Chapter 5
Wetland Trends

Photo credit: Robert Friedman

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CHAPTER SUMMARY

Within the last 200 years, 30 to 50 percent of the wetlands in the lower 48 States have been converted by activities such as agriculture, mining, forestry, oil and gas extraction, and urbanization. About 90 million acres are covered now by wetlands, According to the most recent Federal survey, approximately 11 million acres of wetlands in the lower 48 States were converted to other uses between the mid-1950's and mid-1970's. This amount was equivalent to a net loss each year of about 550,000 acres, or about 0.5 percent, of remaining wetlands. Present nationwide rates of wetland conversion are about half of those measured in the 1950's and 1960's. This reduction is due primarily to declining rates of agricultural drainage and secondarily to government programs that regulate wetlands use. While coastal wetlands are protected reasonably well through a combination of Federal and State regulatory programs, inland, freshwater wetlands, which comprise 95 percent of the Nation's wetlands, generally are not well protected.

Wetland conversion rates and activities vary significantly throughout the country. On the one hand, conversions in the Lower Mississippi River Valley occurred between the mid- 1950's and mid-1970's at rates that were nearly three times the national average; on the other hand, rates in the Atlantic coast (exclusive of Florida) were only 30 percent of the national average. Overall, wetland conversions occurred in coastal areas at rates that were about 25 percent less than inland conversion rates.

Ninety-seven percent of actual wetland losses occurred in ***inland,*** freshwater areas during this 20-year period. Agricultural conversions involving drainage, clearing, land leveling, ground water pumping, and surface water diversion were responsible for 80 percent of the conversions. Of the remainder, 8 percent resulted from the construction of impoundments and large reservoirs, 6 percent from urbanization, and 6 percent from other causes, such as mining, forestry, and road construction. Fifty-three percent of inland wetland conversions occurred in forested acres, such as bottom lands. Of the actual losses of coastal wetlands, approximately 56 percent resulted from dredging for marinas, canals, port development, and to a lesser extent from erosion; 22 percent resulted from urbanization; 14 percent were due to dredged-material disposal or beach creation; 6 percent from natural or man-induced transition of saltwater wetlands to freshwater wetlands; and 2 percent were from agriculture.

NATIONAL TRENDS—NET LOSS AND GAIN

According to the National Wetland Trends Study (NWTS) (8), conducted recently by the U.S. Fish and Wildlife Service (FWS), there were in the mid-1970's approximately 99 million acres of vegetated and unvegetated wetlands in the United States, exclusive of Alaska and Hawaii. * Saltwater (or estuarine) wetlands comprise 5 percent of the wetlands; the rest are freshwater wetlands. (See table 11 for the relationship between the wetland types described in this chapter and those discussed in ch. 1,) About 93 million acres are vegetated types, including areas dominated by emergent plants (emergent wetlands), large trees (forested wetlands), and shrubs and small trees (scrub/shrub wetlands). Between the mid- 1950's and mid- 1970's, there was a net loss of these vegetated wetlands of approximately 11 million acres (fig. 6). Ninety-seven percent of this net loss was attributed to freshwater wetlands.

● Alaska and Hawaii were not included in NWTS. However, the Alaska District of the Corps of Engineers estimates that there may be as many as 223 million acres of wetlands in Alaska, nearly 60 percent of the State, Almost half of this potential wetland acreage (98 million acres) is some type of tundra. overall, the loss of wetlands in Alaska has not been great, although it has been concentrated in a few locations. Figures for Hawaii were not obtained but are expected to be quite low in relation to the data for the lower 48 states.

Table II.—Relationship Between Wetland Types Used for This Report[a]

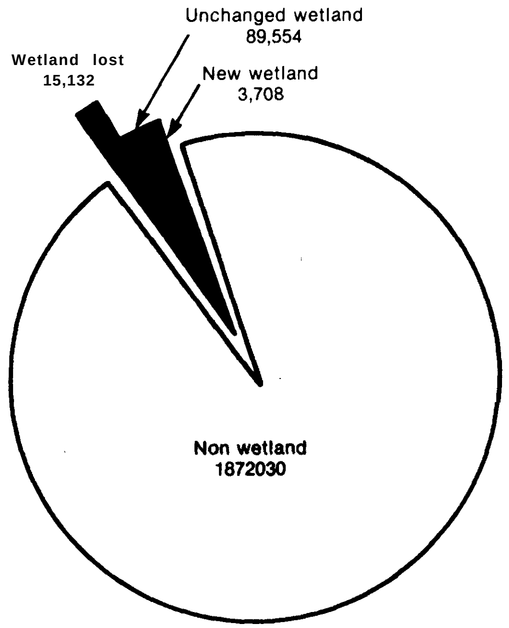
NWTS wetland classification types discussed in this chapter	National Wetland Trends Study code	Wetland types discussed in chapter 2
Estuarine (saltwater:		
• Intertidal vegetated:		
Emergents	3	Salt and brackish marsh (coastal)
Forested/scrub/shrub	4	Mangrove (coastal)
• Intertidal nonvegetated:		
Unconsolidated shore	5	Mudflats (coastal)
Other	7	Submerged beds (coastal)
• Deep water:		
Subtidal	2	Submerged beds (coastal)
Palustrine (freshwater):		
• Vegetated:		
Forested	8	Wooded swamp, bottom land hardwood, bog, pocosin (inland)
Scrub/shrub.	9	Bog, pocosin (inland)
Emergent	10	Freshwater marsh, saline marsh, freshwater tidal marsh (inland)
Tundra[b].	—	Tundra
• Nonvegetated:		
Unconsolidated shore	11	—
Open water	12	—
Other	13	—
Lacustrine (lakes):		
• Deepwater	14	—

[a]terminology for wetlands used in this chapter Includes the classification used by NWTS (the recently adopted USFWS Classification System, with minor modifications to distinguish vegetated and nonvegetated types, and large or deepwater areas from small or shallow-water areas); the old USFWS Circular 39 Classification System, and lay language. Since strict correlations cannot be made between these three categories and information obtained by OTA, all three categories are used in this chapter. The use of this variety of terminology is intended to clarify, rather than confuse, the discussion.

[b]Tundra not included in NWTS data. Under the recent USFWS classification system it is a palustrine/moss-lichen wetland.

SOURCE: W. E. Frayer, T. J. Monahan, D. C. Bowden, and F. A. Grayhill, "Status and Trends of Wetlands and Deepwater Habitats in the Coterminous United States, 1950's to 1970' s," Department of Forest and Wood Services, Colorado State University, Fort Collins, Colo., 1983, p. 31.

Figure 6.—Changes in Wetlands Since the 1950's (thousands of acres)



SOURCE: Original data from FWS's National Wetland Trends Study, 1982.

Factors Affecting Wetland Loss

Major sources of loss identified in NWTS include conversions to agricultural use, urban use, deep water (lakes, subtidal areas), nonvegetated wetlands, and other uses (such as forestry, rangeland, and mining). Major development activities associated with these losses of wetlands included dredging and excavation, filling, draining and clearing, and flooding. These same activities were responsible for wetland losses in Alaska, although fill activities are probably the major source of Alaskan losses.

Wetland characteristics may change and acreages increase or decrease in response to natural factors apart from, or in addition to, the development activities listed above. For example, variations in climate have a major influence on the size and vegetation of wetlands in the prairie-pothole region and in Nebraska, as well as on the ease with which they can be altered for agricultural use (6,9). Natural succession and activity of increased beaver populations were the greatest factors associated with wetland ***alteration*** in Massachusetts between 1951 and 1977; however, development activities were responsible for far more actual losses of wetlands.

Also, changes in sea level, sedimentation, erosion, subsidence, and overgrazing by birds or mammals all have played a role in the loss of wetlands in coastal Louisiana (2). Because of the many factors involved, it is difficult to determine the significance of losses from natural processes relative to those from man's activities. However, there is evidence that until artificial hydrologic changes were made, such as containment of the Mississippi River and canal dredging, there was a slow, long-term net gain of land (including wetlands) in the region (2). The dramatic reverse of these gains implies that much of the loss is man-induced, resulting from a combination of sediment starvation; canal construction; saltwater intrusion from navigation channels; and freshwater pumping for rice irrigation, marsh impoundment, and cattle grazing (2). Losses reported by NWTS are discussed in more detail below, followed by a discussion of wetland trends reported in regional case studies.

The average annual net-loss rate for the Nation's vegetated wetlands in the lower 48 States during the 20-year period of NWTS was about 550,000 acres/yr, or about 0.5 percent of the Nation's wetlands each year. It must be recognized, however, that the rate of loss is not uniform throughout the country. For example, the Lower Mississippi Alluvial Plain lost nearly 190,000 acres/yr, or about 1.6 percent of the region's wetlands each year. The Pacific mountains lost 19,000 acres/yr, but this also represented about 1.6 percent of the region's wetlands lost each year. These two regions had loss

Photo credit: OTA Staff, Joan Harn

A combination of levee and canal construction, saltwater intrusion from navigation channels, freshwater pumping for rice irrigation, marsh impoundments, and cattle grazing have led to major wetland losses in coastal Louisiana rates that were three times the national average. The Atlantic and gulf coastal zones lost about 17,000 acres/yr, or about 0.35 percent of the combined regions' wetlands, a little more than half of the national rate.

Nonvegetated wetlands include about 6 million acres of estuarine and palustrine unconsolidated shore and other types of freshwater open water (areas less than 20 acres in size or less than 2 meters deep). Most of the net gain of about 2 million acres in these nonvegetated wetland types between the mid- 1950's and mid- 1970's involved the net increase of 1.7 million acres in freshwater, open water from the ''other use' category (i. e., land that formerly was neither wetland, agricultural, or urban).

Trend Information

Information from NWTS is the most reliable information available and is used here to identify major sources of loss. The data has strong statistical validity for nationwide figures on wetland gains and losses and represents what happened to wetlands prior to the implementation of the 404 program. Recent information on how these trends may have changed since the implementation of the 404 program in the mid-1970's and the initiation of other efforts to control wetland use is available on a qualitative basis only for some regions of the country. Regional information from NWTS and case studies provide less statistically precise trend information in specific areas of the country. The regional case studies also examine other information sources, including comparative studies and inventories, permit data, and personal interviews.

The recent availability of statistically reliable national estimates of wetlands in the mid-1950's and mid- 1970's necessitates a reevaluation of previous estimates of the loss of 'original' wetland acreage in the lower 48 States since the time of European settlement. All estimates of 'original' acreage are limited by the lack of good data on the amount of land that has been drained or otherwise reclaimed and the relationship between wetlands and wetsoils. The following OTA analysis relies on a comparison of wetlands reported for the mid-1950's by NWTS (8) and the estimates of reclaimed lands for 1950 reported by Wooten (19). To develop an estimate of the maximum percentage of reclaimed lands that were wetlands, NWTS data were compared with the difference between improved lands reported by Wooten and agricultural lands on wetsoils in 1977 reported by the U.S. Department of Agriculture (USDA) (16).

