1987

Status report on the nation's wetlands

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A STATUS REPORT ON THE NATION'S WETLANDS

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B. S., Stephen F. Austin State University, 1980

Presented in partial fulfillment of the requirements

for the degree of

Master of Science

University of Montana

1987

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Dec. 15, 1987

Date

ACKNOWLEDGEMENTS

I wish to thank the National Wildlife Federation, which provided me with the opportunity to work on a subject of this magnitude in a location like Washington, D.C. Not only was I given a free rein in contacting the leading professionals on the subject, I was also allowed considerable license in shaping the content of the final document. The published work for which this paper was the basis, "Status Report on Our Nation's Wetlands," was the product of enumerable revisions and incorporated comments from the many of the best wetland experts in the country. During this process, I was fortunate to have the leadership and guidance of the director of the National Wildlife Federation's Fisheries and Wildlife Division, J. Scott Feierabend, to whom I am deeply indebted.

My work was made much easier by the access to computers, primary information sources, and key agency personnel which came with working for the Federation. Among agency personnel who gave me guidance and insight I particularly wish to thank Dr. Lyndon Lee of the EPA and Mr. Tom Dahl of the USFWS' National Wetlands Inventory. The critical review this paper received from committee members was also very much appreciated.

Finally, I would like to thank my mother and late father, who kept believing in me and were always willing to provide support when I needed it most. This work is dedicated to them.

A STATUS REPORT ON THE NATION'S WETLANDS

INTRODUCTION

The protection of wetlands in the United States is a vital issue which must come to the forefront of our nation's natural resource policy. Less than one-half of the original wetlands acreage remains in the coterminous U.S.. Losses of over 300,000 acres occur annually. Public recognition of the importance of wetlands is of the highest priority if these trends are to be halted. Programs at all levels of government in concert with citizen participation can counter and even reverse the destruction of wetlands, provided that a broad public understanding of wetland values exists and is acted upon. Therefore, it is the purpose of this report to help educate and inform the general public as to why we need wetlands and how we can effectively protect them.

It has been known for some time that the nation's wetlands are imperiled. The U.S. Fish and Wildlife Service (FWS) has long recognized the importance of wetlands as enormously productive wildlife habitat, and through the sale of Duck Stamps and other programs has sought to acquire and protect wetlands since the 1930's. The FWS published a nationwide inventory of the wetlands in 1956, titled Wetlands of the United States. It is

popularly referred to as Circular 39. The authors of this publication recognized the need to curtail wetlands destruction. They recommended cooperative efforts between federal, state, and local authorities to preserve wetlands for waterfowl habitat as a major by-product of all land use planning "before it is too late."[1] How have the nation's wetlands fared in the thirty year period since this appeal was made? In a word, miserably. Between 1954 and 1974, wetlands were destroyed at a net rate of 716 square miles per year. The total acreage of wetlands lost during this period, about 11% of wetlands in the coterminous U.S., covered some 17,000 square miles, an area over twice the size of Massachusetts.[2] Ninety-five percent of this loss was due to human activity.[3]

The following report will show that the loss of wetlands is not something we can afford to take lightly. In providing a variety of essentially "free services" such as wildlife habitat, spawning and rearing areas for economically-important fish and shellfish, buffering zones against storms and floods, recharge and discharge sites for groundwater, and water quality improvement, wetlands are irreplaceable components of the landscape. Few other ecological systems can match either the productivity of wetlands or their ability to perform so

many valuable functions. At the same time wetlands are beautiful places, havens for a multitude of plants and animals and sources of rest and recreation for many people.

Wetlands are defined by the U.S. Fish and Wildlife Service using three parameters: frequency of flooding (hydrology), soils (hydric soils), and plants (hydrophytes or emergent aquatic vegetation). The formal definition developed by the Service over four years of field testing and scientific review describes wetlands as:

> "lands transitional between terrrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season each year."

This definition is also used by the Environmental Protection Agency, the U.S. Army Corps of Engineers, and

recent federal legislation affecting wetlands.

The discussion of wetland types and distribution in this report centers on the two most common wetland systems: estuarine (salt-water dominated) and palustrine (fresh-water). Estuarine wetlands generally exist as either emergent, intertidal, or scrub-shrub systems. Palustrine wetlands most often occur as emergent, scrub-shrub, or forested. Emergent wetlands are marsh-like, scrub-shrub wetlands are bogs or mangrove swamps, and forested wetlands are most often bottomland hardwoods or cypress swamps. The FWS classification scheme also includes such classes as rock bottom, unconsolidated bottom, aquatic bed, rocky shore, unconsolidated shore, and moss-lichen wetlands. These classes are not discussed in this report.

The status of wetlands as addressed in this report is also based largely on information generated by the U.S. Fish and Wildlife Service. The original amount of wetland acreage thought to have existed in the coterminous U.S. has been estimated at 215 million acres.~ Current wetland acreage in the coterminous U.S. is probably less than 95 million acres, using the latest annual loss estimates of 300,000 acres per year and the estimate of wetlands remaining in the mid-1970's (99

million acres). It is important to note this is an estimate based on statistical analyses, and does not represent a thorough inventory of all wetland areas. Such a survey is currently underway via the FWS's National Wetlands Inventory which is expected to be finished by the turn of the century. The primary facts to bear in mind are that today's wetlands represent a fraction of what there once was, and that destruction and degradation of the remaining wetland base continues at an alarming rate.

The U.S. Army Corps of Engineers, as primary stewards of the nation's wetlands, bear the responsibility for issuing permits for any activity construed as a dredge or fill of waters of the U.S. The EPA, U.S. Fish and Wildlife Service, and other federal and state agencies also play roles in wetlands protection. However, if existing efforts were adequate, we would not be continuing to lose wetlands at the rate of 300,000 acres annually. This report looks at these efforts and offers suggestions to enhance them. The conclusion of the report takes what is known about wetland types, values, status, and protection and discusses this information in the context of public education and involvement. Again, the citizenry of the United States must make informed decisions if the destruction of wetlands is to be

stopped. Without popular support backing government programs, the question will not be whether wetlands can be protected, but rather how long they will last.

I. WHAT ARE WETLANDS?

Anyone who has ever walked across a wet meadow and suddenly found himself or herself ankle-deep in water and mud knows what a wetland is. They are the wet places of the world, the places we think of as swamps, bogs, and marshes.

A. Wetland Origins

In some areas of the country, the water table is at the ground surface due to geologic processes and the effects of climate over time in shaping and determining geography. In other places water from precipitation drains through the ground until it reaches layers of nonporous material, at which point it flows laterally. This water may surface as a spring. Along the shores of lakes, ponds, and the ocean water saturates the soil or substrate and creates the basis for a wetland. The edges of streams and rivers can also create saturated soil conditions, sometimes involving discharge from or recharge into the groundwater which flows and percolates beneath the surface. Finally, water from rainfall or snow-melt may simply have no place to drain, just

collecting where it is deposited. This is the case with arctic permafrost tundra where surface layers of the soil remain frozen while the surface thaws from time to time. In areas where clayey soils inhibit drainage, water can collect and in time form the basis for other types of wetlands.

All of the places described above can be wetlands, depending on three principal considerations: frequency of flooding (hydrology), wetland vegetation (hydrophytes), and soils (hydric soils). Hydric soils are covered with water often enough to become oxygen deficient from time to time. The combination of saturated soils, wetland plants, and the availability of water in certain amounts through the growing seasons creates a unique environment. In general, wetlands can occur in any basin that holds water long enough for hydric soils to form and for hydrophytic plants to sprout, take root, and survive.[5]

The diversity of relationships between plants, soils, water, and climate within wetlands provide for a rich variety of wetland types across the continent. Central to what sets wetlands apart from other ecological systems is the adaptations plants have made to survive and thrive in saturated soils. Soils that become saturated no longer have free oxygen available for plant roots.

Oxygen intake through the roots is vital to most plants for growth and the respiration process. Most wetland plants have adapted to this anoxic, stressful condition through the formation of air spaces (aerenchyma) that allow for the passage of oxygen from exposed portions above the waterline down through the stem to the roots.[6] In the case of the water lily (Nuphar luteum), for example, air taken into gas spaces on the surface of young leaves is forced down through aerenchyma to the roots by a slight pressure gradient generated by sunlight warming the leaves. The older leaves cannot support the pressure gradient and so act as return flow gates for carbon dioxide from root respiration.[7]

B. Wetland Types and Distribution

The National Wetlands Inventory, an ongoing component of the U.S. Fish and Wildlife Service's wetlands research efforts, has a detailed classification system for wetlands and associated deepwater habitats. Wetlands are classified within Marine, Estuarine, Riverine, Lacustrine, or Palustrine systems.[8] The Marine system, including the open ocean and associated coastline, is essentially a deepwater habitat with wetlands limited to beaches, rocky shores, and some coral reefs.[9] Estuarine areas include most coastal wetlands, such as tidal salt

marshes, mangroves, coastal rivers, intertidal flats, and some associated deepwater areas.[10] Riverine systems are freshwater river and stream channels and are again mainly deepwater habitats.[11] Lacustrine systems are also deepwater dominated and include lakes, reservoirs, and ponds.[12] The majority of freshwater wetlands are palustrine systems, such as marshes, bogs, and swamps.[13] Because estuarine and palustrine wetlands are the most abundant form, they have received the bulk of study and attention.

1. Estuarine Wetlands

As described by Ralph Tiner in "Wetlands of the United States: Current Status and Recent Trends," the three major types of estuarine wetlands are emergent (such as salt marshes), intertidal flat (mostly unvegetated areas between high and low tide marks), and scrub-shrub (mangrove swamps and other woody vegetation in tidal areas). Because the salt content, or salinity, of seawater requires special adaptations for controlling cell dehydration among the plants and animals living in it, tidal marshes and mangrove wetlands are distinct from freshwater wetlands in their structure and origins.

