Wetlands of Pennsylvania=s Coastal Zone: Wetland Status, Preliminary Functional Assessment, and Recent Trends (1986-1999)

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Introduction

Since 1985, the U.S. Fish and Wildlife Service has been cooperating with the Pennsylvania Department of Environmental Protection to inventory wetlands in the State=s Coastal Zone and to evaluate wetland changes over time. To date, two reports on the status and trends of wetlands in Pennsylvania=s Coastal Zone have been produced (Tiner and Anderson 1986; Tiner et al. 1987). In 1999, the Pennsylvania Department of Environmental Protection=s Office of Water Management, Coastal Zone Management Program (PACZM) provided funds to the Service for updating wetland inventory and trends information for the Coastal Zone. This report presents the findings of this work.

Study Area

The study area is the Pennsylvania Coastal Zone. This area is divided into two sections: 1) Delaware Estuary Coastal Zone, and 2) Lake Erie Coastal Zone. The former area is associated with the Delaware River which ranges from slightly brackish tidal to tidal fresh to nontidal fresh waters (around Trenton, New Jersey).

The Delaware Estuary Coastal Zone contains approximately 50 square miles in Delaware and Buck Counties and the City of Philadelphia. The following U.S. Geological Survey topographic quads cover the Delaware Estuary Coastal Zone: Marcus Hook, Philadelphia, Beverly, Woodbury, Landsdowne, Bridgeport, Trenton East, Trenton West, Bristol, Camden, and Frankford.

The Lake Erie Coastal Zone contains roughly 63 square miles of land in Erie County. It is located on the following quads: North East, Swanville, Erie North, Erie South, Harborcreek, Fairview, Fairview SW, East Springfield, and Conneaut.

Study Objectives

The purpose of this project was to: 1) updated NWI data for the Pennsylvania Coastal Zone, 2) enhance the NWI data by adding hydrogeomorphic-type attributes for landscape position, landform, and water flow path, 3) use the improved NWI database to produce a preliminary assessment of wetland functions for the study area, and 4) conduct a wetland trends analysis for the Pennsylvania Coastal Zone.

Methods

Updating the Wetlands Inventory

This work involved photointerpretion of 1999 - 1:24,000 color infrared (CIR) photography to identify the current status of wetlands within Pennsylvania's Coastal Zone (both Lake Erie and Delaware Estuary units). Using this photography, a set of photo overlays were prepared delineating wetlands one acre and larger and classified according to the Service's official wetland classification system (Cowardin et al. 1979).

An initial field trip to each study area was conducted on November 22 and 23, 1999 for the Lake Erie area and on December 9 and 10, 1999 for the Delaware Estuary. After photointerpretation was completed, a series of 1:24,000 map overlays were compiled through the use of zoom transfer scope to match applicable U.S. Geological Survey topographic maps. The draft maps were reviewed in the field by PACZM personnel and revised accordingly. Final NWI maps were digitized to create a wetland digital database for the Pennsylvania Coastal Zone. Acreage summaries of wetlands were generated from the database.

Enhanced Wetland Classification

Using the updated NWI digital database, wetlands were separated from permanent waterbodies (deepwater habitats - lakes and reservoirs; shallow waters - ponds) since the functional analysis focuses on wetlands. Ponds were separated from other wetlands, so that additional modifiers could be added to better describe their characteristics.

Three main descriptors (landscape position, landform, and water flow path) were applied to each wetland by interpreting map information and consulting aerial photos where necessary. "Keys to Waterbody Type and Hydrogeomorphic-type Wetland Descriptors for U.S. Waters and Wetlands (Operational Draft)" (Tiner 2000) was used to classify these features. Additional modifiers were added, where appropriate, to depict features such as headwater, drainage-divide, and human-impacted wetlands.

Landscape position defines the relationship between a wetland and an adjacent waterbody if present. For the subject area, four landscape positions were possible: 1) lotic (along rivers and streams and on their active floodplains), 2) lentic (along lakes and reservoirs), 3) terrene (mainly isolated or outflow wetlands), and 4) estuarine (along estuaries; for Delaware Estuary Coastal Zone only). Lotic wetlands may be further subdivided by river/stream gradients as high (e.g., shallow mountain streams on steep slopes), middle (e.g., streams on moderate slopes), low (e.g., mainstem rivers with considerable floodplain development or streams in flat sections in higher terrain), and intermittent (i.e., not flowing year-round; this gradient is a recent addition to the classification system). Watercourses mapped as linear (one-line) features on NWI maps and on a U.S. Geological Survey topographic map were designated as streams, whereas two-lined channels (polygonal features) were classified as rivers. Lentic wetlands were divided into two categories: natural and dammed, with the latter type being further subdivided to separate wetlands associated with reservoirs from those along water-level controlled lakes, when possible.

Landform is the physical form or shape of a wetland. Seven types were recognized in the study area: 1) basin, 2) flat, 3) slope, 4) floodplain, 5) island, 6) fringe, and 7) interfluve (see Table 1 for definitions). Note that basin and flat may also be applied as sub-landforms to the floodplain and interfluve landforms.

Water flow path descriptors describe the flow of water associated with wetlands. Six types of flow were applied to wetlands in the study area: 1) throughflow, 2) outflow, 3) inflow, 4) bidirectional flow, 5) bidirectional flow-tidal, and 6) isolated. For this project, surface water connections are emphasized, since: 1) it is not possible to determine ground water linkages (especially outflow) without hydrologic investigations and 2) the study relied on photointerpretation and existing digital data to produce the classifications. Throughflow wetlands have either a watercourse (e.g., stream) or another type of wetland above and below it, so water passes through them (usually by way of a river or stream, but sometimes by ditches). Nearly all lotic wetlands are throughflow, except for isolated wetlands on the floodplain (lotic floodplain isolated) and others with an outflow stream (lotic floodplain outflow). Lakeshore (lentic) wetlands crossed by streams were also designated as throughflow wetlands. Outflow wetlands have water leaving them, moving downstream via a watercourse or a slope wetland. Inflow wetlands are sinks where no surface water outlet exists, yet water is entering via an intermittent stream or an upslope wetland. Bidirectional flow wetlands are lentic wetlands where fluctuating lake or reservoir levels appear to be the primary surface water source for raising and lowering water levels (including water tables). Note that shallow water wetlands along Lake Erie were designated as throughflow wetlands, since they do not appear to be exposed on a frequent basis and represent the littoral zone of the lake. If, however, they are periodically exposed, then their water flow path might be better classified as bidirectional. Isolated wetlands are essentially closed depressions where water comes from surface water runoff and/or groundwater discharge.

Table 1. Definitions and examples of landform types (Tiner 2000).

Landform Type	**General Definition**	**Examples**
Basin*	a depressional (concave) landform	lakefill bogs; wetlands in the saddle between two hills; wetlands in closed or open depressions, including narrow stream valleys
Slope	a landform extending uphill (on a slope; typically crossing two or more contours on a 1:24,000 map)	seepage wetlands on hillside; wetlands along drainageways or mountain streams on slopes
Flat*	a relatively level landform, often on broad level landscapes	wetlands on flat areas with high seasonal ground-water levels; wetlands on terraces along rivers/streams; wetlands on hillside benches; wetlands at toes of slopes
Floodplain	a broad, generally flat landform occurring on a landscape shaped by fluvial or riverine processes	wetlands on alluvium; bottomland swamps
Fringe	a landform occurring along a flowing or standing waterbody (lake, river, stream) and typically subject to permanent, semipermanent flooding or frequent tidal flooding; including wetlands within stream or river channels and estuarine wetlands with unrestricted tidal flow	buttonbush swamps; aquatic beds; semipermanently flooded marshes; salt and brackish marshes; river and stream gravel bars/banks
Interfluve	a broad, level to imperceptibly depressional, landform occurring between two drainage systems, typically associated with coastal and glaciolacustrine plains	flatwood wetlands on coastal or glaciolacustrine plains
Island	a landform completely surrounded by water (including deltas)	deltaic and insular wetlands; floating bog islands

*May be applied as sub-landforms within the Floodplain and Interfluve landforms.

Preliminary Assessment of Wetland Functions

Using the new wetland database, a preliminary assessment of wetland functions was performed for the Pennsylvania Coastal Zone. This analysis highlighted wetlands that are likely to perform certain functions at significant levels, such as surface water detention, sediment retention, nutrient cycling, streamflow maintenance, shoreline stabilization, fish habitat, waterfowl and waterbird habitat, and other wildlife habitat (see discussion of rationale below). Statistics for the study watersheds were generated by ARC/INFO software. The location of wetlands of significance for different functions can be accessed from the digital database provided to PACZM.

