Delaware's Wetlands

Status and Recent Trends

Acknowledgments

This booklet reflects the work of both the U.S. Fish and Wildlife Service and the Delaware Department of Natural Resources and Environmental Control. Most of the information comes from a study of wetland trends in the state completed by the Service's National Wetlands Inventory Program (FWS-NWI). This study and the production of the booklet were supported by the Watershed Assessment Section in the Division of Water Resources of the Delaware Department of Natural Resources and Environmental Control (DNREC). DNREC also provided data from its 1992 statewide wetlands mapping project for inclusion in this booklet. Peggie Emslie (DNREC) served as project officer for the trends study, while David Saveikis (DNREC) saw the need for this information and secured necessary funding. Ms. Emslie and Mark Biddle (DNREC) helped obtain funding for production of the booklet, while Mark also reviewed the draft booklet. Ralph Tiner (FWS-NWI) served as principal investigator for the trends study.

The wetland trends analysis data in this report were derived through conventional aerial photointerpretation techniques by John Swords (FWS-NWI). Sue Schaller (FWS-NWI) performed geographic information analysis for the original wetlands trends report, while Herb Bergquist (FWS-NWI) helped access geospatial data for this booklet, including production of the wetland distribution figure. Debbie Sullivan (DNREC) provided wetland and upland acreage summaries from the state wetlands inventory database for use in this booklet. The booklet was designed by Craig Malone.

I also thank people who contributed photographs for use in this publication. Photo credits are shown for each photo, except for those taken by the author.

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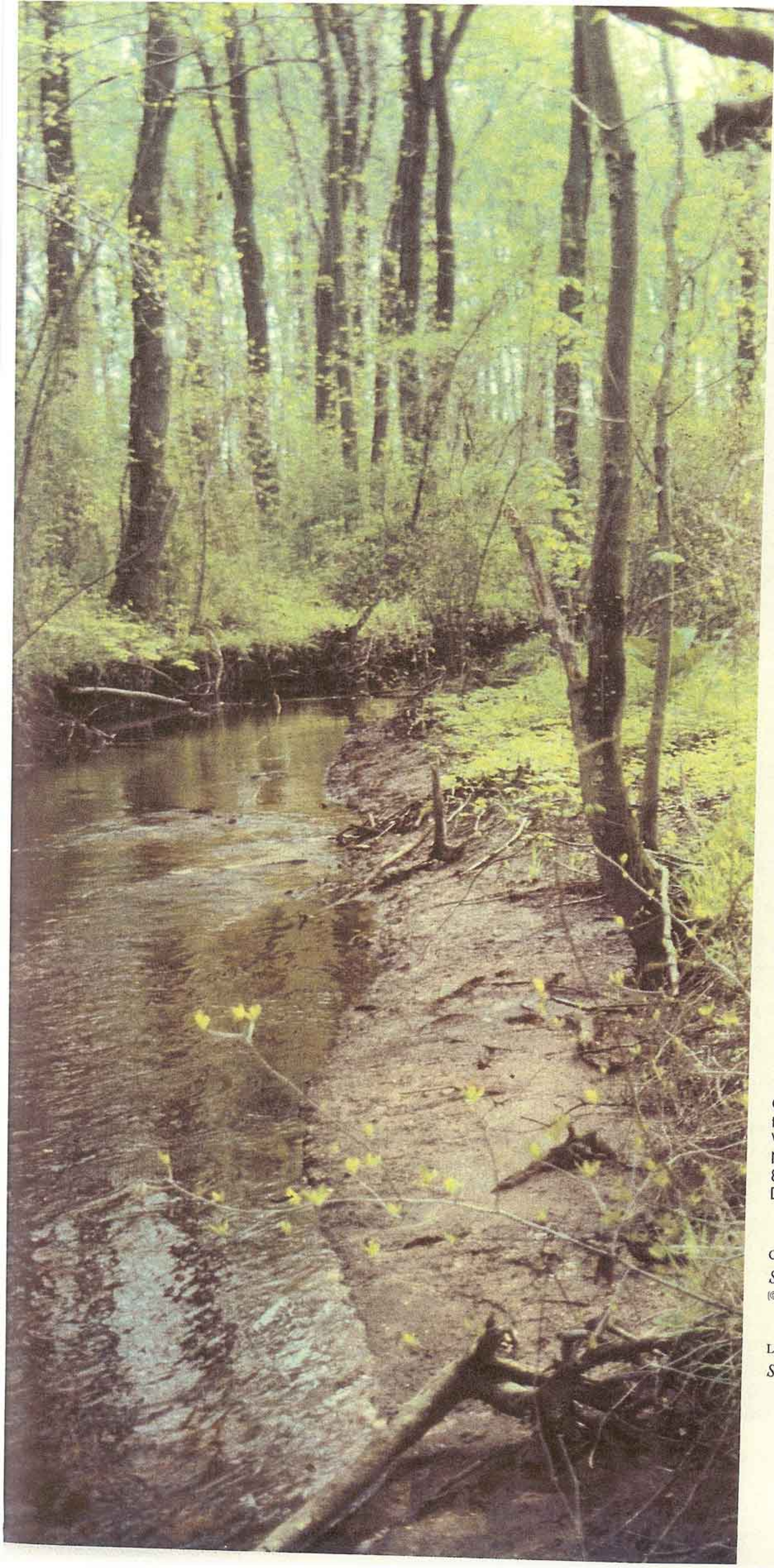

Delaware's Wetlands

Status and Recent Trends

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Copies of this booklet may be obtained from the Watershed Assessment Section, Division of Water Resources, Delaware Department of Natural Resources and Environmental Control, 820 Silver Lake Boulevard, Suite 200, Dover, DE 19904-2464; 302-739-4590.

COVER:

Salt marsh in the Inland Bays drainage basin.
(© KEITH CLANCY)

LEFT:

Streamside red maple swamp.

Delaware's coastal marshes are vital to supporting the state's fishing industry.

Preface

This report is based largely on the results of a wetland trends analysis performed by the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) Program. The work was funded by the Delaware Department of Natural Resources and Environmental Control (DNREC), Division of Water Resources. A technical report on the study findings — *Wetland Trends in Delaware: 1981/2 to 1992*[1] — was published in 1999 (please refer to this report for details of study methods). Upon completion of this study and publication of the technical report, DNREC saw the need for a public information booklet to convey this new and important information to the public.

The study involved a comparison of aerial photographs from the early 1980s to the early 1990s for an area representing over 60 percent of the state. Of the four drainage basins in the state, all of the Piedmont and Inland Bays basins were evaluated, while 75 percent and 60 percent of the Delaware Bay and Chesapeake Bay basins were examined, respectively. This large "sample" of wetlands was possible because the state recently completed a detailed inventory of wetlands at 1:12,000 based on 1992 aerial photographs. These data were compared with 1981/82 aerial photos from the NWI's original wetland inventory for Delaware to determine wetland trends. Wetland trends were identified as going to (loss) or coming from (gain) a specific land use or land cover type. Major categories of land use and land cover were: 1) industrial development, 2) commercial development, 3) residential development, 4) highways and roads, 5) ponds, 6) transitional land (land undergoing some type of development — unknown use), 7) rangeland (open fields and thickets), 8) cropland, 9) pasture, and 10) upland forest. Wetland trends included changes from one wetland type to another caused by human-induced actions, mainly timber harvest. Changes as small as 0.1 acre were identified.

Data on the current status of wetlands comes from DNREC's digital wetland data — the most comprehensive source available to date. These data provide readers with a statewide perspective on the abundance and current distribution of Delaware wetlands.

Besides the wetland status and trends information, this booklet provides brief descriptions of the state's major wetland types, a discussion of the future prospects for Delaware wetlands, and a list of resource agencies and additional sources where readers can obtain more information about the state's wetlands and wetlands in general.

1 Tiner, R., J. Swords, and S. Schaller. 1999. *Wetland Trends in Delaware: 1981/2 to 1992*. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA. National Wetlands Inventory report. 46 pp.

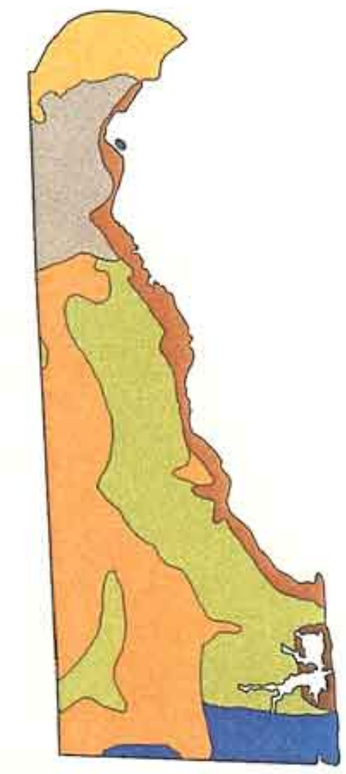
Introduction

Most people are now familiar with the word "wetlands" — the term used to describe the collection of marshes, swamps, bogs, wet meadows, wet flatwoods, and other seasonally waterlogged environments. Wetlands are lands that are periodically flooded or saturated near the surface for periods long enough to affect plant growth and soil development. Scientists have determined that the minimum wetness for a wetland is saturation within 1 foot of the ground surface for 2 weeks or more during the growing season in most years (every other year on average).[2] These areas are also wet for much of the non-growing season (from late fall to early spring). These conditions create waterlogged soils and substrates that are essentially devoid of oxygen for significant periods. Plants colonizing such sites are called "hydrophytes" (water-loving plants) because they possess special adaptations that allow them to grow and reproduce in oxygen-deficient (anaerobic) saturated soils. These wet soils are called "hydric soils" and they exhibit unique characteristics reflective of prolonged and frequent anaerobic conditions. Consequently, the presence of hydrophytic vegetation and hydric soils are used as indicators of wetlands and for delineating their boundaries.

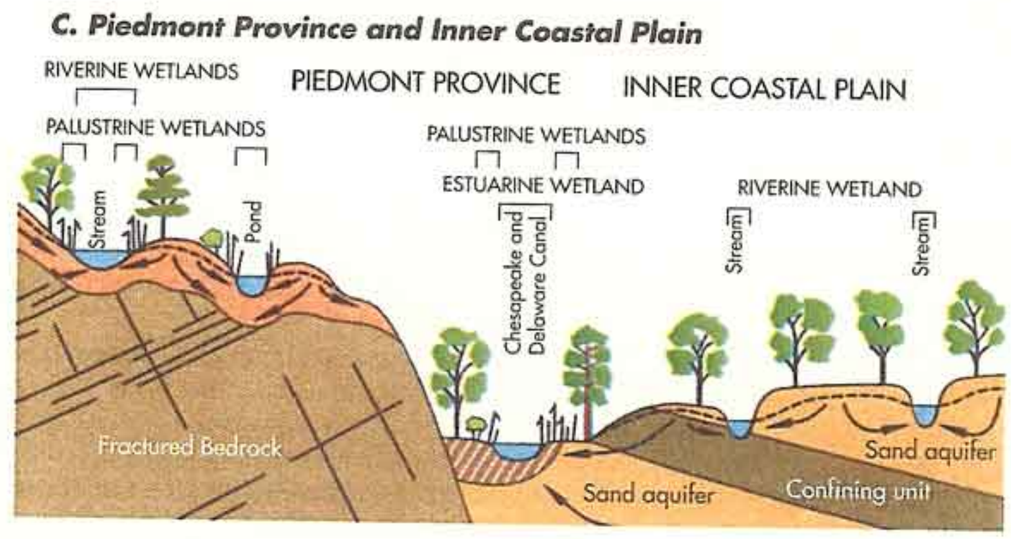
In Delaware, wetlands have formed along the shores of Delaware Bay, various rivers and streams, in depressions or basins (including ponds and impoundments), and on broad flat areas between stream systems (called "interfluves") on the coastal plain. These are places subjected to frequent flooding or prolonged saturation associated with seasonal high water tables.

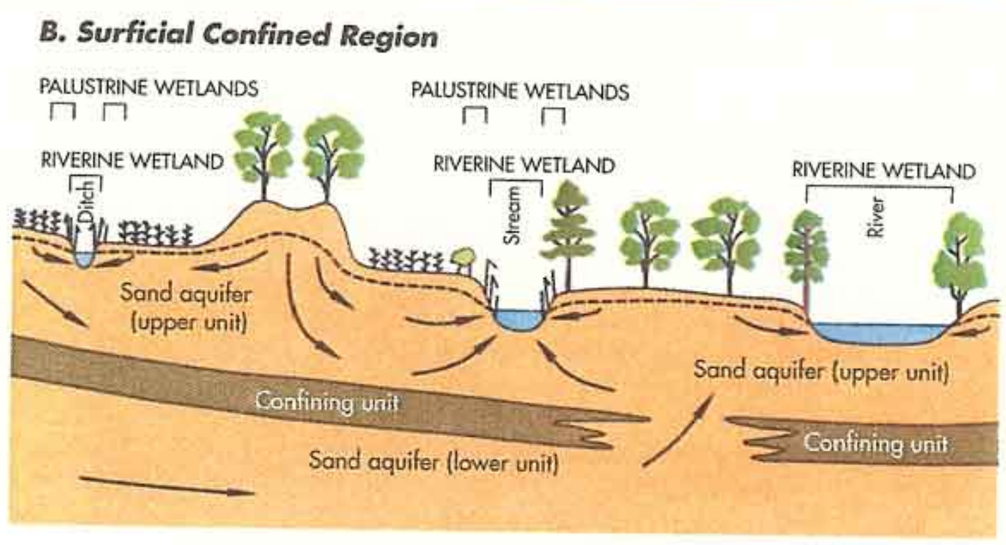
Wetlands are among the state's most valuable natural resources. They temporarily store surface water thereby reducing flood damage to homes, businesses, and cropland. Their soils and vegetation help improve water quality by removing and retaining nutrients, processing chemical and organic wastes, and reducing sediment loads of adjacent waters. Vegetated wetlands provide valuable buffer strips along streams that can significantly enhance local water quality as well as serving as travel corridors for resident wildlife. Their

