Scenic/recreation	WTP[3]	$7	na	na	na	na	na	na	Broadland fens, U.K.	1991	1.028	Gren, and others, 1994
Nonmarketed-amenity/cultural functions (number, mean, median)						4	$2,722	$448					

na = not available. [1]Published values standardized to 6-percent discount rate over a 50-year accounting period and converted to 1992 U.S. dollars. [2]VAMP = Value of annual marginal product. [3]WTP = Willingness to pay. [4]REP = Replacement value. [5]Dam = Damages avoided. [6]MVP = Marginal value of production. [7]TC = Travel cost. [8]UDV = User day values. [9]MHV = Marginal housing value.

Appendix II—Wetland Trend Data, Methods, and Results

The primary sources of information on the national status and trend in wetland acreage are five studies: An estimate of wetland extent in 1780 and 1980 by the Fish and Wildlife Service, two statistical estimates of wetland extent and change from 1954-74 and 1974-83 by the Fish and Wildlife Service, the 1982-1992 National Resources Inventory conducted by Natural Resources Conservation Service, and a compilation of State and Federal wetland estimates reported in 1996 (Dahl, 1990; Dahl and Johnson, 1991; Frayer, and others, 1983; Heimlich and Melanson, 1995; USDI-USGS, 1996). A third study by the U.S. Fish and Wildlife Service was released in draft as this report went to press, but is not included in the estimates derived here (Opheim, 1997). Most of these inventories (except Dahl, 1990, and USDI-USGS, 1996) produce estimates based on samples of wetland change at points or sample plots, with the plot or point acreage multiplied by a statistical expansion factor to represent remaining U.S. wetlands.

Unfortunately, more wetlands are generally inventoried at the early date of succeeding inventories in each of these multi-period survey efforts, although it is clear that U.S. wetland resources continue to be reduced. These inconsistencies result from changes in focus from waterfowl habitat to all wetlands, changes in wetland definition, differences in geographic scope, improvements in survey materials used by Fish and Wildlife Service technicians, and increasing knowledge and experience with wetlands by Natural Resources Conservation Service field technicians. Thus, inventories for 1954 done in 1954 and in the early 1980's resulted in an apparent increase in U.S. wetlands from 74.4 million acres of wetlands for waterfowl habitat to 108.1 million acres of all wetlands. The inventory for 1974 done using black and white photography in the early 1980's shows 99 million acres, but use of better infrared photography in inventories done in the late 1980's show an increase in wetlands to 105.9 million acres, resulting in an adjustment of the earlier figure. Wetland acreage in 1982 was adjusted between the 1982 and 1992 National Resources Inventory inventories (excluding Federal wetlands), increasing from 78.4 million to 112.2 million acres. The 1780 wetland acreages, although based on a variety of sources with more or less credibility, raise questions in States where the acreage of wetlands estimated in 1780 is less than the acreage inventoried in modern inventories.

Differences in coverage between National Wetland Status and Trends Analysis inventories conducted by the U.S. Fish and Wildlife Service and the National Resources Inventory, conducted by USDA's Natural Resources Conservation Service of the U.S. Department of Agriculture, result in differences in wetland inventory results. For example, the National Wetland Status and Trends Analysis inventories development in urban areas as "urban," while the National Resources Inventory includes development for rural transportation, housing, and industry in rural areas. Clearly, any attempt to develop a systematic, consistent picture of the change in U.S. wetland acreage from 1780 to 1992 using these data must entail some process of adjustments from the published data to account for differences in scope and changes in wetlands inventoried over time. Recognizing the problems of inconsistent inventory methods, Vice-President Gore's Clean Water Action plan calls for USDA and USDI to use common data and reference points in carrying out future wetland inventories (Gore, 1997).

The estimates reported here involve three adjustments:

- Adjusting 1780 estimates where they are lower than later inventories;
- Adding an estimate of Federal wetlands to the 1982 and 1992 National Resources Inventory data; and
- "Benchmarking" the level of wetlands to more recent, higher estimates so that the series shows the decline in wetlands over time.