The most commonly accepted estimate of 30- to 40-percent loss of original wetlands is based in part on estimates of wetland acreage both originally and in the 1950's reported in Circular 39 (3, 15). In Circular 39, FWS estimated that a minimum of 45 million acres of wetlands had been reclaimed by the mid-1950's. If this estimate is valid and is added to the 104 million acres of wetlands that NWTS reported for the mid- 1950's, then there would have been a minimum of 149 million acres of 'original' wetlands, not the 127 million estimated by USDA's Soil Conservation Service (SCS). NWTS data, therefore, indicate that FWS Circular 39 estimates were about 20 percent too low.

The minimum value of 45 million acres of reclaimed wetlands by the mid-1950's was developed from data prepared by USDA; however, according to Wooten, a total of 135 million acres had been reclaimed by 1950. Many of these lands were probably just wetsoils, and not wetlands. The relationship between wetsoils and wetlands cannot be determined with existing information. Recent USDA information on wetsoils is correlated with Circular 39 wetland types 3-20 on non-Federal rural lands. NWTS information on wetlands uses the new FWS classification that doesn't correspond directly to Circular 39 wetland types 3-20, but instead to types 1-20. Also, NWTS doesn't distinguish Federal from non-Federal lands.

Sixty percent of the increase in agricultural land on wetsoils between the mid-1950's and mid-1970's appears to have come from wetlands if we compare the difference between improved lands reported by Wooten in the 1950's and agricultural lands on wetsoils in 1977 reported by USDA with NWTS estimates of wetlands in the mid- 1950's and mid-1970's. This estimated 60 percent compares favorably with the estimate discussed later in this chapter, that 65 percent of the lands drained between 1955 and 1975 were wetlands. Assuming that the proportion of wetlands to wetsoils that are being converted to agricultural use probably has been increasing over time (since it's probably easier to convert wetsoils to other uses than wetlands), then the percentage of wetsoils that were reclaimed wetlands prior to the mid-1950's was 60 percent at most. If we then assume that at most 60 percent of the 135 million acres of reclaimed lands reported by Wooten were wetlands and add NWTS'sestimate of 104 million acres of wetlands in the mid-1950's, we can derive a maximum value for "original' wetlands of 185 million acres.

Thus, previous estimates of loss of original wetlands probably were low. If the SCS estimate of 127 million acres of original wetlands is accepted, then losses may have been as low as 30 percent. If only one-third of the reclaimed lands were wetlands, as was assumed for the purposes of Circular 39, then there was an original acreage of 149 million acres for a loss of nearly 40 percent. If at most 60 percent of the reclaimed lands were wetlands (as a means of developing a maximum estimate of 185 million acres of original wetlands), then as much as 50 percent of the original wetlands may have been converted. All of these estimates are limited by the lack of good data on the amount of land that has been drained or otherwise reclaimed and the relationship between wetlands and wetsoils.

VEGETATED WETLAND TRENDS

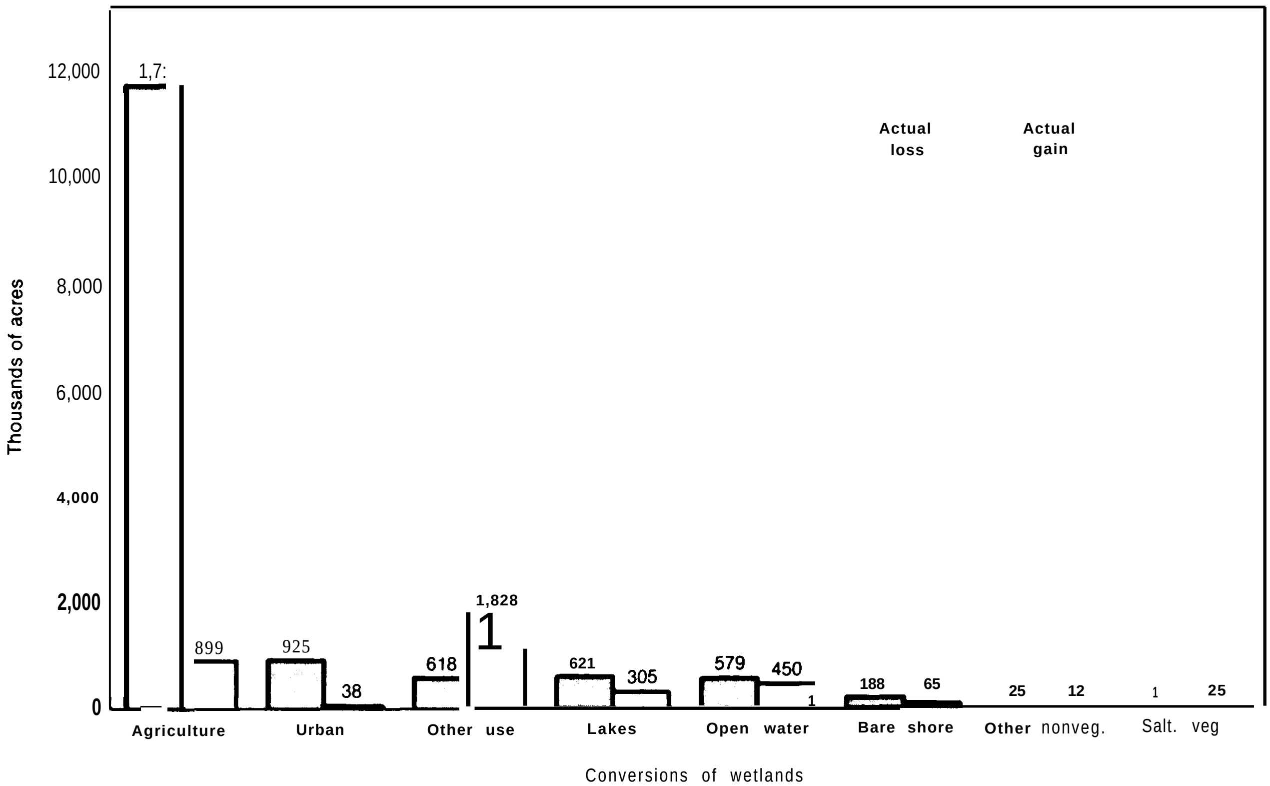
Freshwater Wetlands

Since freshwater areas comprise 95 percent of the Nation's vegetated wetlands, freshwater wetland losses are similar to overall national trends (see fig. 7). There was a net loss of 11 million acres of freshwater vegetated wetlands between the mid-1950's and mid-1970's, representing a reduction of 11 percent. Forested wetlands accounted for 54 percent of the net loss of freshwater vegetated wetlands, emergent marshes accounted for 42 percent, and scrub-shrub wetlands accounted for 4 percent. Information on actual losses and gains are presented below and summarized in table 12.

Actual losses of freshwater vegetated wetlands totaled 14.6 million acres. Agricultural land use was responsible for 80 percent of these losses. The remaining 20 percent was comprised of urban use (6 percent), other use (4 percent), nonvegetated habitat (open water, 4 percent; unconsolidated shore, 1 percent; and other nonvegetated habitat, less than 1 percent), deepwater types (4 percent), and saltwater vegetated wetlands (less than 1 percent). These losses to nonvegetated open water and deep water are most likely associated with impoundments (e. g., farm ponds, water supply, flood control and recreational reservoirs, and waterfowl-management impoundments). They also could be associated with drainage practices that concentrate water in the lowest lying wetland to allow drainage of other wetlands in the watershed. Factors associated with the loss to unconsolidated shore might also be associated with impoundments, especially if water levels fluctuate. Other possible factors responsible for such loss include grazing, plowing, and natural climatic shifts associated with reductions in wetland vegetation. Losses to saltwater wetlands may result from decreased freshwater outflows" or destruction of dikes in coastal areas.

Actual gains in freshwater vegetated wetlands totaled 3.6 million acres. Roughly 50 percent of the gains were from the ' 'other uses' category. These gains can be accounted for primarily by increases in emergent and scrub-shrub wetlands surrounding newly constructed farm ponds on lands that were formerly neither wetlands nor in agricultural use. According to information from SCS, about 50,000 farm ponds, averaging 0.5 acre in size, were constructed each year during the period analyzed in NWTS (18). Other gains were from agriculture (25 percent), nonvegetated types (13 percent from open water and 2 percent from unconsolidated shore), deep water (8 percent), urban areas (1 percent), and saltwater vegetated wetlands (1 percent). Most of these gains probably were related to successional changes associated with abandonment of former land uses, such as the lack of maintenance of drainage ditches for forestry and agriculture, or natural factors like beaver activity, construction of roads that block drainage, construction of irrigation ditch

Figure 7.—Freshwater Wetland Trends (mid-1950's to mid-1970's)



SOURCE: USFWS National Wetland Trends Study, 1982

Table 12.—Probable Causes of Freshwater Vegetated Wetland Changes

	Acres	Cause of loss
Freshwater wetland loss to:		
Agriculture	11,720,000	Drainage, flooding, excavation, clearing, land-leveling, filling, ground water pumping, and surface water diversions for conversion to cropland
Urban use	925,000	Fill for development
Deep water	621,000	Impoundments
Other use	618,000	Drainage, excavation, filling for forest management, mining, other
Open water	579,000	Impoundments, drainage/flooding, excavation, climatic changes
Unconsolidated shore	188,000	Impoundments, grazing, plowing, climatic changes
Other nonvegetated	25,000	
Saltwater vegetated	1,000	Decreased freshwater outflow, destruction of dikes
Total	14,677,000	
	Acres	**Cause of gain**
Freshwater wetland gains from:		
Other uses	1,828,000	Succession around margins of newly constructed farm ponds
Agricultural use	899,000	Lack of maintenance on drainage ditches, dikes
Open water	450,000	Succession around margins of existing ponds
Deep water	305,000	Succession around margins of larger water bodies
Unconsolidated shore	65,000	Vegetation establishment
Urban use	38,000	Drainage and open space management
Saltwater vegetated wetlands	25,000	Increased freshwater outflow, construction of dikes
Other nonvegetated	12,000	—
Total	3,622,000	

SOURCE: Data from FWS National Wetland Trends Study, 1963 systems that may leak and support some wetland vegetation, and construction of dikes in coastal areas.