Estuarine emergent wetlands occur largely on the Atlantic

and Gulf coasts, though they are found on the West coast and the Alaskan coast in some areas. Intertidal flats are most common in Maine and Alaska. Scrub-shrub estuarine wetlands are best represented by the mangrove swamps of the South Florida coast.

2. Palustrine (Freshwater) Wetlands

Freshwater wetlands occur as either Palustrine, Riverine, or Lacustrine wetlands. Palustrine wetlands are the most common form, and are largely grouped within emergent, scrub-shrub, and forested classes. Palustrine systems also occur within rock bottom, unconsolidated bottom, aquatic bed, unconsolidated shore, and moss-lichen wetland classes. These latter classes are not included in the following discussion for the sake of brevity.

a. Palustrine Emergent Wetlands

Emergent wetlands are what most of us think of as marshlands. These are the prairie potholes, freshwater nontidal marshes and tidal marshes with dissolved salt concentrations of less than 0.5%, inland salt marshes, fens, wet meadows, edges of rivers and lakes, and the extensive saturated tundra areas of Alaska.

b. Palustrine Scrub-Shrub Wetlands

Palustrine scrub-shrub wetlands occur as shrub swamps, pocosins (upland boggy areas on the Carolinas' coastal plain), and bogs. Bogs are notable in their variety and the amount of time required for their formation. Northern peat bogs occur in areas where glaciation has scoured the land, forming lakes, ponds, and depressions. Bogs are areas of poorly-drained and acidic substrates due to granitic soils. In addition, nutrients and agents of decomposition, like bacteria, are severly limited. The accumulation of peat from decomposed plant material occurs at a very slow rate on the order of 0.2 to 2 mm (1/25th of one inch) per year.[14] When one considers that some of these bogs have peat layers up to 40 feet thick, a great deal of time is obviously involved in their creation.

c. Palustrine Forested Wetlands

Palustrine forested wetlands are the most abundant wetland type in the Eastern United States.[15] Common forms are red maple swamps, bottomland hardwood forests and swamps, cedar and cypress swamps, black spruce bogs, and Western hemlock and alder wetlands of the Northwest.

d. Riparian Wetlands

Riparian wetlands are also an important wetland type, particularly in the arid and semiarid western U.S. where they provide essential wildlife habitat. "Riparian" is a term used largely in the western states to designate parts of palustrine, riverine, and lacustrine wetlands which lie within and adjacent to streams, rivers, and other waters which periodically flood and deposit nutrient rich alluvial sediments on their flood plains. Major floods can scour out these deposits while flushing the wetland system. The wetlands may occupy narrow stretches along western rivers, or can be several miles wide as in the southern bottomland hardwoods. Rivers can change channels, creating oxbow lakes which eventually fill and become wetlands.

e. Lacustrine Wetlands

Lacustrine wetlands typically occur on the edges of ponds, lakes, and other large bodies of water. Major lakes can provide water for extensive basin wetlands, such as in the Great Lakes region.[16]

Wetlands can also be created biologically, as is the case

with beavers. Beavers dam streams and flood areas which in turn provide habitat for wetland plants, both emergents (those with portions above water) and subemergent or aquatic plants. Blanket bogs of northern forests and sedge meadows can help enlarge and build the wetlands they occupy, while animals such as crayfish, alligators, and others create depressions which trap water and can influence the rate of peat buildup and plant distribution.[17] The foremost biological influence in marshes is plant life. Wetland plants capture and convert sunlight into usable energy for cell growth, build up biomass from their decay, slow water movement, seal off basins, aid in the collection of sediments and nutrients, and protect large areas from the effects of wind.[18] Not to be overlooked are the activites of humans in creating artificial wetlands. Such wetlands can differ greatly from naturally occurring ones in terms of structure and function, but they still fit the formal definition. These areas include reservoirs, farm ponds, mining pits and excavations, and poor drainage areas caused by road construction, levees, irrigation systems, fills, and buildings.[19] Many wetlands have been intentionally created for a variety of purposes, including wildlife habitat and wastewater treatment.

II. WETLAND VALUES AND FUNCTIONS

When we talk about wetland "value", we are often looking at wetlands only in terms of what they represent to humans. This is unfortunate, for two reasons. First, an anthropocentric (or "human-centered") point of view does not recognize the worth of plants, animals, and ecological systems to exist unto themselves. We judge a particular system's worth (in this case, wetlands) on the basis of its usefulness to humans, be it for nature study, recreation, development for condominiums, drainage for crop production, or use as a dumpsite for our unwanted wastes. Secondly, we often fail to appreciate the more subtle or discreet aspects of the natural world, concentrating instead on those things which we derive some benefit from. As a result, we may profoundly disturb the balance of a system by disregarding the ecological implications of our actions. With this in mind, we should not separate wetlands into categories of those useful to humans and those we can do away with.

In the following discussion, the values referred to are mostly human-centered ones. It is, of course, these values that form the basis for the laws and regulations protecting wetlands. Economic values particularly often

determine the way a wetland - or any other ecosystem - will be used. Such a basis for placing values can result in the loss of wetland systems which conflict with more profitable land uses.

Wetlands have been described as having three levels of value: the component, or population, level; the ecosystem level; and the global level.[20] The population level refers to organisms that depend on wetlands to survive.[21] These include animals harvested for pelts (furbearers and the alligator), waterfowl, fish and shellfish, timber and plant products, and endangered and threatened species.

Ecosystem values include flood control, storm abatement, recharge of aquifers, pollution control and water quality improvement, and aesthetics.[22] These values stem from functions a wetland performs as a whole, though not all wetlands are capable of doing all of these things - or even a majority. For example, small wetlands can contribute greatly to groundwater recharge, while a larger one may have very little recharge capability because of the impermeable soils underneath it.[23]

Global values of wetlands are possibly the most discrete because these are attributed to all wetlands systems. It is thought that wetlands play a significant role in the

global cycles of nitrogen, sulfur, methane, and carbon dioxide.[24] Most wetlands receive agricultural runoff waters rich in nitrogen from fertilizers, which they are ideally suited to treat due to their biogeochemistry. Similarly, wetlands can remove sulphur from the environment, which is important when one considers the enormous loads of sulfates fossil-fuel burning puts into the atmosphere.

With the idea of population, ecosystem, and global values in mind, one can understand the difficulty in placing a value on a wetland. This can be compounded by the fact that wetlands usually have a far greater value to society than for the individual landowner.[25] To the developer of an industrial complex on San Francisco Bay, the worth of the marshes as fish and wildlife habitat cannot compare to the profit in dollars realized from construction. Also, wetlands cannot be judged by size alone. The interspersion of wetlands with other parts of the landscape creates a whole environment, with a small wetlands area often playing a tremendous role in the function of the total ecosystem.[26] Finally, development of a wetland can totally alter the hydrology of an area.[27] These considerations reveal how damaging human activities can be for the long-term health of wetland systems.

A. Economic Values of Wetlands

There is no denying, in economic terms alone, the worth of wetlands to humans is enormous. For example, in the Southeast coastal region (Virginia through Texas), 96% of the commercial and more than 50% of the recreational fish and shellfish harvest are species that depend on estuarine areas for all or part of their lives.[28] In 1981, shrimp and menhaden taken from Louisiana coastal waters alone were worth $200 million at dockside, and almost $3.5 billion after processing. The U.S. Congress, in the 1985 Emergency Wetlands Resources bill, valued marine commercial and recreational fisheries nationwide at more than $10 billion.

Muskrats, another example, are harvested from wetlands for their pelts. The muskrat harvest for the year 1975-1976, mostly from wetlands in the Midwest and Louisiana, numbered 6,475,000 pelts with a dollar value of $22.6 million dollars.[29] In the 1979-1980 season, 8,634,753 pelts were harvested for a total value of more than $74,526,000.[30]

The U.S. Fish and Wildlife Service estimates that, in 1980, 1.9 million waterfowl hunters spent about $307

million in pursuit of wetland-dependent ducks, geese, and other waterfowl. The FWS estimates for 1980 conclude that about 55 million people spent almost $10 billion observing and photographing waterfowl and wetland areas.[31]

B. Habitat Values

As Ralph W. Tiner, Jr., noted in Wetlands of the United States: Current Status and Recent Trends (1984), over 12 million ducks breed annually in U.S. wetlands with millions more spending the winters here. Waterfowl banded in North Dakota wetlands alone have been recovered in 46 states, 10 provinces in Canada, and 23 other countries. Threatened and endangered species rely heavily on wetlands for their survival. As of June, 1986, 188 animals and 103 plants were listed as threatened or endangered in the United States. Of these, 50 percent (94) of the animals and 28 percent (29) of the plants are directly or indirectly wetland dependent.[32] Additionally, of the 2500 plants in need of protection, perhaps 700 are wetland related.[33] These numbers are especially alarming when estimated wetlands loss rates of up to 1200 acres per day are considered. It would be remiss not to mention the remarkable diversity of wetland life in general. Approximately 5,000 species of plants,—

190 species of amphibians, and about one-third of all bird species occur in U.S. wetlands.[34] One freshwater tidal marsh can contain 20 to 50 plant species, while over 100 woody plant species occur in bottomlands.[35]

C. Floodflow Retention Values

Wetlands have extraordinary value as temporary water storage areas. Wetlands absorb floodwaters and release these waters slowly. In fact, it is this process which makes many wetlands possible. Of about 134 million acres within the coterminous United States with severe flooding problems, 2.8 million acres are urban and 98.2 million are agricultural.[36] It is no coincidence that most of these agricultural acres are wetlands or what once were wetlands. As a footnote, the U.S. Water Resources Council in 1978 estimated potential property damage in the U.S. from flooding to be $3.4 billion in 1975 alone.