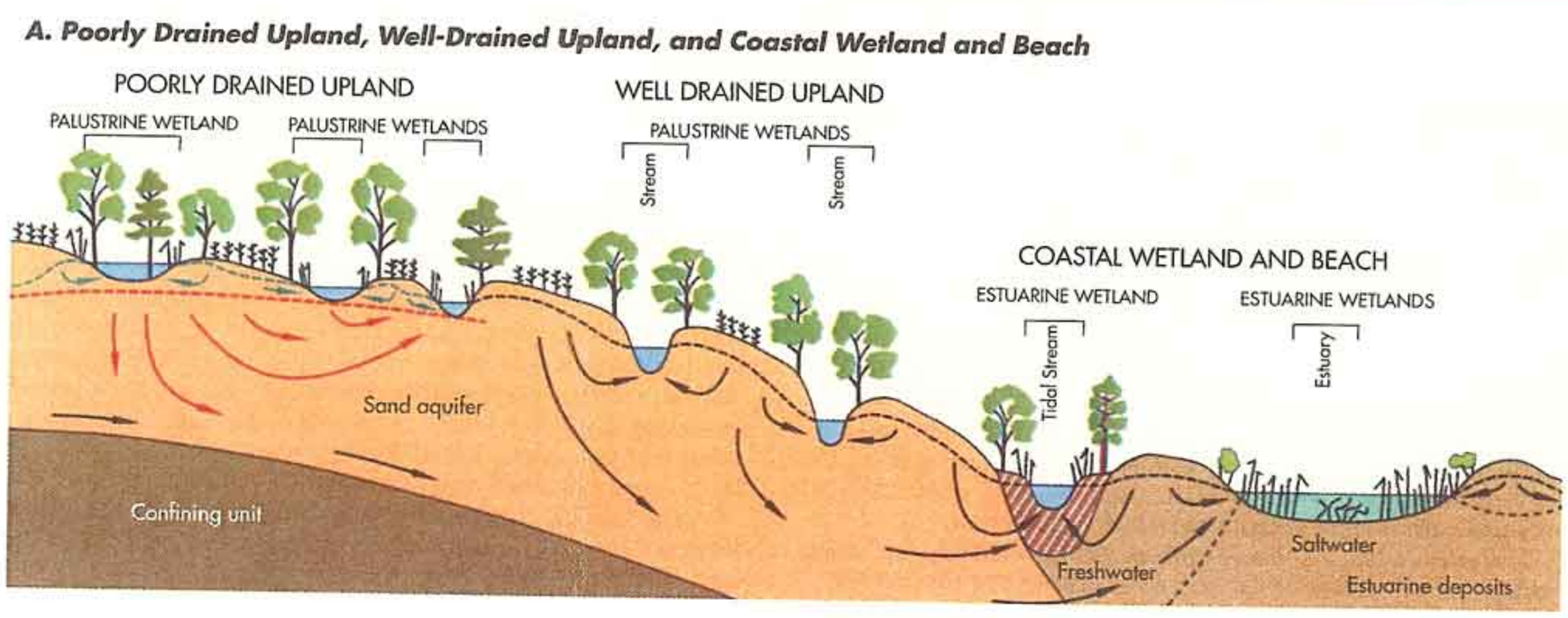
2 Source: *Wetlands Characteristics and Boundaries* (1995) published by National Academy Press, Washington, DC 20418.



Hydrogeomorphic regions referenced in diagrams







Wetlands develop where groundwater discharges, surface water accumulates, or in areas flooded by tides. This cross-sectional diagram shows groundwater flow paths that create wetlands at different locations on the landscape (blue arrows — flow during wet season; red arrows — flow during dry season; black arrows — general path of groundwater flow)

Source: M. A. Hayes. 1996. Delaware wetland resources. In: *National Water Summary on Wetland Resources.* U.S. Geological Survey, Reston, VA. Water-Supply Paper 2425. pp.147–152.

Salt marsh (estuarine emergent wetland) dominated by salt hay cordgrass, with high-tide bush in background.

BILL ZINNI

Oak-dominated palustrine forested wetland on broad flat landscape. Note blackened leaves indicative of prolonged inundation.

location between land and water also allows wetland vegetation to stabilize shorelines, thereby reducing erosion. Coastal wetlands are highly regarded as nursery grounds for estuarine fishes. Ninety-eight percent of Delaware's commercially important fishes are wetland-dependent. Common estuarine fishes include American eel, alewife, American shad, menhaden, white catfish, channel catfish, white perch, striped bass, yellow perch, sea trout, Atlantic croaker, and winter flounder. Nearly all freshwater fishes also depend on wetlands for food, nursery grounds, or spawning areas. Recreational fishing produces about $20 million annually in the state. Numerous wildlife species rely on wetlands including commercially important species like muskrat, game species including waterfowl, marsh rabbits, and deer, and non-game animals like frogs, turtles, salamanders, wading birds, shorebirds, and songbirds. Much of Delaware's remaining inland wetlands is forestland and may be of commercial importance to the forest products industry. Overall, wetlands yield economic values to many residents and offer aesthetic and recreational opportunities for the enjoyment of residents and visitors alike. They do this while providing vital fish and wildlife habitat and serving numerous other functions that benefit society.

Delaware Wetland Types

The majority of Delaware wetlands fall into two general types: estuarine wetlands and palustrine wetlands. Estuarine wetlands are intertidal salt to brackish environments including tidal marshes, mudflats, and sandy beaches associated with coastal embayments, rivers, and streams. Palustrine wetlands are inland freshwater, waterlogged or flooded habitats, mostly vegetated areas like marshes, wet meadows, swamps, and wet flatwoods, but also including shallow ponds. Less common types in Delaware are marine wetlands (limited to the shore of the Atlantic Ocean; ocean beaches), riverine wetlands (within river channels and mostly in the intertidal zone of freshwater rivers), and lacustrine wetlands (the shallow water zone of lakes, reservoirs, and deepwater impoundments). Brief descriptions of the major types are given below. For more detailed characterizations of Delaware wetlands, see *Wetlands of Delaware* listed in the back of booklet (under *Additional Readings*). Field guides for identifying wetland plants are also listed there.

Estuarine Wetlands

Estuarine wetlands are coastal wetlands subjected to either daily or less frequent flooding by salt water tides. Most of these wetlands are vegetated (typically by nonwoody plants), while others are non-vegetated. The vegetated ones are commonly called "salt marshes" or "brackish marshes" (technically called *estuarine emergent wetlands* when they are characterized by herbaceous plants). These tidal wetlands are dominated by "halophytes" (salt-loving plants). Non-vegetated estuarine wetlands include beaches along Delaware Bay and intertidal mud flats observed at low tide in coastal embayments and along tidal rivers.

Salt marshes occur in the more saline portions of estuaries (waterbodies where ocean water mixes with fresh water). These marshes are most common along Delaware Bay, south of the Chesapeake and Delaware Canal, where they form behind protective beaches. Two zones of vegetation may be observed in these marshes based on their elevation and corresponding frequency and duration of flooding: 1) low marsh zone (or regularly flooded zone) and 2) high marsh zone (or irregularly flooded zone). The low marsh occurs below mean high tide and is flooded at least once a day. It is characterized by a tall growth form of smooth cordgrass which grows up to 6 feet or more in height. Located above mean high tide, the high marsh is flooded less often (e.g., once every couple of weeks) and its vegetation patterns are more complex. The low marsh may grade gently

Brackish marsh (estuarine emergent wetland) in New Castle County. Note presence of common reed, especially along creek banks.

Brackish marsh along a tributary of the St. Jones River. Note occurrence of common reed and narrow-leaved cattail along forest edge.

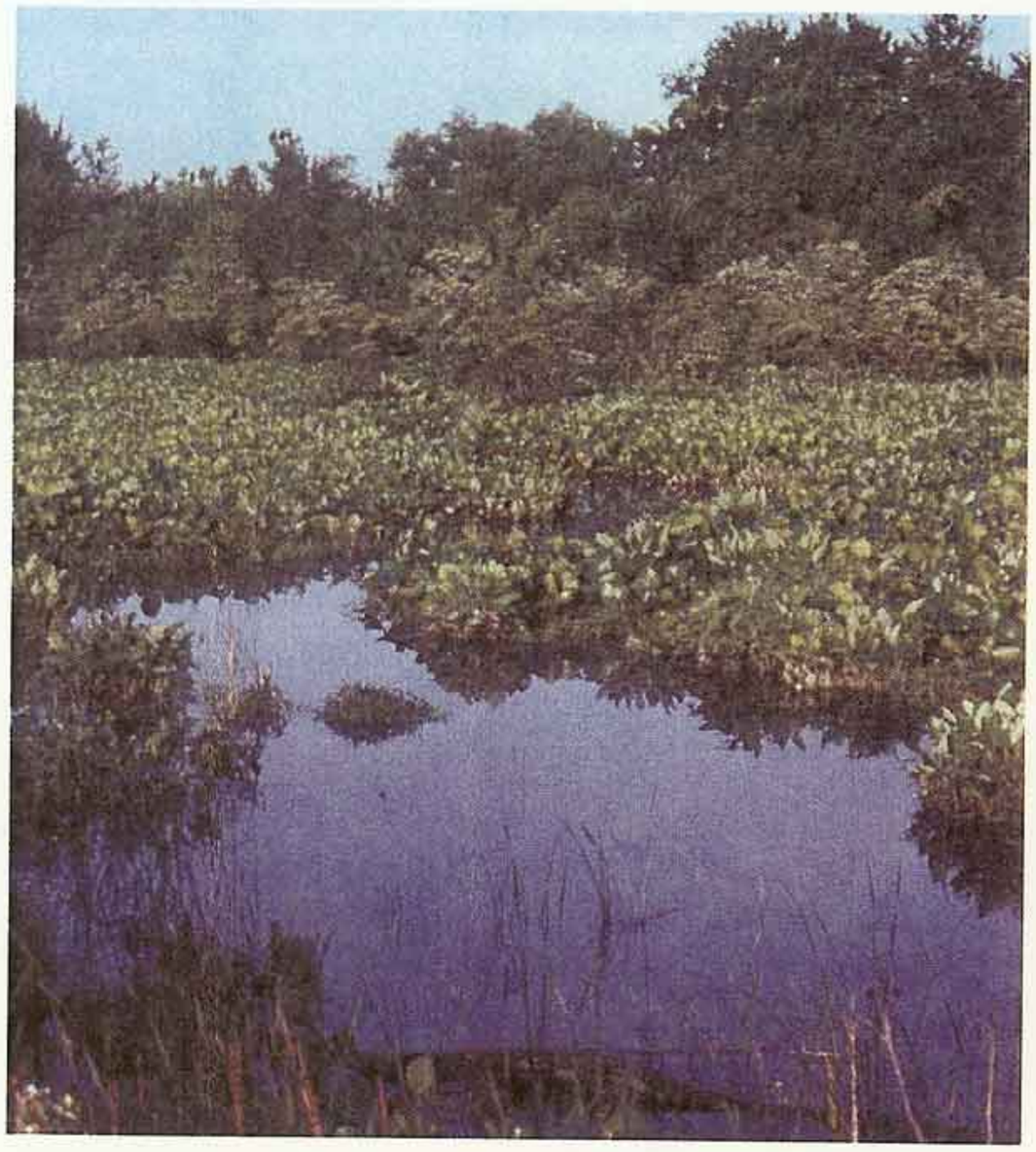
into a "lower high marsh" where smooth cordgrass still predominates but grows in a stunted form (less than eighteen inches tall) due to stress from long-term anaerobic conditions. The "upper high marsh" is better drained and supports a mosaic of halophytic species including salt hay grass, salt or spike grass, common reed, marsh orach, sea lavender, salt marsh aster, and black grass. Large stands of each of the first three species are characteristic, with the first two species often forming mixed associations. Switchgrass, a clump-forming grass, frequently dominates the upper border of salt marshes and may form grassy fields above the salt marsh. Shrubs, such as high-tide bush, groundselbush, wax myrtle, and red cedar, may be common along the uppermost edges of the salt marshes. The former two species may develop rather extensive shrub thickets in some places.

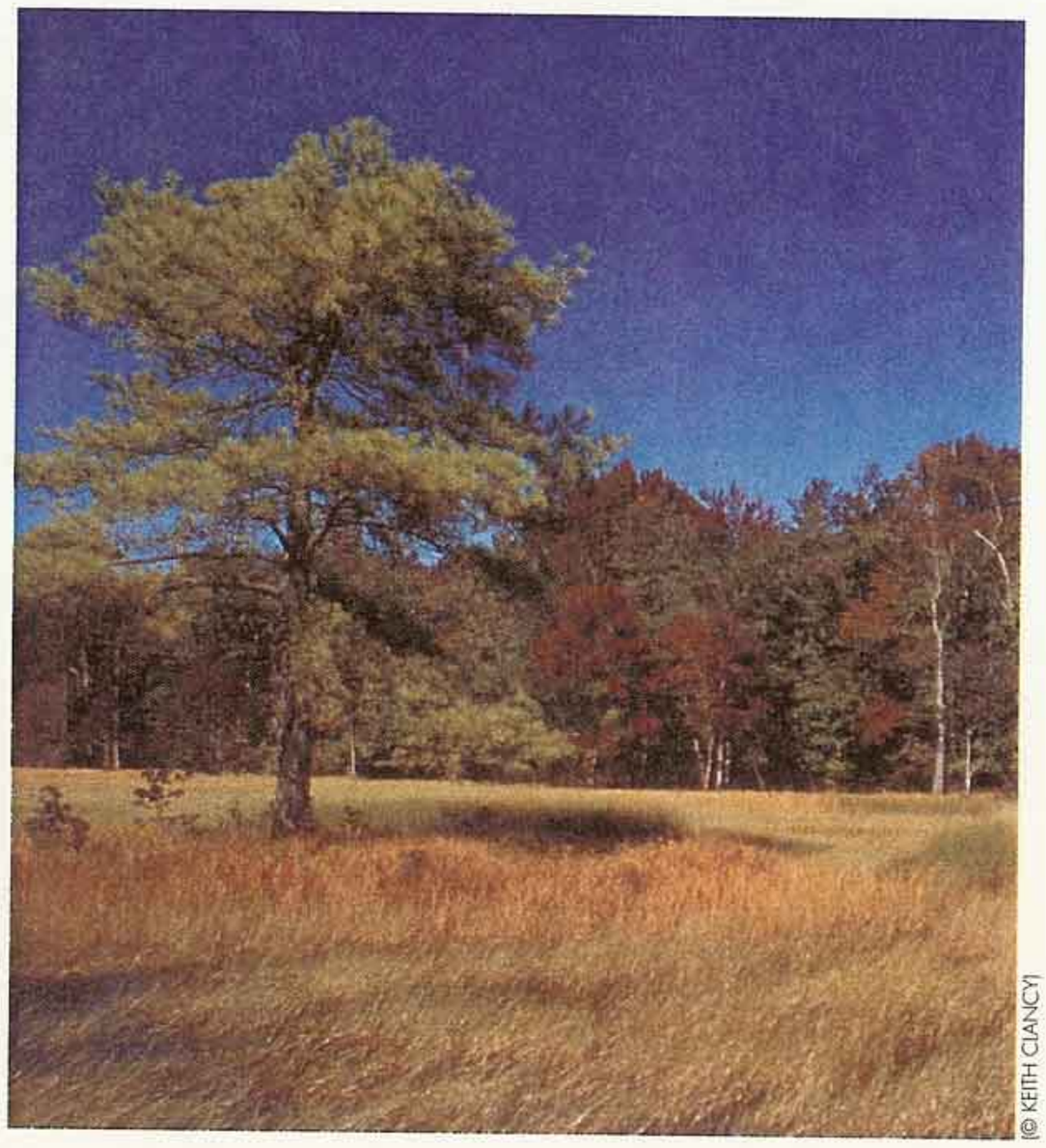
Occurring further upstream along coastal rivers, **brackish marshes** are exposed to more variable salinities, ranging from fresh in spring (due to high river discharges) to moderately salty in summer (low river flows). In the more seaward brackish marshes, salt marsh species, such as common reed, smooth cordgrass, salt hay grass, spike grass, and switchgrass, begin to intermix with more brackish species like narrow-leaved cattail, big cordgrass, and rose mallow. Further upstream, species with freshwater affinities including arrow arum, pickerelweed, soft-stemmed bulrush, spatterdock (yellow pond lily), and arrowheads may dominate.