General Scope and Limitations of Preliminary Functional Assessment

At the outset, it is important to emphasize that the functional assessment presented in this report is preliminary. Wetlands having potential to perform each of eight functions at significant levels were highlighted based on characteristics interpreted through remote sensing along with general information available from the scientific literature, the best professional judgment of the senior author and other wetland specialists. Since the focus of this report is on wetlands, an assessment of waterbodies (e.g., estuarine waters, lakes, rivers, and streams) at providing the listed functions was not done, despite their rather obvious significant performance of functions like fish habitat and surface water detention. Also, no attempt was made to produce a more qualitative ranking for each function or to rank wetlands based on multiple functions as this would require more input from others and more data, well beyond the scope of this study. For a technical review of wetland functions, see Mitsch and Gosselink (1993), and for a broad overview, see Tiner (1998).

Functional assessment of wetlands can involve many parameters. Typically such assessments have been done in the field on a case-by-case basis by comparing features of the “assessment site” to those required to perform certain functions (e.g., by actual measurement of performance or comparison with those of a “reference site”). The present study does not seek to replace the need for such assessments as they are the most thorough means of assessing functions for individual wetlands. Yet, for a large geographic area, field-based assessments are not practical or cost-effective or even possible given access considerations. For area-wide planning purposes, a more generalized assessment is worthwhile for targeting wetlands that may provide certain functions, especially for those functions dependent on landscape position and vegetation lifeform. Subsequently, these results can be field verified when it comes to actually evaluating particular wetlands for acquisition or other purposes.

This study employs a watershed assessment approach called "Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF). W-PAWF applies general knowledge about wetlands and their functions to produce a preliminary assessment that highlights possible wetlands of significance based on their predicted performance of various functions for watersheds and other large geographic areas. To accomplish this objective, the relationships between wetland characteristics and various functions must be simplified into a set of practical criteria. Such assessments could also be further expanded to consider the condition of the associated waterbody and the neighboring upland or to evaluate the opportunity a wetland has to perform a particular function or service to society, for example.

W-PAWF does not account for the opportunity that a wetland has to provide a function resulting from a certain land-use practice upstream or the presence of certain structures or land-uses downstream. For example, consider two wetlands of similar size, vegetation, and landscape position. One may be downstream of a land-clearing operation that has generated considerable suspended sediments in the water column, while the other is downstream from an undisturbed forested subbasin. The former should be actively performing sediment trapping, while the latter is not. Yet if land-use conditions in the latter subwatershed area change, the second wetland will likely trap sediments as well as the first wetland. The entire analysis tends to ignore opportunity since such opportunity may present itself sooner or later and the wetland is there to perform this service at higher levels than presently. Moreover, opportunity is difficult to predict.

W-PAWF also does not consider the condition of the adjacent upland (e.g., level of disturbance) or the actual water quality of the associated waterbody which may be regarded as important metrics for assessing the "health" of individual wetlands. Collection and analysis of these data were beyond the scope of the study, but could be incorporated at a later date by PACZM from available digital data and supplemented with aerial photointerpretation as needed.

We further emphasize that the preliminary assessment does not obviate the need for more detailed assessments of the various functions. This assessment should be viewed as a starting point for more rigorous assessments, as it attempts to cull out wetlands that may likely provide significant levels of performance for certain functions based on generally accepted principles and the source information used for this analysis. This type of assessment is most useful for regional, watershed, or area-wide planning purposes. For site-specific evaluations, additional work will be required, especially field verification, collection of site-specific data for potential functions (e.g., following Brinson's hydrogeomorphic assessment approach and other onsite evaluation procedures), and comparison with reference wetlands (Brinson 1993). Many sources of data may exist to help refine the findings of this report. Additional modeling could be done, for example, to identify habitats of likely significance to individual species of animals (based on their specific life history requirements). We see these analyses as the next phase in an analysis of wetland functions where a more indepth analysis of specific functions for individual wetlands is warranted.

We also recognize limitations derived from source data. These limitations include conservative interpretations of forested wetlands (especially evergreen types) and drier-end wetlands (e.g., wet meadows, especially those used as pastures; see Tiner 1997b for additional discussion) and the omission of small or narrow wetlands. Despite these limitations, the NWI dataset represents the most extensive database on the distribution, extent, and type of wetlands in Pennsylvania's Coastal Zone.

Rationale for Preliminary Functional Assessment

Eight functions were evaluated: 1) surface water detention, 2) streamflow maintenance, 3) nutrient transformation, 4) sediment retention, 5) shoreline stabilization, 6) fish habitat, 7) waterfowl and waterbird habitat, and 8) other wildlife habitat. The criteria used for identifying these functions from the digital wetland database are discussed below.

In developing a protocol for designating wetlands of potential significance, wetland size was generally disregarded from the criteria, with the exception of the "other wildlife habitat" function. This approach was followed because it was felt that PACZM personnel using the digital database should determine appropriate size criteria as a means of limiting the number of priority wetlands, if necessary.

Surface Water Detention

This function is important to reducing downstream flooding and lowering flood heights, both of which aid in reducing property damage from such events. In a landmark report on the relationships between wetlands and flooding at the watershed scale, Novitzki (1979) reported that watersheds with 40 percent coverage by lakes and wetlands had significantly reduced flood flows (i.e., lowered by as much as 80%) compared to similar watersheds with no or few lakes and wetlands in Wisconsin. Floodplain and other lotic wetlands (basin and flat types) provide this function at significant levels. Wetlands dominated by trees and/or dense stands of shrubs (with higher frictional resistance) could be deemed to provide a higher level of this function as such vegetation may further aid in flood desynchronization versus similar wetlands with emergent cover. Trees and dense shrubs produce high roughness which helps dissipate energy and lower velocity of flood waters. Yet, this parameter was not applied to the data set as emergent wetlands along waterways are also likely to provide significant flood water storage. Floodplain width could also be an important factor in evaluating the significance of performance of this function by individual wetlands (e.g., for acquisition or strengthened protection). There is no quantitative information to establish a significance threshold for size so floodplain width was not used as a selection factor in this study.

Wetlands in lake basins provide significant surface water storage during high water periods. Lentic wetlands were therefore designated as significant for surface water detention. Terrene basins and ponds should store surface water in localized areas, with throughflow ponds receiving waters from a larger drainage areas than other ponds.

The following wetland types were identified as having potential significance for surface water detention:

High - Estuarine Fringe, Lentic Basin, Lentic Fringe, Lotic Basin, Lotic Floodplain, Lotic
Fringe, Lotic Island basin, Ponds Throughflow (in-stream) and associated Fringe and Basin wetlands, Ponds Bidirectional and Bidirectional Tidal and associated wetlands, and Terrene Throughflow Basin

Moderate - Lotic Flat, Lotic Island Flat, Other Terrene Basins, and Other Ponds and associated wetlands

Streamflow Maintenance

Many wetlands are sources of groundwater discharge and some may be in a position to sustain or seasonally contribute to streamflow in the watershed. Such wetlands are critically important for supporting aquatic life in streams. Wetlands located in the upper reaches of each watershed (i.e., headwater wetlands = along first order streams) are important sources of groundwater discharge. Many of these wetlands are the actual sources of perennial streams. Since lakes and many ponds are also important providers of streamflow, lentic basin and fringe wetlands and throughflow ponds were also considered important for streamflow maintenance, with the natural ones being rated higher than created ones. Floodplain wetlands are known to store water and release water to streams over time. Consequently, they were identified as moderately significant for streamflow maintenance. Outflow wetlands directly discharging into Delaware River or major rivers were not considered significant, since their contribution to streamflow of these rivers is probably minimal.

The following types were identified as wetlands with predicted significant potential for streamflow maintenance:

High - Headwater Wetlands (Terrene, Lotic, and Lentic), and Headwater Ponds and Lakes (classified as PUB...on NWI)
Moderate - Lotic (Nontidal) Floodplain wetlands, Other Throughflow Ponds and Lakes (classified as PUB on NWI) and their associated wetlands, Terrene Outflow wetlands, Outflow Ponds and Lakes (classified as PUB... on NWI), and
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Throughflow Ponds and Lakes (classified as PUB...on NWI)

Nutrient Transformation

Vegetated wetlands recycle nutrients, but those having a fluctuating water table are best able to recycle nitrogen and other nutrients. Vegetation slows the flow of water which causes deposition of mineral and organic particles and nutrients (nitrogen and phosphorus) bound to them, whereas hydric soils are the places where chemical transformations occur (Carter 1996). Microbial action in the soil is the driving force behind chemical transformations in wetlands. Microbes need a food source -- organic matter -- to survive, so wetlands with high amounts of organic matter should have an abundance of microflora to perform the nutrient cycling function. Wetlands are so effective at filtering and transforming nutrients that artificial wetlands are constructed for water quality renovation (Hammer 1992). Natural wetlands performing this function help improve local water quality of streams and other watercourses.