Adjusting 1780 Estimates

First, estimated acreages in 1780 for States that are less than modern State acreage estimates are increased to the extent of hydric soils present in the State, adjusted for the ratio of State 1992 National Resources Inventory wetlands to 1992 National Resources Inventory wetlands on hydric soils. The rationale is that hydric soils retain evidence of soil development under anaerobic conditions typical of permanently or seasonally saturated soils. Hydric soils thus indicate past wetland conditions, even if their hydrology and vegetation has been altered to remove them from wetland status in the present. Adjusting for the ratio of total wetlands to wetlands on hydric soils accounts for the fact that not all wetlands are inventoried as occurring on hydric soils, either because they are known to occur on nonhydric soils or because soil information is missing. Comparison of Dahl's 1780 estimate with the 1954 estimates (adjusted below to total 115 million acres) shows more wetlands in 1954 than in 1780 in Georgia, Oregon, Idaho, and Vermont. Comparing Dahl's 1780 estimate with the 1992 National Resources Inventory (totaling 111.4 million acres) shows more wetlands in 1992 than 1780 in an additional five States: New York, Montana, Kansas, Utah, and New Hampshire (see appendix table 2).

A very conservative adjustment would be to replace the existing numbers in the four States with the hydric soils, increased by the ratio of total 1992 wetlands to 1992 wetlands on hydric soils, where this results in larger acreage. In the case of Oregon and Idaho, the existing 1780 estimate is larger than the adjusted hydric acreage. This adjustment results in a new 1780 total of 221.9 million acres, an increase of about 700,000 acres. A more liberal adjustment would be to replace all of the 1780 estimates in the States above with the adjusted hydric acreage, where larger. This results in a new 1780 total of 224.3 million acres, an increase of about 3.2 million acres. The more liberal adjustment for all States was used.

Adding Federal Wetlands to the 1992 National Resources Inventory

The second adjustment adds an estimate of Federal wetland acreage by State to National Resources Inventory estimates of non-Federal wetlands to make them more comparable with Fish and Wildlife Service National Wetland Status and Trends Analysis estimates of total wetland acreage. This adjustment was accomplished by dipping the point location of the northeast corner of each of the approximately 3,600 National Wetland Status and Trends Analysis sample plots into a geographic information system coverage of Federal land ownership (at a scale of 1:2,000,000) to estimate the proportion of points that are in Federal ownership. When expanded, this is a useable estimate of federally owned wetland acreage. Because of the checkerboard pattern of much Federal ownership in the West, which is not reflected in the small-scale geographic coverage, the acreage estimates in the 17 western States were halved to reflect that acreage in National Wetland Status and Trends Analysis plots occurring on Federal land is likely to include substantial acreages of private land. This procedure results in an estimated 12.5 million acres of Federal wetlands, which is remarkably consistent with an earlier estimate of Federal wetland acreage made by Dale Pierce, of the Fish and Wildlife Service (Heimlich and Langner, 1986).

Appendix table 2—Adjustment of 1780 wetland estimates, selected States

State	Dahl (1990) 1780	Adjusted 1954	NRI 1992	Adjusted 1780
		Thousand acres		
Georgia	6,843.2	**7,928.2**	6,646.2	7,211.1
New York	2,562.0	1,088.4	**3,717.5**	3,417.0
Oregon	2,262.0	**2,265.0**	902.9	2,262.0
Montana	1,147.0	359.4	**1,256.3**	2,184.6
Idaho	877.0	**1,128.1**	679.7	877.0
Kansas	841.0	488.1	**915.1**	1,000.7
Utah	802.0	722.5	**1,069.0**	833.9
Vermont	341.0	**360.8**	**710.0**	726.6
New Hampshire	220.0	182.2	**476.1**	599.4
Nine-State total	15,895.2	14,522.7	16,372.8	19,112.3

Numbers have been bolded for emphasis.
Source: ERS, USDA analyses of various data.

Benchmarking to Recent Wetland Totals

The final adjustment is to benchmark all the modern estimates of wetland acreage to a single level, preserving the observed changes between inventories and rates of change over the inventory periods, but providing for a monotonic decrease in U.S. wetland acreage from 1780 to 1992. Because of differences between methods, both the most recent estimate from U.S. Geological Survey (1996), totaling 113.3 million acres, and the 1992 National Resources Inventory estimate (totaling 123.9 million acres) were used as benchmarks, providing a range of estimated wetland acreages for each inventory date (1954, 1974, 1982-3, and 1992).