Palustrine Wetlands

Freshwater marshes, swamps, and ponds represent Delaware's palustrine wetlands. Some are tidally influenced (their waters rise and fall with the tides), but they occur upstream of the area of saltwater penetration. Most of Delaware's palustrine wetlands are dominated by trees. Locally called "swamps" or "winter wet woods," these wetlands are seasonally flooded or saturated for variable periods. In contrast, marshes and wet meadows are characterized by herbaceous (nonwoody) plants, with marshes flooded for extensive periods and wet meadows typically possessing saturated soils. Palustrine vegetated wetlands may be separated into three major types based on their dominant vegetation: 1) emergent wetlands (e.g., marshes and wet meadows) characterized by grasses, sedges, and other nonwoody plants, 2) scrub-shrub wetlands represented by low- to medium-height woody plants (less than 20 feet tall), and 3) forested wetlands dominated by trees (woody plants 20 feet or taller).

Three types of **palustrine emergent wetlands** are common in Delaware: 1) tidal fresh marshes, 2) nontidal marshes, and 3) wet meadows. Tidal fresh marshes are among the most diverse plant communities found in the state. These marshes are flooded daily due to tidal influence on river water. Common species include spatterdock, narrow-leaved cattail, rose mallow, bur-marigold, yellow flag, smartweeds, tearthumbs, wild rice, sweet flag, arrowhead, water hemp, common reed, pick-





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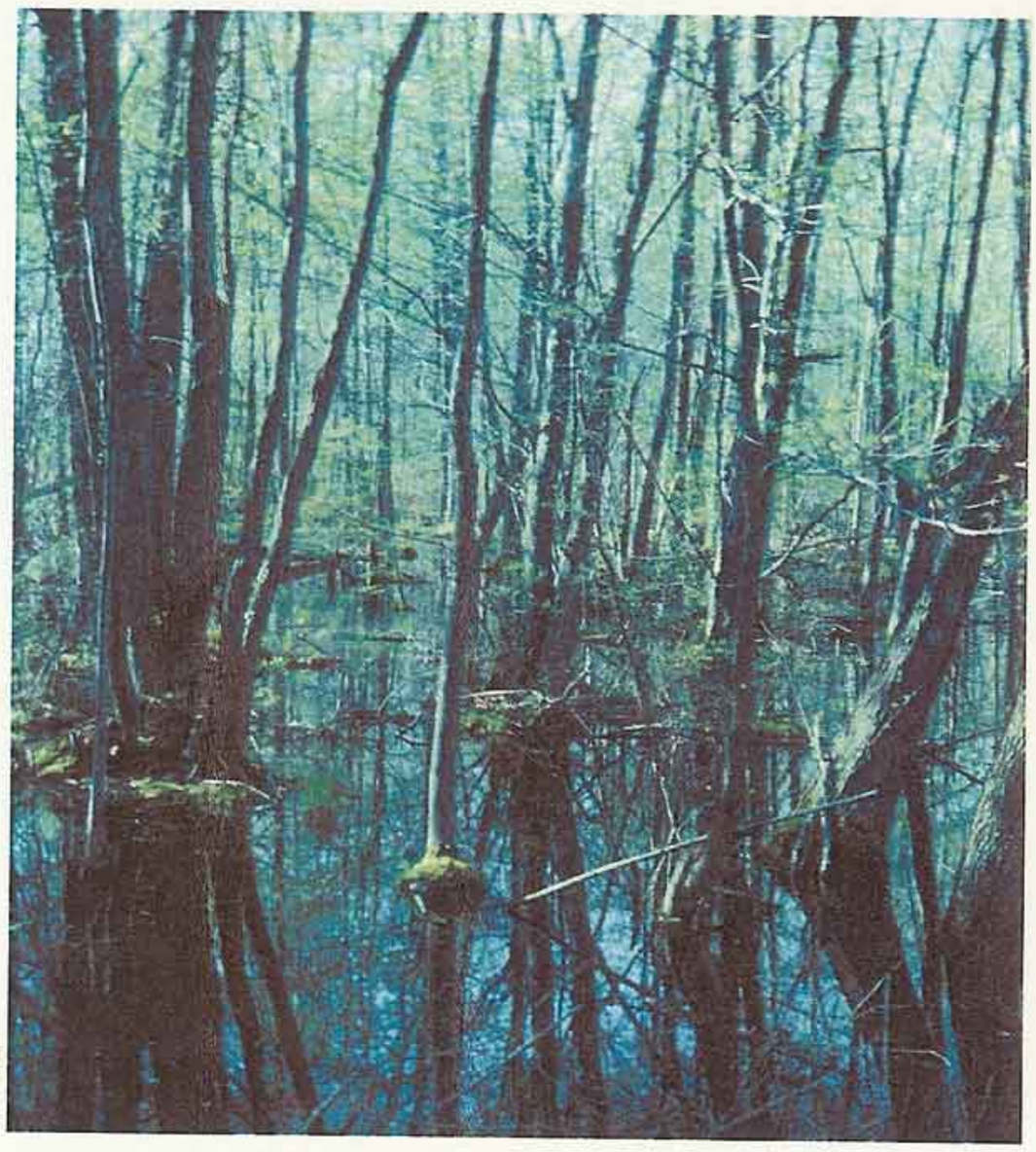

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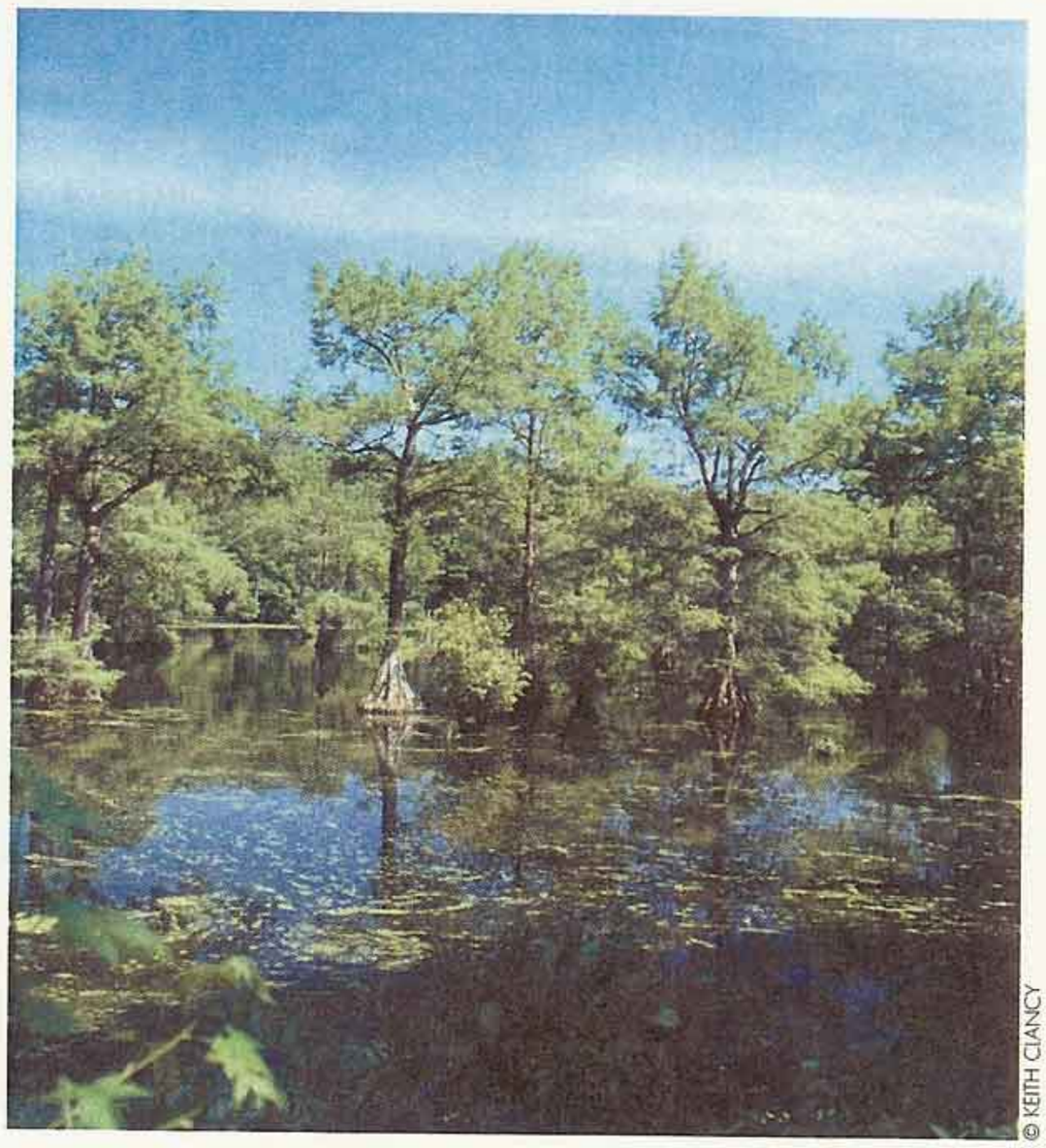

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CLOCKWISE FROM TOP LEFT:

Slightly brackish (oligohaline) marsh on the Smyrna River.

Wet meadow (savanna) at Huckleberry Pond in Sussex County.

Cypress swamp at Trussum Pond.

Forested pothole wetland in Kent County.

BILL ZINNI

Palustrine forested wetland in the Piedmont drainage basin.

erelweed, arrow arum, water-willow, and river bulrush. Scattered trees and shrubs may grow in these marshes, with willows, buttonbush, swamp rose, red maple, and wax myrtle frequently occurring. Nontidal marshes are flooded for extended periods (usually a few months or more) during the year. Typical plants include broad-leaved cattail, bur-reed, rice cutgrass, reed canary grass, sedges, and most of the other plants listed above for tidal fresh marshes. Wet meadows include wet fields and pastures where the soils are saturated near the surface for prolonged periods and may be inundated for brief periods. Common species include soft rush, reed canary grass, common reed, sedges, goldenrods, Joe-Pye-weeds, and asters. Wet meadows may be dominated by a single species or by a diverse assemblage of plants.

Palustrine scrub-shrub wetlands (or shrub swamps) are wet thickets that may be seasonally flooded or saturated near the surface by seasonal high water tables. Common wetland shrubs include buttonbush, silky dogwood, and smooth alder, while saplings of red maple, ashes, and black willow are also representative. Tidally flooded shrub swamps occur along coastal rivers (e.g., Spring Creek, Murderkill River, St. Jones River, Cedar Creek, and Broadkill River). Although wax myrtle and red maple tend to dominate these swamps, a diverse assemblage of other shrubs and herbaceous plants forms mixed communities. In nontidal areas, buttonbush is most abundant in nearly permanently flooded depressions (e.g., Delmarva potholes), with other species being characteristic of periodically flooded or saturated scrub-shrub wetlands.

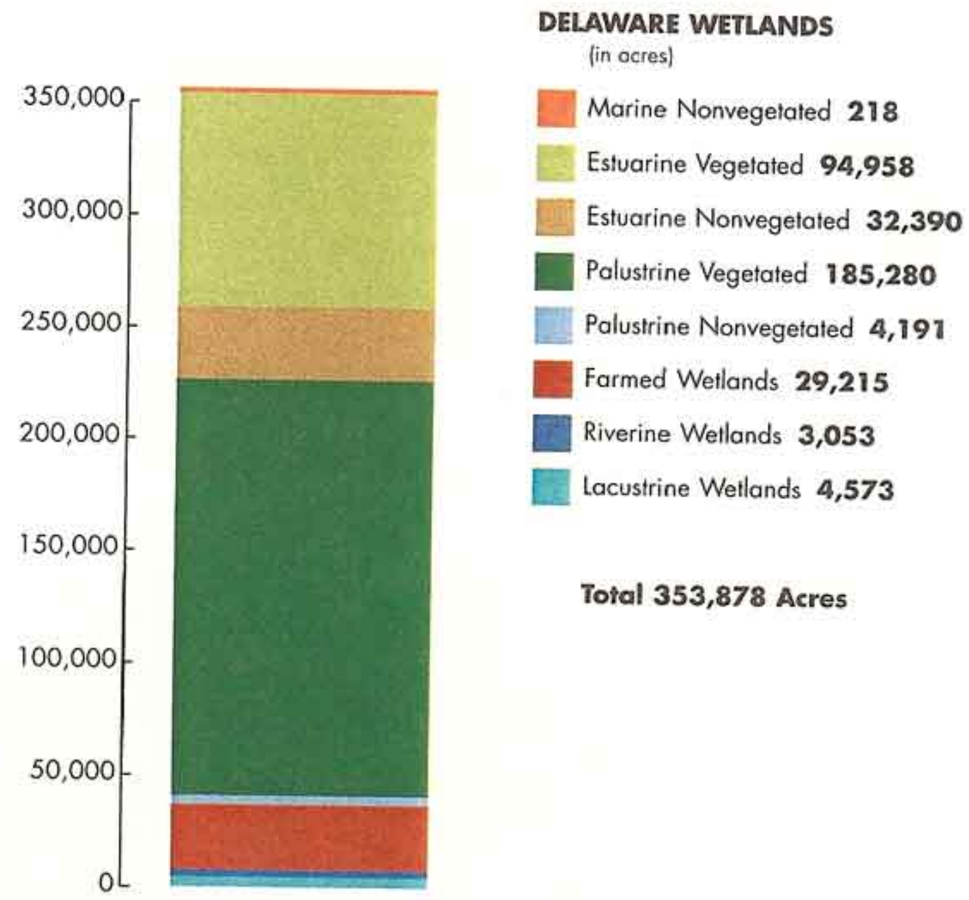
Most of Delaware's freshwater wetlands are **palustrine forested wetlands.** They may be flooded by high tides (tidal swamps) or not (nontidal swamps). The former occur along upper tidal reaches of the Nanticoke, Mispillion, and Murderkill Rivers, for example. Green ash, red maple, and black gum are most abundant in these tidal swamps. Nontidal swamps may be dominated by evergreen or deciduous trees including loblolly pine, pond pine, Atlantic white cedar (less commonly), red maple, sweet gum, various oaks (water, willow, pin, basket, and swamp white), sweet bay, and river birch. Shrubs often form a dense understory in many forested wetlands. Common shrubs include sweet pepperbush, highbush blueberry, winterberry, southern arrowwood, maleberry, fetterbush, Virginia sweet-spire, swamp azalea, wax myrtle, and inkberry. Woody vines, such as common greenbrier (forming virtually impenetrable thickets), poison ivy, and Japanese honeysuckle (carpeting the ground), are characteristic of many swamps. Numerous forested wetlands, often called "wet flatwoods" or "winter wet woods," occupy broad flats on drainage divides ("interfluves"). Flatwoods are among the most-difficult-to-recognize wetlands since they are typically seasonally saturated (i.e., mainly wet during the winter and early growing season due to high water tables) and are characterized by plants that occur in both wetlands and coastal plain uplands.