In the case of the Charles River outside of Boston, Massachusetts, the U.S. Army Corps of Engineers opted for preserving wetlands over extensive flood control construction. The Corps found that if 40% of the Charles River wetlands were lost, flood damage could be expected to increase at least $3 million annually; destruction of all wetlands in the basin could result in $17 million in

flood damage annually.[37] Between lands acquired in fee and easement since 1971, the total area of the project now encompasses some 8,115 acres of wetlands. Annual costs for the project averaged $617,000, for a total cost of $8 million; however, annual benefits averaged $2.1 million, a cost benefit which will continue to be enjoyed for years to come.

D. Water Quality Enhancement Values

Wetlands are only beginning to be understood as natural systems for the maintenance of water quality. The main attribute is their ability to remove nutrients, process chemical and organic wastes, and reduce sediment loads in water.[38] However, wetland systems are delicately balanced and cannot accept unlimited amounts of wastes and contaminants.

III. WETLAND STATUS AND TRENDS

As Shaw and Fredine aptly stated in the opening paragraphs of Circular 39, "the great natural wealth that originally made possible the growth and development of the United States included a generous endowment of shallow-water and water-logged lands."[39] There is little doubt that for thousands of years prior to European colonization the native people of North America took advantage of this abundant wealth for food, fiber, housing, and many other uses. Compared to those that came after them, the native North Americans had a benign and quite possibly beneficial impact on wetland areas. Whatever signs of use they left behind were probably soon hidden by the profusion of growth in wetland systems.

Europeans arriving in the New World, as they called it, brought with them a system of values and beliefs that was to alter dramatically the shape of the landscape. For centuries they had vigorously sought to take everything the land could produce with little thought for preserving other kinds of values. The colonists, and those that followed, sought only to carve out safe haven for their accustomed lifestyles from the wilds of this country. Wetlands were as much an obstacle to this movement as the native peoples and the magnificent deciduous forests

which once covered Eastern North America.

A. Wetland Losses in the United States

Exactly how many acres of wetlands were here at the time of colonization is unknown. Circular 39, in 1956, was the first major attempt to inventory wetlands on a basis other than for potential agricultural use. The most comprehensive study to date on wetlands trends in the U.S. was a 1983 report done for the Fish and Wildlife Service by Colorado State University.[40] This document provided the statistical base for most United States wetlands trends analyses to date. The report concentrates on wetland loss rates for the 20-year period between 1954 and 1974. Using published drainage estimates, the report lists original wetland acreage for the coterminous U.S. at 215 million acres, including nonvegetated wetland areas. The FWS report states that net wetlands loss during the 20-year study period averaged 458,000 acres per year, with total annual losses of about 550,000 acres.[41] Current rates of wetland loss have slowed somewhat, with estimates ranging from 300,000 to 450,000 acres per year. The U.S. Army Corps of Engineers places 1987 losses at 300,000 acres per year.[42]

Of vegetated wetlands, ninety-five percent are freshwater. The remaining five percent, saltwater and estuarine wetlands, experienced a net loss of 373,000 acres from the 1950s to the 1970s, a removal of 7.6 percent of those remaining.[43] The current loss of coastal areas in Louisiana alone is 60 square miles per year, or over 38,000 acres.[44] The mid-1970s estimate for all coastal wetlands remaining was around 5 million acres. At current rates coastal wetlands could be eliminated completely before the end of the next century.

Freshwater wetlands experienced a net loss of 11 million acres from the 1950s to 1970s, for a reduction of about 11 percent from those remaining in 1954. Forested wetlands made up 54 percent of this loss, emergent wetlands 42 percent, and scrub-shrub wetlands 4 percent.[45] Actual losses during the study period were 14.6 million acres, with agriculture alone claiming 80 percent.[46]

Current estimates of nationwide wetlands acreage vary. The amount remaining in the mid-1970s, about 99 million acres according to FWS, has been reduced to no more than 95 million acres today using conservative estimates. Some authorities believe that as few as 80 million acres

remain (outside of Alaska, which contains perhaps 220 million acres of permafrost tundra wetland), and that perhaps 30 million of those are so badly contaminated or degraded as to make them nonfunctional.[47]

It is misleading to assume that wetland losses occur uniformly across the nation and that all wetland habitats have the same productivity and function. As an example, from the 1950s to 1970s, estuarine wetlands losses were heaviest in the Gulf states of Louisiana, Texas, and Florida. This is where the productive estuaries that support the bulk of the commercial and sport fisheries are found. In terms of inland wetlands, the greatest losses during the same period occurred not in the prairie pothole region, which has received much attention nationally, but rather in the southeastern bottomland hardwoods. The resulting loss of wildlife habitat, flood abatement, and erosion control in this area has implications and magnitude beyond the percentage of national loss it contributes to.

B. Causes of Wetlands Loss in the United States

The 200-year siege on this nation's wetlands, resulting in the loss of more than half of all those in the 48 coterminous states, was partially carried out as national

policy with the balance stemming from a multitude of smaller activities. As is often the case, many seeming insignificant and unrelated activities can combine to create a major impact. The Minnesota farmer, installing a tile drainage outlet for a one-acre prairie pothole he intends to cultivate, does not see a connection with the marsh property owner who illegally dumps fill to build his home upon. Similarly, when highways and shopping malls are constructed over wetlands or a large chemical manufacturer contaminates an adjacent wetland with toxic wastes, the implied argument is that there are other wetlands somewhere else, and that the loss of one or two isn't that important. As a result, up to 1200 acres of wetlands are destroyed each day in the United States in defiance of federal and state policies which place wetland conservation as a high priority.

Wetland eradication has been supported by national policy for the bulk of our country's history. In 1763, 13 years before the Revolutionary War, George Washington and others formed a company whose purpose was to drain the Great Dismal Swamp along the Virginia-North Carolina border for agriculture.[48] The plan failed; however, the view that wetlands are an impediment to national growth continued to prevail upon national policy until quite recently. As a key element to much of this policy,

agricultural conversion has been the foremost cause of wetland losses during most of our nation's history.

1. Agricultural Impacts on Wetlands

The first national policy on wetlands was in the form of the Swamp Land Acts of 1849, 1850, and 1860. The first act granted Louisiana all swamp and overflow lands unsuited for agriculture for the purpose of providing flood control in the Mississippi River Valley.[49] The act was extended to Alabama, Arkansas, California, Florida, Illinois, Indiana, Iowa, Michigan, Mississippi, Missouri, Ohio, and Wisconsin in 1850. Minnesota and Oregon were included in 1860. The intent of the acts was twofold: flood control through the construction of levees and drainage, and the eradication of mosquito breeding areas.[50] The net result was the granting of almost 65 million acres of wetlands to these states by 1954, much of which was "reclaimed". A good deal of these lands were used by the states for generating revenue, obtaining properties through exchanges, giving to railroads to encourage transportation, or lining the pockets of various officials and companies, as was the case in Iowa.[51]

The drainage and loss of wetlands as a direct result of federal support continued into the 1980s. The Agricultural Conservation Program provided technical assistance and cost-sharing to landowners for the purpose of draining wetlands.[52] During the 40-year history of this program (1940 to 1980) nearly 57 million acres of wet farmland and wetlands were drained, especially in the 1940s and 1950s.[53] This amounts to an area larger than Utah. Over 5 million acres were drained in Minnesota alone.[54] Presidential Order 11990, signed by President Carter in 1977, brought an end to this program but various incentives for wetland conversion continued. These were in the form of tax credits and deductions for land clearing, installation of drainage tile, drainage expenses, capital investments for farming, and interest payments.[55]

The problem of federal regulation of wetlands conversion for agriculture is exacerbated by the fact that, of the 95 million acres of wetlands left in the lower 48 states, only 12.5 million are owned or leased by the federal government.[56] More than 80 percent of nonfederal lands are privately owned. The palustrine wetlands most subject to conversion for cultivation are almost 85 percent privately owned.[57] Legislation has been passed to deter conversion by removing federal aid to those who

do so, but implementation of this has been haphazard. The Corps of Engineers, the primary permitting agency for wetlands regulation, cannot prohibit drainage if no dredge or fill is involved in the operation. The combination of all the above, and other factors such as price supports and changes in market values for different crops, resulted in the startling statistic that agricultural activities were responsible for 87 percent of all wetlands loss in the coterminous U.S. between the 1950s and 1970s.[58]

The Rainwater Basin of Nebraska is an excellent case in point for not only illustrating the extreme losses of wetlands due to drainage but also the ecological consequences of such activity. Wetlands in this area formed in depressions with clay substrates on the rolling plains of central and south-central Nebraska. The entire area is about 4,200 square miles in size, originally consisting of over 4,000 basins totaling 94,000 acres and covering all or parts of 17 counties.[59] A 1961 inventory by Nebraska Game and Parks revealed that only 720 basins remained intact, a loss of 82 percent of all basins and 63 percent of wetland acreage.[60] A second inventory in 1981 brought worse news: less than 400 basins, or 10 percent of the original number, still existed representing 20,000 acres of the original 94,000.[61] This

loss of almost 80 percent of all the wetlands in the Rainwater Basin has had tragic consequences for the estimated 2 1/2 million migratory waterfowl that depend on this area to rest, feed, and perform pair bonding each spring in preparation for breeding in areas to the north. The Rainwater Basin has been compared to the midsection of an hourglass representing the Central Flyway. As more birds are crowded into increasingly smaller areas, the incidence of disease (e.g. avian cholera) grows dramatically. About 80,000 waterfowl died in a cholera outbreak here in 1980, the second largest die-off recorded in this country.[62] Included were 5 percent of the mid-continental population of white-fronted geese. During the last decade, an estimated 200,000 ducks and geese have been killed by avian cholera in this region.[63] Because only 43 percent of the Rainwater Basin wetlands remaining are protected by state or federal agencies, efforts are underway to identify key basins in advance of any disturbance and inform landowners about the importance of these areas.