Simmons et al. (1992) found greater than 80 percent nitrate removal from groundwater during both the growing season and dormant season in Rhode Island streamside (lotic) wetlands. Groundwater temperatures throughout the dormant season were between 6.5 and 8.0 degrees C, so microbial activity was not limited by temperature. Even the nearby upland, especially transitional areas with somewhat poorly drained soils, experienced an increase in nitrogen removal during the dormant season. This was attributed to a seasonal rise in the water table that exposed the upper portion of the groundwater to more organic matter (nearer the ground surface), thereby supporting microbial activity and denitrification. Riparian forests dominated by wetlands have a greater proportion of groundwater moving within the biologically active zone of the soil that makes nitrate susceptible to uptake by plants and microbes (Nelson et al. 1995). Riparian forests on well-drained soils are much less effective at removing nitrate. In a Rhode Island study, Nelson et al. (1995) found that November had the highest nitrate removal rate due to the highest water tables in the poorly drained soils, while June experienced the lowest removal rate when the deepest water table levels occurred.

From the water quality standpoint, wetlands associated with watercourses are probably the most noteworthy. Numerous studies have found that forested wetlands along rivers and streams are important for nutrient retention and sedimentation during floods (Whigham et al. 1988; Yarbro et al. 1984; Simpson et al. 1983; Peterjohn and Correll 1982). Consequently, lotic wetlands that are seasonally flooded or wetter (e.g., semipermanently flooded) should be performing this function at significant levels. Wetlands along lakes (lentic wetlands) with similar water regimes and vegetated tidal wetlands should also perform this function well. These types of vegetated wetlands tend to have a build-up of organic matter at the surface that provides for increased microbial populations responsible for denitrification and nutrient cycling. Terrene basin and slope wetlands with throughflow may also be significant nutrient recyclers due to high contact with low order streams that may be carrying nutrient loads from various sources in the watershed. Terrene outflow basin and slope wetlands may be important recyclers locally. Wetlands with a saturated water regime were not considered significant for nutrient transformation, since these wetlands have only seasonally high water tables and typically lack high organic matter content in the upper soil layer. These wetlands should receive study to determine their nutrient transformation potential.

The following wetland types were identified as having potential significance for nutrient transformation:

High - Vegetated wetlands with seasonally flooded and wetter (C, E, F, and H) water regimes, Mixed unconsolidated bottom-vegetated wetlands with C, E, F, and H water regimes (this includes Lotic, Terrene, and Lentic wetlands - mostly floodplain, basin, interfluve-basin, and fringe types), Vegetated tidal wetlands (and mixes with nonvegetated classes) with N, P, R, and T water regimes

Moderate - Vegetated wetlands with temporarily flooded (A) water regime, Lotic tidal vegetated wetlands with temporarily flooded-tidal (S) water regime.

Retention of Sediments

Many wetlands form in areas of sediment deposition. The sediment retention function improves water quality by capturing sediments with bonded nutrients or contaminants. Estuarine fringe and island wetlands; lotic and lentic basin, island, and fringe wetlands; terrene throughflow basin wetlands; and throughflow ponds are likely to trap and retain sediments at significant levels. Flat wetlands along rivers and streams, other basin wetlands, and other ponds (palustrine unconsolidated bottoms), and lotic tidal fringe (nonvegetated) may also perform this function at moderate levels (e.g., less frequently or for local areas).

Wetlands identified as having potential significance for sediment retention were the following:

High - Estuarine Fringe and Island, Lentic Basin, Lentic Fringe (vegetated only), Lentic Island (vegetated), Lotic Basin, Lotic Floodplain, Lotic Fringe (vegetated only), Lotic Island, Throughflow Pond (in-stream) and associated vegetated wetlands, Bidirectional and Bidirectional Tidal Ponds and associated wetlands, and Terrene Throughflow Basin

Moderate - Lotic Flat, Lotic Tidal Fringe (nonvegetated), Other Terrene Basin, Terrene wetlands associated with ponds (Fringe-pond, Basin-pond, and Flat-pond), and Other Ponds and associated wetlands (excluding slope wetlands)

Shoreline Stabilization

Vegetated wetlands located along shorelines of rivers, streams, and lakes, help prevent upland erosion and stabilize shorelines. Water level fluctuations may be due to natural events or artificial manipulation. The former changes occur during snowmelt, spring runoff, and after heavy rainfalls, while the latter changes may be induced by reservoir management or by hydroelectric dam management. Shorelines along large lakes are often exposed to long wind-driven fetches that can cause significant shoreline erosion. Vegetated wetlands along these waterbodies help stabilize the shoreline.

For this analysis, estuarine, lotic, and lentic vegetated wetlands forming the shores of these waterbodies were predicted as having high potential for this function. The following wetland types were identified as having potential significance for shoreline stabilization:

High - Estuarine Fringe (vegetated only), Lentic wetlands (vegetated, except island types), Lotic wetlands (vegetated, except island and isolated types)

Moderate - Terrene wetlands (vegetated) associated with pond shores

Provision of Fish Habitat

The assessment of potential habitat for fish is based on general relationships between fish and wetlands that could be refined for particular fish species of interest at a later date by PACZM. Nearly all fish require permanent water, yet many also require and utilize seasonally flooded and semipermanently flooded wetlands for breeding and nursery grounds when in a flooded condition. Tidal wetlands are important spawning and nursery grounds for many species of coastal fishes. Please note that this asssessment of fish habitat is focused on wetlands, not deepwater habitats, hence the exclusion of the latter from this analysis despite their obvious importance to fish.

For nontidal wetlands, the assessment emphasized semipermanently flooded wetlands over seasonally flooded types due to the longer duration of surface water. To benefit fish, these wetlands should be associated with a permanent waterbody such as a lake, pond, or perennial river or stream.

Forested wetlands along streams provide canopy coverage over the water thereby lowering stream temperatures and moderating daily fluctuations. These types of lotic stream wetlands and lentic throughflow wetlands were identified as being significant for fish habitat, although they themselves do not provide such habitat. It important to further recognize that riparian upland trees yield similar benefits.

Also depending on stream width and shrub height and canopy coverage, scrub-shrub wetlands and shrub uplands may provide similar benefits for moderating stream temperatures. They were not identified as significant for stream shading due to the variability of these parameters. Further investigation by PACZM or state fisheries biologists may aid in assessing this condition on a case-by-case basis or across the Coastal Zone.

Although not highlighted for this function, all wetlands that are significant for the streamflow maintenance function should be considered vital to sustaining a watershed's ability to provide instream fish habitat. While these wetlands may not be providing significant fish habitat themselves, they support base flows essential to keeping water in streams for aquatic life. They can be seen on the streamflow maintenance thematic map.

The following wetland types were identified as having potential significance for providing fish habitat:

High - Estuarine Wetlands, Lacustrine Semipermanently Flooded (excluding Phragmites PEM5F and wetlands along intermittent streams), Lacustrine Littoral Aquatic Bed, Lacustrine Littoral Unconsolidated Bottom/vegetated wetland, Lacustrine Littoral vegetated wetland with a Permanently Flooded water regime, Palustrine Semipermanently Flooded (excluding Phragmites PEM5F and wetlands along intermittent streams; must be associated with a *permanent* waterbody such as PUBH, L1UBH, or R2/R3UBH), Palustrine Aquatic Bed, Palustrine Unconsolidated Bottom/vegetated wetland, Palustrine vegetated wetland with a Permanently Flooded water regime Palustrine Emergent wetlands with N, R, or T water regimes (excluding where EM5 is only dominant), Ponds (PUBH.. on NWI; not PUBF) associated with Semipermanently Flooded vegetated wetlands, Riverine Tidal Emergent, Riverine Unconsolidated Shore wetlands (excluding those with an S water regime)

Moderate - Lentic wetlands that are PEM1E, Lotic River or Stream wetlands that are PEM1E (including mixtures with Scrub-Shrub or Forested wetlands), Semipermanently flooded Phragmites wetlands (PEM5F) where associated with a permanent waterbody, Other Ponds and associated Fringe wetlands (i.e., Terrene Fringe-pond)

Important for Stream Shading - Lotic Stream wetlands that are Palustrine Forested wetlands (includes mixes where forested wetland predominates; excluding those along intermittent streams)

Provision of Waterfowl and Waterbird Habitat

Waterfowl and waterbirds use certain wetland types for nesting, brood rearing, and feeding. For these wetland-dependent birds, the wetter wetlands are generally preferred. Consequently, wetlands along the edges of open water may be most desirable, including aquatic beds, semipermanently flooded wetlands, impounded or beaver-modified vegetated wetlands, ponds, and estuarine wetlands. Wetlands with a high interspersion of vegetation and open water are particularly significant. Seasonally flooded emergent wetlands forming the shores of lakes, rivers, and streams were deemed as wetlands with moderate potential for spring-summer use by waterfowl and some waterbirds.