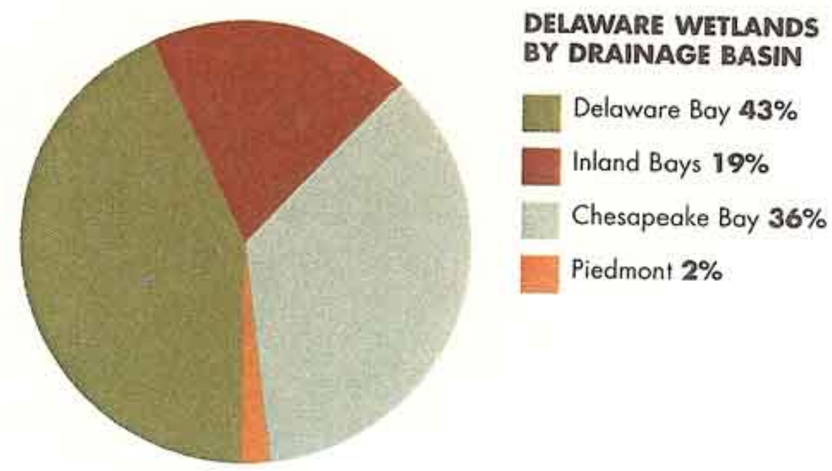
Current Status of Wetlands

Nearly 30 percent of the state is covered by wetlands, with over 350,000 acres inventoried (see accompanying figure for general distribution of types).[3] Estuarine wetlands represent about one-third of the state's wetlands, while palustrine wetlands encompass nearly all of the remainder. Over 75 percent of Delaware's wetlands are vegetated (i.e., emergent, scrub-shrub, and forested types).

Estuarine wetlands predominate the coastal zone along the shores of Delaware Bay where 69 percent of this type occurs. Twenty-nine percent of the estuarine wetlands is associated with the Inland Bays drainage basin, while the remaining 2 percent occurs in the Piedmont basin (northern Delaware).

Palustrine wetlands abound in the central and southern parts of the state. Fifty-seven percent of these wetlands occurs in the Chesapeake basin and 27 percent is found in the Delaware Bay drainage basin. Pothole-type depressional wetlands (e.g., Delmarva potholes) predominate along the Maryland border, with the highest concentrations found between Townsend and Hartly. Floodplain-type wetlands occur along major rivers, such as the Nanticoke River, and their tributaries. Many former floodplain wetlands have been dammed to form impoundments of various sizes (e.g., Haven Lake on the Mispillion River, Collins Pond on the Nanticoke, Cubbage and Swiggetts Ponds on Cedar Creek, and Killen and Coursey Ponds on the Murderkill River).



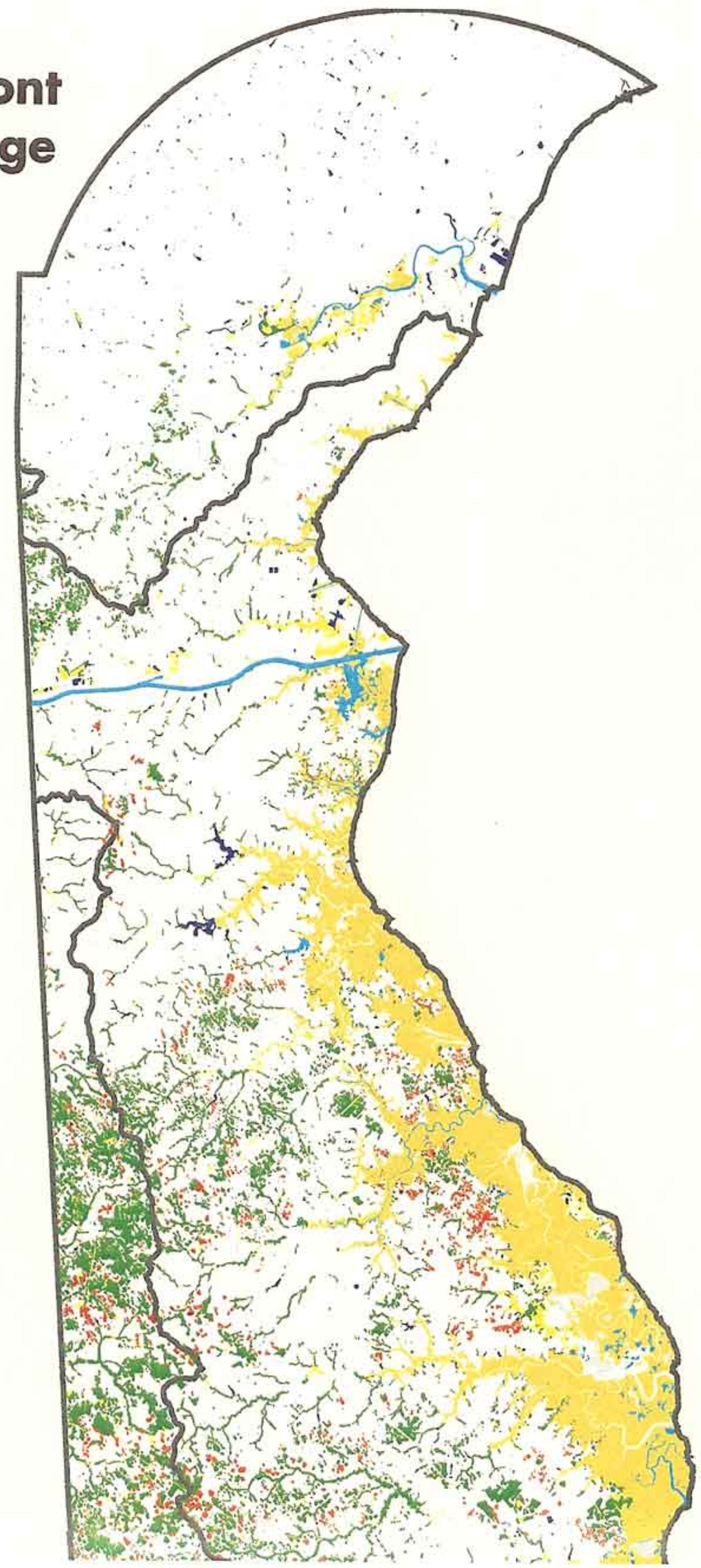


3 The NWI mapping in the early 1980s reported about 223,000 acres of wetlands in *Wetlands of Delaware* (Tiner 1985). The difference between this number and the state's figure (reported here) is mainly due to the inclusion of farmed wetlands and many flatwood wetlands (not mapped by the NWI) and a much smaller minimum mapping unit in the state's mapping effort.

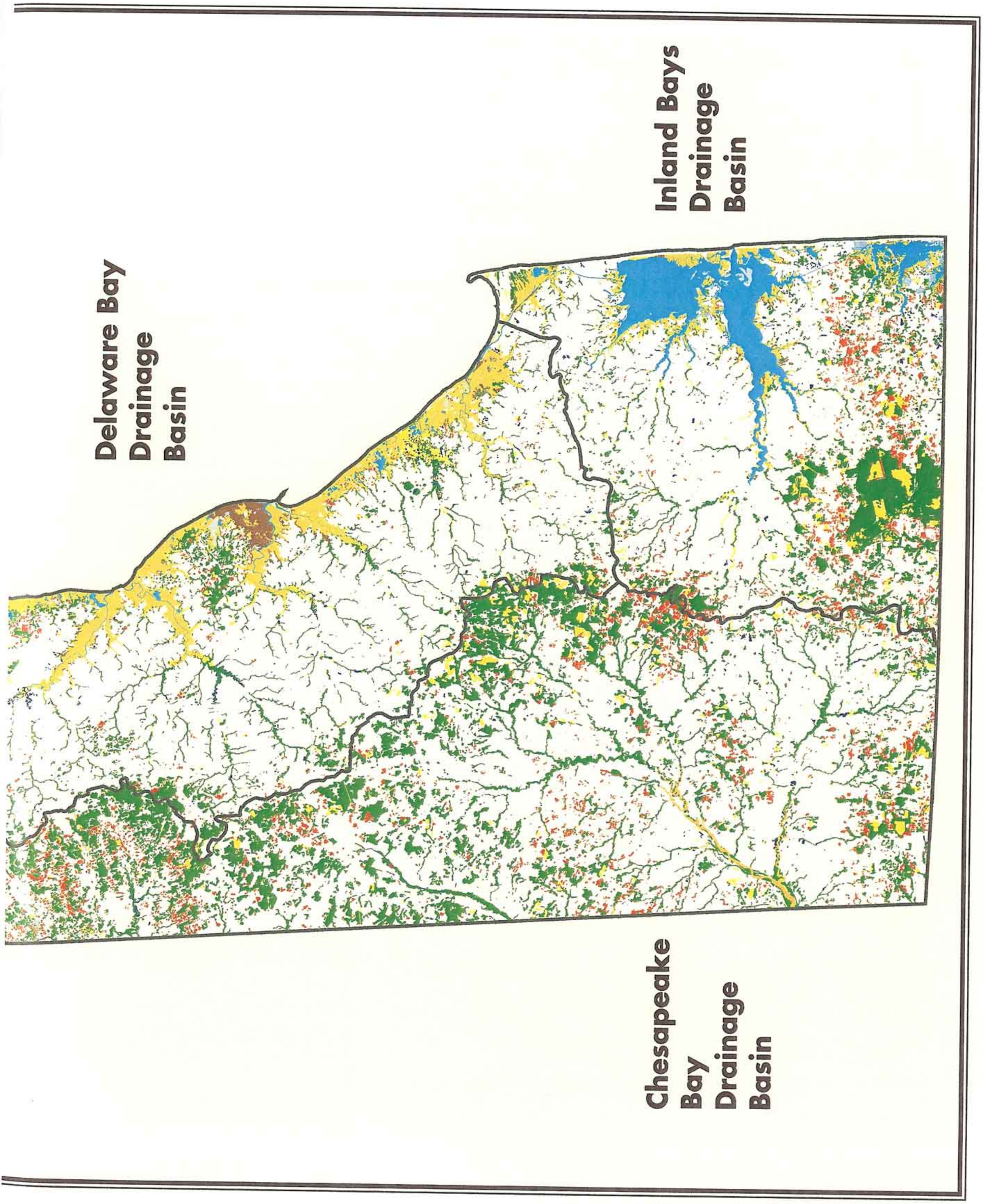
American bittern

Delaware Wetlands

Piedmont Drainage Basin



- Estuarine Emergent Wetlands
- Estuarine Nonvegetated Wetlands
- Estuarine Other Vegetated Wetlands
- Fresh Water
- Riverine Wetlands
- Palustrine Farmed Wetlands
- Palustrine Forested Wetlands
- Palustrine Other Vegetated Wetlands
- Salt Water


Delaware Bay
Drainage
Basin
Inland Bays
Drainage
Basin
Chesapeake
Bay
Drainage
Basin

Forces Changing Wetlands

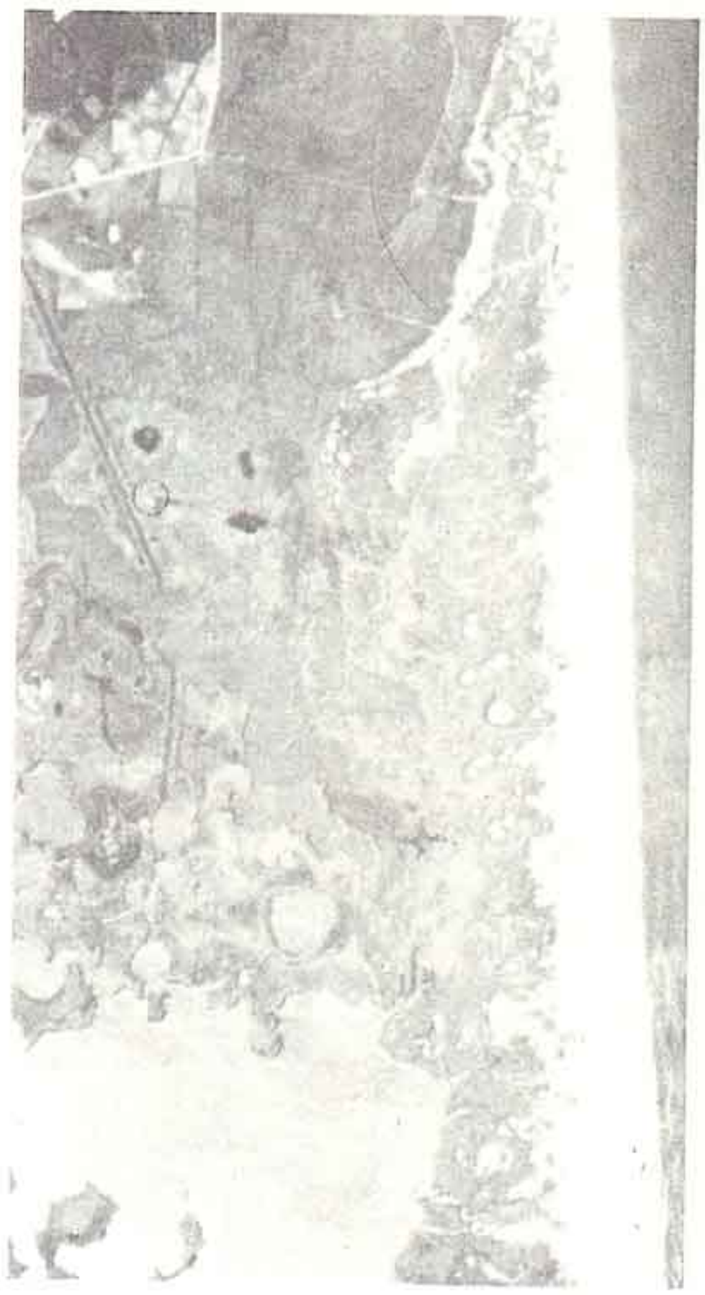
Natural processes and human actions affect wetlands in various ways. Changes in vegetation often result from natural events such as droughts, rising sea level, hurricanes, episodic floods, fire, and animal actions. Rising sea level also produces long-term changes in wetland hydrology and the extent of estuarine waters and wetlands. Grazing by muskrats and snow geese have a tremendous impact on the vegetation of many Delaware wetlands, especially tidal wetlands where large eat-out areas can be observed.