Many of the drained basins are potentially recoverable if outflow is halted. However, to bring this about will require a major political effort involving such factors as tax incentive programs and citizen involvement. Meanwhile, for the Rainwater Basin thousands of years of

waterfowl staging and breeding are drawing to an end.

The prairie pothole region of the United States, primarily within North and South Dakota, Iowa, and Minnesota, is another vitally important wetland area for waterfowl that has been severely impacted by agriculture. The pothole region encompasses some 300,000 square miles in the upper midwest and Canada. In Iowa, 99 percent of the natural marshes have been drained, along with 9 million acres of potholes in Minnesota and 4 million of the original 7 million pothole acres in the Dakotas.[64] Constituting 10 percent of the waterfowl breeding area in North America, the Prairie Pothole region produces 50 percent of the continent's ducks in an average year, with larger numbers in wet years.[65] As in Nebraska, wetland conversion and degradation through altering hydrological flows continues at rates of over 30,000 acres per year.[66]

Not all agricultural conversion of wetlands occurs in the midwestern farm belt. In fact, the greatest losses have occurred in the southeastern hardwood bottomlands, particularly Louisiana and Mississippi.[67] During the 1950s to 1970s period, more than 1.7 million acres were lost to crop production, primarily soybeans and cotton, in each state.[68] Arkansas lost 1.5 million acres during

this period. Altogether, over 80% of the Mississippi River alluvial floodplain forests have been cleared with the process continuing. Some of the sites cleared are over 28,000 acres in size.[69]

Other substantial wetlands destruction linked to agriculture occurs in the western riparian areas. The narrow corridors of vegetation along streams and rivers support a disproportionate amount of life in adjacent upland areas.[70] Because of overgrazing and trampling by cattle, dam construction, groundwater pumping, and conversion to cropland, riparian areas are the most altered land form in the West.[71]

Though agriculture is responsible for the lion's share of wetlands destruction that has occurred in the last two centuries, urban and industrial development has contributed significantly to losses, especially within the last few decades. Development can be divided into three areas: residential, commercial, and industrial. The effects of each can be profound and are usually irreversible.

2. Urban and Industrial Development Impacts on Wetlands

Of the 11 million acres of wetlands lost between the

1950s and 1970s, 8 percent was due to urban development and the remaining 5 percent due to "other" development.[72] The filling of wetlands for home sites, the building of highways, the dredging of canals and waterways, the construction of industrial and commercial complexes in or adjacent to wetlands, and many more activities contribute to development pressure. This problem is particularly severe along the coastlines, with the majority of residential development occurring in Florida, Texas, New Jersey, New York, and California.[73] Post-war urban and industrial development along with the loss of Louisiana's coastal marshes combined to more than double the rate of coastal wetland loss from 1954 to 1978.[74] With the majority of our nation's population living along the coasts, the pressure for development is intense despite federal and state regulations. Many types of wetland development fall through the cracks of such regulation as economic incentives and population pressures prompt people to circumvent the system.

A case in point involves the Poconos area of northeastern Pennsylvania. This region of glaciated uplands contains a unique assemblage of bogs and hummocks. Otters and black bears can be found here, one of the last places of refuge in the state for the latter. The completion of Interstate Highways 80 and 84 through the area completely

changed the accessibility of this remote area. What was formerly a 2 1/2-hour drive from either New York City or Newark, New Jersey can now be completed in one hour. Development pressure for homesites increased rapidly with the improved accessibility, and in very little time subdivisions were expanding dramatically. Illegal filling of wetlands was rampant, and a major clampdown by state and federal agencies ensued. Developers countered by getting federal right-of-way road permits, which were used to construct elaborate networks of roads in and around wetland areas. Lots including wetlands were then sold to private owners who were able to get Corps of Engineers permits which allowed fill of less than one acre above headwaters. At the same time, bogs mined for peat became small lakes following removal of the layers of slowly decomposing vegetation which had built up over thousands of years. Developers then subdivided the areas around these lakes and sold them as lots. Thousands and thousands of acres of subdivisions currently exist, with thousands more proposed in the Poconos during the first 6 months of 1987. Some of these proposed subdivisions cover up to 1,000 acres each. Two counties within this area, Pike and Wayne, are the fastest growing in the state. Illegal activity persists; 2 or 3 illegal filling operations can cover as much area as all those legally permitted by the Corps of Engineers in the entire state

for the whole year.[75]

Another example of development impacts upon wetlands is California's San Francisco Bay, which was once surrounded by lush tidal marshes which supported an immensity of life. Diking and development have destroyed almost all of these tidal marsh areas; only 10 to 25 percent of the original wetlands remain.[76] Even so, these remaining wetlands make up 89 percent of those remaining in a state which has lost over 90 percent of all its wetlands. Accordingly, San Francisco Bay wetlands play a vital role as staging and wintering grounds for migratory waterfowl and shorebirds requiring wetland habitat. Behind the dikes, seasonal wetlands perform those functions formerly provided by the tidal marshes. Seasonal wetlands use the winter's rainfall and run-off to support vegetation and provide habitat, then continue to supply nesting areas as they dry out in the summer months. Unfortunately for these wetlands, development pressure from the "Silicon Valley" area nearby is spelling their doom. Of the 10,000 acres of seasonal wetlands left, most are unprotected because they were diked off from tidal action before 1966.[77] This was the year that the San Francisco Bay Conservation and Development Commission took jurisdiction for increasing bay access, halting wetlands loss, and stopping filling in of the bay.[78]

Currently, developers are resorting to devious methods to destroy wetlands in the interest of quick profits. The Corps of Engineers estimates that 70 illegal fills of wetlands have occurred in the last 5 years.[79] Some developers have found ways of eliminating a wetland's characteristics before applying for a Corps of Engineers dredge-and-fill permit, thus removing Corps jurisdiction. This is done through planting grains, installing drainage pipes and ditches, pumping off standing water, and disking up wetland areas to circumvent the law.[80] Thousands of acres have thus been converted, with destruction now being focused on non-tidal salt marshes which are designated endangered species habitat.[83] In the South Bay, virtually every acre of meadow wetland has been targeted by development proposals since 1984.[82]

In other areas, such as northern New Jersey, urban sprawl continues to consume inland wetland areas at a rapid pace.[83] While government agencies can regulate dredge and fill operations by major development interests, the activities of innumerable smaller operations cannot always be controlled due to limitations in budget and staff. A great amount of illegal filling no doubt occurs in much the same manner as the illegal dumping of trash and wastes on roadsides throughout the nation. Such activity poses considerable problems for regulation.

3. Contamination Impacts on Wetlands

Just how widespread the contamination of the nation's wetlands by the introduction of toxics, nutrient overloads, and wastes has become is still an unknown. Certainly, the number of wetlands in totally pristine condition is quite small, if only because of airborne substances entering wetland systems and subsequently changing the rate of deposition of a chemical in the site.[84] The sources of wetlands contamination can be direct, such as the disposal of oil drums filled with organic chemical solvents into marshy areas. They can also be more discreet, as is the case with the selenium contamination of national wildlife refuges in the West, many of which are located in areas with high concentrations of naturally occurring selenium. A major problem in coping with wetlands contamination is the sheer bulk of substances which can potentially find their way into a site. Over six million man-made chemical compounds exist with more produced each year for commercial and agricultural use. Fish and wildlife toxicity and sublethal effects data for these substances are scanty at best.[85] Most wetlands exist in basins where surface waters or groundwaters can transport chemical compounds for deposition, which makes them

especially susceptible to contamination. Agricultural water delivery systems contribute to this process, transporting nutrient and pesticide runoff in potential combination with naturally occurring soil elements like salts, selenium, boron, and arsenic.[86] The mix accumulates in soils, sediments, plants, and animals with often tragic results for the wetland system.

a. Role of the EPA in Curbing Wetlands Contamination

The U.S. Environmental Protection Agency is responsible for the monitoring of the National Priority List (NPL) of Superfund sites across the country. These are places which have qualified for federal clean-up funds due to the immensity of their pollution and contamination problems. The number of NPL sites which are entirely wetlands, contain wetlands, or are immediately adjacent to wetlands is still being determined through review of the description of each from field reports. Though more accurate information is forthcoming and EPA scientists are trying to tighten the statistics, it appears that a significant number, 58 percent by best estimate, of Superfund sites are wetland-related. Of these, many contain slurries of organic wastes which have accumulated over many years. Some may contain radionuclides which reach the site either through groundwater or by direct

breach of a system, as has happened at nuclear power plants and weapons facilities. How these substances react with each other and combine is still an unknown.[87]

b. Contamination of National Wildlife Refuges

As natural collection basins, the national wildlife refuges of this country can be viewed as an indicator of contamination extent. Of the 434 refuges in the system, 87 or almost 1 out of 4 show signs of contamination, according to a preliminary survey done in 1986 by the U.S. Fish and Wildlife Service. All 87 needed either corrective action, in-depth on-site monitoring and analysis, or a priority need for additional reconnaissance monitoring. The six general categories for contaminants on refuges include agricultural contaminants, municipal and industrial wastes, dumps, landfills, and buried drums, military activities, mining activities, and oil and gas products. Though much of the refuge contamination problem is agriculturally related, municipal and industrial wastes and those from other categories combine at some sites to further complicate the problem. Serious contamination problems exist at the following refuges: Kesterson and Seal Beach (California), Johnston Island (storage site for nerve gas, dioxin, and plutonium southwest of Hawaii where

containment structures are deteriorating), Crab Orchard (Illinois), Wheeler (Alabama), Great Swamp (New Jersey), Eastern Shore and Fisherman Island (Virginia), and Kenai (Alaska).[88]

Widespread deaths and deformities of waterfowl at Kesterson National Wildlife Refuge in the San Joaquin Valley of California, brought refuge contamination into the limelight in 1985. An elaborate Bureau of Reclamation irrigation system, financed by taxpayers to subsidize corporate farming operations, carried selenium from area soils into the refuge basin. Concentrations of 4200 parts per billion have been found here, as compared to the EPA level of 10 parts per billion for safe drinking water.[89] Kesterson, like many other refuges, has become a death trap for migratory waterfowl. Estimates for clean-up run over $5 billion, and drain water continues to enter the system as refuge employees use explosive devices to scare away waterfowl. The current solution being sought involves creating resin filters that could remove selenium from the drain water.