The following wetland types were identified as having potential significance for providing waterfowl and waterbird habitat:

High - Estuarine wetlands, Lacustrine Semipermanently Flooded, Lacustrine Littoral Aquatic Bed, Lacustrine Littoral vegetated wetlands with an H water regime, Lacustrine Unconsolidated Shores (F, E, or C water regimes; mudflats), Palustrine Semipermanently Flooded (excluding PEM5F, but including mixtures containing EM5), Palustrine Aquatic Bed, Palustrine vegetated wetlands with an permanently flooded (H) water regime, Palustrine Unconsolidated Shores (F or drier; mudflats), Seasonally Flooded/Saturated Palustrine wetlands impounded or beaver-influenced (all vegetation types [except PEM5Eh and PEM5Eb] and associated PUB waters, Palustrine Unconsolidated Shores (F, E, and C water regimes; mudflats), Lotic River or Stream wetlands that are PEM1E (including mixtures with Scrub-Shrub or Forested wetlands; excluding PEM5E), Ponds associated with Semipermanently Flooded vegetated wetlands, Palustrine Tidal Emergent wetlands (PEM1R and PEM1T and mixes with other EM and with SS and FO; excluding wetlands where EM5 is the only EM), Riverine Tidal Emergent wetlands, and Riverine Tidal Unconsolidated Shores (except with S water regime)

Moderate - Phragmites wetlands that are Seasonally Flooded/Saturated and wetter (PEM5E; PEM5F; PEM5H, and PEM5R) *and* associated with a waterbody, Other Lacustrine Littoral Unconsolidated Bottom, and Other Palustrine Unconsolidated Bottom

Provision of Other Wildlife Habitat

The provision of other wildlife habitat by wetlands was evaluated in general terms. Species-specific habitat requirements were not considered. In developing an evaluation method for wildlife habitat in the glaciated Northeast, Golet (1972) designated several types as outstanding wildlife wetlands including: 1) wetlands with rare, restricted, endemic, or relict flora and/or fauna, 2) wetlands with unusually high visual quality and infrequent occurrence, 3) wetlands with flora and fauna at the limits of their range, 4) wetlands with several seral stages of hydrarch succession (habitat diversity), and 5) wetlands used by great numbers of migratory waterfowl, shorebirds, marsh birds, and wading birds. Golet subscribed to the principle that in general, as wetland size increases so does wildlife value, so wetland size was important factor for determining wildlife habitat potential in his approach. Other important variables included dominant wetland class, site type (bottomland v. upland; associated with waterbody v. isolated), surrounding habitat type (e.g., natural vegetation v. developed land), degree of interspersion (water v. vegetation), wetland juxtaposition (proximity to other wetlands), and water chemistry.

Emphasis for assessing "other wildlife" was placed on conditions that would likely provide significant habitat for other vertebrate wildlife (mainly herps, interior forest birds, and mammals). Opportunistic species that are highly adaptable to fragmented landscapes were not among the target organisms, since there seems to be more than ample habitat for these species now and in the future. Rather, animals whose populations may decline as wetland habitats become fragmented by development are of more concern. For example, breeding success of neotropical migrant birds in fragmented forests of Illinois was extremely low due to high predation rates and brood parasitism by brown-headed cowbirds (Robinson 1990). Newmark (1991) reported local extinctions of forest interior birds in Tanzania due to fragmentation of tropical forests. Fragmentation of wetlands is an important issue for wildlife managers to address. Some useful references on fragmentation relative to forest birds are Askins et al. (1987), Robbins et al. (1989), Freemark and Merriam (1986), and Freemark and Collins (1992).

Vernal pools are typically isolated seasonal ponds within a large forest tract. Such pools are vital amphibian breeding areas for species like spotted salamanders, wood frogs, spring peepers, and gray tree frogs and some of these animals only reproduce in such places. The adults spend their lives in the neighboring forests as burrowing animals (i.e., mole salamanders) or as tree frogs. Natural isolated and outflow ponds surrounded by woodlands may represent such sites as well as forested areas with a large collection of depressional wetlands (basins).

Given the broad nature of this assessment of "other wildlife habitat", the PACZM may want to refine this assessment in the future by having biologists designate "target species" that may be used to identify important wildlife habitats in the Coastal Zone. After doing this, they should identify criteria that may be used to identify potentially significant habitat for these species.

The following wetland types were identified as having potential significance for providing other wildlife habitat:

High - Large vegetated wetlands ($\geq$20 acres, excluding open water and nonvegetated areas), Small diverse wetlands (10-20 acres with 2 or more covertypes; excluding EM5 as one of the covertypes), Areas with large numbers of small isolated etlands (within an Upland Forest matrix), and Interconnected Wetlands (with corridor vegetation mostly intact)

Moderate - Other vegetated wetlands (including Phragmites wetlands)

Wetland Trends Analysis

Upon completion of the basic wetland inventory (1999 status), the Service performed a wetland trends analysis for the subject area. This was accomplished by comparing 1999 aerial photographs with 1986 - 1:36,000 CIR photos to determine changes in wetlands during the 12-year period. Wetland losses and gains will be identified and classified by the cause and nature of the change. A wetland change overlay (1:24,000) for each map area was prepared and digitized. These overlays were forwarded to the PACZM for their use. The results of the wetland trends analysis are summarized in this report.

Results

Delaware Estuary Coastal Zone

Wetland Characterization

Wetlands were classified according to the U.S. Fish and Wildlife Service's official wetland classification system (Cowardin et al. 1979) and by landscape position, landform, and water flow path descriptors following Tiner (2000).

Wetlands by NWI Type

In 1999, the Delaware Estuary Coastal Zone possessed over 3,000 acres of wetlands (Table 1). About 49 percent of the wetlands were vegetated, with the remaining 51 percent being nonvegetated shallow water areas or tidal flats. Some of the latter may include tidal marsh dominated by wild rice (Zizania aquatica), an annual plant that is not visible on early spring photography, thereby resembling a mudflat. Approximately 1,464 acres of tidal wetlands were inventoried. They represented 47 percent of the wetlands. Seventy-one percent of these wetlands were riverine types (mostly nonvegetated), with the remainder being mostly palustrine vegetated types.

Overall, 64 percent of the wetlands fell within the palustrine system (e.g., freshwater marshes, swamps, and ponds), whereas 34 percent were riverine wetlands (mostly tidal flats) and lacustrine and estuarine wetlands each represented only 1 percent. Palustrine emergent wetlands were the predominant vegetated wetland type, occupying about 853 acres (excluding mixed types). Forested wetlands were next in abundance, totaling about 227 acres (excluding mixed types). Riverine tidal flats (unconsolidated shores) and ponds (palustrine unconsolidated bottoms) were the predominant nonvegetated wetland types, accounting for 863 acres and 619 acres, respectively.

From a hydrology standpoint, 53 percent of the wetlands was nontidal and 47 percent tidal (Table 2). Of the nontidal wetlands, 35 percent was permanently flooded, 33 percent seasonally flooded (including seasonally flooded/saturated), and 25 percent temporarily flooded. For the tidal wetlands, 71 percent was regularly flooded, while 15 percent was seasonally flooded-tidal and 13 percent temporarily flooded-tidal.

About 43 percent (1,332.9 acres) of the wetlands in the Delaware Estuary Coastal Zone have been altered or created by excavation, diking/impounding, and ditching (Table 3). Of these activities, excavation has had the greatest effect. Many of the wetlands affected by excavation may have been created by such action as about 600 acres were associated with ponds. Impoundment was the second-ranked disturbance factor with 224 acres affected. Of this total, four acres were also excavated and 19 acres of wetlands constructed on artificial substrates within impoundments (i.e., dredge material disposal areas). Only 34 acres of wetlands were partly drained by ditching. Many other wetlands were affected by adjacent land uses, as common reed (Phragmites australis), an opportunistic invasive species that colonizes disturbed sites, was found in 837 acres of palustrine emergent and mixed emergent wetland types or 54 percent of the vegetated wetlands in this Coastal Zone.