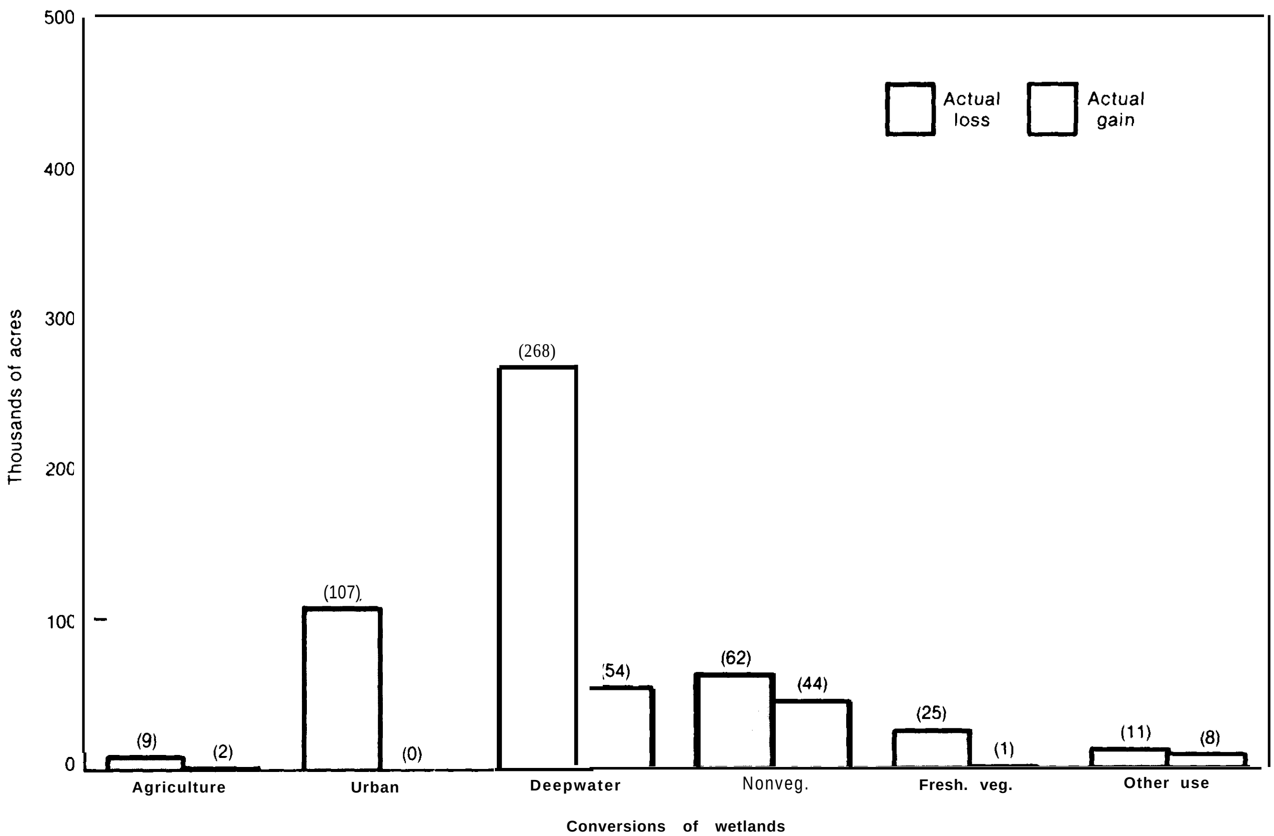
Saltwater Wetlands

Saltwater-loss trends differ from those of freshwater since conversions to deep water and urban use are most prevalent. Agricultural use has had little impact on saltwater wetlands in recent years (see fig. 8). There was a net loss of 373,000 acres of saltwater vegetated wetlands between the mid-1950's and mid-1970's, representing a 7.6-percent reduction. Emergent saltwater wetlands comprised 95 percent of these net losses. The remaining 5 percent were saltwater forested and scrub-shrub wetlands. Information on actual losses and gains is presented below and summarized in table 13.

Actural losses in saltwater vegetated wetlands totaled 482,000 acres. Conversions to deep water were responsible for 55 percent of these losses. This amount probably can be attributed to dredging for canals, port and marina development, and erosion. Urban use accounted for 22 percent of the losses. Conversions to nonvegetated types (i.e., unconsolidated shore, 11 percent; and other, 2 percent) were likely to be associated with dredged-material disposal practices, removal of vegetation for recreational development, such as beach creation, and death of vegetation associated with changes in salinity. Transitions to freshwater vegetated wetlands were responsible for 6 percent of the losses. Such transitions could be related to increases in freshwater outflow or dike construction. Agriculture and other uses were each responsible for 2 percent of the losses.

Actual gains in saltwater vegetated wetlands totaled 109,000 acres. Roughly 50 percent of the gain was from deepwater areas, and 40 percent was

Figure 8.—Saltwater Wetland Trends (mid-1950's to mid-1970's)



SOURCE USFWS National Wetland Trends Study, 1982

Table 13.-Probable Causes of Saltwater Vegetated Wetland Changes

	Acres	Cause of loss
Saltwater wetland loss to:		
Deep water	268,000	Dredging for canals, port and marina development, erosion
Urban use	107,000	Fill for development
Unconsolidated shore	50,000	Dredged material disposal, removal of vegetation for recreational development, death of vegetation
Freshwater vegetated wetlands	25,000	Increased freshwater outflow, dike construction
Agriculture	9,000	Diking for conversion
Other uses	11,000	Filling for port development
Other nonvegetated	12,000	—
Total	482,000	
	Acres	Cause of gain
Saltwater wet/and gain from:		
Deep water	54,000	Natural establishment of vegetation, marsh creation efforts
Nonvegetated types	44,000	Same as deep water
Other uses	8,000	Same as deep water
Agriculture	2,000	Destruction of dikes
Freshwater vegetated wetlands	1,000	Reductions in freshwater outflow, dike construction, increased saltwater inflow
Total	109,000	

SOURCE: Data from FWS National Wetland Trends Study, 1983.

from nonvegetated types. Reasons for these changes probably include natural establishment of vegetation and marsh-creation efforts associated with dredged-material disposal and erosion-control practices. Other uses were responsible for 7 percent of these gains, and abandonment of agricultural lands accounted for 2 percent of the gains. The remaining 1 percent were gains from freshwater vegetated wetlands that may be associated with reductions in freshwater outflow, destruction of dikes, or increased saltwater flow.

Regional Trends

Using national figures of wetland losses and gains can be misleading. Farm ponds—such as in Missouri— even with aquatic plant improvements through plant succession, cannot compensate for potholes lost in the prairie-pothole area. A wide variety of migratory birds uses the latter for reproduction and rarely or infrequently uses the former. Regional information on wetland use was obtained by OTA from four primary sources: NWTS, other inventory and trend studies, permit information, and interviews.

NWTS (8)

For OTA's study, NWTS grouped its data into 13 regions so that wetland losses and gains on regional levels could be analyzed. The regions are listed in table 14 and shown in figure 9. Although this study was based on a stratified random sampling, very large standard errors are associated with its data on a regional level.[1] The regional data reflect actual losses and gains in wetlands and other land uses at the sample sites. Such data indicate probable trends in wetland use in a region, especially if they can be supported by other sources of evidence.

Regional data provide an average picture over a large area and do not necessarily reflect the actual status of wetlands within a single State in the region. For example, in the Upper Midwest, Illinois lost 186,905 acres, or 23 percent, of the wetlands that were present in the mid-1950's; Wisconsin lost 133,872 acres, or 3 percent, of wetlands present in

[1]The following explanation of statistical reliability is from W. E. Frayer & Associates, "Status and Trends of Wetlands and Deepwater Habitats in the Coterminous United States, 1950's to 1970's—Final Draft 1982, " National Wetlands Inventory, Office of Biological Services, U.S. Fish and Wildlife Service:

> Standard errors for overall wetland loss figure for physiographic regions range from a low of 11 percent of the measured loss in the gulf coastal zone to a high of over 134 percent of the measured loss in the intermontane region. The majority of the standard errors for physiographic regions are from 15 to 35 percent of the measured loss. Reliability can be stated generally as "we are 68 percent confident that the true value is within the interval constructed by adding to and subtracting from the entry the SE%/100 times the entry " For example, if an entry is 1 million acres and the SE percent is 20, then we are 68-percent confident that the true value is between 800,000 and 1.2 million acres. An equivalent statement for 95-percent confidence can be made by adding and subtracting twice the SE% /100 to and from the entry, respectively.

Table 14.—Physiographic Regions Used for Regional Analysis of National Wetland Trends Study Data

Region
1—Atlantic coastal zone[a]
2—Gulf coastal zone[b]
3—Atlantic coastal flats[a]
4—Gulf coastal flats[b]
5—Gulf-Atlantic rolling plain
6—Lower Mississippi Alluvial Plain
7—Eastern highlands
8—Dakota-Minnesota drift and lake bed flats
9—Upper Midwest
10—Central
11 —Rocky Mountains
12—Intermontane
13—Pacific mountains

[a]Atlantic regions do not include Florida.

[b]Gulf regions include Florida.

SOURCE: Office of Technology Assessment

the region. Data from Minnesota more closely reflect the trends for the entire region. Minnesota lost 447,709 acres, or 8 percent, of wetlands in the upper midwest portion of the State.