Another type of refuge contamination is found at Laguna Atascosa NWR on the south Texas coast. Over 100 commonly used crop pesticides have found their way into the Arroyo Colorado drainage canal which flows through the refuge.[90]

The effects upon fish and wildlife are as yet undocumented.

Lead poisoning of waterfowl as a result of consuming lead shot has been firmly established. Pellets from shotgun shells lie in bottom sediments of wetlands, are inadvertently swallowed by waterfowl, and eventually poison the bloodstream. Birds of prey can then consume poisoned birds, extending the damage. Federal actions are underway to outlaw the use of lead shot for waterfowl hunting before the end of the decade.

The degree and extent of wetland contamination in the United States is only beginning to be understood. The consequences of this contamination on the health of plants, animals, and humans will surely be receiving much closer scrutiny, as will the causes, mitigation, and clean-up of affected areas.

4. Hydrologic Impacts on Wetlands

Because water, or the lack of it, is the determining factor for wetland existence, the impacts of human activity such as construction of dikes, ditches, channels, levees, highways, and certainly drainage systems can mean death for wetland systems. The extreme

rate of loss along the Louisiana coast can at least partially be attributed to human activity. Channelization and levee building along the Mississippi River, canal dredging for navigation and oil and gas operations, and subsidence from oil and gas and groundwater extraction have combined to increase erosion and salt water intrusion, while preventing the natural deposition of sediments for marsh building.[91]

In south Florida, drainage and flood control have drastically altered the ecological stability of the Kissimmee River Basin, Lake Okeechobee, the Everglades, and Big Cypress Swamp. Flooding in 1928, 1947, and 1948 resulted in the construction of almost 800 miles of new and improved levees, and 500 miles of canals.[92] Channelization alone destroyed 40,000 acres of wetlands and aided drainage of 100,000 more.[93] Fish and wildlife populations plummeted as a result of serious impact to wetlands habitat, water level fluctuations, and hydroperiods. Efforts are now underway to restore the Kissimmee River. However, agricultural and urban advances on former wetlands are not likely to retreat.

Mining operations, such as for coal, peat, and phosphate, can not only disrupt hydrology but completely destroy wetland environments. The excavation of limestone in

South Florida for concrete destroys the substrate for emergent marshes.[94] Phosphate, used in manufacturing fertilizer, is found directly beneath some wetlands, resulting in their complete destruction.[95] The excavation and fill of riparian areas in the West and in Alaska for the recovery of gold, copper, tin, platinum, and other deposits also completely destroys the natural structure of these habitats.[96] Surface mining of coal can physically destroy wetlands, and the acidic drainage from mine tailings can contaminate the basins it flows into. Oil and gas production can require channels through marshlands, as is the case in Louisiana, to reach drill sites. These channels facilitate the intrusion of salt water which kills vegetation and removes soils. Buggy tracks through the marshes also create conduits for salt water movement; the combination of canals and tracks criss-cross some areas to the point where vegetation is almost non-existent. Spoil pits and drilling mud from oil and gas operations release a mixed bag of toxics and pollutants which have been shown to be extremely bioaccumulative, magnifying in the food chain.[97] As noted before, the long-term extraction of oil and gas is linked to large-scale lowering of land elevation (subsidence) which can drastically modify hydrologic regimes, as is the case along the Louisiana coast.

IV. PROGRAMS TO CONTROL WETLAND LOSSES

State and Federal recognition of the value of and need for protection of wetlands has come a long way from the time of swamp land acts and incentive programs for large-scale drainage and development. Federal agencies involved in wetlands protection include the Army Corps of Engineers, the Environmental Protection Agency, the Fish and Wildlife Service, the National Marine Fisheries Service, the U.S. Geological Survey, the Bureau of Reclamation, the Forest Service, the National Park Service, the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, and the Federal Highways Works Administration.

A. Section 404 and other Federal Wetland Protection Laws

The primary vehicles for regulation of wetlands development are Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. The U.S. Army Corps of Engineers has permitting authority through these Acts over activities which can adversely affect wetlands. Activities requiring Section 10 permits include the construction of piers, wharfs, jetties, weirs, bulkheads, breakwaters, and transmission lines, and work which modifies navigable waters such as dredging, fill, or

excavation. Section 10 represents the traditional role of the Corps, that of protecting and maintaining the navigable capacity of the nation's waters.

As pollution of the nation's waters became a widely recognized problem in the 1960s, legislation was formulated which eventually became the Federal Water Pollution Control Act of 1972. An amendment to this Act, Section 404, gave the EPA and Corps responsibility for respectively monitoring and permitting activities which result in discharge of fill or dredged material into waters of the United States. The Clean Water Act of 1977 further clarified and streamlined the 404 program.

The Corps of Engineers has responsibility for issuing permits on a case-by-case basis, but consultation with EPA and other agencies is required by law. EPA sets environmental standards, defines activities that may be exempted, has approval and oversight of state assumption of some 404 authority (nontidal waters and isolated wetlands), and has veto power over the Corps if need be.[98] Although by law any activity involving a discharge into waters of the United States requires a 404 permit, many activities fall within a nationwide permitting process. Twenty-six different nationwide permits cover tens of thousands of activities annually.[99] The idea

behind these permits is to provide authorization for activities similar in nature that will cause only minimal individual and cumulative adverse environmental impacts.[100] Whether or not this works remains a point of contention among natural resources agencies and the conservation community. The Corps estimates that some 50,000 activities annually are covered by nationwide permits, headwaters. As mentioned earlier, the result of this process in the Poconos of Pennsylvania is having disastrous consequences.

The Corps adamantly insists that its role is that of regulating development, not protecting and preserving wetlands. Additionally, many activities which can destroy or degrade a wetland are outside the scope of 404 regulations. Wetlands can be drained, excavated, flooded, plowed, shaded to the point vegetation dies, poisoned, burned, mowed, grazed, and have trees pushed into them without violating the requirement for permitting. The percentage of permit applications which the Corps approves is quite high; in 1985 only 4.3 percent of individual applications received were denied.[101] This was out of about 8500 applications received, which covered an estimated 10,000 to 12,000 dredge-and-fill activities.[102] The Fish and Wildlife Coordination Act requires that the Corps consider mitiga-

tion measures for dredge-and-fill activities as assessed by the Fish and Wildlife Service in order to offset habitat degradation. The manner in which mitigation is used by the Corps to justify certain developments has been a point of contention. The EPA was forced to use its 404(c) veto power in 1985 over a Corps permit which, through mitigation, would have allowed an 80-acre shopping center, Attleboro Mall, to be built on a 50-acre red maple swamp in Attleboro, Massachusetts. Development approval was based on the creation of 48 acres of new wetland from a gravel pit and an upland/ wooded swamp area nearby. This mitigation measure was controversial because of questions regarding the replacement of all wetland values lost and the dependency of the mall development upon the original wetland site. Though on many fronts the Corps, EPA, the Fish and Wildlife Service, and other federal and state agencies are working towards mutually-cooperative ends, this example emphasizes the often controversial role of the Corps as wetlands regulator.

B. Controlling Agricultural Impacts on Wetlands

Because such a high amount (87 percent) of wetlands loss from the 1950's to the 1970's was due to agriculture, changes have recently been made to remove incentives for

agricultural conversion. The Food Security Act of 1985 included provisions, known as "swampbuster", which deny eligibility for farm program benefits on any land to persons who grow agricultural commodities on converted wetlands after December 23, 1985.[103] Probably the most important benefits denied under the Act are deficiency payments for commodity program recipients, which cover the difference between market prices and established target prices for crops within this program.[104] Swampbuster's effect on the estimated 38.9 million acres of nonfederal wetlands on which program crops are likely to be grown is questionable.[105] The recent farm crisis has made wetland conversion unprofitable compared to buying or leasing land from operators leaving farming.[106] Also, in the absence of swampbuster provisions only about 20 percent of remaining wetlands would net even short-term profits due to the cost of seed, fertilizer, and conversion of the wetland.[107] Conditions could conceivably change to make wetland conversion profitable again. Fortunately, the 1986 tax reform tightened those tax credits that still existed under the swampbuster provisions.[108]

C. The Emergency Wetlands Resources Act

Another recent, significant piece of Federal legislation

is the Emergency Wetlands Resources Act of 1986. Representing years of effort by conservationists, this Act provided for a number of needed revenue sources for wetlands acquisition and inventory. The U.S. Fish and Wildlife Service purchases wetlands in order to preserve waterfowl habitat. The major instrument for this is the Migratory Bird Conservation Fund. Revenues for this fund come from receipts of federal migratory bird hunting stamps, or Duck Stamps, which are required of all waterfowl hunters aged 16 and over. The Wetlands Loan Act of 1961 provided additional revenues to this fund in order to speed up the process of acquiring waterfowl habitat threatened by agricultural drainage.[109] As of 1985, a total of 2,313,861 acres of wetlands had been acquired through this fund as either easements or fee simple lands. The Land and Water Conservation Fund is used to acquire natural areas and outdoor recreation lands and as a result of the Emergency Wetlands Resources Act can be used to acquire migratory waterfowl areas. This fund requires yearly appropriations by Congress, and is authorized to provide up to $900 million per year for acquisition.[110]It forgave repayment of advances made to the Migratory Bird Conservation Fund under the Wetlands Loan Act while extending the availability of other funds. Revenues for the Migratory Bird Account were increased through raising Duck Stamp prices, requiring entrance

fees to some National Wildlife Refuges, and matching duties paid on imported arms and ammunition.