Wetlands by Hydrogeomorphic-Type

When classifying wetlands by hydrogeomorphic-type, vegetated wetlands and exposed nonvegetated types are emphasized, with ponds being considered waterbody type. From the landscape position standpoint, most of the wetland acreage in the Delaware Estuary Coastal Zone were associated with rivers and streams (lotic), while terrene wetlands had the highest number (339 vs. 315 for lotic wetlands) (Table 4). Most of the wetlands associated with lakes and reservoirs (lentic wetlands) were along dammed/impounded waterbodies. From the landform perspective, fringe wetlands represented the most acreage and were second-ranked in number, whereas basin wetlands were most numerous and second-ranked in acreage (excluding ponds) (Table 5). Bidirectional flow wetlands occupied the greatest wetland acreage in this area, largely due to tidal influence of the Delaware River (Table 6). A total of 269 wetlands occupying 521 acres were classified as isolated (i.e., geographically isolated – surrounded by upland).

Pond Types

Several types of ponds were classified during this inventory (Table 7). A total of 428 ponds were mapped. Only 21 “natural” ponds were identified, amounting to 10 acres. They were ponds that appeared to be naturally-formed and relatively unaltered by people. In contrast, altered ponds (including excavated or impounded waterbodies created for various purposes) predominated. Nearly 400 excavated ponds were identified in the Delaware Estuary Coastal Zone, accounting for almost 600 acres. Only 16 ponds were classified as diked/impounded.

Table 1. Wetland status for the Delaware Estuary Coastal Zone of Pennsylvania - 1999.

Wetland Type	**Acreage**
Estuarine Wetlands	
Nonvegetated	
Unconsolidated Shore	37.6
Subtotal	37.6
Total Estuarine	*37.6*
Palustrine Wetlands	
Vegetated	
Aquatic Bed	1.9
Emergent (tidal)	246.2
Emergent (nontidal)	607.0
Emergent/Shrub and Shrub/Emergent	155.2 (67.4=tidal)
Emergent/Forested and Forested/Emergent	41.5 (22.1=tidal)
Emergent/Unconsolidated Bottom	8.4
Scrub-Shrub	14.5 (1.2=tidal)
Shrub/Forested and Forested/Shrub	63.8 (18.7=tidal)
Forested	227.4 (23.7=tidal)
Subtotal	1,365.9
Nonvegetated	
Unconsolidated Bottom	618.6 (6.0=tidal)
Unconsolidated Shore	22.2
Subtotal	640.8
Total Palustrine	*2,006.7*
Lacustrine Wetlands	
Nonvegetated	
Unconsolidated Bottom	9.0
Unconsolidated Shore	26.3
Subtotal	35.3
Total Lacustrine	*35.3*
Riverine Wetlands	
Vegetated	
Emergent (tidal)	177.9
Subtotal	177.9
Nonvegetated	
Unconsolidated Shore (tidal)	863.0
Unconsolidated Shore (nontidal)	9.1
Subtotal	872.1
Total Riverine	1,050.0
GRAND TOTAL (all wetlands)	3,129.6

Table 2. Wetland acreage in the Delaware Estuary Coastal Zone by water regime.

Water Regime	Acreage
Nontidal Water Regimes	
Temporarily Flooded	413.6
Saturated	13.5
Seasonally Flooded	235.9
Seasonally Flooded/Saturated	312.3
Semipermanently Flooded	58.8
Permanently Flooded	578.2
Artificially Flooded	51.5
Subtotal Nontidal	1,663.8
Tidal Water Regimes	
Regularly Flooded	1,046.4
Seasonally Flooded-Tidal	217.7
Temporarily Flooded-Tidal	183.5
Semipermanently Flooded-Tidal	12.8
Permanently Flooded-Tidal	5.5
Subtotal Tidal	1,465.9

Table 3. Altered wetlands (including ponds) in the Delaware Estuary Coastal Zone.

Alteration	Acreage
Partly Drained	33.9
Diked/Impounded	201.2
Diked/Impounded + Excavated	3.7
Diked/Impounded + Artificial Substrate	19.1
Excavated	1,075.0
Total	1,332.9

Table 4. Wetlands of the Delaware Estuary Coastal Zone classified by landscape position, landform, and water flow path (excluding ponds).

Wetland Type (Landscape Position, Landform Water, Flow Path)	**Number of Wetlands**	**Acreage**
Estuarine Fringe Bidirectional Tidal	3	37.6
Lentic Dammed/Impounded		
Basin Bidirectional	1	1.0
Basin Throughflow	27	113.1
Basin (former floodplain) Bidirectional	10	29.1
Basin (former floodplain) Throughflow	1	3.2
Flat Throughflow	2	2.3
Flat (former floodplain) Bidirectional	3	10.5
Fringe Bidirectional	11	25.5
Fringe Throughflow	1	0.5
Island Bidirectional	2	1.5
Subtotal	58	186.7
Lentic Other Artificial		
Basin Bidirectional	2	1.7
Basin Isolated	1	3.1
Basin Throughflow	2	3.6
Flat Bidirectional	1	4.0
Fringe Bidirectional	5	12.7
Island Bidirectional	1	0.8
Subtotal	12	25.9
Lotic River Low Gradient		
Basin Throughflow	1	0.9
Flat (former floodplain) Throughflow	1	2.9
Floodplain (basin) Throughflow	15	24.7
Floodplain (flat) Isolated	5	7.6
Floodplain (flat) Throughflow	11	73.4
Fringe Throughflow	3	3.7
Fringe (river island) Throughflow	2	2.1
Island Throughflow	1	0.3
Subtotal	39	115.6

Lotic River Tidal Gradient		
Basin (pond) Bidirectional Tidal	2	0.7
Flat Bidirectional Tidal	3	1.2
Floodplain (basin) Bidirectional Tidal	6	5.1
Floodplain (flat) Bidirectional Tidal	24	84.9
Floodplain (flat) Isolated	1	0.4
Fringe Bidirectional Tidal	183	915.3
Fringe (river island) Bidirectional Tidal	2	316.8
Island (basin) Bidirectional Tidal	6	14.6
Island (flat) Bidirectional Tidal	6	85.2
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Subtotal	233	1,424.2
Lotic Stream Low Gradient		
Basin Throughflow	2	1.4
Flat Throughflow	2	5.1
Floodplain (basin) Throughflow	5	11.2
Floodplain (flat) Throughflow	5	7.9
Fringe Throughflow	3	0.7
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Subtotal	17	26.3
Lotic Stream Middle Gradient		
Floodplain (basin) Throughflow	4	6.9
Floodplain (flat) Throughflow	1	0.8
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Subtotal	5	7.7
Lotic Stream Intermittent Gradient		
Basin Throughflow	4	3.0
Flat Throughflow	6	7.4
Floodplain (basin) Throughflow	4	6.2
Floodplain (flat) Throughflow	5	4.7
Fringe Throughflow	1	0.2
--------------------------------------	---	----
Subtotal	20	21.5
Lotic Stream Tidal Gradient		
Fringe Bidirectional Tidal	1	0.9
--	---	----
Subtotal	1	0.9

Terrene

Basin Isolated	113	143.9
Basin Outflow	19	21.3
Basin Throughflow	7	14.5
Basin (former floodplain) Isolated	5	9.0
Basin (former floodplain) Outflow	3	2.8
Basin (pond) Isolated	59	122.1
Basin (pond) Outflow	4	5.1
Basin (pond) Throughflow	15	23.2
Flat Isolated	58	123.8
Flat Outflow	10	57.8
Flat Throughflow	2	1.7
Flat (former floodplain) Isolated	3	6.3
Flat (former floodplain) Outflow	1	1.5
Flat (pond) Isolated	22	92.5
Flat (pond) Outflow	4	5.5
Flat (pond) Throughflow	1	0.2
Fringe (pond) Isolated	7	19.7
Fringe (pond) Outflow	3	1.3
Fringe (pond) Throughflow	3	4.8
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Subtotal	339	657.0

Total for All Wetlands (excluding ponds)	388	2,503.4

Table 5. Wetlands (excluding ponds) in the Delaware Estuary Coastal Zone classified by landform.