Results of Adjustments

The results of all three adjustments are shown in appendix table 3. The first series has the liberal adjustment to 1780 estimates and is controlled by the 1996 U.S. Geological Survey acreage. In this series, wetland acreage declines from 224.4 million acres in 1780 to 113.3 million acres in 1992. The second series also has the liberal adjustment to 1780 estimates, but is controlled by the 1992 National Resources Inventory estimate, plus the estimated Federal wetlands acreage. Thus, the most recent estimate of U.S. wetlands ranges from 113.3 million to 123.9 million acres, which is 50 to 55 percent of 1780 wetlands.

Appendix table 3—Alternative adjusted historical statistics on wetlands

Wetland region	State	1996 USGS high land controls[1] Adjusted 1780 FWS[3]	Adjusted 1954 NWSTA[4]	Adjusted 1974 NWSTA[5]	1982 NRI + Federal[2]	1992 NRI + Federal[2]	1992 NRI + Federal controls[2] Adjusted 1780 FWS[3]	Ajusted 1954 NWSTA[4]	Adjusted 1974 NWSTA[5]	1982 NRI + Federal[2]	1992 NRI + Federal[2]
Total		224,355.5	125,831.6	116,678.4	114,086.5	113,296.7	224,346.8	136,480.4	127,327.2	124,735.2	123,945.4
Central Plains (CP) wetland region:											
CP	KS	1,000.7	313.4	444.8	427.4	435.4	1,000.7	793.1	924.5	907.1	915.1
CP	NE	2,910.5	2,186.9	1,999.1	1,901.5	1,905.5	2,910.5	1,487.3	1,299.5	1,201.9	1,205.9
CP	OK	2,842.6	832.4	945.1	922.3	949.7	2,842.6	380.0	492.7	469.9	497.3
CP subtotal		6,753.8	3,332.8	3,389.1	3,251.2	3,290.6	6,753.8	2,660.5	2,716.8	2,578.9	2,618.3
Delta and Gulf (DL) wetland region:											
DL	AR	9,848.6	4,251.3	2,699.0	2,762.9	2,763.6	9,848.6	4,627.8	3,075.5	3,139.4	3,140.1
DL	LA	16,194.5	11,204.3	9,463.7	8,916.0	8,784.2	16,194.5	13,614.7	11,874.1	11,326.4	11,194.6
DL	MS	9,872.0	5,887.7	4,174.6	3,998.6	4,067.0	9,872.0	7,495.7	5,782.6	5,606.6	5,675.0
DL	TN	1,937.0	873.9	811.2	786.0	787.0	1,937.0	892.4	829.7	804.5	805.5
DL	TX	15,999.7	7,471.5	7,707.8	7,630.6	7,612.4	15,999.7	5,514.7	5,751.0	5,673.7	5,655.5
DL subtotal		53,851.8	29,688.7	24,856.3	24,094.1	24,014.2	53,851.8	32,145.3	27,312.9	26,550.7	26,470.8
Mountain (MT) wetland region:											
MT	AZ	931.0	469.6	579.4	579.4	600.0	931.0	100.7	210.5	210.5	231.1
MT	CO	2,000.0	1,010.0	1,015.0	1,002.4	1,000.0	2,000.0	701.0	706.0	693.4	691.0
MT	ID	877.0	381.8	390.5	391.1	385.7	877.0	921.9	930.6	931.2	925.8
MT	NV	487.4	340.9	243.2	238.5	236.4	487.4	430.4	332.7	328.0	325.9
MT	NM	720.0	474.6	481.3	481.3	481.9	720.0	76.7	83.4	83.4	84.0
MT	UT	833.9	594.9	593.2	577.7	558.0	833.9	1,284.0	1,282.3	1,266.8	1,247.1
MT	WY	2,000.0	1,244.7	1,250.6	1,250.6	1,250.0	2,000.0	926.4	932.3	932.3	931.7
MT subtotal		7,849.3	4,516.5	4,553.2	4,521.0	4,512.0	7,849.3	4,441.1	4,477.8	4,445.6	4,436.6
Midwest (MW) wetland subregion:											
MW	IL	8,212.0	1,435.9	1,281.8	1,289.2	1,254.5	8,212.0	1,542.3	1,388.2	1,395.6	1,360.9
MW	IN	5,600.0	816.4	811.6	815.3	813.0	5,600.0	772.2	767.4	771.1	768.8
MW	KY	1,566.0	613.7	635.0	639.5	650.0	1,566.0	410.6	431.9	436.4	446.9
MW	MI	11,200.0	6,465.1	6,327.5	6,315.2	6,244.4	11,200.0	7,675.2	7,537.6	7,525.3	7,454.5
MW	MN	15,070.0	11,713.1	11,048.4	10,726.5	10,700.0	15,070.0	12,751.1	12,086.4	11,764.5	11,738.0
MW	MO	4,844.0	593.0	626.9	627.0	643.0	4,844.0	935.4	969.3	969.4	985.4
MW	OH	5,000.0	470.9	497.0	502.7	482.8	5,000.0	925.3	951.4	957.1	937.2
MW	WI	9,800.0	5,501.4	5,390.6	5,382.4	5,331.4	9,800.0	6,716.3	6,605.5	6,597.3	6,546.3
MW subtotal		61,292.0	27,609.5	26,618.8	26,297.8	26,119.1	61,292.0	31,728.3	30,737.6	30,416.6	30,237.9