The Emergency Wetlands Resources Act set a timetable for the National Wetlands Inventory and requires the Secretary of Interior to examine and suggest changes in Federal policies affecting wetlands. It also authorized state and Federal wetlands acquisition through the Land and Water Conservation Fund. These developments are especially important in light of the fact that inventory and acquisition are the strongest measures for determining what wetland resources exist and what their status is, and for protecting those areas which are critical habitat and are potentially imperiled.

The Water Bank, administered by the U.S. Department of Agriculture's Agricultural Stabilization and Conservation Service (ASCS), authorizes $10 million per year for 10-year leasing of waterfowl habitat.[111] As of April, 1987, the Water Bank Program has entered into 4615 lease agreements, protecting 153,073 acres of wetlands and 332,861 acres of adjacent uplands. Water Bank funding has slackened considerably in recent years and its future is uncertain.

D. National Wetlands Inventory

Congress has mandated the U.S Fish and Wildlife Service to produce wetland maps for the entire United States. The National Wetlands Inventory (NWI) is currently mapping top priority sites including the entire coastal zone, the flood plains of major rivers, and the prairie pothole region. This work is to be finished sometime in 1988. Within ten years the NWI is to finish mapping the rest of the coterminous U.S., with maps for Alaska and other areas to follow shortly thereafter. The NWI is also responsible for updating the Report on Wetland Status and Trends by 1990 and at 10-year intervals thereafter. Other NWI projects include the production of a national list of wetland plants, a list of hydric soils, and a wetland values database.

E. Mitigation of Impacts to Wetlands

As wetlands are increasingly utilized for various management purposes, be it for wildlife habitat, sewage and wastewater treatment, flood control, or other uses, the realm of mitigation, creation, and restoration become more important. Many drained prairie potholes, for instance, can be restored by simply removing or blocking the drain tile. A large number of 404 permits require mitigation, which is essentially replacing loss with an

equal amount of the same wetland habitat. Wetlands have also been artificially created for a variety of purposes. The concepts of restoration, mitigation, and creation have a long way to go in terms of coordination between state and federal agencies, the types of values and functions which are socially desirable for wetlands, and the entire science of creating wetland environments.

A significant problem with wetland mitigation involves conflicting ideas as to what it means. Traditionally, mitigation has been used to describe the acquisition and preservation of undisturbed, natural habitats to replace those destroyed by development, the reduction of existing pollution sources to compensate for new ones, or betterment habitats to replace lost values.[112] The debate over wetland mitigation is centered on three questions: What should policy be concerning whether, when, and what mitigation should be required; what does mitigation technically involve; and who should be responsible for implementing and managing mitigation projects and how best to effect mitigation requirements.[113] The measurement of what "successful mitigation" means also remains unresolved.

Industry has numerous complaints about the current use of mitigation in resolving development conflicts.

Disagreement between the Corps and EPA over when mitigation is appropriate, how much and what kind should be provided, and the resultant delays in receiving a permit put industry in a frustrating situation.[114] The diversity of agencies which can comment on a proposed wetlands development is also regarded as prohibitive.[115] Because mitigation often means acquiring another wetland property to replace the one impacted by development, the shrinking number of wetlands creates more problems for the developer.[116] Industry appears particularly irritated by the movement towards no-net loss of wetlands. This would remove a popular mitigation tool, that of buying privately held wetlands and transfering them to the public domain to "replace" wetlands lost to development.[117] Essentially, industry would like to see the EPA and Corps more involved in planning efforts, more willing to grant permit approval responsibilities to states that have good wetland programs, and more willing to accept wetland losses as an unavoidable cost of doing business.[118] Industry also sees going to court as an alternative to the planning process.[119]

The Army Corps of Engineers has gone ahead for some years now using mitigation as the tool to tip the "public interest balance" so that a proposed wetland development might proceed.[120] As might be expected, the

conservation community has differing perspectives on mitigation. That perhaps thousands of mitigation projects have been approved with no overriding philosophy embracing short and long-term effects and compliance monitoring demonstrates large gaps in wetland protection regulations.

In 1978, the Council on Environmental Quality (CEQ) defined mitigation as including five elements: avoiding impact, minimizing impact, rectifying the impact, reducing or eliminating the impact, or compensating for it. The Fish and Wildlife Service and EPA have promulgated regulations which require wetland-impacting projects to be approached with these elements in the order given. The Corps does not recognize any sequence in this regard, which has provided an incentive for developers to present mitigation proposals when applying for permits.[121] As a result, it is likely that mitigation proposals for wetland replacement or enhancement become justification for natural wetland destruction.[122] This is a far cry from mitigation's purpose, which is that it be used only when wetland destruction is unavoidable according to the Council on Environmental Quality (CEQ).

The donation of mitigation lands, or "green mail",

involves the destruction of one wetland in exchange for not destroying another one.[123] No guarantee that the donated wetland might not itself soon be targeted is inherent in the process.[124] The promise of making new wetlands in exchange usually means altering an existing wetland, thus destroying its natural quality, or using a convenient upland site like an abandoned gravel quarry to "create" a "replacement".[125] Thus, from a conservationist's viewpoint, the mitigation process is sloppy and misguided at best.

Even more confusion exists in regard to mitigating wetlands contamination, particularly "Superfund" sites. The current 404 mitigation guidelines as developed by CEQ involve these five steps for replacement of values lost. These are interpreted by the EPA as to be followed in the order given.

1. Avoid the impact altogether.
2. On-site/in-kind (the same kind of wetland in the same place).
3. On-site/out-of-kind.
4. Off-site/in-kind (the same wetland type in a different place).
5. Off-site/out-of-kind.

Since most Superfund clean-up work in wetlands involves not only dredge and fill but sometimes complete destruction of a wetland, 404 regulations come into play. To compound this, Superfund money (currently) cannot be used for mitigation. The best solution for a Superfund or other hazardous or toxic waste-contaminated wetland is often to contain it, sealing it off from contact with the surrounding environment. In the case of a wetland contaminated with nuclear wastes, with a half-life of 42,000 years, providing more wetland on the same site would be ridiculous. Therefore, off-site/in-kind mitigation ranks right behind avoidance in dealing with many contaminated wetlands.[126]

F. Wetland Creation

The whole question of man-made wetlands has yet to be resolved. Such wetlands have been successfully created over phosphate mining operations in Florida and for acid-drainage control from coal mines in Tennessee. Such artificial wetlands have so far been site- and purpose-specific, to a large degree. Whether a northern peat bog, a coastal salt marsh, forested swamp, or a riparian wetland can be created by humans is an open question.

One example of successful creation of wetlands to fit many needs occurs on the coast of northern California, 280 miles north of San Francisco. The residents of Arcata, California (population 14,800) were faced with paying for an expensive regional sewage treatment facility in order to meet water quality standards for effluent into nearby Humboldt Bay.[127] Instead, they were able to get approval and financing (in 1979, after a 3-year struggle) to use a wetland system along with upgrading their existing plant to handle wastewater. Building on a site which contained an old railroad trestle, an abandoned county dump, and the remains of a lumber mill, Arcata created 96 acres of wetlands and 22 acres of adjacent upland area for a total cost of $675,550.[128] Most of the work involved clearing and blading; the vegetation was provided courtesy of Mother Nature. The State Water Resources Control Board approved the process in 1983, and effluent entered the marshes 3 years later.[129] Not only does the Arcata system provide treatment at a much reduced cost, but the water entering the bay is cleaner than it would have been with the regional plant in place.[130]

There is another side to the Arcata story. The Arcata Marsh and Wildlife Sanctuary is used by almost 200 species of birds and thousands of ducks and shorebirds;

112,000 people use the trails, bird blinds, and picnic facilities each year. Stickleback fish control mosquitos in the marshwater, and a municipal salmon hatchery rears salmon, steelhead, and cutthroat trout using wastewater for nutrients. The salmon are released in a nearby stream, where they return to spawn.[131]

Though not all created wetlands offer such a success story, the Arcata example represents an encouraging example. Whether development interests will heed the lesson Arcata has to teach remains an unanswered question.

G. State Programs for Wetlands Regulation

Though the federal government carries the bulk of the weight associated with wetland protection under Section 404 of the Clean Water Act, the role of the states is anything but unimportant. If EPA requirements are met, states can assume the legal responsibilities for administering those 404 regulations that deal with waters not traditionally used for navigation.[132] More importantly, because of tight budgets and rapidly disappearing wetland acres, state and federal managers are working together to maximize their effectiveness.[133] A recent study by the EPA examined the

status of wetlands programs in all 50 states. Highlights from the study are as follows:[134]

1. 13 states have environmental policy acts;
2. 55 state taxation programs exist that fund wetlands regulation, including property tax abatement, sales tax, and income tax incentives;
3. there are 88 state acquisition programs, some targeted specifically at wetlands;
4. 23 well-developed state research and development programs exist;
5. there are 31 specific coastal wetlands regulatory programs and 55 additional coastal programs that provide some wetlands protection benefits;
6. 21 specific inland wetlands programs exist along with 29 other inland programs which provide some wetlands protection benefits.