The proportion of wetlands and percentage of loss vary considerably in the different physiographic regions (see table 15). Three regions have a greater proportion of land area as wetlands and a greater loss rate than the national averages of 5 percent and 11 percent, respectively: Lower Mississippi Alluvial Plain, gulf coastal flats, and gulf-Atlantic rolling plain. Five regions have a greater proportion of land area as wetlands and loss rates at less than or equal to the national averages: Atlantic coastal zone, gulf coastal zone, Atlantic coastal flats, Dakota-Minnesota drift and lakebed flats, and Up-

Figure 9.— Physical Subdivisions

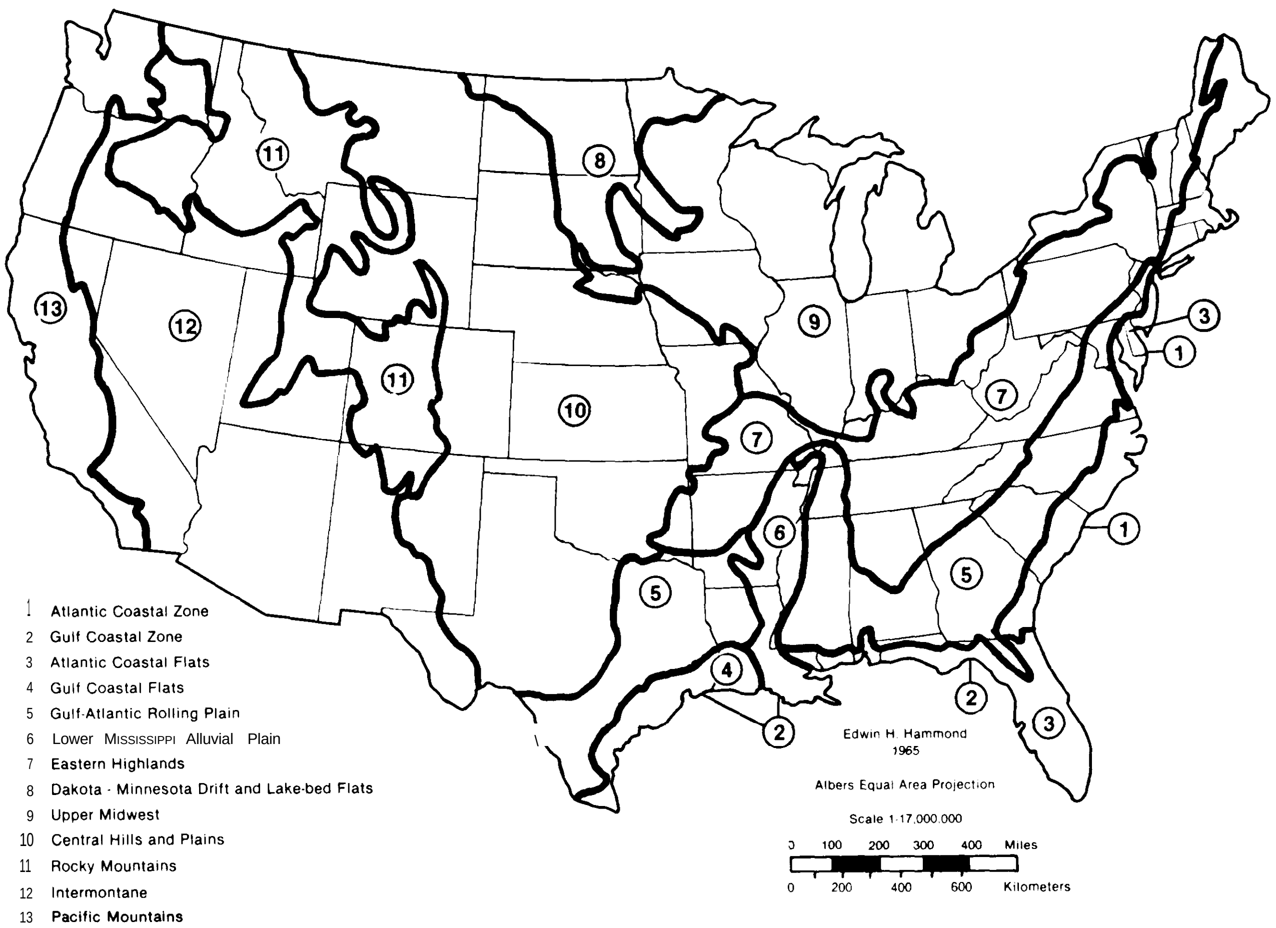


Table 15.—Pattern of Wetland Loss by Physiographic Region

Region	Wetland portion of region (mid-1950's) (%)	New loss of wetlands (mid-1950's-mid-1970's (%)	Actual loss (acres)	Actual gain (acres)	Standard error for net change (%)
I—Atlantic coastal zone[a]		3	84,000	48,000	52.3[c]
2—Gulf coastal zone[b]	28	9	371,000	70,000	11.3[d]
3—Atlantic coastal flats[a]	36	11	1,274,000	74,000	15.0[e]
4—Gulf **coastal flats**[b]	**27**	13	1,872,000	341,000	14.5[f]
5—Gulf-Atlantic rolling plain	8		2,310,000	291,000	31.2[g]
6—Lower Mississippi Alluvial Plain	36	32	3,749,000	331,000	8.6[h]
7—Eastern highlands	2	2	322,000	211,000	68.8[g]
8—Dakota-Minnesota drift and lake bed flats	10	9	816,000	424,000	33.6[g]
9—Upper Midwest	8	7	2,286,000	754,000	16.8[g]
10—Central	1	3	763,000	637,000	(i)
11-Rocky Mountains	4	<1	125,000	112,000	(i)
12—Intermontane	1	12	685,000	320,000	(i)
13—Pacific mountains	1	31	473,000	94,000	77.1

[a]Atlantic regions do not include Florida.
[b]Gulf regions include Florida.
[c]Standard error given is for saltwater wetlands. The freshwater wetlands had a net gain of 10,626 acres with a standard error of 86.9 percent.
[d]Standard error given is for saltwater wetlands. The freshwater wetlands had a net gain of 2,137 acres with a standard deviation greater than this value.
[e]Standard error given is for freshwater wetlands, Saltwater wetlands had a net loss Of 866 acres with a standard deviation greater than this value.
[f]Standard error given is for freshwater wetlands. Saltwater wetlands had a net gain of 933 acres with a standard error of 81.6 percent.
[g]Standard error is for all vegetated wetlands measured in region which included exclusively freshwater types.
[h]Standard error is for freshwater wetlands. Saltwater wetlands had a net loss of 22,282 acres with a standard error of 67.8 percent.
[i]Standard deviation is greater than estimated net change.

SOURCE: Original data from FWS National Wetland Trends Study, 1983.

per Midwest. Two regions have a lower proportion of land area as wetlands and loss rates greater than the national average: Pacific mountains and Intermontane. Three regions have a lower proportion of land area as wetlands and loss rates less than the national average: Eastern highlands, Central, and Rocky Mountains. Although the amount of wetland acreage lost from these areas with relatively few wetlands may not have contributed much to the national totals, such losses may be environmentally significant on a regional level.

The percentage of wetland loss to various activities varies among the physiographic regions (see table 16). The actual losses of vegetated freshwater wetlands to agriculture range from 1 to 90 percent. However, agricultural use was the greatest cause of loss of vegetated freshwater wetlands in all regions, and the proportion of agricultural loss was greater than the national average (i.e., 80 percent) in six regions.

In all 11 physiographic regions with predominantly vegetated freshwater wetlands, the losses to agriculture were greater than any gains in wetlands from agriculture. However, there were two exceptions to this net loss to agriculture when data from ***subdivisions*** comprising the physiographic regions were examined. (Standard errors are extremely high for subdivision data.) Agriculture is a source of net gain of wetlands in the Adirondack-New England subdivision of the Eastern highlands region. This trend is supported by the findings of the New England case study, which notes increases in wetlands from agricultural abandonment and the lack of maintenance of drainage ditches. Agriculture is also a source of net gain of wetlands in the Columbia Basin subdivision of the Intermontane region. Wetland increases associated with irrigation development may be partially responsible for this trend.

Conversions to urban use were the second most important cause of actual losses in two regions, the third most important cause in three regions, and the least important cause in six regions. Proportions of loss to urban use range from O to 36 percent. These proportions are greater than the national average (6 percent) for urban loss in three regions: gulf coastal flats, Eastern highlands, and Upper Midwest.

In all regions, losses to urban use were greater than any gains in wetlands from this use, with one

Table 16.—Percentage of Vegetated Wetland Loss to Different Uses by Physiographic Region[a] (mid-1950's to mid-1970's)

Region	Agriculture	Urban	Other	Water/nonvegetated
1—Atlantic coastal zone[b]	5	36	5	54
2—Gulf coastal zone[c]	1	19		78
3—Atlantic coastal flats[b]		6	2(+)	3
4—Gulf coastal flats[c]	66	19	4(+)	11
5—Gulf-Atlantic rolling plain	84		4(+)	9
6—Lower Mississippi Alluvial Plain	90	3	3 (+)	4
7—Eastern highlands	38	22	5 (+)	35
8—Dakota-Minnesota drift and lake bed flats	83		4 (+)	12(+)
9—Upper Midwest	71	8	3 (+)	18
10—Central	63	5	15 (+)	17 (+)
11—Rocky Mountains		0	19 (+)	10 (+)
12—Intermontane	88	1	7 (+)	4 (+)
13—Pacific mountains	87	1	7 (+)	5

[a] (+) indicates there was a net gain in wetlands from the use category in the region. If (+) is *not* indicated, then there was a net loss *from* that use category.
[b] Atlantic regions do not include Florida.
[c] Gulf regions include Florida.

SOURCE: Original data from FWS National Wetland Trends Study, 1983.

exception. Urban use is a source of wetland gain in the West central rolling hills subdivision of the Central region which can be attributed to a gain in wetlands in Iowa, accompanied by a slightly lower rate of wetland conversion to urban use in Nebraska. Gains of wetlands from urban use in Iowa could be associated with flood plain management activities.

The combined category of deep water, open water, and other nonvegetated types was the second most important cause of actual losses of vegetated freshwater wetlands in six of the regions and the third most important cause in the remaining five regions. The proportion of these losses was greater than the national average (10 percent) in five regions.

These losses to deep water, open water, and other nonvegetated types were accompanied by gains in freshwater vegetated wetlands from these categories, resulting in a net gain in 4 of the 11 regions, including Dakota-Minnesota drift and lakebed flats, Central, Rocky Mountains, and Intermontane. All other regions had a net loss of vegetated wetlands from these categories. Subdivision data on these net changes show five exceptions each for the general region trends of net loss and net gain of vegetated wetlands from this category. Again, standard errors for these numbers are very high.

Conversions to other uses were the second most important cause of loss in three regions, the third in four regions, and last in the remaining four regions. Proportions of loss from other uses range from 2 to 19 percent. These proportions are greater than the national average (4 percent) in five regions. In all regions, these losses to other uses were accompanied by gains, resulting in a net gain in freshwater vegetated wetlands from this category. This gain is relatively small when compared to the overall losses of wetlands.

Two physiographic regions comprise 98 percent of the data for saltwater wetlands: Atlantic coastal zone and the gulf coastal zone. The remaining 2 percent is primarily from the Lower Mississippi Alluvial Plain. A very small amount of saltwater wetlands was also measured in the gulf and Atlantic coastal flats regions. No data were collected for saltwater wetlands of the Pacific coast.

The Atlantic coastal zone and gulf coastal zone (including Florida) both showed a net loss of salt and brackish wetlands. However, in the Atlantic region, this loss was attributed primarily to urban use. There was also a net loss due to agriculture, conversions to freshwater wetlands, and other uses. A net gain of vegetated wetlands resulted from deep water, open water, and other unvegetated areas. In the gulf region, the net loss of salt and brackish wetlands was due primarily to deep water and nonvegetated areas. Louisiana and Florida accounted for 84 percent and 10 percent of these losses, respectively. Erosion, subsidence, and dredging for canals and marinas were probably responsible for these trends. Urban losses also were significant. Additional losses were due to agricultural and other uses.