People have had both positive and negative impacts on wetlands. Unfortunately, most human activities to date have caused wetland loss and degradation. For example, Delaware may have lost as much as 54 percent of its wetlands since the 1780s.[4] Human impacts to Delaware wetlands have included: 1) filling for commercial, industrial, and residential development, 2) disposal of dredged material and garbage (e.g., sanitary landfills), 3) dredging for navigation and marinas, 4) conversion to cropland or pasture, 5) conversion of natural wetland forests to pine plantations, 6) creation of diked impoundments for water supply and wildlife management, 7) pond construction, 8) alteration of hydrology (e.g., drainage and channelization projects), 9) direct or indirect discharge of pollutants (e.g., oil, pesticides, herbicides, and other chemicals, sediment, domestic sewage, and agricultural wastes), and 10) spreading invasive and/or exotic species (e.g., common reed and Japanese honeysuckle). Since the 1970s, government has increased protection and management of wetlands through state and federal laws. This has helped significantly reduce human impacts. In addition, natural resource agencies have initiated wetland restoration programs that seek to improve the quality of degraded wetlands and to increase wetland acreage (e.g., bring back lost wetlands and create new ones).

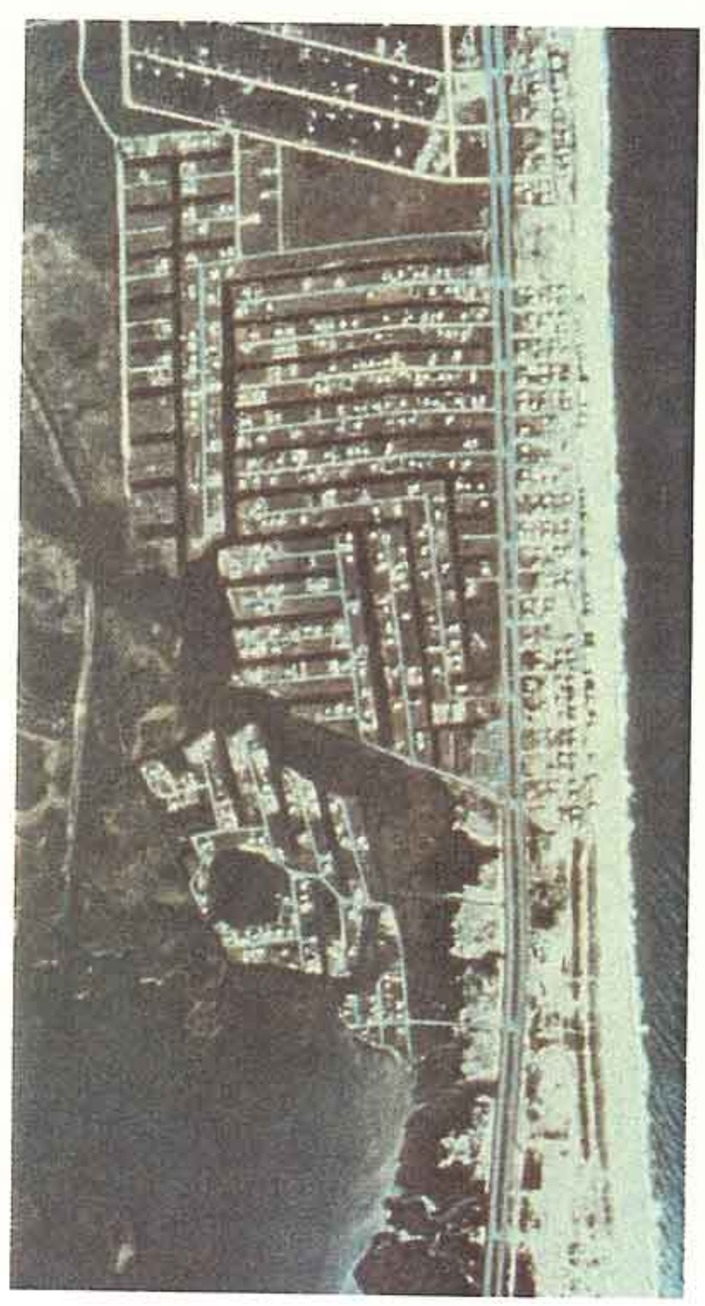
This time series of aerial photos shows significant development of coastal wetlands in the Bethany Beach area between 1937 and 1973 and very little change thereafter. In 1973, the state enacted the "Wetlands Act" that restricted development in tidal wetlands.

4 Dahl, T.E. 1990. Wetland Losses in the United States, 1780s to 1980s. U.S. Department of Interior, Fish and Wildlife Service, Washington, DC. Report to Congress.

1937



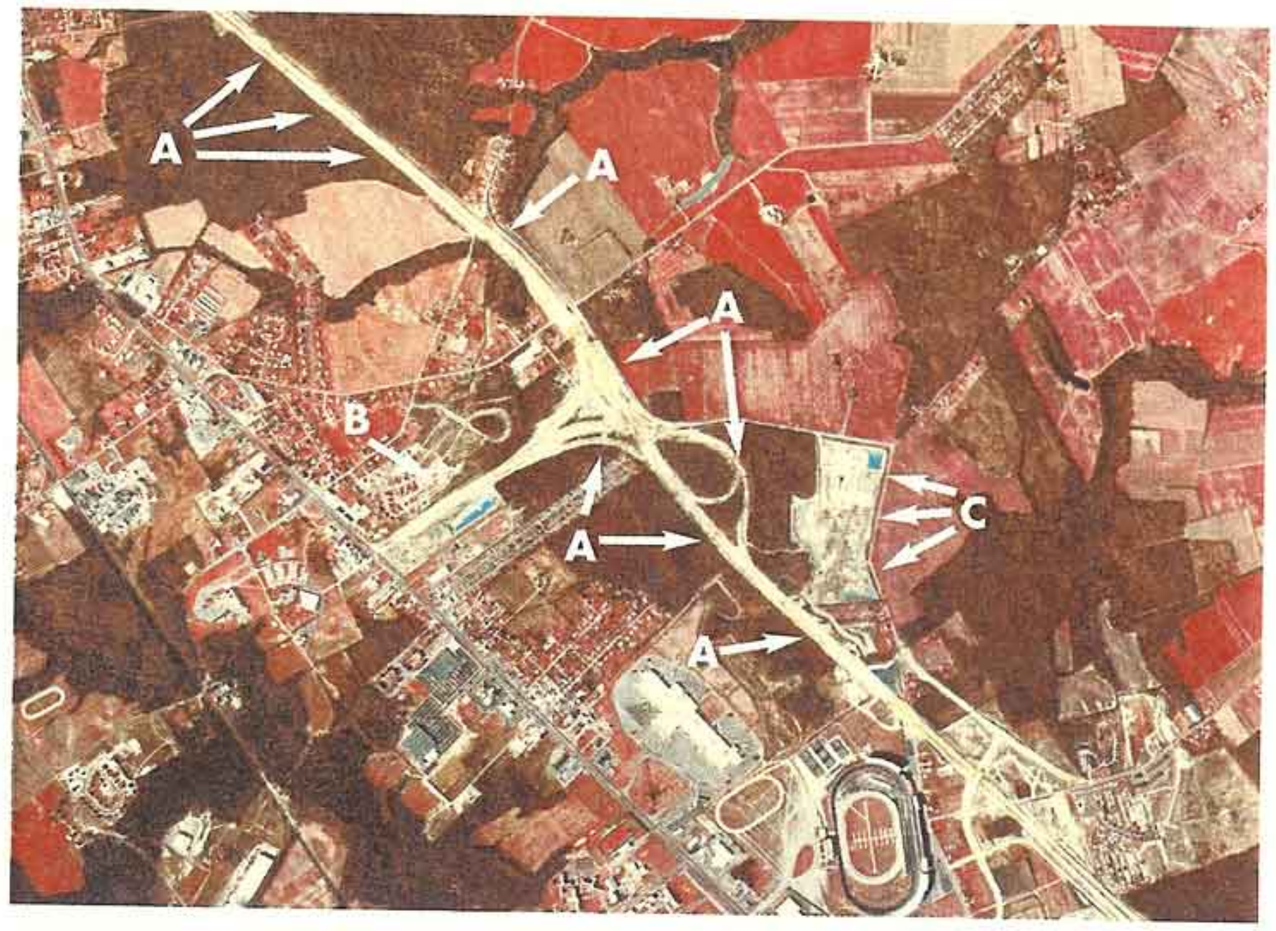
1973



1992

Statewide Wetland Trends

Wetland trends for Delaware were determined by comparing aerial photographs from two time periods: April 1981/March 1982 and March 1992. Trends were analyzed for the state's four major drainage basins: 1) Piedmont, 2) Delaware Bay, 3) Chesapeake Bay, and 4) Inland Bays. A complete analysis for the Piedmont and Inland Bays basins was performed, while about 75 percent of the Delaware Bay drainage area and 60 percent of the Chesapeake Bay basin were evaluated. For the latter basins, wetland trends were estimated from the data collected.[5] The data presented below are for the entire state, with the drainage basin results presented in the following section — Drainage Basin Summaries.



Wetland impacts in the Dover area in 1992. Arrows indicate general areas of road construction (A) and residential development (B) in palustrine wetlands plus pond creation in upland (C).

Vegetated Wetland Changes

Nearly 2,000 acres of vegetated wetlands were destroyed from 1981/2 to 1992. Most of this loss involved palustrine vegetated wetlands (Table 1), with almost 1,900 acres of these wetlands eliminated. The main cause of wetland loss for the palustrine vegetated wetlands was agricultural activities which accounted for half of their losses. Residential development also exacted a heavy toll on these wetlands, causing nearly 25 percent of the losses. Pond construction and highway/road projects affected nearly equal amounts of palustrine vegetated wetlands, with each being responsible for about 7 percent of the losses.

Palustrine forested wetlands experienced the greatest losses. About 1,500 acres were converted to nonwetlands, ponds, and farmed wetlands. Forested wetlands alone accounted for 76 percent of the total loss of vegetated wetlands. Statewide losses of other palustrine vegetated wetlands were 255 acres of palustrine scrub-shrub wetlands and 129 acres of palustrine emergent wetlands. In all, palustrine vegetated wetlands comprised 95 percent of the recent losses of Delaware's vegetated wetlands.

Timber harvest of forested wetlands was significant, affecting nearly 3,500 acres. About 2,050 acres of palustrine forested wetlands were harvested during the study decade. While these wetlands are now emergent or scrub-shrub wetlands, they should eventually revert to forested wetlands after a few decades.[6] Other changes resulting from previous timber cuts were: 1) about 750 acres of palustrine emergent wetlands became shrub wetlands, 2) roughly 300 acres of emergent wetlands became forested wetlands, and 3) over 350 acres of shrub wetlands became forested wetlands. Seventy-seven percent of these changes occurred in the Chesapeake Bay drainage basin.

About 106 acres of estuarine vegetated wetlands were lost. Over half of the losses were due to impoundments, mostly saltwater impoundments. Nearly a third of the losses were due to filled wetland for unknown purposes, while filling for highway/road projects and for residential development accounted for just 11 acres of coastal marsh loss.

Changes in Nonvegetated Wetlands

Changes in pond acreage were the most dynamic, with a statewide net gain of 610 acres — 890 new pond acres were established, while 280 acres of pre-existing ponds were destroyed. Conversion to land with unknown future use accounted for 64 percent of these pond losses. About half of the gain in pond acreage came from agricultural land, while 21 percent of the new ponds was built in former upland plant communities (e.g., forests and meadows) and 16 percent was constructed in wetlands. Forested wetlands were most affected by pond construction with 95 acres of ponds created in this wetland type (amounts to 67 percent of the vegetated wetlands converted to ponds). Nearly 200 acres of tidal flats were converted to a dredged material disposal site at the mouth of the Christina River. This single action was responsible for virtually all of the estuarine nonvegetated wetland loss during the study period.

5 See the report *Wetland Trends in Delaware: 1981/82 to 1992* (Tiner et al. 1999) for details on study methods and results.

6 Planting pines to create pine plantations in these wetlands and associated forestry management practices probably degrade the habitat quality of these wetlands for wildlife when compared to more diverse forested wetlands.

Table 1. Statewide changes in vegetated wetlands (1981/2–1992)

Wetland Change	Cause	Acreage Affected
Estuarine Vegetated		
Gain from	Palustrine Forested Wetland	1.1
	(Subtotal)	(+1.1)
Loss to	Estuarine Impoundment	44.9
	Transitional Land	18.2
	Rangeland	14.5
	Freshwater Pond	7.3
	Tidal Flat	5.7
	Highway/Road	5.5
	Residential Development	5.3
	Commercial Development	2.1
	Palustrine Emergent Wetland	1.1
	Industrial Development	0.9
	(Subtotal)	(–105.5)
Net Estuarine Vegetated Wetland Change		–104.4 (loss)
Palustrine Vegetated		
Gain from	Pond Colonization	34.8
	Cropland	20.3
	Rangeland	10.6
	Pasture	9.5
	Upland Forest	4.6
	Farmed Wetland	3.4
	Lacustrine Deepwater	2.9
	Sand/Gravel Pits	1.3
	Estuarine Wetland	1.1
	Idle Fields	0.9
	Transitional Land	0.2
	(Subtotal)	(+89.6)
Loss to	Agriculture-related*	954.2
	Residential Development	435.7
	Pond Construction	135.1
	Highway/Road	128.5
	Rangeland	88.1
	Industrial Development	49.8
	Transitional Land	32.7
	Airport	27.5
	Riverine Deepwater Habitat	14.9
	Commercial Development	11.0
	Estuarine Deepwater (impoundment)	5.9
	Upland Forest (drained)	4.9
	Estuarine Emergent Wetland	1.1
	Transportation/Communication	0.7
	(Subtotal)	(–1890.1)
Type Change	Timber Harvest	2035.4
	Post-timber Harvest Succession**	1426.6
	Palustrine Forested Wetland to Palustrine Emergent Wetland (excavated)	10.1
	(Subtotal)	(3472.1)
Net Palustrine Vegetated Wetland Change***		= –1800.5 (loss)
TOTAL NET CHANGE IN VEGETATED WETLAND		= –1904.9 (LOSS)

*Does not include pond construction on farms. **Following pre-1981/2 timber harvest. ***Excludes Palustrine vegetated acreage changing type.

Drainage Basin Summaries

The status and recent trends of wetlands in Delaware's four drainage basins follows. The status data come from the DNREC's wetland mapping program, while the trends findings come the U.S. Fish and Wildlife Service's 1999 study.[7]

Delaware Drainage Basins

- Piedmont Drainage Basin
- Delaware Bay Drainage Basin
- Chesapeake Bay Drainage Basin
- Inland Bays Drainage Basin

Piedmont Drainage Basin

Wetland Status

The Piedmont drainage basin in northern Delaware occupies 9 percent of the state's land mass. Wetlands are not particularly widespread in this area of rolling hills and urban development. About 6,400 acres of wetlands remain, representing 5 percent of the drainage basin.

Streamside wetland along White Clay Creek.