The EPA states that some examples of very good state programs include the Michigan Environmental Policy Act, Missouri's state sales tax, Florida's Save Our Coast and Conservation and Recreation Lands Trust (CARL) programs, and New Jersey's Green Acres Program. Overall, state managers see a very real need for EPA to take a much stronger role in helping to coordinate, fund, and support state wetland programs nationwide. The current trend

seems to be towards greater local and state involvement in wetlands protection.

V. CONCLUSION: STOPPING WETLAND LOSSES

This report demonstrates that, without a greatly expanded and accelerated protection and education effort, this nation's wetland resources will be in dire straits. Current state and federal protective measures are lacking in scope and are simply unable to cope with the relentless development, degradation, contamination, and abuse of wetland systems. What we have learned is that, in many cases, such as Louisiana's coastal marshes, it is already too late to halt the loss. As we have altered the planet's surface to suit our own needs we have sown the seeds of destruction; not only for ourselves but for the abundance of plant and animal life with whom we share our world.

In many ways wetlands losses represent the costs of short-sighted management of our natural resources. These systems have contributed greatly to the vast natural wealth of this country, providing us with a bounty of goods and services which we have taken largely for granted in our ignorance. Now, as floodwaters rage unabated, population levels of fish, shellfish, and waterfowl plummet, and the water quality in rivers, streams, lakes and oceans diminishes, a pattern is

emerging. The truth is, quite simply, that unless we are willing to respect and protect the natural world, we are in danger of losing those things we value most. These are clean water, clean air, and the good productive earth at our feet.

Wetlands are woven into the fabric which provides us these things. By virtue of their productivity and dynamic ecology wetlands are factories of life. People across the nation are awakening to the many benefits wetlands provide, as is the case in Arcata, California. A great deal of research is currently underway to determine how both natural and created wetlands can be utilized to stabilize shores, treat wastewaters, grow food crops, and provide areas for wildlife and recreation. However, the real issue remains unresolved: How are we to halt the continued loss of hundreds of thousands of acres of wetlands each year?

The answer to this question is rooted in the causes of wetlands loss. Farmers drain and till wetlands to take advantage of productive soils and to maximize their crop yields. Developers choose wetland sites to fill and build upon because they are often the only undeveloped areas in the proximity of economically-important urban centers. Flood control structures, highways, irrigation

systems and canals can isolate wetlands from water sources or drastically change water movement through them. Contaminants carelessly released into the environment are often easily transported with water flows into wetland areas. All of these causes of wetlands loss are due to inadequate protection of wetlands and a lack of concern for maintaining wetland values and functions. Therefore, stronger protective measures are called for in addition to inducing people to care about wetlands much more than their actions would indicate they do.

Unfortunately, stating these solutions to wetlands loss is much simpler than making them happen. Greater protection and concern for wetlands must occur at all levels of our society: locally, statewide, regionally and at the federal level. This will require a coordinated effort by government, the conservation community and the general public. This effort must be supported by a far-reaching philosphy based on law and biological understanding.

At the federal level, a clear need exists to formulate a national policy on wetlands. Such a policy would place the same level of concern on wetlands which is currently afforded the air, soil, and water resources of this country. Central to the success of such a policy would

be the reworking of existing federal wetlands programs. The U.S. Army Corps of Engineers, though changing for the better, has not demonstrated the ability to adequately protect wetlands. Also, as the agency responsible for many of the flood control and impoundment projects which destroy wetlands, the Corps is a many-headed and contradictory beast. The Environmental Protection Agency is a much more logical choice for vesting with this responsibility. The EPA should have final responsibility for determining allowable impacts to wetlands, rather than the current system which allows wetland destruction to proceed if the Corps feels it is in the public interest. The EPA would instead have as its mandate the protection and restoration of all remaining wetlands. New wetlands can be created for specific uses, such as erosion control or wastewater treatment, according to EPA guidelines and rules for compliance monitoring and performance testing. In the meantime, naturally occurring wetlands can be kept in as pristine a state as possible so they continue to provide a full range of ecological functions other than those useful to humans.

Wetlands need to be elevated from private to public property in the minds of Americans, since they are a shared natural resource. Congress and the courts have made it clear that wetlands are to be considered public

domain by virtue of the Clean Water Act and the commerce clause of the U.S. Constitution. The Corps and other agencies have been reluctant to take this to the fullest extent possible. Most landowners would argue that a wetland on their property belongs to them, not to the people of the United States. Allowing this misperception to persist only encourages many people to illegally destroy wetlands.

Until a new national wetlands policy can be brought about, other avenues exist to improve current wetlands protection efforts. The mandate of the Clean Water Act can be expanded through congressional action to include those activities which fall through the cracks of dredge-and-fill oriented regulation. The U.S. Fish and Wildlife Service, the Corps, and other agencies should be taken to court for failure to carry out the letter of the law. The fallibility of nationwide permits and local discretion of Corps officers in stipulating allowable activities in wetlands often results in unnecessary and illegal wetland destruction. Agency actions (and inactions) in conflict with the law can go unnoticed and unchallenged. Diligent monitoring and appropriate responses from the conservation community and the private sector are thus a necessary component of national wetlands protection.

At the state level, wetland programs should become more coordinated and centralized. Currently, many states spread what wetlands programs exist between Fish and Wildlife, Natural Resources and Water Quality agencies. Though it is appropriate for all of these agencies to be involved in wetlands protection, they can have differing agendas and priorities regarding the same wetland habitats. A more logical and cost-effective approach would place the bulk of wetlands protection responsibility with the agency best suited to do field monitoring, enforcement, and cooperative management with federal agencies. Section 401 of the Clean Water Act provides the basis for state water quality boards to assume responsibility for parts of the 404 program. State legislatures must in turn ensure adequate funding, staff and support if these boards are to be given full rein. Once again, monitoring from citizen and conservation groups is necessary to keep wetlands protection efforts from becoming subverted by politics and hidden agendas.

Locally, planning boards and county commissions can zone wetland areas for greenbelt or other such protected status. The issue of "taking" without just compensation has long been considered a barrier for this type of

strategy. However, zoning is a legitimate tool to reinforce the concept of wetlands as public, rather than private, domain. The role of mitigation in balancing wetland impacts must be ironed out into very specific elements. Replacement of a wetland visually does not replace it ecologically. Nor does creating a wetland that looks good for two or three years after project completion ensure that it will provide replacement for functions lost over several decades into the future. Avoidance of impacts altogther must be the primary goal of a successful mitigation policy. Where it can be shown that impacts are unavoidable, performance bonds should be posted and long-range compliance monitoring and performance testing carried out per project. The best strategy would be to not let any impact proceed until the replacement wetland has been proven successful on a variety of ecological levels. No net-loss of wetland value, function, or area covered should be central to any mitigation effort.

The problem of wetlands contamination is only one aspect of a much greater picture. The production of toxic materials and hazardous wastes has yet to be addressed in national policy. Contamination from point and nonpoint sources can be prevented if the leadership of this country is willing to recognize the scope of the problem

and invest in solutions. Obviously, industry is responsible for the production of huge amounts of contaminants and should bear the costs of treatment and disposal. This is only part of the issue. Public demand for and consumption of products that result in environmental contamination is one of the most pervasive and perverse elements of our society. Coping with this issue will require massive societal change and is beyond the scope of this report. The contamination of wetlands can hopefully be slowed through greater monitoring and restriction of pollution sources. The wanton disposal of hazardous wastes without regard to environmental fate can simply no longer be tolerated and should be met with the strictest enforcement whenever encountered. In the case of agricultural runoff bearing contaminants, greater regulation of chemical applications on crops and monitoring end-of-drain flows can help to get a handle on this insidious problem.

Protection by regulation and enforcement is only part of the answer. Positive reinforcement must go hand in hand with regulatory efforts. The expansion of federal programs like the Water Bank and Conservation Reserve Program is necessary to provide financial incentives for wetland protection. Farmers need more of a reason than swampbuster gives them to not convert wetlands.

Encouraging the protection and enhancement of wetlands on agricultural lands through monetary inducements is a logical step. The Rainwater Basin of Nebraska, as an example, should have its value as migratory waterfowl habitat recognized by paying landowners to keep wetlands healthy and intact. Regional assessments of wetland values and functions, such as those being carried out by the EPA, FWS, and other agencies, can be the basis for targeting landowner incentive programs to those parts of the country most in need of wetland protection.

Finally, the importance of education and information programs is not to be understated. Television programming, magazine and newspaper articles, and other mass media tools are important vehicles for developing understanding and support for wetland systems. Classroom educational packages are necessary to promote wetland values in young people. Land managers like the Soil Conservation Service and county agents need to educate landowners about the benefits of keeping wetlands on their property. Urban populations should be informed as to the aesthetic values and biological functions wetlands provide, thus creating local resistance to developers keen on converting wetlands to other uses. Wetlands themselves make ideal "living classrooms" for introducing both young and older audiences to wildlife and ecological

values. Establishing interpretive centers and encouraging attendance at existing ones on wetland sites is an asset to any community.

Bringing about the changes needed to protect the nation's remaining wetlands will be a lengthy and demanding task. Taking steps like the ones described will enhance natural resource management and promote greater understanding and respect for wetlands and other ecological systems in this country. Protecting wetlands is a vital part of preserving the bounty of life on this planet, a goal which we must all face eventually - or we face the consequences.