See notes at end of table.

--Continued

Appendix table 3—Alternative adjusted historical statistics on wetlands—Continued

		1996 USGS high land controls[1]					1992 NRI + Federal controls[2]				
Wetland region	State	Adjusted 1780 FWS[2]	Adjusted 1954 NWSTA[3]	Adjusted 1974 NWSTA[4]	1982 NRI + Federal[2]	1992 NRI + Federal[2]	Adjusted 1780 FWS[3]	Ajusted 1954 NWSTA[4]	Adjusted 1974 NWSTA[5]	1982 NRI + Federal[2]	1992 NRI + Federal[2]
Northeast (NE) wetland subregion:											
NE	CT	670.0	208.8	182.2	179.3	172.5	670.0	397.4	370.8	367.9	361.1
NE	DE	479.8	299.9	262.7	226.5	223.1	479.8	340.0	302.8	266.6	263.2
NE	ME	6,460.0	6,450.7	6,464.5	6,470.7	6,460.0	6,460.0	5,512.6	5,526.4	5,532.6	5,521.9
NE	MD	1,658.7	617.2	596.9	597.8	591.6	1,650.0	1,053.6	1,033.3	1,034.2	1,028.0
NE	MA	818.0	620.4	616.9	621.5	588.5	818.0	626.1	622.6	627.2	594.2
NE	NH	599.4	582.0	604.2	605.0	591.4	599.4	466.6	488.8	489.7	476.1
NE	NJ	1,500.0	960.2	933.9	934.6	916.0	1,500.0	744.3	718.0	718.7	700.1
NE	NY	3,417.0	2,391.7	2,418.0	2,419.4	2,400.0	3,417.0	3,709.2	3,735.5	3,736.9	3,717.5
NE	PA	1,127.0	415.5	423.2	422.2	404.0	1,127.0	959.3	967.0	966.0	947.8
NE	RI	102.7	69.6	69.4	69.4	65.2	102.7	100.5	100.3	100.3	96.1
NE	VT	726.6	367.0	370.7	371.6	364.5	726.6	712.5	716.2	717.1	710.0
NE	WV	134.0	97.4	102.0	102.8	102.0	134.0	94.6	99.2	100.0	99.2
NE subtotal		17,693.2	13,080.3	13,044.5	13,020.8	12,878.8	17,684.5	14,716.7	14,680.9	14,657.2	14,515.2
Pacific (PA) wetland subregion:											
PA	CA	5,000.0	1,469.5	1,214.6	1,254.2	1,235.9	5,000.0	2,134.4	1,879.5	1,919.1	1,900.8
PA	OR	2,262.0	1,592.6	1,123.6	1,495.6	1,500.0	2,262.0	1,522.9	1,053.9	1,425.9	1,430.3
PA	WA	1,350.0	966.1	949.7	950.5	938.0	1,350.0	1,040.1	1,023.7	1,024.5	1,012.0
PA subtotal		8,612.0	4,028.2	3,287.9	3,700.3	3,673.9	8,612.0	4,697.4	3,957.1	4,369.5	4,343.1
Prairie Pothole (PP) wetland subregion:											
PP	IA	4,000.0	497.1	416.5	420.0	421.9	4,000.0	1,257.9	1,177.3	1,180.8	1,182.7
PP	MT	2,184.6	499.9	824.1	823.5	840.3	2,184.6	1,022.2	1,346.4	1,345.9	1,362.7
PP	ND	4,927.5	2,523.3	2,637.6	2,505.4	2,490.0	4,927.5	3,858.0	3,972.3	3,840.1	3,824.7
PP	SD	2,735.1	2,101.9	1,779.2	1,771.8	1,780.0	2,735.1	2,466.0	2,143.3	2,135.9	2,144.1
PP subtotal		13,847.2	5,622.2	5,657.4	5,520.7	5,532.2	13,847.2	8,604.2	8,639.4	8,502.7	8,514.2
Southeast (SE) wetland subregion:											
SE	AL	7,567.6	3,280.5	3,145.3	3,115.0	3,100.0	7,567.6	3,917.8	3,782.6	3,752.3	3,737.3
SE	FL	20,325.0	12,906.4	11,461.4	11,202.1	11,038.6	20,325.0	13,119.0	11,674.0	11,414.7	11,251.2
SE	GA	7,211.1	8,000.6	7,854.2	7,786.7	7,714.3	7,211.1	7,242.8	7,096.4	7,028.8	6,956.4
SE	NC	11,089.5	7,828.7	6,975.9	5,777.1	5,689.5	11,089.5	7,398.4	6,545.6	5,346.8	5,259.2
SE	SC	6,414.0	4,820.8	4,735.9	4,690.6	4,659.0	6,414.0	4,040.0	3,955.1	3,909.8	3,878.2
SE	VA	1,849.0	1,116.4	1,098.5	1,109.2	1,074.6	1,849.0	1,768.9	1,751.0	1,761.7	1,727.1
SE subtotal		54,456.2	37,953.4	35,271.2	33,680.7	33,276.0	54,456.2	37,486.9	34,804.7	33,214.1	32,809.4