Landform	Number	Acreage
Basin	278	502.7
Fringe	228	1,341.8
Flat	119	322.7
Floodplain	86	233.8
Island	16	102.4

Table 6. Wetlands (excluding ponds) in the Delaware Estuary Coastal Zone classified by water flow path.

Water Flow Path	Number	Acreage
Bidirectional	272	1,549.1
Nontidal	(36)	(86.8)
Tidal	(236)	(1,462.3)
Isolated	269	520.8
Outflow	44	95.3
Throughflow	142	338.2

Table 7. Pond types, water flow path, number, and acreage in Delaware Estuary Coastal Zone.

Pond Type	**Water Flow Path**	**Number**	**Acreage**
Natural	Isolated	13	7.0
	Throughflow		
	Headwater	3	0.8
	Outflow	1	0.7
	Bidirectional-tidal	4	1.6
	Subtotal	21	10.1
Diked/Impounded	Isolated	2	0.3
	Throughflow	10	14.3
	Headwater	(3)	(3.5)
	Other	(7)	(10.8)
	Outflow	2	1.3
	Headwater	(1)	(0.6)
	Other	(1)	(0.7)
	Bidirectional-tidal	2	2.4
	Subtotal	16	18.3
Excavated	Isolated	321	465.3
	Commercial	(1)	(0.2)
	Industrial	(3)	(6.1)
	Sewage Treatment	(3)	(2.8)
	Other	(314)	(456.2)
	Throughflow	35	61.1
	Fragmented	(2)	(5.8)
	Headwater	(7)	(4.2)
	Other	(26)	(51.1)
	Outflow	24	51.7
	Human-induced	(2)	(4.0)
	Headwater	(5)	(3.3)
	Commercial	(10)	(17.4)
	Other	(7)	(27.0)
	Bidirectional-tidal	11	20.5
	Subtotal	391	598.6
Total for All Ponds		428	627.0

Preliminary Assessment of Wetland Functions

Wetland functions were predicted for wetlands in the Delaware Estuary Coastal Zone. Table 8 summarizes the results for each function (see Methods for rationale). Refer to the digital database for the locations of these wetlands. As one can see, the wetland functions performed by most wetlands were surface water detention and sediment retention. Other functions that may be performed at significant levels for over half of the wetlands in the study area included fish habitat and waterfowl/waterbird habitat, with other wildlife habitat and nutrient transformation predicted for nearly half of the wetlands. The presence of extensive tidal wetlands in the subject area was responsible for the high percent of wetlands important to fish, waterfowl, and waterbirds.

Table 8. Extent of wetlands predicted to perform various functions at significant levels for the Delaware Estuary Coastal Zone.

Function	Predicted Level	Acreage	Percent of Wetlands in Subject Area
Surface Water Detention	High	1,856.5	59
	Moderate	1,053.4	34
Streamflow Maintenance	High	96.0	3
	Moderate	270.5	9
Nutrient Transformation	High	953.7	30
	Moderate	570.4	18
Sediment Retention	High	954.7	31
	Moderate	1,919.0	61
Shoreline Stabilization	High	781.0	25
	Moderate	285.0	9
Fish Habitat	High	1,184.3	38
	Moderate	588.0	19
	Important for Stream Shading	16.3	<1
Waterfowl/Waterbird Habitat	High	1,219.0	39
	Moderate	847.4	27
Other Wildlife Habitat	High	765.9	24
	Moderate	777.8	25

Wetland Trends

During the 13-year study period (1986-1999), some wetlands in the Delaware Estuary Coastal Zone experienced changes, but the end result was a net gain of 5.3 wetland acres for this region (Table 9). Wetland losses of about 101 acres were balanced by 106 acres of gain, yet the qualitative differences were not evaluated (i.e., not part of this study).

A total of 106.4 acres of wetland gains occurred. Over half of the gains were attributed to pond creation, mostly on fields and industrial lands. Seventy-eight percent of the wetland gain (82.8 acres) was in nonvegetated wetlands (mostly ponds and excavated tidal flats). About 24 acres of vegetated wetland were established, with 14.7 acres of tidal marsh and 8.9 acres of nontidal emergent wetland created.

More nonvegetated wetlands also were destroyed than vegetated wetlands: 62.9 acres to 38.2 acres, respectively. The causes of wetland losses were many including: airport construction (20.6 acres), industrial development (16.7 acres), and recreational land development (15.4 acres). Another 25.7 acres of losses were not attributed to a particular land use since the land was disturbed (in transition) in 1999.

Table 9. Wetland trends in the Delaware Estuary Coastal Zone: 1986-99. Wetlands are palustrine types except where noted.

Wetland Gains

1999 Wetland Type	1986 Land Type	Acres
Lacustrine Unconsolidated Shore	Herb/Shrub Field	3.0
	Disturbed Land	4.6
	-----------------------	----
	Subtotal	7.6
Emergent (Nontidal)	Industrial Land	2.5
	Agricultural Land	0.8
	Herb/Shrub Field	0.8
	Disturbed Land	3.7
	Deciduous Forest	0.2
	-----------------------	----
	Subtotal	8.9
Emergent (Tidal)	Disturbed Land	2.8
	Herb/Shrub Field	11.9
	-----------------------	------
	Subtotal	14.7
Unconsolidated Bottom (Pond)	Industrial Land	21.3
	Airport	1.5
	Agricultural Land	0.5
	Herb/Shrub Field	23.3
	Deciduous Forest	3.2
	Disturbed Land	7.0
	------------------------	-----
	Subtotal	56.8
Riverine Unconsolidated Shore (Tidal)	Other Urban Land	0.4
	Herb/Shrub Field	13.0
	Forest	3.4
	Disturbed Land	1.6
	-----------------------	-----
	Subtotal	18.4
Total Wetland Gain		+106.4

Table 9 (continued).

Wetland Losses

1986 Wetland Type	1999 Land Type	Acres
Emergent (Nontidal)	Commercial Land	0.2
	Industrial Land	1.7
	Recreational Land	15.4
	Airport	17.4
	------------------------	-----
	Subtotal	34.7
Emergent (Tidal)	Airport	1.6
Forested	Clearcut Forest	1.4
	Sand/Gravel Pit	0.5
	------------------------	-----
	Subtotal	1.9
Unconsolidated Bottom (Pond)	Commercial Land	6.5
	Junkyard	7.9
	Industrial Land	15.0
	Airport	1.6
	Utility Land	1.2
	Herbaceous Field	2.9
	Herb/Shrub Field	1.8
	Deciduous Forest	0.3
	Disturbed Land	25.7
	------------------------	------
	Subtotal	62.9
Total Wetland Loss		-101.1
NET WETLAND CHANGE (Gains-Losses = 106.4-101.1)		+5.3 (NET GAIN)

Lake Erie Coastal Zone

Wetland Characterization

Wetlands were classified according to the U.S. Fish and Wildlife Service's official wetland classification system (Cowardin et al. 1979) and by landscape position, landform, and water flow path descriptors following Tiner (2000).

Wetlands by NWI Type

In 1999, the Lake Erie Coastal Zone had nearly 10,000 acres of wetlands (Table 9). Over half (54% or about 5,400 acres) of the wetlands were lacustrine wetlands associated with the shallow water zone of Lake Erie. Forty-six percent of the wetlands were palustrine types. Only nine acres were associated with the riverine system. Due to the inclusion of the shallow water zone of Lake Erie as wetlands, only 44 percent of the wetlands in the Lake Erie Coastal Zone were vegetated.

Of the vegetated wetlands, forested wetlands predominated.[1] These types occupied roughly 3,310 acres (excluding mixtures with other wetland classes), representing 75 percent of the vegetated wetlands. Broad-leaved deciduous forested wetlands predominated. Only 121 acres of mixed deciduous and evergreen forested wetlands were mapped. Emergent wetlands were second-ranked in abundance. They represented 10 percent of the vegetated wetlands and totaled 441 acres. Shrub-dominated wetlands occupied 249 acres and accounted for six percent of the vegetated wetlands.

Given the abundance of shallow water wetlands along Lake Erie, permanently flooded wetlands accounted for 54 percent of the wetlands (Table 10). Seasonally flooded types represented over 2,500 acres, ranking second, while temporarily flooded wetlands were next in abundance (see footnote 1 below).

Few wetlands appeared to be altered (Table 11). Only 218 acres of partly drained wetlands were inventoried and 134 acres of excavated wetlands (including ponds) were mapped.

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[1]The hydrology of many wetlands classified as temporarily flooded for the Lake Erie Coastal Zone may actually be better defined as seasonally saturated. Wetlands on broad flats (e.g., flatwoods) are wettest during the winter and spring due to high water tables and although pockets of inundated depressions may exist, surface water is absent from most of the wetland.