Regional Case Studies

Ten OTA regional case studies (table 17) of trends in wetland use in 21 States provided information from three major sources:

- Wetland inventory and trend information (other than NWTS): There are few reliable trend studies. Moreover, there are many problems with comparing inventory studies to establish trends, owing to variations in wetland definitions, size categories, and study areas. For example, in Minnesota, a 1950 inventory examined wetlands within 15,803 square miles (mi^2) of the prairie-pothole region. A 1955 inventory looked at Circular 39 types 1-8 in western Minnesota; in 1964, types 3-5 were inventoried in 19 western Minnesota counties; and in 1982, types 3-5 (over 10 acres) were inventoried in 14 western Minnesota counties (6).
- Permit information on section 404 and State programs: There are few cases where data have been compiled for particular permit programs. Data that are available generally report only what has been allowed under the reported permit program and exclude information on illegal activity and activities taking place in wetlands that aren't covered by the permit pro-

Table 17.—Wetland Case Study Sites

Region/States	OTA contractor
New England/Massachusetts, Connecticut, Rhode Island, Vermont, Maine, and New Hampshire	Water Resources Research Center University of Massachusetts Amherst, Mass, 01003
North and South Carolina	School of Forestry and Environmental Studies Duke University Durham, N.C. 27706
Gulf Coast and Lower Mississippi River/Louisiana, Texas, and Mississippi	Coastal Ecology Laboratory Center for Wetland Resources Louisiana State University Baton Rouge, La. 70803
Prairie Potholes/Minnesota, North and South Dakota	Department of Agricultural Economics and Center for Environmental Studies N.D. Agricultural Experiment Station North Dakota State University Fargo, N.D. 58105
California and Alaska	ESA/Madrone, Environmental Consultants 23-B Pamaron Way Novato, Calif. 94947
New Jersey	JACA Corporation 550 Pinetown Road Fort Washington, Pa. 19034
Washington	Shapiro and Associates, Inc. The Smith Tower, Suite 812 506 Second Avenue Seattle, Wash. 98104
Nebraska	Center for Great Plains Studies 1213 Oldfather Hall Lincoln, Nebr. 68588
Florida	Center for Governmental Responsibility Holland Law Center University of Florida Gainesville, Fla. 32611

SOURCE: Office of Technology Assessment

gram. The 404 program provides only very general unverifiable estimates of acreages of wetlands converted by permitted projects on a districtwide basis.

- Interviews: Interviews are probably the best qualitative source of information if they are accompanied by information from the other data sources. However, they must be viewed strictly as expert testimony.

OTA information from the regional case studies allows the following general conclusions about past and current wetland trends:

- Agricultural practices are a major factor associated with wetland loss in inland areas of North Carolina, South Carolina, Maryland, Florida, Nebraska, and California, plus the prairie-potholes and Lower Mississippi River Valley. Losses to wetlands continue in these areas today. More detailed information on agricultural conversions is provided at the end of this chapter.
- LOSS of coastal freshwater and saltwater wetlands to open water, deep water, and unvegetated areas through dredging and filling for marinas and canals is a major factor in South Carolina, North Carolina, Texas, Louisiana, California, New Jersey, Florida, and Washington. The rate of loss from man's activities has been reduced as a result of regulatory efforts under the Federal section 404 program and State programs. Some projects are not approved; others are approved with required measures for restoration or creation of wetlands. Regardless of mitigation measures, however, losses continue to occur.
- Loss of inland wetlands to open and deep water areas from impoundments occurs in New England, Nebraska, Lower Mississippi River Valley, and prairie-potholes areas. Losses related to agricultural development and the farm pond exemption continue, although the construction of farm ponds may result in new wetlands forming on adjacent lands. Losses from newly designed impoundments and channels for flood control and municipal water supply continue, but projects are handled in a more environmentally sensitive manner in accordance with Federal and State environmental and regulatory policies. Some projects may require mitigation.
- Urban development has been a major factor in wetland loss in coastal areas in South Carolina, Florida, Mississippi, California, Washington, New Jersey, New England, and Alaska. Federal and State regulatory programs have slowed the loss considerably. Current losses usually are restricted to water-dependent projects and often require mitigation. Losses continue in areas that are not subject to regulation and from small projects that potentially may have significant cumulative impacts. Losses also continue in areas (e. g., southeast and south-central Alaska) where there are few alternative construction sites in nonwetlands.
- Sources of loss from other uses include forestry, mining, port development, road construction, and succession to nonwetlands. These activities are important to varying degrees in many areas, including North Carolina, the Lower Mississippi River Valley, Florida, New England, Nebraska, prairie-potholes, Maryland, California, Alaska, and Washington. Losses continue for nonregulated activities and areas. Losses also continue for activities subject to regulation, but again are generally handled in a more environmentally sensitive manner in accordance with Federal and State environmental and regulatory policies.

Case study information can reveal further some of the specific factors associated with these losses in different regions. The following tables summarize case study information on the major national trends for vegetated wetlands. Tables 18 to 21 present information on conversions to agriculture, open and deep water, urban development, and other uses, respectively. Conversions to other nonvegetated wetlands were not addressed specifically in the case studies. The category ' 'other uses' includes information on forestry, mining, ports, road construction, and activities in nonwetlands. The tables include information on how the conversions are accomplished, important regions and types of wetland involved, reasons why the changes occur, and current and past trends, where available. Impacts of activities causing conversions are discussed further in chapter 6; the current programs that reg-

Table 18.-Agricultural Conversions of Wetlands (mid-1950's to mid-1970's)

How accomplished	Important regions/ wetland types	Reasons	Trend
Major drainage, flooding	Prairie potholes of Minnesota, North Dakota, South Dakota/shallow, moderately deep marshes and seasonally flooded flats	Opportunity to gain additional cropland Elimination of nuisance by avoiding potholes within cropland. Change in farming from diversified crops and livestock to row crops and small grain Increase in tractor horsepower Increases avoidance costs Increase in center-pivot irrigation Climatic variations Absence of financial incentives to maintain wetlands Drainage opportunities from channel projects and rural roads ditches Tax benefits for drainage	Of original, 25 to 30 percent of acres remain; greatest percentage and acreage drained in Minnesota. However, this is extremely variable within region, varying by 12 to 95 percent. Continuing conversion. Annual drainage rates estimates range from 0.1 to 5.0 percent, Almost half remaining wetlands are under protective programs; of these, 90 percent are permanent forms
Major drainage, flooding, excavation, land-leveling	Nebraska Rainwater Basin/shallow, moderately deep marshes and seasonally flooded flats	Intensify or expand cropland Drainage opportunities through rural road upgrading and improvement Drought incidence Possible Federal or State cost-sharing assistance for reuse systems or leveling associated with irrigation Tax benefits for drainage Available farm equipment	Continuing conversion. Remaining are 15- to 25-percent original acres and 10- to 15-percent original basins. Protection programs cover 50 to 85 percent of remaining acreage. Nearly 90 percent of these are in permanent form
Ground water pumping, associated land-leveling and filling	Nebraska Sandhills/wet meadows	Conversion of rangeland to cropland Long-term reduction in ground water levels and seasonal ground water variations due to expanding center-pivot irrigation increase efficiency of center pivot Expand hay production into wetter areas	Accelerating conversion rate in last 10 years. Remaining are 85 to 95 percent of original acres and more than 95 percent of original basins
Ground water pumping, surface water diversions	Nebraska-Central Platte Valley/wet meadows	Indirect impact of regional irrigation development Conversion of rangeland to cropland	Of original wet meadows 30 to 45 percent remaining
	California—Klamath Basin/emergent marshes	Conversion of rangeland to cropland	Of original acreage 40 percent remaining. Continuing conversions on private and managed wetlands. Approximately 50 percent of remaining wetland and lake areas in national wildlife refuges and State wildlife management areas
Normal farming: land-leveling of flood-irrigated areas, shift in crops, shift in planting and harvest schedules	California–Central Valley/emergent marshes	Less water available Increased pumping costs Clean farming practices Pestacide/herbicide use Flood control Irrigation technology	More than 90 percent converted from 1850 to 1978. Continuing conversions of ricelands to less water-intensive crops. Degradation of habitat on secondary wetland areas. Of remaining acreage, 20 percent in public ownership
Drainage, land-leveling	California–Central Valley/emergent marshes	Less water available Higher taxes on nonagricultural lands Increased pumping costs Degradation of habitat on secondary wetland areas	See above description of overall trends of Central Valley. Conversion of private wetlands to agriculture. Reduction of flooded public acreage

Table 18.—Agricultural Conversions of Wetlands (Continued)

How accomplished	Important regions/ wetland types	Reasons	Trend
Clearing vegetation	Lower Mississippi River Valley/bottom land hardwoods	Soybean demand Relative price of timber Drought incidence Flood-control projects	Significant conversion prior to 1937. Forty-four-percent reduction, 1937 to 1977. Forest remaining O to more than 60 percent (1979), Rate of clearing peaked 1967 (except Louisiana). Clearing rates related to remaining forest. Continuing conversion
Clearing vegetation drainage	North and South Carolina/bottom land hardwoods	Relative price of timber Improved drainage equipment Refined use of lime, fertilizer, pesticides Improved seed stocks Agribusiness investment	increase from 1930's to 1950's from reforestation of abandoned farms. Increasing rate of conversion 1950's to 1970's
Clearing vegetation, drainage	North Carolina/pocosins	Improved drainage equipment	By 1979, 33 percent totally developed. Of remaining areas, 65 percent owned by agricultural and forest products industries. Five percent protected from drainage through public ownership or lease
Clearing vegetation, drainage	South Carolina/carolina bays	Large-scale agriculture Forestry	Ninety-five percent altered
Clearing vegetation, drainage	South Florida/cypress	Agricultural and urban uses	Conversions occurred from 1900 to 1973, including 25 percent of cypress domes and stands and 12 percent of scrub cypress. Continuing conversions
Lack of drainage, ditch maintenance	New England/wooded wetlands	Agricultural abandonment	Wetlands recreated
Mowing, seeding, fertilizing, grazing	South Florida/wet prairies, sawgrass	Expanded agriculture Transform areas to dry land to prepare for urban development (and avoid regulations associated with fill in wetlands)	Conversion of 45 to 52 percent of wetlands from 1900 to 1973. Continuing conversions