[1]USDI-USGS (1996). [2]Heimlich and Melanson (1995). [3]Dahl (1990). [4]Frayer, and others (1983). [5]Dahl and Johnson (1991).
Source: ERS analysis of data from the studies cited above.

Appendix III—Estimating Wetland Conversion for Agriculture in the Absence of Swampbuster and Section 404 of the Clean Water Act

Estimating the economic effects of wetland conversion is a two-step process. This appendix provides a detailed description of the methods and data used to make these estimates.

Step One: Estimating Potential Wetland Conversion

Wetlands are considered *potentially convertible* when the net present value (NPV) of expected return to crop production after conversion exceeds total costs of conversion (the NPV of return to land in its wetland condition plus drainage and clearing costs) by a proportion of total costs equal to the landowner's discount rate or a minimum return per acre:

$$\max_j(NPV_j) - NPV_i - CC_i > \max[r(NPV_i + CC_i)\ ,\ m]$$

where NPV_j is the estimated net present value of returns to crop j after drainage (corn, sorghum, barley, oats, wheat, rice, cotton, or soybeans), NPV_i is the opportunity cost of land in its wetland condition use (forestry, pasture, or crop production), CC_i is the cost of draining and clearing land for crop production, r is the landowner's discount rate, and m is the minimum return per acre needed to justify the investment in drainage and clearing for crop production. Net present values are defined over a finite time horizon, which varies by wetland condition land use. For forested wetland, the time horizon is the length of a single forestry rotation. Other sites are assigned a 10-20 year time horizon, depending on the drainage technology used. The minimum return requirement excludes sites where conversion may not be undertaken due to low overall returns.

Potential wetland conversion at baseline prices is estimated for two scenarios. In the **low conversion** scenario we assume r=.06, m=$100 per acre, and exclude land which National Resources Inventory indicates has no probability of conversion to crop production in the foreseeable future. Natural Resources Conservation Service field technicians who collect National Resources Inventory data assess the probability that noncropland sites (including wetlands) will be converted to crop production based on potential agricultural returns, the cost of developing wetlands for crop production, and whether similar land had been converted to crop production in the past 3 years (USDA-SCS, 1991). Since National Resources Inventory estimates of conversion potential are based, in part, on economic considerations, we estimated a **high conversion** scenario, assuming that r=.06 and m=$500 for land where the National Resources Inventory indicates no conversion potential, and r=.06 and m=$100 otherwise. In both cases, wetland sites which are projected to be enrolled in the Conservation Reserve Program are excluded from consideration.[9]