Table 9. Wetland status for the Lake Erie Coastal Zone of Pennsylvania – 1999. Wetlands classified by NWI type following Cowardin et al. (1979).

Wetland Type	**Acreage**
Palustrine Wetlands	
Vegetated	
Aquatic Bed	8.6
Emergent	441.4 (356.0 acres of Phragmites; 37.0 a mixed w/Phragmites)
Emergent/Shrub and Shrub/Emergent	173.3
Scrub-Shrub	248.6
Deciduous Forested	3,188.7
Evergreen Forested	0.7
Mixed Forested	120.5
Dead Forested	1.7
Forested/Emergent	1.8
Forested/Shrub and Shrub/Forested	183.4 (includes 28.9 a w/evergreen forested)
Subtotal	4,368.7
Nonvegetated	
Unconsolidated Bottom	199.7
Unconsolidated Bottom/Emergent	3.7
Unconsolidated Shore	10.6
Subtotal	214.0
Palustrine Total	4,582.7
Lacustrine Wetlands	
Vegetated	
Aquatic Bed	26.2
Nonvegetated	
Unconsolidated Bottom	5,165.7
Unconsolidated Shore	211.6
Subtotal	5,377.3
Lacustrine Total	5,403.5
Riverine Wetlands	
Nonvegetated	
Unconsolidated Shore	9.0
Riverine Total	9.0
GRAND TOTAL (all wetlands)	9,995.2

Table 10. Wetland acreage in the Lake Erie Coastal Zone by water regime.

Water Regime	**Acreage**
Temporarily Flooded	1,884.1
Saturated	74.5
Seasonally Flooded	945.9
Seasonally Flooded/Saturated	1,561.2
Semipermanently Flooded	130.6
Permanently Flooded	5,398.9

Table 11. Altered wetlands (including ponds) in the Lake Erie Coastal Zone.

Alteration	**Acreage**
Partly Drained	218.0
Diked/Impounded	60.5
Excavated	134.3

Wetlands by Hydrogeomorphic-Type

When classifying wetlands by hydrogeomorphic-type, vegetated wetlands and exposed nonvegetated types are emphasized, with ponds being considered waterbody type. From the landscape position standpoint, most (62%) of the wetland acreage in the Lake Erie Coastal Zone was classified as lentic, given the inclusion of the shallow-water zone of Lake Erie as wetland (Table 12). Terrene wetlands were second-ranked in acreage (36%) and top-ranked in numerical abundance (51% of the wetlands). Wetlands along rivers and streams (lotic) were less common, representing only 2 percent of the wetland acreage. From the landform perspective, fringe wetlands represented the most acreage and were third-ranked in number, whereas basin wetlands were most numerous (249 wetlands) and third-ranked in acreage (Table 13). Interfluve wetlands were second-ranked in both acreage and number. Throughflow wetlands were top-ranked in wetland acreage, with most of this acreage attributed to the inclusion of shallow-water shoreline habitats of Lake Erie as throughflow wetlands (Table 14). Bidirectional flow wetlands were top-ranked in number and third-ranked in acreage. Outflow wetlands, mostly headwater wetlands of tributaries draining into Lake Erie, were second-ranked in both number and acreage. A total of 104 wetlands occupying 400 acres were classified as isolated (i.e., geographically isolated – surrounded by upland).

Pond Types

Several types of ponds were classified during this inventory (Table 15). A total of 288 ponds were identified and classified. Only 32 “natural” ponds were mapped, amounting to 27 acres. They were ponds that appeared to be naturally-formed and relatively unaltered by people. In contrast, altered ponds (including excavated or impounded waterbodies created for various purposes) predominated. A total of 171 excavated ponds were identified in the Lake Erie Coastal Zone, accounting for almost 123 acres, while 85 diked/impounded ponds, representing 60 acres, were inventoried.

Table 12. Wetlands of the Lake Erie Coastal Zone classified by landscape position, landform, and water flow path (excluding ponds). *Note: Shallow water non-vegetated wetlands associated with Lake Erie; water flow path assigned based on water flow path of the lake which is throughflow.

Wetland Type (Landscape Position, Landform Water, Flow Path)	**Number of Wetlands**	**Acreage**
Lentic Natural		
Basin Bidirectional	3	10.2
Basin Throughflow	1	0.8
Basin (barrier beach) Bidirectional	116	508.8
Flat (barrier beach) Bidirectional	28	162.5
Fringe Bidirectional	53	421.3
Fringe Throughflow*	11	4,749.4
Fringe (barrier beach) Bidirectional	28	211.5
Subtotal	240	6,064.5
Lotic River Low Gradient		
Floodplain (basin) Throughflow	1	2.6
Floodplain (flat) Throughflow	1	10.5
Fringe Throughflow	4	3.0
Subtotal	6	16.1
Lotic River Middle Gradient		
Basin Throughflow	1	0.4
Fringe Throughflow	8	2.3
Subtotal	9	2.7
Lotic Stream Low Gradient		
Flat Throughflow	4	13.0
Floodplain (basin) Isolated	2	1.3
Subtotal	6	14.3
Lotic Stream Middle Gradient		
Basin Throughflow	8	62.7
Flat Throughflow	5	7.2
Fringe Throughflow	8	3.7
Subtotal	21	73.6

Lotic Stream Intermittent Gradient		
Basin Throughflow	15	33.5
Flat Throughflow	3	27.3
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Subtotal	18	60.8
Terrene		
Basin Inflow	2	12.1
Basin Isolated	50	173.4
Basin Outflow	22	66.7
Basin Throughflow	12	39.3
Basin (barrier beach) Isolated	5	6.8
Basin (pond) Isolated	6	4.0
Basin (pond) Outflow	7	16.9
Basin (pond) Throughflow	1	0.8
Flat Isolated	16	91.1
Flat Outflow	5	16.7
Flat Throughflow	7	31.7
Flat (barrier beach) Isolated	10	45.8
Flat (pond) Isolated	3	3.5
Interfluve (basin) Isolated	7	55.8
Interfluve (basin) Outflow	98	1,581.2
Interfluve (flat) Isolated	5	18.4
Interfluve (flat) Outflow	56	1,311.0
Slope Outflow	1	0.7
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Subtotal	313	3,475.9
Total for All Wetlands (excluding ponds)	613	9,707.9

Table 13. Wetlands (excluding ponds) in the Lake Erie Coastal Zone classified by landform.

Landform	**Number**	**Acreage**
Basin	249	936.4
Fringe	112	5,391.2
Flat	81	398.8
Floodplain	4	14.4
Interfluve	166	2,966.4

Table 14. Wetlands (excluding ponds) in the Lake Erie Coastal Zone classified by water flow path.

Water Flow Path	**Number**	**Acreage**
Bidirectional	228	1,314.3
Inflow	2	12.1
Isolated	104	400.1
Outflow	189	2,993.2
Throughflow	90	4,988.2

Table 15. Pond types, water flow path, number, and acreage in the Lake Erie Coastal Zone.

Pond Type	**Water Flow Path**	**Number**	**Acreage**
Natural	Isolated		
	Interdunal	9	6.7
	Other	6	4.5
	Throughflow		
	Headwater	1	0.2
	Bidirectional	16	16.0
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	Subtotal	32	27.4
Diked/Impounded	Inflow	2	1.0
	Outflow		
	Headwater	32	23.7
	Throughflow		
	Headwater	48	34.1
	Other	3	1.1
	----------------------	----	-----
	Subtotal	85	59.9
Excavated	Isolated		
	Sewage Treatment	3	6.6
	Other	133	87.8
	Throughflow		
	Headwater	12	10.1
	Outflow		
	Headwater	23	18.0
	----------------------	------	--------
	Subtotal	171	122.5
Total for All Ponds		288	209.8

Preliminary Assessment of Wetland Functions

Wetland functions were predicted for wetlands in the Lake Erie Coastal Zone. Table 16 summarizes the results for each (see Methods for rationale). Refer to the digital database for the locations of these wetlands. Most of the wetland acreage in this coastal zone provides some significant water storage (surface water detention) and potential waterfowl/waterbird habitat, due to the inclusion of the shallow-water zone along Lake Erie. Almost half of the wetlands may transform nutrients at significant levels and serve as habitat for other wildlife. About one-third of the wetlands help maintain streamflow and retain sediments.

Table 16. Extent of wetlands predicted to perform various functions at significant levels for the Lake Erie Coastal Zone.