SOURCE OTA Regional Case Studies

Table 19.—Conversions of Wetlands to Open-Water and Deep-Water Environments

How accomplished	Region/type	Reasons	Trend
Fill, flooding	New England/forested and marsh	Municipal reservoirs Flood control Blocked drainage from highway construction Farm ponds Recreational ponds Beaver activity	Majority of change from beaver activity. Between early 1950's to mid-1970's 47 percent of change from man's activities attributed to impoundments. Continuing conversions but with reduced impacts on wetlands from large-scale project due to regulatory requirements. Continuing conversions to farm ponds
Fill, flooding, excavation	Lower Mississippi River Valley/forested and marsh	Flood control impoundments, navigation channels	Continuing construction of formerly authorized projects (e.g., Yazoo Pumps)
Fill, diversion, flooding, excavation	Lower Colorado River Valley, Salton Sea/desert riparian marshes and forests	Flood control, irrigation, urban water-supply impoundments	Most of conversions associated with dams building occurred prior to 1940's. Channelization, dredging, and levee projects continue. Some wetlands created in large impoundments. Small habitat restoration and preservation activities along river
Flooding	Prairie potholes-Minnesota, North Dakota, South Dakota/emerfgent marsh	Concentrate surface water and provide drainage for other wetlands	See trends for agricultural conversions–table 18.
Flooding, excavation	Nebraska Rainwater Basin/marsh	Create irrigation reuse pits Reservoirs Irrigation canals	See trends for agricultural conversions–table 18
Fill, flooding, diversions	Nebraska–Platte River Valley, other rivers and streams/marsh and riparian habitat	Impoundments and diversions for irrigation and power	See agricultural conversions-table 18
Fill, flooding	South Carolina coast/fresh and salt marsh	Impoundments for rice culture, waterfowl management	Transition from swamp and salt marsh to fresh marsh. Impoundment construction in 19th century. Majority now managed for waterfowl. Areas not maintained reverted to original state. Resurgence of interest in reconstructing old impoundments mostly for wintering waterfowl and hunting. Some interest in aquiculture. Proposed impoundments in these areas covered the majority of permit applications for South Carolina. Very little was permitted in 1978
Fill, flooding, excavation	North Carolina coast/salt marsh	Impoundments and ditches for mosquito control	From 1956 to 1967, 17 percent of salt marsh converted. Rate of conversion slowed by using pesticides, open marsh water-management. Difficulty in getting 404 permits because of questions about success of control techniques and magnitude of problem
Dredging, fill, erosion, subsidence, salinity intrusion	Mississippi deltaic plain–coastal Louisiana and Mississippi/fresh and salt marsh	Natural processes: –storm-caused erosion —subsidence —sea-level rise Development activities: –canals for oilfield access (spoil banks) –harbors Combination natural/development: –prevent sediment from accumulating and compensating for natural losses —salinity intrusion from canals kills freshwater vegetation —some impoundments	From 1955 to 1978, 55 percent of fresh marsh converted to other uses. Continuing conversions. Slight increase in salt marsh (2 percent), 1955 to 1978. Net loss of all marsh, approximately 20 percent. Canals responsible for 65 percent or more of total conversion

Table 19.—Conversions of Wetlands to Open-Water and Deep-Water Environments (Continued)

How accomplished	Region/type	Reasons	Trend
Dredging, fill, erosion, subsidence, salinity intrusion	Chenier Plain–Texas, southwest Louisiana/fresh and salt marsh	Direct wetland conversions due to dredging Additional conversions induced by canals for oil access Some impoundments, ricefields	From 1952 to 1974, 30 percent of marsh (fresh and salt) converted to other uses. Continuing conversions
Fill, flooding, clearing	Coastal Louisiana/fresh and salt marsh and swamp	Crayfish culture–construction of leveed open ponds, use of ricefields, clearing swamp and marsh ponds	Thirtyfold increases in acreage for crayfish culture from 1960 to 1980. Uncertain whether clearing of forested wetlands will increase because of questions about relative productivity of open v. forested ponds. Uncertain how State regulatory program will deal with requests to clear lands. Of current crayfish culture, 45 percent of area is swamp/marsh ponds; the remainder are ricelands and open ponds
Dredge and fill	South Carolina coast/barrier islands–fresh and salt marsh	Water-dependent development Marinas, ports (restrictions on certain marina development activities)	Probably a reduced rate of conversion and now only for water-dependent activities. Less than 100 acres of saltwater wetlands converted since 1977. About 3,000 fresh and saltwater acres converted between 1954 and 1968
Dredge and fill	New Jersey coast/fresh and salt marsh	Residential lagoons Marinas	Tens of thousands of acres converted during 1950's and 1960's. Conversions considerably reduced since 1973. Compensation of wetlands required for large controversial projects. Few acres initially converted in Atlantic City region
Dredge and fill	Florida/barrier islands–mangroves	Finger-fill canals	Reduced conversion rates due to regulation
Dredge and fill	Southern California coast	Marinas	Reduced conversion rates due to regulation
Flooding	Alaska–southcentral and southeast regions/flood plain wetlands	Hydroelectric development	Increased demands for power; several hydroprojects currently being planned

SOURCE OTA Regional Case Studies.

Table 20.—Wetland Losses From Urban Development

How accomplished	Region/type	Reasons	Trend
Fill, stormwater management	South Carolina-Hilton Head Island/freshwater marshes	Barrier island development–resorts and second homes	Prior to implementation of Special Area Management Plan in 1982, 33-percent conversion and 20-percent alteration of freshwater wetlands. Plan should help reduce these changes
Fill	New Jersey –pinelands/forested wetlands	Residential, commercial development	Conversion of several thousand acres per year in 1960's and 1970's. Since 1979, rates of conversion have declined to perhaps several hundred acres per year as a result of Pinelands Commission Policies. Protection of Atlantic white cedar
Fill	New Jersey-Passaic Basin/freshwater meadows and swamps	Highway development; subsequent residential, industrial, and commercial use	Reduction by 20 to 50 percent of Troy Meadows and Great Piece, Little Piece, and Hatfield swamps. Conversions continuing; many wetlands zoned for industrial and commercial use
Dredge and fill	California–San Francisco Bay/tidal wetlands	Urban and industrial use	Conversion of 75 percent of original wetlands-60-percent reduction when considering wetlands newly created from sedimentation. Former diking of wetlands for agriculture and salt ponds. Pressure to develop diked historic wetlands for urban use. Most filling of current wetlands for nonwater-dependent development halted by Corps, San Francisco Bay Conservation Development Commission policies. Some conversions due to port and harbor development continue. About 50 percent of remaining wetlands preserved as refuges, parks. Preserved areas threatened with salinity increases due to upstream water diversions
Dredge and fill	California–southern coast/tidal wetlands, mostly salt marsh	Urban use, port construction, sedimentation from upstream development, oil exploration, marina development, higher real estate values in coastal areas	Conversion of 75 percent of all wetland areas. Of original tidal wetlands, 10 percent remain in Los Angeles and Orange counties. Continuing population growth. Continuing pressure to develop all 28 south coast estuary/wetland areas. About 40 percent of remaining acreage is protected. Regulatory programs of Coastal Commission and Corps have restricted some development and require compensation for other development
Fill	New Jersey-Hackensack Meadows/emergent wetlands	Waste disposal, urban and commercial development	Reduction in rate of wetland conversion. From 1950 to 1970, 3,000 to 3,500 acres filled. Conversion estimates since 1972 range from 495 to 1,200 acres, depending on definition used. Designated 3,576 acres for preservation. However, some wetlands initially designated for preservation were filled for sports complexes and turnpike exchanges. Other wetlands slated for nonwater-dependent development

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Table 20.—Wetland Losses From Urban Development (Continued)

How accomplished	Region/type	Reasons	Trend
Fill	New Jersey–Atlantic City	Residential and commercial development, highway fills, landfills, dredge material disposal	Substantial reduction in conversion rate since 1973 with State and Federal regulation. Continuing conversions from major public works projects (e.g., regional wastewater treatment plant, airport runway extension) that will likely include compensation, Continuing conversions also stemming from cumulative impacts of small projects (e. g., bulkheading). Limited protection for freshwater marsh areas
Fill	New England/coastal wetlands	Residential and industrial/commercial development, highway construction	Conversion rates probably reduced considerably due to increased effectiveness of State and Federal regulations. Some increases in wetlands acreage from agricultural abandonment
Drainage through ditches or dike construction and pumping; dredge and fill	South Florida/freshwater wetlands	Residential development	Continuing development in areas covered by Corps general permits for headwater areas. Development of plans to limit road construction and housing density in certain areas. Reduced rates of conversion in areas that are covered by Federal and State regulations. Conversion of wetlands to agriculture and subsequent conversions of agricultural lands to urban use
Fill, bulkheading, clearing, dredging, mowing, lowering water levels	Washington–Western lakes/freshwater marsh	Residential purposes: establish yards, beaches, boat access, lawns	Wetlands reduced on Lake Washington from 2,300 acres in 1902 to 1,400 acres in 1936. Since 1936, about 500 acres filled. Recent development activities generally require dedication of portion of wetlands for habitat preservation under State Shoreline Management Act
Fill	Alaska–urban areas, especially Anchorage and coastal towns of south-central and southeast regions/bogs, coastal marsh, and forested wetlands	Population increases, lack of alternative building sites Road construction Recreational development Industrial developments	Wetland conversions limited to some areas to lower value wetlands through local wetland plans (Anchorage). Conversions in other areas not so limited

SOURCE: OTA Regional Case Studies

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Table 21.-Wetland Losses From Other Activities