\End Notes

1. S. P. Shaw and C. G. Fredine, Wetlands of the United States, U.S. Dept. of the Interior, Fish and Wildlife Service, Circular 39 (1956), p. 4.

2. Tiner, R.W., 1984, Wetlands of the United States: Current Status and Recent Trends, National Wetlands Inventory, Fish and Wildlife Service, U.S. Dept. of Interior, Washington, D.C., p. 31.

3. U.S. Congress, Office of Technology Assessment, Wetlands: Their Use and Regulation (Washington, D.C.: U.S.G.P.O., 1984), p. 91.

4. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 3.

5. Weller, Milton W., 1981. Freshwater Marshes. University of Minnesota Press, Minneapolis. p. 7.

6. Mitsch, W.J., and J.G.Gosselink. 1986. Wetlands. Van Nostrand Reinhold Company, Inc. New York, p. 130.

7. Ibid., p. 132.

8. Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service. FWS/OBS/.79/31, p. 3.

9. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 5.

10. Ibid.

11. Ibid.

12. Ibid.

13. Ibid.

14. Mitsch, et al., p. 151.

15. Ibid., p. 11.

16. Weller, Milton W. 1981. Freshwater Marshes, p. 9.

17. Ibid., p. 11.

18. Ibid.

19. Kusler, Jon A. 1983. Our National Wetland Heritage: A Protection Guidebook. Environmental Law Institute, Washington, D.C. p. 13.

20. Greeson, P.E., J.R. Clark, and J.E. Clark, eds., 1979. Wetland Functions and Values: The State of Our Understanding, Proceedings of National Symposium on Wetlands, Lake Buena Vista, Florida, American Water Resources Association Tech. Publ. TPS 79-2, Minneapolis, Minn., p. 16.

21. Mitsch, et al., Wetlands, p. 393.

22. Ibid., p. 399.

23. Ibid., p. 404.

24. Ibid., p. 405.

25. Ibid., p. 407.

26. Ibid., p. 408.

27. Ibid.

28. Eno, A.S., R.L. DiSilvestro, and W.J. Chandler, eds. 1986. Audubon Wildlife Report. The National Audubon Society, New York, N.Y., p. 317.

29. Mitsch, et al. Wetlands, p. 394.

30. U.S. Congress, OTA, Wetlands: Their Use and Regulation, p. 55.

31. Ibid.

32. Niering, W.A. "Endangered, Threatened, and Rare Wetland Plants and Animals of the Continental United States." National Wetlands Newsletter, May-June 1987, p. 16.

33. Ibid.

34. U.S. Congress, OTA, Wetlands: Their Use and Regulation, p. 41.

35. Ibid.

36. Tiner, R.W., 1984, Wetlands of the United States: Current Status and Recent Trends, Washington, D.C., p. 21.

37. Ibid.

38. Ibid., p. 18.

39. Shaw, S.P. and C.G. Fredine, 1956, Wetlands of the United States, p. 3.

40. Frayer, W.E., T.J. Monahon, D.C. Bowden, and F.A. Graybill. 1983. Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950s to 1970s. Dept. of Forest and Wood Sciences, Colorado State University, Ft. Collins.

41. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 31.

42. Personal communication, John Studt, Technical Section of Regulatory Branch, U.S. Army Corps of Engineers, Wash., D.C. June 1987.

43. U.S. Congress, OTA. Wetlands: Their Use and Regulation, p. 93.

44. Newsweek, June 22, 1987. "Louisiana's Bayou Blues," p. 54.

45. U.S. Congress, OTA. Wetlands: Their Use and Regulation, p. 91.

46. Ibid.

47. John R. Clark, "Assessment for Wetlands Restoration", 1985, National Wetlands Assessment Symposium, Portland, Maine, p. 250.

48. Richardson, Curtis J. 1981. Pocosins. Hutchison Ross Publishing Company, Stroudeberg, Pennsylvania. p. 23.

49. Shaw, S.P. and C.G. Fredine, Wetlands of the United States (Circular 39), p. 5.

50. Ibid.

51. Ibid.

52. U.S. Congress OTA 1984, Wetlands: Their Use and Regulation, p. 77.

53. Ibid.

54. Ibid.

55. Ibid., p. 78.

56. Heimlich, Ralph E. and Linda L. Langer, "Swampbusting in Perspective". Journal of Soil and Water Conservation, July-August 1986. p. 219.

57. Ibid., p. 220.

58. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 31.

59. Ibid., p. 47.

60. Personal communication, Kenny Diamond, USFWS Region 6, July 16, 1987.

61. Ibid.

62. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 47.

63. Furst, Felice F., "A New Approach to Wetlands Protection for Nebraska's Rainwater Basin", National Wetlands Newsletter, Vol. 8, No. 4, July-August 1986, p. 5.

64. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 42.

65. Ibid.

66. Ibid.

67. Heimlich, R.E. and L.L. Langer, "Swampbusting in Perspective", p. 220.

68. Ibid.

69. Gosselink, J.G. and L.C. Lee, 1987, Cumulative Impact Assessment in Bottomland Hardwood Forests, Center for Wetland Resources, Baton Rouge, LA. p. 2.

70. Heimlich, R.E. and L.L. Langner, Swampbusting: Wetland Conversion and Farm Programs. USDA. Agricultural Economic Report No. 551, August 1986, p. 23.

71. Ibid.

72. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 32.

73. Ibid.

74. Ibid., p. 33.

75. Personal communication, Ed Perry, Assistant Supervisor, State College Field Office, Region 5, U.S. Fish and Wildlife Service, July 22, 1987.

76. Tennefoss, Lynn, "Bay Area Activists Lock Horns with Wetland Developers", Audubon Activist, July/August 1987, p. 14.

77. Ibid.

78. Ibid.

79. Ibid.

80. Ibid.

81. Ibid.

82. Ibid.

83. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 34.

84. Wentz, W. Alan, "Functional Status of the Nation's Wetlands", presentation to International Symposium on the Ecology and Management of Wetlands, Charleston, SC, June 1986.

85. Action Plans Summary, Contaminant Issues of Concern, National Wildlife Refuges, Dept. of the Interior, USFWS, July 1986. p. 1.

86. Ibid.

87. Personal communication with Dr. Lyndon Lee, Chief Wetland Ecologist, U.S. Environmental Protection Agency, July 1987.

88. Action Plans Summary, Contaminant Issues of Concern, USFWS, July 1986.

89. Lee, W.S., "The National Wildlife Refuge System", Audubon Wildlife Report 1986, The National Audubon

Society, New York, N.Y. p. 441.

90. Action Plans Summary, Contaminant Issues of Concern, USFWS, July 1986.

91. Tiner, R.W. 1984. Wetlands of the United States: Current Status and Recent Trends, p. 38.

92. Ibid.

93. Ibid.

94. U.S. Congress, OTA, Wetlands: Their Use and Regulation, p. 106.

95. Ibid.

96. Ibid.

97. Action Plans Summary, p. 5.

98. Barton, K., "Federal Wetlands Protection Program", Audubon Wildlife Report 1986, National Audubon Society, New York, N.Y., p. 384.

99. Ibid., p. 386.

100. Ibid.

101. Ibid., p. 389.

102. Ibid.

103. Heimlich, R.E., "Economics of Wetland Conversion: Farm Programs and Income Tax", National Wetlands Newsletter, Vol. 8, No. 4, July-August 1986, p. 7.

104. Ibid.

105. Ibid., p. 8.

106. Ibid.

107. Ibid., p. 10.

108. Goldman-Carter, J., "Implementing Swampbuster: Assessment and Recommendations", position paper for the National Wildlife Federation, June 1987, p. 38.

109. Barton, K., "Federal Wetlands Protection Program", Audubon Wildlife Report 1986, p. 376.

110. Ibid., p. 377.

111. Ibid.

112. La Roe, E.T., "Wetland Habitat Mitigation: An Historical Overview", National Wetlands Newsletter, Vol. 8, No. 5, Sept.-Oct. 1986, p. 9.

113. Ibid.

114. Wilmar, Mile, "Mitigation: The Applicant's Perspective", National Wetlands Newsletter, Vol. 8, No. 5, Sept.-Oct. 1986, p. 16.

115. Ibid., p. 17.

116. Ibid.

117. Ibid.

118. Ibid., p. 16.

119. Ibid.

120. Barrows, D.P., "Mitigation in the Army Corps of Engineers Regulatory Program," National Wetlands Newsletter, Vol. 8, No. 5, Sept./Oct. 1986, p. 11.

121. Golet, F.C., "Critical Issues in Wetland Mitigation: A Scientific Perspective", National Wetlands Newsletter, Vol. 8, No. 6, Sept./Oct. 1986, p. 4.

122. Ibid.

123. Newman, V.D., "Reinenting the Swamp", National Wetlands Newsletter, Vol. 8, No. 6, Sept./Oct. 1986, p. 15.

124. Ibid.

125. Ibid.

126. Lee, Dr. Lyndon C., Chief Wetlands Ecologist, EPA Office of Wetlands Protection, personal communication, July 1987.

127. Price, J. William, "The Marsh That Arcata Built", Sierra Magazine, May/June 1987, p. 51.

128. Ibid., p. 52.

129. Ibid.

130. Ibid., p. 55.

131. Ibid.

132. U.S. Congress, OTA, Wetlands: Their Use and Regulation, p. 187.

133. EPA "State Wetland Protection Programs: Status and Recommendations", Office of Wetlands Protection, Dec. 1986, p. 1.

134. Ibid.