Crop Returns

Eight commonly grown crops are considered: barley, corn, cotton, oats, rice, sorghum, soybeans, and wheat, including summer fallow rotations and double cropping, where appropriate. County-level crop prices are devised as follows: Prices from the posted county price data base for market year 1994 (Murray, 1996) are divided by U.S. average prices from *Agricultural Prices: Annual Summary, 1994* (USDA-NASS, 1994) to obtain a relative price for each county. Relative prices are multiplied by USDA baseline projections (USDA-WAOB, 1997) for national average prices to obtain prices used in the simulation. Site specific crop yields are devised by multiplying county average crop yields for 1991-95, obtained from *Crop Production* (USDA-NASS, various), by an index of relative productivity calculated from the productivity index (PI) developed by Pierce, and others, (1983) and calculated from the Soil Interpretive Record (SIR) database. The relative productivity index for a particular crop is the ratio of site specific PI to average PI for sites within the county where National Resources Inventory cropping history shows production of that crop.

Crop production cost data are at the State level (USDA-ERS 1991, 1993, 1997). The most recent State data, from 1989, are updated to 1995 by multiplying State costs by the ratio of 1995 to 1989 production costs at a regional level. We assume that the

[9]National Resources Inventory points that are most likely to be enrolled in a 36.4-million acre Conservation Reserve Program, given potential economic and environmental benefits, projected by Tim Osborn, Economic Research Service, USDA.

purchase cost of land is sunk and will not enter into the conversion decision and that unpaid operator labor costs will not increase due to wetland drainage.

Pasture Returns

State average pasture rental rates for 1994 are adjusted to site-specific conditions using the productivity index (PI) and to USDA baseline economic conditions using estimates of the percentage change in pasture rental rates from a 1-percent change in beef prices and costs. These estimates are obtained from regional regression models of pasture rents on beef prices and costs. Regional models are specified as:

$$R_{ps} = \prod_s \alpha_s^{d_s} \prod_i X_i^{\beta_i} \in$$

which can be written as:

$$\ln R_{ps} = \sum_s d_s \ln\alpha_s + \sum_i \beta_i \ln X_i + \ln \in$$

where R_{ps} is the State-average pasture rental rate for State s, d_s is a dummy variable for State s, the X's are a beef price and cow-calf cost index, the $\ln\alpha$'s and β's are parameters to be estimated, and $\ln\in$ is an error term. Regions are north-central States (Corn Belt and Lake States farm production regions), the South (the Southeast, Delta, and Appalachian farm production regions), Plains States (Northern and Southern Plains), and the West (Mountain and Pacific Coast States). Estimates are reported in appendix table 4. In the West, parameter estimates for the beef price index and cow-calf cost variables are not significantly different from zero, perhaps because of the large amounts of Federal land on which grazing fees are established by nonmarket procedures. For Western States, average pasture rental rates are assumed to be constant at 1994 levels. Estimated pasture rental rates average $13.06 per acre, but range up to $66 per acre.

Appendix table 4—Estimated percentage change in pasture rental rates (t-ratio in parentheses)

Item	North	South	Plains	West
Beef price index	0.92	0.50	1.11	-0.31
	(8.51)	(6.09)	(6.64)	(-0.44)
Cow-calf costs	-1.42	-1.16	-2.09	.82
	(-22.72)	(-22.34)	(-13.12)	(0.72)

Source: ERS analysis.

Beef price data are from various issues of *Agricultural Prices: Annual Summary* (USDA-NASS, 1994). Cow-calf production costs were obtained electronically from the Economic Research Service, U.S. Department of Agriculture (USDA-ERS, 1996).

Forest Returns

Returns to bottomland hardwood rotations are calculated for 13 Southern States. In the North, where rotation lengths are considerably longer than in the South, forestry is assumed to be a residual land use (that is, wetland that cannot be profitably drained for other uses is retained in forested wetland), although some management may eventually be undertaken to encourage desirable species (Luppold, 1996). In Western States, data limitations preclude estimation of forest opportunity costs.