How accomplished	Region/type	Reasons	Trend
Forestry:			
Clearing, partial drainage, planting pine plantations	North Carolina/pocosins	Pulp and paper production. Management to maximize forest growth	Continuing conversions–65 percent of remaining pocosin and other freshwater wetlands in North Carolina owned by agricultural and forest products industries
Clearing, planting hardwood plantations	Lower Mississippi River Valley/bottom land hardwoods	Pulp and paper production Management to maximize forest growth	
Selective cutting, partial drainage	North Carolina, lower Mississippi River Valley/bottom land hardwoods	Demand for hardwood products	Continuing drainage. Land of major forest companies in 27 eastern counties of North Carolina is 25-percent wetland
Mining:			
Excavation of limerock	South Florida/emergent marsh	Fill for construction, manufacture of concrete. Need to locate on edge of urbanized areas	Continuing conversion of wetland; however, projects are now designed for reduced impacts on fish and wildlife habitat, water quality, and hydrology as a result of Federal and State regulations. Some proposals in important wetlands denied when alternative sites available. Filling of previously mined sites for urban/commercial development
Excavation, water diversion, and clearing vegetation	California-desert conservation area/riparian vegetation	Availability of gold, minerals, and other materials (e.g., borax, potash, soda ash, lithium, sand, and gravel)	Continuing mining on an additional 25,000 acres, only a small percentage of which are wetlands and riparian areas
Excavation of phosphates, water diversion	North Carolina/bottom land hardwoods, fresh and salt marsh, pocosins	Recovery of phosphate ore for the manufacture of fertilizer products	Conversions continuing but at a variable rate, depending on general economic conditions and, especially demand for agricultural produce. Increased permit requirements for expansion of operations
Excavation and fill	Alaska/forested flood plain wetlands of Yukon region, northwest/wet tundra, southeast/forested flood plain wetlands	Availability of gold, copper, tin, platinum, antimony, mercury, and the like. Extensive mineral and coal resources in remote locations. Tailing disposal. Road and facility construction	Conversions continuing. Placer mining is not regulated under section 404
Excavation of peat, water diversion (proposed)	North Carolina/pocosins	Synfuel development	State mining permits granted on 20,000 acres. No other permits required owing to imitation of 5ft^3/s by 404 program. Actual mining operation dependent on funding and possible support from Synthetic Fuels Corp.
Port development:			
Dredge and fill	Washington-Puget Sound–Puyallup River/brackish marsh	Port development	Continual conversion to port facilities 1880 to present. From 1880 to 1940, about 1,900 acres of vegetated wetlands filled. By 1980, only 14 acres original marsh remained
Dredge and fill	Washington-Grays Harbor/saltwater marshes	Port development, navigational dredging	Increases in intertidal flats and marshes and decreases in open water between 1890 and 1981. No wetland conversions from dredged material disposal since 1976. Proposed fill of about 90 acres of vegetated wetlands and 400 acres of intertidal flats as part of Grays Harbor Estuary Management Plan
Excavation, fill	Alaska/coastal wetlands	Harbors and canneries for commercial fisheries. Oil and gas terminals	Conversions continuing, losses, primarily related to oil and gas development
Fill	Washington–Puget Sound–Snohmish Estuary/brackish marsh	Industrial and port expansion. More efficient earth-moving machinery-fill more economical than piers and pilings for foundations. Solid waste, wood waste, and dredged material disposal	Drainage and diking 9,000 acres for agriculture, 1880 to 1940. Port and industrial development since 1940. Landfilling urban waste 1965 to 1979 of about 200 acres. Other filling of less than 70 acres 1970 to 1980 (mostly wood waste, dredged material). Some breaching of dikes 1947 to 1970, increasing wetlands from agriculture

Table 21.–Wetland Losses From Other Activities (Continued)

How accomplished	Region/type	Reasons	Trend
Road construction:			
Dredge and fill	New England/all wetland types	Highway development	Major source of wetland conversion from mid-1950's through early 1970's, Continuing construction in wetlands, but now generally designed to minimize wetland impacts; compensation sometimes included
Dredge and fill, drainage	Nebraska-Rainwater Basin/freshwater emergent marshes	Rural road improvements for safety and drainage to protect road subgrade-ditch cleaning, including some deepening and widening	Impacts on wetland from new road alinements minimal if Federal funding involved. Continuing wetland conversions associated with maintenance and improvements of existing roads (even if Federal funding is used).
Fill	Alaska–primarily North Slope/also south-central region—Kenai National Moose Range/wet and moist tundra	Access roads. Production and transport facilities and pipelines. Drill pad construction	Conversions continuing. Some secondary impacts now limited as a result of better understanding of how to prevent thermal erosion of permafrost
Transitions to nonwetlands:			
Erosion and sedimentation from offsite activities isolate wetlands from tidal influence	California–north and central coast estuaries/brackish marsh	Forestry, agricultural development practices in watershed	Conversions continuing. Greater use of BMPs in recent years should help reduce this problem; however, impact can continue for many years after sediment-releasing source is terminated, owing to material working its way down river channel
Erosion and sedimentation from off site activities raise wetland elevations	Maryland Chesapeake Bay/freshwater marshes	Agricultural and development practices	Conversions continuing
Erosion and sedimentation from offsite activities fill isolated wetlands	Prairie potholes–Minnesota, North Dakota, South Dakota, Nebraska Rainwater Basin/freshwater marshes	Agricultural practices	Conversions continuing
Disposal of nonfill material (wood waste)	Western Washington, California/brackish and freshwater wetlands	Disposal of waste from timber harvest and forest products plants	Conversions continuing. Questions about regulatory authority
Disposal of nonfill material (garbage)	California–San Francisco Bay, New Jersey–Hackensack Meadows/brackish and freshwater wetlands	Landfills for urban waste	Continuing wetland conversions at existing sites, Questions about regulatory authority, Conversion rates expected to decline in future as site selection receives closer scrutiny at local level and alternatives for waste disposal are considered (e. g., energy recovery, comporting)

SOURCE OTA Regional Case Studies

ulate these activities are discussed in chapters 7, 8, and 9. Further elaboration on the reasons for the major source of loss, due to converson to agriculture is presented following the tables.

Agricultural Conversions

Information on Federal policy and national trends in agricultural land use was obtained from a working paper on agricultural policies prepared for OTA, except where other sources are noted.

Trends in Agricultural Conversions

Eighty percent of freshwater wetland losses occurring between the mid-1950's and the mid-1970's were attributed to agricultural conversions, according to NWTS data. Only 2 percent of estuarine wetlands were lost to agriculture during this 20-year period. Conversions of estuarine wetlands to agricultural use were greater prior to 1950. For example, in the Snohomish Estuary of western Washington, conversion of wetlands to agricultural use was greatest prior to 1940 but continued to increase at a reduced rate until about 1960 (14). In California, diking of northern coastal wetlands for agriculture primarily occurred prior to 1950 (7). Since that time, many of the diked former agricultural areas have been filled for other uses. On the east coast, former diked estuarine wetlands used for agriculture have in many cases reverted back to estuarine wetlands or been maintained for nonagricultural purposes such as waterfowl production (13).

Although the general trend is the loss of wetlands to agriculture, there have been some relatively small gains in wetlands from former agricultural lands. Agriculture-related losses and gains of freshwater vegetated wetlands were 11.7 million and 899,000 acres, respectively. Similar losses and gains of estuarine wetlands were 9,000 and 2,000 acres, respectively. Some parts of New England actually had net gains in wetlands from agricultural land use. Some of these agricultural lands have reverted to wetland through lack of maintenance of former drainage ditches. However, the majority of abandoned agricultural areas have been converted to other nonwetland uses (1 7).

Wetland conversion to agriculture almost always involves surface drainage, but drainage may occur in areas that are not wetlands. USDA has prepared estimates of surface and subsurface drainage of all lands between 1900 and 1980. The data do not cover wetlands separately. By examining these drainage data in relation to NWTS estimates of wetland loss to agriculture between the mid-1950's and mid- 1970's, it is possible to make some estimates of wetland loss to agriculture between 1975 and 1980 on a nationwide basis.

Pavelis(11) estimates that about 17 million acres, or about 850,000 per year, were surface-drained between 1955 and 1975 (table 22). During approximately the same period of time, NWTS estimates that 11 million acres of wetlands, about 550,000 acres/yr, were converted to agricultural land. This amount represents about 65 percent of the surface drainage. Between 1975 and 1980, just over 2 million acres, or about 426,000 acres/yr, were surface-drained. Even if all the drained lands were wetlands, the rate of wetland conversion (requiring surface drainage) has declined by at least 20 percent. However, if the proportion of drained wetlands to overall drained land has remained about 65 percent since 1975 the rate of actual wetland conversion to agricultural land would be about 275,000 acres/yr or about 50 percent of past wetland drainage rates. If gains in wetland acreage due to agriculture are proportional to those of the mid- 1950's to mid-1970's, net conversion rates would be just over 250,000 acres/yr.

Interpretation of these nationwide figures may be somewhat misleading. In the past, drainage was concentrated in the Midwest, the Lower Mississippi River Valley, and the Atlantic and Texas coasts. More recently, although new drainage has been at a virtual standstill in many parts of the country, significant drainage activity still is taking place in the Lower Mississippi River Valley, Florida, and the Southeast in general (12). For example, data from the Lower Mississippi River Valley show that rates of clearing of bottom land hardwoods (which is often accompanied by drainage for crop production) continued to increase between 1967 and 1977 in Louisiana. Louisiana also had the greatest percentage of remaining forest in 1978. But in the five

Table 22.–Surface and Subsurface Drainage of Farmland, 1900-1980

Year	Farmland currently drained		Acreage shares		Annual change, past 5 years		Undepreciated drainage[a]	
	Surface drainage systems	Subsurface drainage systems	Surface drainage systems	Subsurface drainage systems	Surface drainage systems	Subsurface drainage systems	Surface drainage systems	Subsurface drainage systems
	(Millions of acres)[b]		(Percent)		(Thousands acres per year)[c]		(Millions of acres)	
1900	5.271	1.024	83.7	16.3	—	—	3.975	1.014
1905	9.775	1.902	83.7	16.3	900	176	7.447	1.877
1910	18.673	3.632	83.7	16.3	1,780	346	15.313	3.572
1915	29.344	5.701	83.7	16.3	2,134	414	25.029	5.541
920	43.452	5.993	87.9	2.1	2,822	58	38.131	5.573
925	41.420	6.143	87.1	2.9	-406	30	41.412	6.143
930	42.676	6.687	86.5	3.5	251	109	38.514	6.010
935	38.606	7.244	84.2	5.8	-814	111	32.697	6.118
940	36.532	8.905	80.4	9.6	-415	332	19.298	4.711
945	40.769	9.555	81.0	9.0	847	130	15.800	3.291
950	57.980	11.949	82.9	7.1	3,442	479	22.849	5.394
955	64.995	13.670	82.7	7,3	1,443	344	29.172	6.510
1960	70.784	15.823	81.7	18.3	1,117	431	34.252	7.550
1965	76.013	17.630	81.2	18.8	1,046	361	35.244	9.048
1970	79.753	19.331	80.5	19.5	748	340	21.773	10.426
1975	82.563	20.817	79.9	20.1	566	297	17.588	11.912
1980	84.715	22.768	78.8	21.2	427	390	13.931	13.863

[a] "Undepreciated drainage" refers to surface drainage systems in place for less than 20 years, to those subsurface systems in place for less than 30 years if installed before 1940, or to those subsurface systems in place for less than 40 years if installed in 1940 or thereafter. Note that by 1980 surface and subsurface systems were about equal in importance on an "undepreciated basis," even though surface systems are still in much wider use, as indicated by the acreages and percentage distributions for current drainage (cols. 1 to 4). Such a breakdown is useful as an overall indicator of general age and condition of farm drainage systems and was helpful for measuring active gross capital stocks and net capital values.
[b] Acreages for surface and subsurface drainage add to the overall net acreage drained.
[c] Rates of increase or decrease for surface and subsurface drainage add to the overall change for all farm drainage.