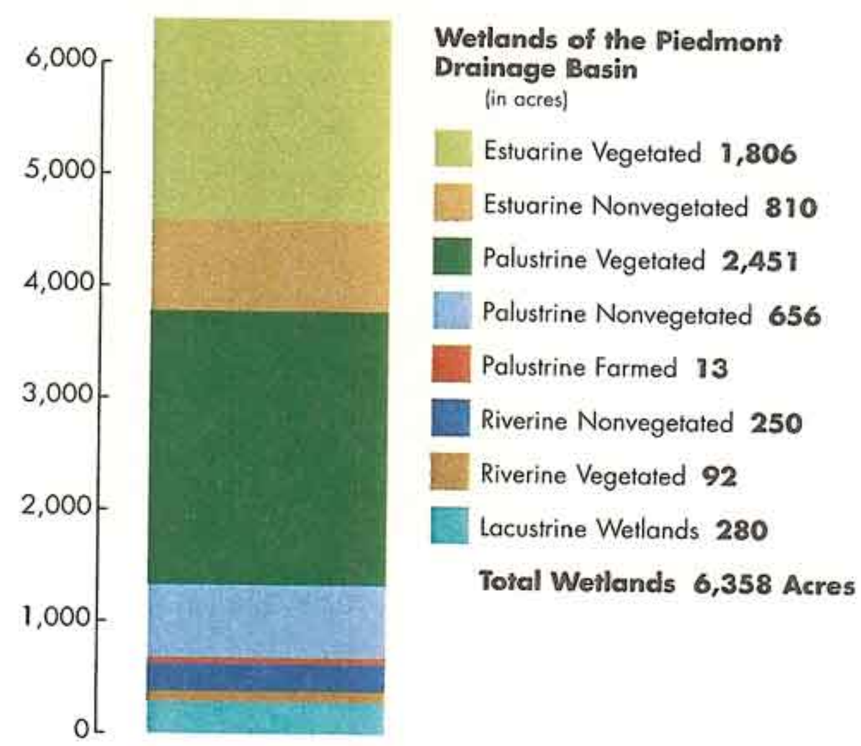
Wetland Trends

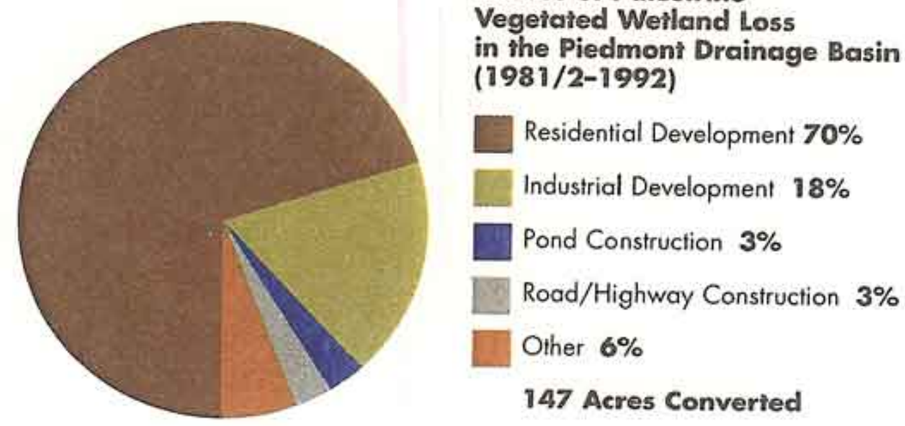
From the 1980s to the 1990s, Piedmont vegetated wetlands experienced net losses of nearly 140 acres. Palustrine vegetated wetlands received the greatest impact. Estuarine wetlands in the Piedmont basin were not significantly impacted by development during the study decade. Only 0.7 acres of estuarine emergent wetland were converted to industrial development and 0.5 acres of estuarine nonvegetated wetland became impounded estuarine deepwater habitat. Only 9 acres of palustrine vegetated wetlands became established during the decade — mostly the result of emergent plant colonization of ponds.

Palustrine forested wetlands experienced the heaviest losses, with 110 acres converted to dryland. These wetland losses accounted for 75 percent of the total losses of palustrine vegetated wetlands. Nearly 26 acres of palustrine scrub-shrub wetlands were lost, mostly to residential development. About 10 acres of palustrine emergent wetlands were converted to upland (8 acres) or ponds (2 acres). Two acres of palustrine farmed wetland were converted to home sites.

Only 14 acres of palustrine forested wetlands were harvested for timber. This produced a 1-acre gain in palustrine emergent wetland and a 13-acre gain in palustrine scrub-shrub wetland due to vegetation changes. These changes are successional stages of forested wetlands in various states of recovery after timber harvest.

Pond acreage declined in the Piedmont drainage area. This was the only drainage area in the state to experience a net loss in ponds, with a net loss of about 116 acres of ponds recorded. Despite the construction of nearly 66 acres of new ponds, nearly 182 acres of pre-existing ponds were destroyed, producing the net loss of acreage during the 1980s. Most (93%) of the gains came from upland sites. Most of the losses were due to filled land that was in a transitional state (its intended use could not be determined), although it is likely to be residential or industrial development.

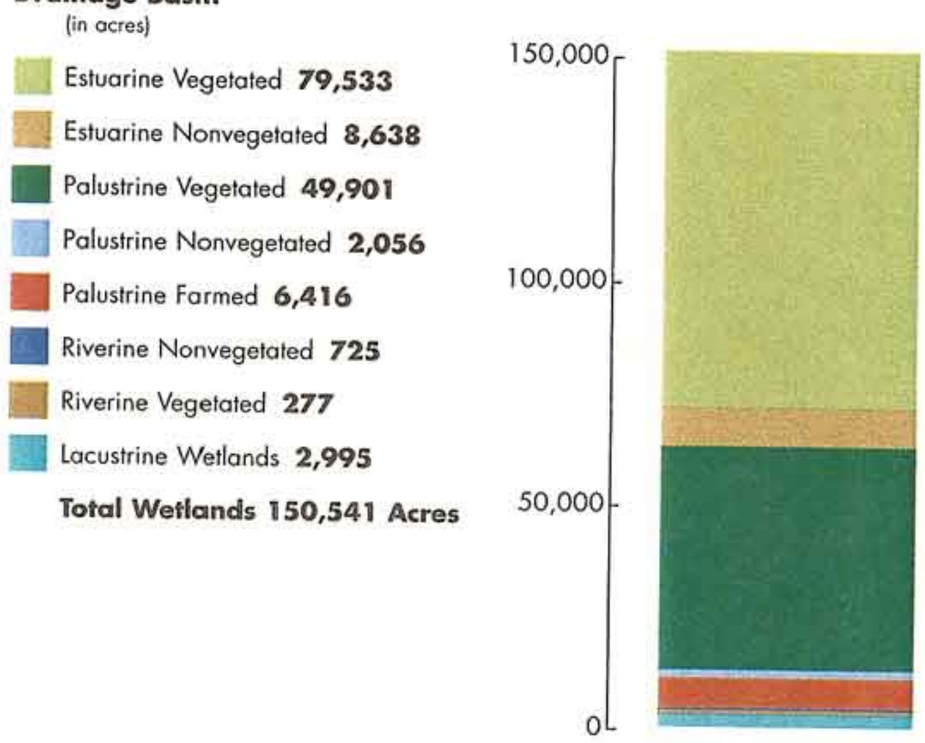




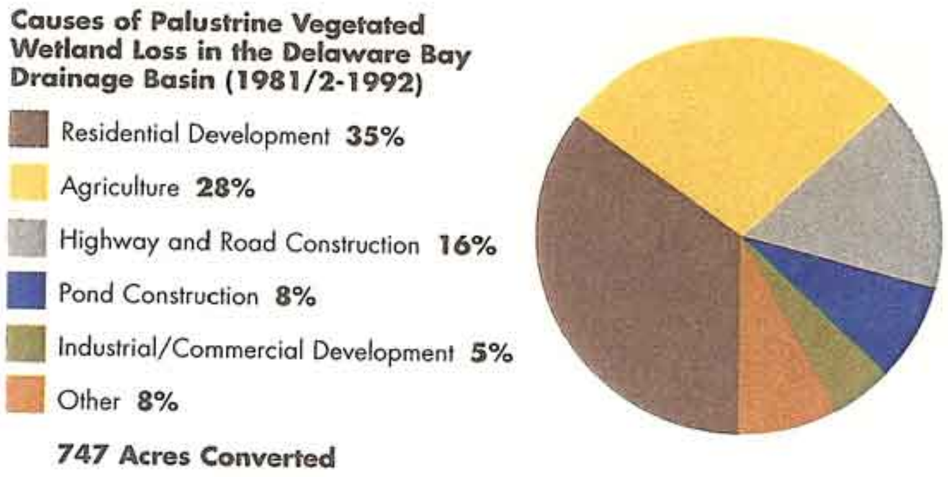
7 Wetland status data provided by Mark Biddle in July 2001; wetland trends data from Tiner et al. 1999. *Wetland Trends in Delaware: 1981/82 to 1992.* U.S. Fish and Wildlife Service, Hadley, MA.

Stand of big cordgrass in a brackish marsh.

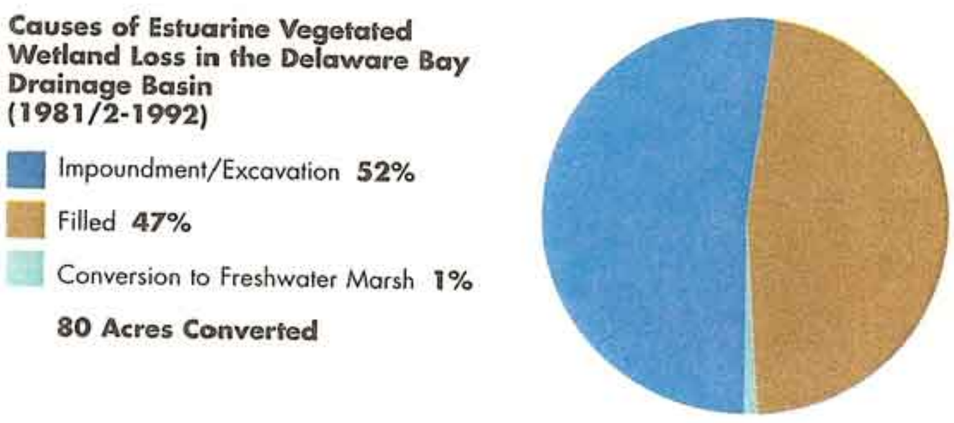
Wetlands of the Delaware Bay Drainage Basin
(in acres)



Causes of Palustrine Vegetated Wetland Loss in the Delaware Bay Drainage Basin (1981/2-1992)



Causes of Estuarine Vegetated Wetland Loss in the Delaware Bay Drainage Basin (1981/2-1992)



Delaware Bay Drainage Basin

Wetland Status

The Delaware Bay drainage basin is the largest of the four major drainages in Delaware, occupying 40 percent of the state. Located on the eastern side of the state, it includes a mixture of urban/suburban areas, forests, and agricultural land. Wetlands encompass slightly more than 150,000 acres or 29 percent of the drainage area.

Wetland Trends[8]

From 1981/2 to 1992, there was a net loss of both estuarine and palustrine vegetated wetlands (78 acres and 679 acres, respectively). Palustrine forested wetlands received the heaviest impacts, with 444 acres converted to dryland or water (mostly ponds). Palustrine scrub-shrub wetlands were next (202 acres converted), followed by emergent wetlands (101 acres lost, mostly to cropland and pasture). Sixty-five acres of new emergent wetlands became established (mostly through pond colonization and re-establishment on farmland) for a net loss of only 37 acres in this type. Nearly 250 acres of palustrine vegetated wetlands changed type (e.g., forested to emergent), mostly due to forestry, with only 4 acres of forested wetlands converted to emergent wetland due to excavation.

Palustrine farmed wetlands experienced a net loss of 26 acres. Twenty-eight acres were converted to uplands, ponds, or emergent wetlands, while only 2 acres of new farmed wetlands were established in former pastures. Fifty-three percent of the losses was due to pond construction, while 28 percent was due to construction of farm buildings and 8 percent to residential development.

Estuarine losses totaled 80 acres. Over half of these losses (or 41 acres) were attributed to impoundment or excavation creating waterbodies (deepwater habitats or ponds). The proposed use of most of the 37 acres of filled estuarine marsh could not be determined,[9] while about 6 acres were converted to roadways.

Ponds experienced a net increase of 215 acres, whereas estuarine tidal flats had a net loss of over 200 acres. While 88 acres of preexisting ponds were converted to upland or vegetated wetlands, 303 acres of ponds were built for a net gain. Of the pond acreage created, 36 percent came from cropland, while about 26 percent came from wetlands (mostly palustrine vegetated types). Of the lost pond acreage, about half was filled for various types of upland development. Nearly 37 percent of the lost pond acreage became palustrine emergent wetlands due to sedimentation and subsequent colonization by emergent vegetation. Construction of a dredged material disposal site at the mouth of the Christina River eliminated 199 acres of tidal flats (10 acres represented by dikes and 189 acres contained the dredged material). About 3 acres of tidal flats became estuarine deepwater habitat at the mouth of the Mispillion River apparently due to natural erosional forces.

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8 Reported trend numbers are estimates based on an evaluation of 75 percent of the basin.

9 The cause was designated as transitional land where the land was disturbed and as rangeland where open fields and shrub thickets occupied the fill.

Chesapeake Bay Drainage Basin

Wetland Status

The Chesapeake Bay drainage basin is located in the western part of Delaware and includes watersheds of rivers flowing westerly into Chesapeake Bay, especially the Nanticoke, Chester, and Choptank Rivers. It represents 35 percent of Delaware's land surface area and occupies a portion of the coastal plain where wetlands are quite abundant. Wetlands occupy nearly 130,000 acres or 28 percent of the drainage basin. Floodplain wetlands are common along various rivers and tributary streams and an extraordinarily high number of very small isolated depressional wetlands called "Delmarva potholes" occur on broad interstream divides.