Bottomland hardwood yields (oak-cypress-gum stands) are from McClure and Knight (1984). Yields for high, medium, and low productivity sites are matched to National Resources Inventory sites using the site index (SI) from the SIR data base. Soils with an SI of less than 60 are classified as low, SI 60-78 as medium, and SI above 78 as high. Hardwood saw timber and pulpwood prices are from Timber Mart South (Norris, 1986). Regeneration costs are from *The South's Fourth Forest* (USDA-FS, 1988). Base prices are a 3-year average and are adjusted up by 1.5 percent per year to match USDA Forest Service projections (Haynes, 1990).

Returns are calculated for a single rotation of 30-40 years, depending on expected prices and site productivity. Rotation length is chosen on the basis of maximum NPV. Timber is assumed to be harvested in a clear-cut operation yielding both saw timber and pulpwood. Returns are estimated for a 6-percent discount rate. The average NPV of expected returns to bottomland hardwood forestry is $137 per acre but ranges up to $442 per acre, depending on site productivity and stumpage prices.

Drainage and Clearing Costs

The cost of drainage, annual drainage maintenance, and land clearing was also estimated by local technical experts (USDA-SCS, 1989) by major land resource area and State. These costs were adjusted to 1995 levels using the index of purchases of nonresidential farm structures (Pavelis, 1996).

Step Two: Estimating Longrun Economic Effects

Commodity price, crop acreage, and farm income effects of the proposed wetland delination change are derived as comparative static impacts of augmenting land supply in the U.S. Regional Agricultural Sector Model (USMP). USMP is an agriculture sector spatial equilibrium model, as described in McCarl and Spreen (1980), that incorporates agricultural commodity supply, use, and policy measures (House, 1987). USMP has been applied to project the effects on U.S. national and regional agriculture of changes in export levels and variability (Miller, and others, 1985), trade agreements (Burfisher, and others,1992), imports (Spinelli, and others, 1996), input taxes (Peters, and others, 1997), irrigation policy (Horner, and others, 1990), ethanol production (House, and others, 1993), wetlands policy (Heimlich, and others, 1997), sustainable agriculture policy (Faeth, 1995), and various other policy and program scenarios.

USMP models production of 10 crops: corn, sorghum, oats, barley, wheat, rice, cotton, soybeans, hay and silage. Sixteen primary livestock production enterprises are included, the principal being dairy, swine, beef cattle, and poultry. Coefficients in crop and livestock enterprise budgets were developed from USDA's National Resources Inventory, Cropping Practices Survey (CPS), and Farm Costs and Returns Survey (FCRS) data. USDA's Economic Research Service and National Agricultural Statistical Service collect CPS and FCRS data. Several dozen processed and retail products are included in the model structure, including dairy products, pork, fed and nonfed beef, poultry, soy meal and oil, livestock feeds, and corn milling products. Acreage, commodity supply/use, Conservation Reserve Program acreage, prices, production practices, and so forth are validated exactly to USDA baseline projections for 2001 (USDA-WAOB, 1997) and corresponding geographic information. For example, USMP's base U.S. corn acreage planted in 2001 equals the USDA baseline projection (80.5 million acres) and corn acreage in each model region/practice stratum is determined by share information from National Resources Inventory and CPS regional data. On the demand side, domestic use, exports, ending stocks, and price levels for crop and livestock commodities and most processed or retail products are endogenously determined within the model structure with domestic consumption, commercial stock, export and other demand functions specified with elasticities from the FAPSIM econometric simulation model (Green and Price, 1987).

We use the regional acreage of potentially convertible wetlands to shift land supply curves in USMP's 45 regions. Regions are specified as the intersection of the 10 USDA Farm Production Regions and the 26 USDA Land Resource Regions (USDA-SCS, 1981). We assume that converted wetlands may then be cropped at the regional marginal cost of production that existed prior to the wetlands conversion. Comparative static adjustments to the wetland delineation acreage shifts explain how the sector changes between the base period and several years later when the change has worked itself out and the sector returns to equilibrium. Changes are recorded in both aggregate indicators, such as U.S. farm income, and detailed indicators, such as acreage in corn-bean rotation in the central Corn Belt. USMP acreage planted and commodity supply response use a positive mathematical programming formulation (Howitt, 1995) with U.S. aggregate commodity supply response calibrated to supply response elasticities from the FAPSIM model. Responses in individual region, tillage practice, rotation and other strata follow nested adjustment functions which are part of the PMP calibration, and sum up to aggregate response. No exogenous bounds or flexibility constraints are used.

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