SOURCE: G. A. Pavelis, unpublished draft, "Farmland Drainage in the United States, 1900 to 1980: Acreage, Investment and Capital Values, 1982."

other States in the study region, clearing had peaked between 1957 and 1967. The study notes that ' 'rates of acreage decreases in bottom land hardwood forest area closely reflect the magnitude of reduction in total hardwood forest area by State (10). " Thus, although national drainage rates have declined, wetland drainage probably is continuing in some areas.

How Wetlands Are Lost to Agriculture

Wetlands are lost to agriculture through two primary means: direct conversions by draining and/or clearing and indirect conversions associated with normal agricultural activities. Direct conversions of wetlands for the purpose of expanding agricultural operations probably result in far more lost wetland acreage than do the indirect conversions on a nationwide basis. However, indirect conversions may be the major factor associated with loss of wetlands to agriculture in some regions of the country. Conversion activities are summarized in table 18.

Examples of direct conversion of wetlands to agriculture include drainage to expand crop acreage in the prairie-pothole region, construction of irrigation reuse pits to improve irrigation efficiency and to drain wetlands in the Rainwater Basin of Nebraska, clearing and draining bottom land hardwoods for soybean or rice production in the Lower Mississippi River Valley and for soybeans and other crops in North Carolina, and the mowing-chopping-seeding-grazing sequence for improving Florida sawgrass for agriculture.

Examples of indirect conversions of wetlands associated with normal agricultural activities include the general lowering of the water table for irrigation, which results in drying of ' 'wet meadows, making them suitable for crops in the Platte River Valley and the Sandhills of Nebraska; changing water-management practices associated with crop changes in the Central Valley of California (i. e., when ricefields are converted to orchards, water from flooded ricefields is no longer available for discharge to wetlands); clean farming techniques

Photo credit: U.S. Fish and Wildlife Service

NWTS estimates that between the mid-1950's and mid-1970's 11 million acres of wetlands or about 550,000 acres/yr were converted to agricultural use through drainage and clearing

such as changes in rice-culture practices that result in fewer wetland species growing within ricefields; and changes in seed varieties and equipment that allow earlier planting and later harvests and tend to eliminate wetland vegetation that might grow in cultivated areas at other times of the year.

Individual permits under section 404 generally are not required for these direct and indirect conversion activities, either because they occur in areas covered by nationwide permits, are exempted under law, entail no dredge or fill activities, or involve incidental discharges or vegetation clearing that falls outside the Army Corps of Engineers guidelines for regulated activities. Even in cases where the Corps requires an individual permit, it is likely that the activity will be approved with few modifications due to difficulties associated with demonstrating adverse water quality and cumulative impacts from these activities. (See ch. 8 for further discussion of these issues.)

In the opinion of some agricultural analysts, the 404 program has had a minimal effect on the conversion of wetlands to agriculture or is viewed as being a modest nuisance, but not a significant hurdle for farmers. Although the importance of the 404 program varies in different locations, the Corps generally gets involved in response to a complaint or for very large projects. Monitoring potential agricultural conversion activities and enforcement of section 404 is not now considered possible, given the current manpower and budget of the Corps.

Economic factors (e. g., profits, available land, costs of maintaining wetlands) and Government policies often are cited as reasons for converting wetlands to agricultural use.

ECONOMIC FACTORS

Commodity prices are a major factor in the decision to expend funds to bring wetlands into production. In some parts of the country, when prices are sufficiently high, it can be extremely lucrative to grow crops on wetsoils that may, but not necessarily, include wetlands. For example, in an analysis of minimum prices and potential yields for conversion of different wetsoils to soybean production in the southern Mississippi Valley alluvium, it was found that the minimum price for planting soybeans profitably ranged from $1.05 to $2.31 per bushel (bu) (5). With soybean prices ranging from a low of about $2.00/bu in 1958 to a high of over $7.00/bu in 1976, growing soybeans has been extremely lucrative (10). Production alternatives on these bottom land hardwood acres are not nearly as economically desirable as crop production, For instance, sustained timber production from natural bottom land hardwood stands is not considered to be a viable economic investment. Hardwood plantations can produce good returns on some sites, but crop returns are better (10).

There is general agreement that the primary reasons for draining wetlands in the prairie-pothole region are the economic and technological factors associated with farming, including the:

- elimination of the nuisance and cost of avoiding potholes situated within cropland;
- opportunity to gain relatively productive cropland by draining wetlands (particularly if land is already owned);
- change in farming from a diversified crop-livestock combination to increasing emphasis on row-crop and small-grain production;
- rapid increase in tractor horsepower, which increases avoidance costs and facilitates drainage of potholes by providing the power to operate drainage equipment. This allows the landowner the opportunity to drain his own land during slack periods at low cost;
- continuing increase in the use of center-pivot irrigation systems that are not compatible with potholes;
- variable short-term climatic conditions that increase nuisance and cost factors in a wet year and provide opportunity for low-cost drainage in a dry year;
- short-term net farm income variability, which provides investment capital for drainage during periods of high income and increases the incentive to expand cropland area;
- absence of private returns from maintaining wetlands without Government programs; and
- low returns from Government incentives to preserve wetland relative to profits from conversion (6).

Pressures on agricultural lands from urban use (also an economic issue) may increase demands for agricultural land on wetlands in some parts of the country. For example, in south Florida, land use data for a single county between 1972 and 1980 showed that 23,767 acres of wetlands were converted to agricultural use while 655 acres were urbanized. During that same period, 24,539 acres of agricultural lands were lost to urbanization. Thus it appears that urbanization displaces agriculture, which then moves into wetland areas (l).

Costs of maintaining wetlands may be a factor in the decision to convert to agriculture in a few circumstances. For example, the California case study noted examples where hunting club landowners in the Central Valley found it too costly to maintain wetlands for waterfowl habitat because of local property tax policies. Wetlands were taxed as recreational lands at a higher rate than were agricultural lands. Costs of water and taxes have stimulated some hunt clubs to convert portions of their land for crop use (7); however, property taxes aren't considered to be a factor in conversion to agriculture in most other regions of the country. For example, in Nebraska, wetlands are taxed at a nominal rate (9).

The cost of direct conversions of wetland to agricultural use depends on the characteristics of the area to be converted. Relevant characteristics include how wet it is and for what period of time, the topography, the conversion technique used, and the availability of an outlet for drainage. Ownership of the areas to be converted and of equipment to perform the work also are factors in the cost. For example, the prairie-pothole case study cited six studies of costs of open drainage conducted from 1971 to 1981 by four different investigators. Costs per acre ranged from $11.24 to $400.00 (6). The Nebraska case study makes estimates of conversion costs for different methods for its analysis of the profitability of conversion. Conversion of Rainwater Basin wetlands (with an average size of 10 acres) to irrigated agricultural use with a reuse pit ranged from about $2,000 in 1965 to $6,600 in 1980 (9). Amortized costs over a 30-year period ranged from $12.95 to $84.99/acre/yr in 1965 and 1980, respectively (9). Estimates of landshaping costs in the Sandhills for irrigation vary with the terrain and range from $4,000 to $26,000/center-pivot (9). Converting pocosin wetland to cropland in North Carolina could cost as much as $740/acre (13).

Incentives from Federal programs (and in a few cases, State programs) to landowners to preserve wetlands are sometimes enough to outweigh the profitability of drainage and conversion (see following section). In many cases, however, payments from such programs as USDA's Water Bank Program and FWS easements are less than profits from conversion. A survey of landowner attitudes in Minnesota and North Dakota found that low payments from FWS and Agricultural Stabilization and Conservation Service (ASCS) programs were the overriding reason for refusal to participate in these protection programs (6). (Other important factors listed included the long period that the agreements cover and the lack of information about programs.) The Nebraska case study noted that wetland payments under the ASCS program of $10/acre and State habitat program contracts of $15 to $30/acre appear to be inadequate. To be successful, payments should be increased to the $35 to $45/acre range in Nebraska. The higher range would reflect not only the modest return that may sometimes be received by converting wetlands but also the partial value to society in preserving wetlands (9).

NATIONAL TRENDS IN AGRICULTURAL LAND USE

The amount of total cropland planted nationwide declined between 1954 and 1972 from 355 million to 295 million acres. This decline was largely a result of production controls that were fairly constant throughout the 1960's. Some shifts of lands in and out of production did occur during this time, however. Land in major crops increased from 295 million acres in 1972 to 326 million acres in 1974 and then increased steadily until 1981, when 365 million acres were planted. (The year 1978 was an exception; there was a significant set-aside in that year, so land in crops decreased.) It is widely assumed by agricultural analysts that a major portion of the gains in planted cropland after 1972 came from areas that previously were idled by Government programs.

The nationwide expansion in cropland is attributed to the growth in export demand for grains and oilseeds that began in 1972. Primary factors for this increase in demand include the entry of the Soviets into the international market, a shortfall in crop production on the Indian Subcontinent, and the devaluation of the dollar in 1971. Major increases in commodity prices occurred between 1972 and 1976. Although the prices declined in 1977 and 1978, prices in general were sufficiently high during the late 1970's for farmers to increase their amount of land in crops.

The demand for new cropland is expected to increase over the next 20 years, despite expected advances in productivity. The amount of additional cropland needed will depend on the food needs of the United States, the production capability of U.S. soils, and the total export demand. Maximum estimates for cropland needed by the year 2000 range from 378 million to 437 million acres, depending on rates of increase in crop yields (4). Although USDA's National Resources Inventory identified an estimated 70 million acres of wetlands, the extent that wetland acreage will be used to meet this demand cannot be estimated readily.

Regardless of the availability of nonwetlands to meet future needs for cropland, demand for wetland conversions may well continue as a result of shifting the production of certain crops to different regions of the country. For example, estimates have been made that soybean production on existing cropland can be increased up to 21.5 percent in Louisiana and Mississippi without any environmental damage; destruction of scenic, recreation, and wildlife areas; lowered water tables; or water-quality degradation associated with conversions. Irrigation and precision land-forming would be required to make these improvements in production, and these techniques are being implemented on a fairly large scale. On the other hand, increased production costs of cotton in the West and Southwest associated with irrigation requirements and improvements in pest control may revitalize the cotton industry in the Southeast and in the Lower Mississippi River Valley, where cotton grows well on converted bottom lands with high organic matter.

Since data from the last 10 years are insufficient to provide an accurate estimate of current conversions of wetlands to agricultural use, future projections of wetland conversion rates cannot be made. However, without restrictions on conversions, it can be expected that wetlands probably will continue to be converted for agricultural use. Production on newly converted wetlands may have little impact on the national need for about 400 million acres of cropland over the next 20 years or even on regional incomes from farming. However, it may well make a difference for individual farmers.

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