Wetland Trends[10]

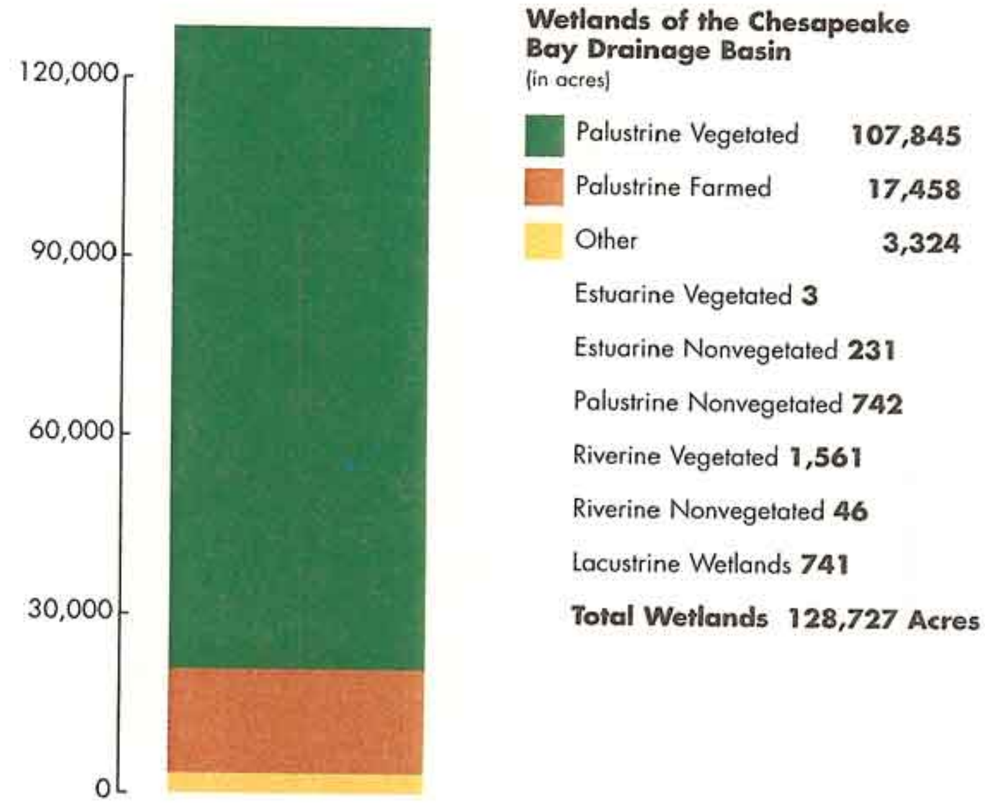
From 1981/2 to 1992, there was a net loss of 712 acres of palustrine vegetated wetlands. An estimated 723 acres were converted to nonwetlands or open water, while only 10 acres of new palustrine vegetated wetlands became established (mostly on agricultural lands).

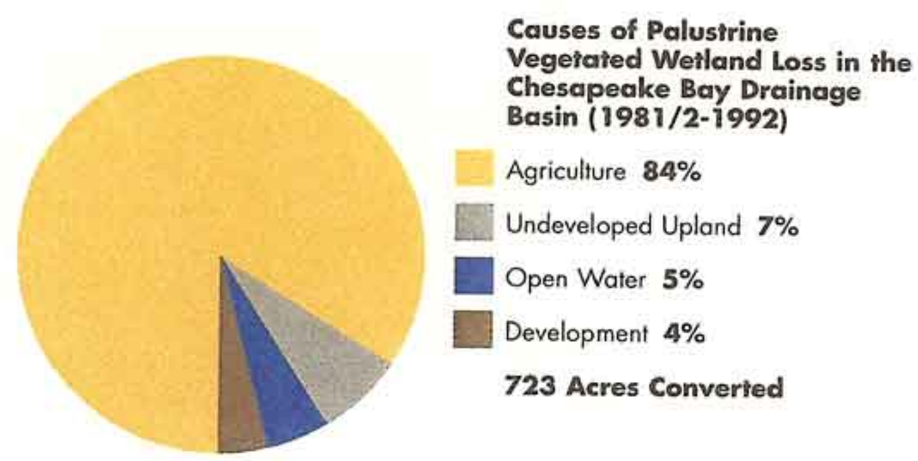
Most of the palustrine vegetated wetland losses involved forested wetlands, with 701 acres destroyed. Over 600 acres of forested wetlands were converted to agricultural uses, with 566 acres becoming cropland (95% became farmed wetlands). The Chesapeake Bay drainage basin also had small net losses of other vegetated wetlands (i.e., a 1-acre loss of emergent wetlands and 11-acre loss of scrub-shrub wetlands).

Forestry practices had a significant impact on wetlands in the Chesapeake Bay basin, affecting 2,721 acres. Nearly 60 percent of this acreage was represented by forested wetlands harvested between 1981/2 and 1992. Other former forested wetlands logged prior to the 1980s were also moving along the successional pathway with 520 acres returning to forested wetlands by 1992, while others were in earlier stages of recovery.

During the study decade, there was a net increase of 212 acres in ponds. About 63 percent of this gain came from agricultural lands (e.g., cropland, pasture, farmed wetland, and idle fields), while 27 percent came from excavations in transitional land and upland forest. Only 8 percent of the new ponds came from palustrine vegetated wetlands.

Aerial photo showing Delmarva pothole wetlands (medium to dark blue depressions) northwest of Hartly.





10 Reported trend numbers are estimates based on an evaluation of 60 percent of the basin.

Inland Bays Drainage Basin

Wetland Status

The Inland Bays drainage basin, located in southeastern Delaware, represents 16 percent of the state's land surface area. Three coastal bays dominate the eastern portion of the basin — Indian River Bay, Rehoboth Bay, and Little Assawoman Bay. The region contains a mixture of urban-suburban-resort development along the coast, with forests and agricultural lands inland. This drainage basin possesses about 68,000 acres of wetlands which comprise 32 percent of the watershed.

Wetland Trends

During the 1980s and early 1990s, the Inland Bays drainage basin suffered net losses of both palustrine and estuarine vegetated wetlands. Most of the losses involved palustrine types, especially forested wetlands. Overall, there was a net loss of 271 acres of palustrine vegetated wetlands (277 acres lost versus 6 acres gained).

Forested wetlands were most adversely affected, with 258 acres lost during the 1980s. This figure represents over 90 percent of the palustrine vegetated wetland losses. Agriculture was the leading cause of forested wetland loss (125 acres), being responsible for 48 percent of the total losses. Residential development and pond construction were also significant causes of forested wetland loss. Small net losses of scrub-shrub wetlands were detected. About 14 acres of these wetlands were converted to nonwetlands or ponds. Palustrine emergent wetlands experienced a net gain of 1 acre (with 10 acres created and 9 acres destroyed) — this was the only vegetated wetland type to increase.[11]

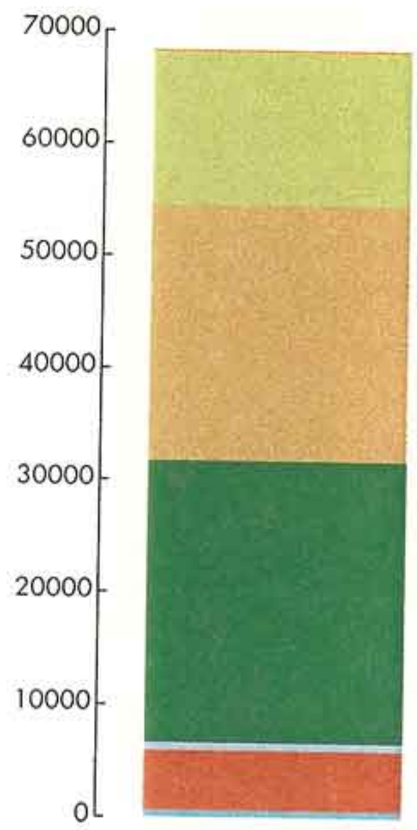
During the study decade, 484 acres of wetlands were impacted by forestry operations. Recently harvested forested wetlands totaled 325 acres. After timber cutting, this acreage became other wetland types (successional stages of forested wetlands): 47 percent became emergent wetlands and 53 percent became scrub-shrub wetlands by 1992. An additional 159 acres were affected by pre-1980 timber harvests (former forested wetlands on the post-harvest successional trajectory to become forested wetlands) with 75 percent reverting to forested wetlands during the 1980s.

Palustrine farmed wetlands experienced a net gain of 50 acres. This was the result of an increase of 75 acres from conversion of palustrine forested wetlands combined with a loss of 25 acres. The losses were mainly attributed to residential development (44%), pond construction (28%), feedlot construction (16%), and farm buildings (8%).

Two types of estuarine vegetated wetlands experienced losses in the 1980s: emergent wetlands and forested wetlands. The latter type represents former freshwater wetlands that are now periodically inundated by tidal salt water. About 20 acres of estuarine emergent wetlands were destroyed. Fifty-seven percent of the acreage was either excavated (8 acres) or impounded (3 acres). Residential development was responsible for 27 percent of the emergent losses. During the 1980s, 6 acres of estuarine forested wetlands became intertidal flats, presumably due to a combination of sea level rise and coastal plain subsidence.

During the study decade, pond acreage increased by nearly 300 acres in the Inland Bays drainage basin. About 40 percent of the gain was from agricultural lands, with 23 percent alone coming from cropland (excluding farmed wetland). Nineteen percent of the gain came from palustrine vegetated wetlands. Only 10 acres of pre-existing ponds were filled.

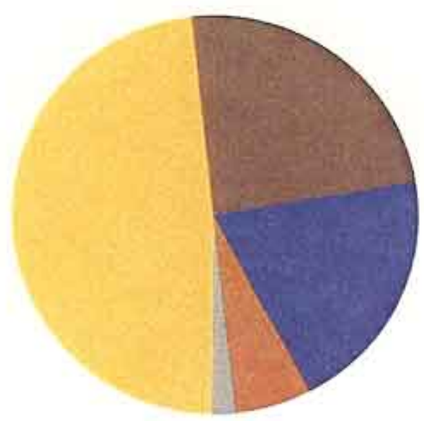
Wetlands of the Inland Bays Drainage Basin
(in acres)



- Marine Nonvegetated **218**
- Estuarine Vegetated **13,616**
- Estuarine Nonvegetated **22,711**
- Palustrine Vegetated **25,083**
- Palustrine Nonvegetated **737**
- Palustrine Farmed **5,328**
- Riverine Nonvegetated **2**
- Lacustrine Wetlands **557**

Total Wetlands 68,252 Acres

Causes of Palustrine Vegetated Wetland Loss in the Inland Bays Drainage Basin (1981/2-1992)



- Agriculture **48%**
- Residential Development **24%**
- Pond Construction **20%**
- Rangeland **6%**
- Other Development **2%**

277 Acres Converted

11 Excluding effects of timber harvest that caused temporary changes in plant composition. Recall that cutting of forested wetlands causes a short-term increase in both palustrine emergent and scrub-shrub wetlands — successional stages of forested wetlands rather than typical emergent or shrub wetlands.

Future of Delaware Wetlands

Significant gains in wetland conservation have been made since the early 1980s. The recent study of Delaware wetland trends documented an enormous drop in the annual loss rate of vegetated wetlands when compared to an earlier study: from about 1600 acres (1955–1981)[12] to about 190 acres (1981/2–1992). Estuarine vegetated wetlands experienced the greatest reduction in losses. They are now lost at a projected rate of about 10 acres per year versus 149 acres (for 1955–1981). Although annual losses of palustrine vegetated wetlands remain much higher than losses of estuarine wetlands (i.e., nearly 10 times that of estuarine vegetated wetlands), their loss rate has also dropped precipitously since the early 1980s. Palustrine vegetated wetlands are being lost at an estimated rate of 180 acres per year (versus 1,459 acres annually from 1955–1981). Pond acreage continues to increase as before, although at a slightly lower annual rate (61 acres versus 80 acres for 1955–1981).

Since 1973, conversion of Delaware's tidal wetlands has been regulated by DNREC in accordance with Delaware's "Wetlands Act." The results of the current study document the effectiveness of this effort in protecting these wetlands. Moreover, it appears that the state is close to achieving no-net-loss of estuarine wetlands.

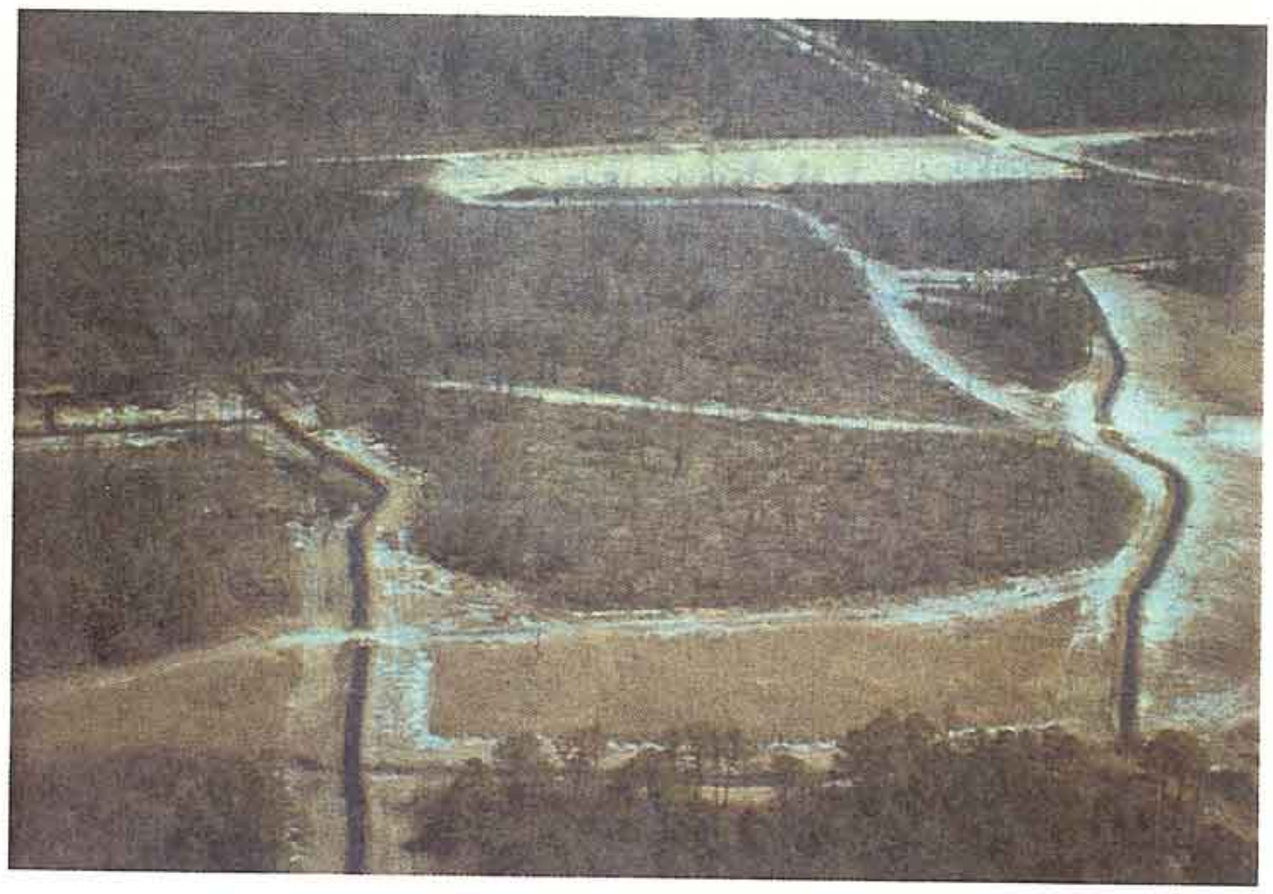
Alterations of Delaware's nontidal wetlands are regulated by the U.S. Army Corps of Engineers in accordance with Sections 404 and 401 of the federal Clean Water Act. While losses of these wetlands have been greatly reduced by the Corps efforts during the 1980s and early 1990s, more action is required to gain no-net-loss status for palustrine vegetated wetlands. Moreover, recent changes in federal wetland regulations regarding jurisdiction over isolated wetlands may place many of Delaware's palustrine wetlands, especially the Delmarva potholes, at risk. Additional efforts are needed to strengthen state and local controls to conserve these valuable wetlands.

Wetland restoration programs may hold the key for achieving the goal of no-net-loss of wetlands statewide. Since 1992, numerous wetland restoration projects have been undertaken or are planned that will likely put this worthy goal within reach in the near future. Many agencies including DNREC, the U.S. Fish and Wildlife Service, the U.S.D.A. Natural Resources Conservation Service, and county conservation districts are working cooperatively to increase wetland acreage and improve the quality of degraded wetlands. Many of these agencies provide cost sharing funds for wetland restoration and enhancement on private lands. Restoration projects include re-establishing hydrology to lost or impaired wetlands and controlling invasive species, especially common reed (*Phragmites australis*).

Common reed occurs mostly in wetlands, but it also colonizes disturbed sites such as landfills.

Although the status of wetlands has greatly improved during the last decade, readers should note that channelization and drainage still pose serious problems for palustrine vegetated wetlands in Delaware. Many of the remaining wetlands in Delaware have been partly drained by ditches. Restoration efforts are needed to improve the functions of these damaged wetlands and to re-establish the functions of lost wetlands. Although it was beyond the scope of the current study to analyze the effects of ditching and channelization beyond their direct effect (excavations and fills large enough to be delineated), a significant amount of ditching was detected during the 1981/2–1992 period. In most cases, it was not possible to determine the magnitude of the effect of such ditching (i.e., if a recently ditched palustrine forested wetland was effectively drained). Onsite investigations are usually required to make a thorough assessment of the scope and effective-

Ditching and channelization projects have destroyed or degraded many wetlands.



12 Source: Tiner, R.W. and J.T. Finn. 1986. *Status and Recent Trends of Wetlands in Five Mid-Atlantic States: Delaware, Maryland, Pennsylvania, Virginia, and West Virginia.* U.S. Fish and Wildlife Service, Northeast Region and U.S. Environmental Protection Agency, Region III. Cooperative technical report. (Available from USFWS, see address on title page.)

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MARK BIDDLE

TOP
Marsh at Prime Hook National Wildlife Refuge.

BOTTOM
Wetland restored from former cropland (2 years old).

ness of drainage. Efforts are now being made to reduce the adverse impacts of agricultural and public drainage projects on wetlands (e.g., minimizing clearing widths and compensation for unavoidable losses of wetlands).

Wetlands are the vital link between land and water resources — a critical resource for all Delawareans. Wetlands help preserve the quality of drinking and recreational waters and protect property from damaging floods, while providing unique habitats for a diverse assemblage of flora and fauna. Delaware may have lost 40–50 percent of its original wetland acreage,[13] making the remaining wetlands even more valuable. We need to work towards preserving wetlands and their functions and, wherever possible, restoring wetlands, streams, and their buffers. These goals require cooperation between government, the business community, and private landowners. By working together to conserve and restore wetlands, Delawareans will continue to enjoy and reap the benefits from the state's wetlands and future residents will receive a priceless inheritance of this watery wealth.

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13 Dahl, T.E. 1990. *Report to Congress: Wetland Losses in the United States 1780s to 1980s.* U.S. Department of Interior, Washington, D.C.

Wetland Resource Guide

ADDITIONAL READINGS

To learn more about wetlands, visit your local community or college library and check out the following:

A Field Guide to Coastal Wetland Plants of the Northeastern United States (1987) by R. Tiner, University of Massachusetts Press, P.O. Box 429, Amherst, MA 01004; 413-545-2219. (guide to coastal marsh plant identification)

Classification of Wetlands and Deepwater Habitats of the United States (1979) by L.M. Cowardin, V. Carter, F.C. Golet, and E.T. LaRoe, U.S. Fish and Wildlife Service, Washington, DC. Posted on web at: *wetlands.fws.gov*. Also available from: U.S. Government Printing Office, Superintendent of Documents, Mail Stop SSOP, Washington, DC 20402-9328; 202-512-0000. (technical wetland classification document FWS/OBS-79/31)

Field Guide to Nontidal Wetland Identification (1988) by R. Tiner, reprinted by the Institute for Wetland & Environmental Education & Research, P.O. Box 288, Leverett, MA 01054; 413-548-8866. (guidebook for identifying wetland plants and hydric soil in Northeast)

Field Indicators of Hydric Soils in the United States (1998) by G.W. Hurt, P.M. Whited, and R.F. Pringle., U.S.D.A. Natural Resources Conservation Service, Wetland Institute, Room 104, Sturgis Hall, Louisiana State University, Baton Rouge, LA 70803; 225-388-1337. (technical guide for identifying hydric soils)

Handbook for Wetlands Conservation and Sustainability (1998) by K. Firehock, L. Graff, J. Middleton, K. Starinchak, and C. Williams, Save Our Streams Program, Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878-2983; 800-BUG-IWLA. (citizen's guide to protecting, restoring, and monitoring wetlands)

In Search of Swampland: A Wetland Sourcebook and Field Guide (1998) by R. Tiner, Rutgers University Press, P.O. Box 5062, New Brunswick, NJ 08903: 732-445-1970. (layperson's guide to wetland ecology and identification of wetland plants, soils, and animals)

Managing Common Reed (Phragmites australis) in Massachusetts (1998) by R. Tiner, U.S. Fish and Wildlife Service, 300 Westgate Center Drive, Hadley, MA 01035; 413-253-8616. (introduction to control techniques)

Our National Wetland Heritage: A Protection Guide (1996) by J. Kusler and T. Opheim, Environmental Law Institute, 1616 P Street NW, Suite 200, Washington, DC 20036; 202-939-3800. (guide to wetland protection strategies for local governments)

Statewide Wetlands Mapping Project—the SWMP (undated) by L.T. Pomatto, Jr., Delaware Department of Natural Resources and Environmental Control, Division of Water Resources, 89 Kings Highway, Dover, DE 19901. (report on state wetland mapping)

Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping (1999) by R. Tiner, Lewis Publishers, CRC Press, 2000 Corporate Boulevard NW, Boca Raton, FL 33231; 561-994-0555. (textbook with indepth review of listed topics)

Wetlands (1994) by W. Niering, National Audubon Society Nature Guide, Alfred A. Knopf, Inc., New York, NY. (introduction to wetlands and field guide to plants and animals; national focus)

Wetlands (2000) by W. Mitsch and J. Gosselink, John Wiley and Sons, Inc., New York, NY 10158-0012; 212-850-6011. (textbook on wetland ecology)

Wetlands: Characteristics and Boundaries (1995) by Committee on Characterization of Wetlands, National Academy Press, 2102 Constitution Avenue NW, Washington, DC 20418; 800-624-6242. (reference book on wetland delineation and related topics)

Wetlands of Delaware (1985) by R. Tiner, Delaware Department of Natural Resources and Environmental Control, Wetlands Section, 89 Kings Highway, Dover, DE 19901; 302-739-4691. (summary of wetlands information for the state)

Wetland Trends in Delaware: 1981/2 to 1992 (1999) by R. Tiner, J. Swords, and S. Schaller, U.S. Fish and Wildlife Service, Ecological Services, Region 5, 300 Westgate Center Drive, Hadley, MA 01035; 413-253-8616. (technical report on state wetland trends)

Winter Guide to Woody Plants of Wetlands and Their Borders: Northeastern United States (1997) by R. Tiner, Institute for Wetland & Environmental Education & Research, P.O. Box 288, Leverett, MA 01054; 413-548-8866. (guide to winter plant identification)

WETLAND CONTACTS

For additional information on wetlands, also contact the following agencies:

Wetland Regulation and Policies

Delaware Department of Natural Resources and Environmental Control
Wetlands and Subaqueous Lands Section
89 Kings Highway, Dover, DE 19901;
302-739-4691, 302-739-5072 (enforcement)
www.dnrec.state.de.us

U.S. Army Corps of Engineers, Dover Office
1203 College Park Drive, Suite 102,
Dover, DE 19904; 302-736-9763

U.S. Environmental Protection Agency
Wetlands and Waterways, Region III
1650 Arch Street, Philadelphia, PA 19103;
800-832-7828 (wetland hotline)
www.epa.gov

U.S. Department of Agriculture
Natural Resources Conservation Service
1203 College Park Drive, Suite 101, Dover,
DE 19904; 302-678-4160
www.nrcs.usda.gov

Wetland Restoration

U.S. Fish and Wildlife Service
Partners for Fish and Wildlife
Chesapeake Bay Field Office
177 Admiral Cochrane Drive,
Annapolis, MD 21401; 410-573-4500

U.S. Fish and Wildlife Service
Delaware Bay Estuary Program
2610 Whitehall Neck Road,
Smyrna, DE 19977; 302-653-9152

Delaware Department of Natural Resources
Watershed Section
89 Kings Highway, Dover, DE 19901;
302-739-4590

Wetland Maps

Delaware Department of Natural Resources and Environmental Control
Wetlands Section
89 Kings Highway, Dover, DE 19901;
302-739-4691
www.dnrec.state.de.us

Gerald A. Donovan Associates, Inc.
429 South Governors Avenue,
Dover, DE 19904; 302-674-2903

U.S Fish and Wildlife Service
National Wetlands Inventory Home Page
http://wetlands.fws.gov
for the wetlands interactive mapper

Wetland Publications and Related Information

Delaware Department of Natural Resources and Environmental Control
Wetlands Section
89 Kings Highway, Dover, DE 19901
302-739-4691 (for *Wetlands of Delaware*)
302-739-4506 (for Delaware Conservationist Magazine)
www.dnrec.state.de.us

U.S. Fish and Wildlife Service
Ecological Services (NWI)
300 Westgate Center Drive,
Hadley, MA 01035; 413-253-8616
http://wetlands.fws.gov or
http://northeast.fws.gov

EPA Wetland Protection Hotline
1-800-832-7828
http://www.epa.gov/OWOW/wetlands/wetline.html

Other Wetland Information and Support Organizations

Delaware Department of Natural Resources and Environmental Control
89 Kings Highway, Dover, DE 19901;
302-739-5297 (Fish and Wildlife)
302-653-2883 (Adopt-a-Wetland Program)

Delaware Estuary Program
1211 Chestnut Street, Suite 900,
Philadelphia, PA 19107; 800-445-4935
www.delep.org

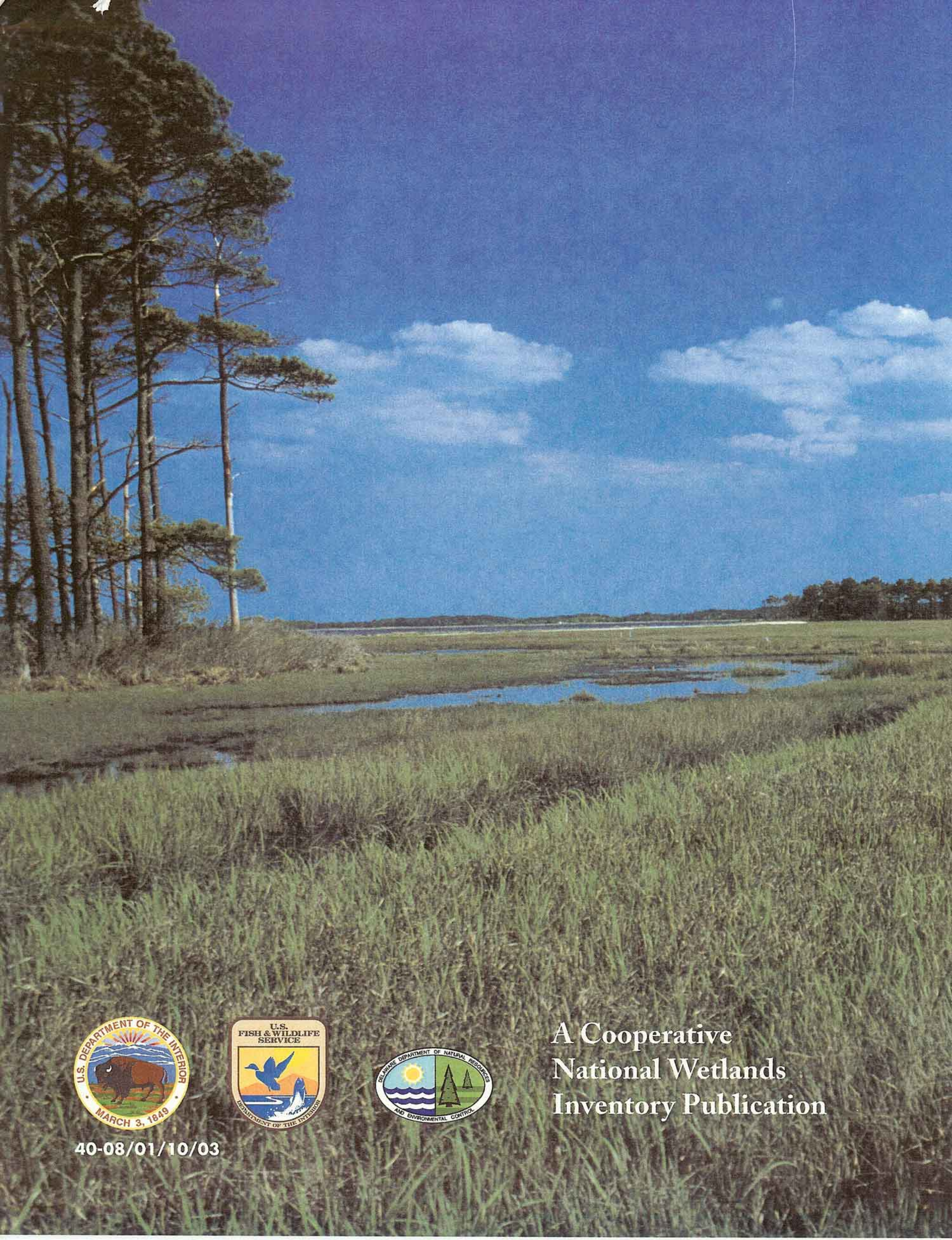
Delaware Cooperative Extension
302-451-2506 (New Castle County)
302-697-4000 (Kent County)
302-856-7303 (Sussex County)

Delaware Nature Society
Ashland Nature Center
P.O. Box 700, Hockessin, DE 19707;
302-239-2334

Abbots Mill Nature Center
RD 4 Box 207, Milford, DE 19963;
302-422-0847

The Nature Conservancy
University Office Plaza, Newark, DE 19771;
302-399-4144

Ducks Unlimited Delaware
State Chairman – Ed Clark
RD 5 Box 21CCC, Seaford, DE 19973;
302-629-8835



A Cooperative National Wetlands Inventory Publication

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