Function	**Predicted Level**	**Acreage**	**Percent of Wetlands in Subject Area**
Surface Water Detention	High	5,758.9	58
	Moderate	2,167.2	22
Streamflow Maintenance	High	3,221.0	32
	Moderate	21.8	<1
Nutrient Transformation	High	2,634.5	26
	Moderate	1,656.0	17
Sediment Retention	High	793.4	8
	Moderate	2,174.7	22
Shoreline Stabilization	High	922.2	9
	Moderate	25.2	<1
Fish Habitat	High	44.3	<1
	Moderate	298.1	3
	Important for Stream Shading	161.7	2
Waterfowl/Waterbird Habitat	High	286.0	3
	Moderate	5,462.5	55
Other Wildlife Habitat	High	3,806.3	38
	Moderate	591.2	6

Wetland Trends

From 1986 to 1999, the Lake Erie Coastal Zone experienced a 84-acre net gain in wetlands (Table 17). This net figure reflects the difference between 120.6 acres of wetland gains (including 51 acres of new ponds) and 36.9 acres of wetland losses.

Most (87% or 104.9 acres) of the wetland gains came from former agricultural land. With abandonment of farming, many previously drained and cultivated areas are reverting to wetlands. These reverted wetlands totaled 64.7 acres, while 40.2 acres of ponds were created on former agricultural land. Overall, there were slightly more vegetated wetlands established than nonvegetated wetlands.

Only 36.9 wetland acres were lost during the 13-year study period, for an annual loss rate of roughly 3 acres. Residential and agricultural development combined for 80 percent of the wetland losses. The former accounted for 45 percent of the losses (16.6 acres) and the latter representing 35 percent (13.1 acres). About 79 percent of the losses affected two wetland types: forested and scrub-shrub wetlands (including mixtures of these two types).

Table 17. Recent wetland trends in the Lake Erie Coastal Zone: 1986-1999.

WETLAND GAINS

1999 Wetland Type	1986 Land Type	Acres
Lacustrine Unconsolidated Shore	Deciduous Forest	0.8
Palustrine Emergent/Shrub	Agriculture (cropland/pasture)	0.9
Palustrine Emergent	Agriculture (idle fields)	2.8
Palustrine Forested/Shrub	Agriculture (idle fields)	4.2
Palustrine Forested	Industrial	1.0
	Other Urban/Suburban	1.5
	Agriculture (cropland/pasture)	4.3
	Agriculture (idle fields)	34.9
	--------------------------------	------
	Subtotal	41.7
Palustrine Scrub-Shrub	Other Urban/Suburban	1.6
	Agriculture (cropland/pasture)	1.7
	Agriculture (idle fields)	15.9
	----------------------------------	------
	Subtotal	19.2
Palustine Unconsolidated Bottom (pond)	Residential Land	0.9
	Commercial Land (junkyard)	0.1
	Industrial Land	1.1
	Agriculture (cropland/pasture)	30.4
	Agriculture (idle fields)	1.5
	Deciduous Forest	8.7
	---------------------------------------	------
	Subtotal	42.7
Palustrine Unconsolidated Shore (pond)	Agriculture (cropland/pasture)	8.3
Total Wetland Gain		+120.6 (68.8=vegetated; 51.8=nonvegetated)

WETLAND LOSSES

1986 Wetland Type	1999 Land Type	Acres
Palustrine Emergent	Residential Land	0.5
	Industrial Land	1.2
	Agricultural Land (cropland/pasture)	0.2
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	Subtotal	1.9
Palustrine Forested/Shrub	Residential Land	2.2
Palustrine Forested	Residential Land	2.0
	Commercial Land (junkyard)	1.8
	Agricultural Land (cropland/pasture)	9.8
	--	-----
	Subtotal	13.6
Palustrine Shrub/Emergent	Residential Land	0.8
Scrub-Shrub	Residential Land	11.1
	Agricultural Land (cropland/pasture)	2.2
	--	------
	Subtotal	13.3
Palustrine Unconsolidated Bottom (pond)	Industrial Land	3.7
	Agricultural Land (cropland/pasture)	0.9
	Deciduous Forest	0.2
	--	-----
	Subtotal	4.8
Palustrine Unconsolidated Shore (pond)	Agriculture (cropland/pasture)	0.3
Total Wetland Loss		-36.9 (31.8=vegetated; 5.1=nonvegetated)
NET WETLAND CHANGE (Gains - Losses = 120.6-36.9)		+83.7 (net gain)

Appropriate Use of this Report

The report provides basic information on wetlands in Pennsylvania's Coastal Zone. It includes an area-wide wetland resource characterization, a preliminary functional assessement of wetlands, and an analysis of recent wetland trends. The results of the functional assessment are an initial screening of wetlands in the two units of Pennsylvania's Coastal Zone (the Delaware Estuary Coastal Zone and the Lake Erie Coastal Zone) to designate wetlands that may have a significant potential to perform different functions. The targeted wetlands have been predicted to perform a given function at a significant level presumably important to a watershed's ability to provide that function. "Significance" is a relative term and is used in this analysis to identify wetlands that are likely to perform a given function at a level above that of wetlands not designated. Protocols established to predict wetlands of potential significance should be reviewed by PACZM staff and others to insure that the correlations are relevant to each of the two study areas. This is especially true for the habitat predictions.

While the results are useful for gaining an overall perspective of "coastal zone" wetlands and their relative importance in performing certain functions, the report does not identify differences among wetlands of similar type and function. The latter information is often critical for making decisions about wetland acquisition and designating certain wetlands as more important for preservation versus others with the same classification. Additional information gained through consulting with agencies having specific expertise in the subject area and by conducting field investigations to verify the preliminary assessments are necessary.

The report and accompanying maps are useful for general natural resource planning, as an initial screening tool for considering prioritization of wetlands for acquisition or strengthened protection, as an educational tool to help the public and nonwetland specialists better understand the functions of wetlands and the relationships between wetland characteristics and performance of individual functions, and for summarizing the current status and recent trends in wetlands of Pennsylvania's Coastal Zone.

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References

Askins, R.A., M.J. Philbrick, and D.S. Sugeno. 1987. Relationship between the regional abundance of forest and the composition of forest bird communities. Biol. Cons. 39: 129-152.

Brinson, M. M. 1993. A Hydrogeomorphic Classification for Wetlands. U.S. Army Corps of Engineers, Washington, DC. Wetlands Research Program, Technical Report WRP-DE-4.

Carter, V. 1996. Wetland hydrology, water quality, and associated functions. In: J.D. Fretwell, J.S. Williams, and P.J. Redman (compilers). National Water Summary on Wetland Resources. U.S. Geological Survey, Reston, VA. Water-Supply Paper 2425. pp. 35-48.

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

Freemark, K. and B. Collins. 1992. Landscape ecology of breeding birds in temperate forest fragments. In: J.W. Hagan III and D.W. Johnston (editors). Ecology and Conservation of Neotropical Birds. Smithsonian Institution Press. pp. 443-453.

Freemark, K.E. and H.G. Merriam. 1986. Importance of area and habitat heterogenity to bird assemblages in temperate forest fragments. Biol. Cons. 36: 115-141.

Golet, F.C. 1972. Classification and Evaluation of Freshwater Wetlands as Wildlife Habitat in the Glaciated Northeast. University of Massachusetts, Amherst, MA. Ph. D. dissertation.

Hammer, D.A. 1992. Creating Freshwater Wetlands. Lewis Publishers, Inc., Chelsea, MI.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands. Van Nostrand Reinhold, New York, NY.

Nelson, W.M., A.J. Gold, and P.M. Groffman. 1995. Spatial and temporal variation in groundwater nitrate removal in a riparian forest. J. Environ. Qual. 24; 691-699.

Newmark, W.D. 1991. Tropical forest fragmentation and the local extinction of understory birds in the eastern Usambara Mountains, Tanzania. Conservation Biology 5: 67-78.

Novitzki, R.P. 1979. The hydrologic characteristics of Wisconsin wetlands and their influence on floods, streamflow, and sediment. In: P.E. Greeson et al. (editors). Wetland Functions and Values: The State of Our Understanding. Amer. Water Resources Assoc., Minneapolis, MN. pp. 377-388.

Peterjohn, W.T. and D.L. Correll. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. Ecology 65: 1466-1475.

Robbins, C.S., D.K. Dawson, and B.A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Mid-Atlantic states. Wildlife Monogr. 103: 1-34.

Robinson, S.K. 1990. Effects of Forest Fragmentation on Nesting Songbirds. Illinois Natural History Survey, Champaign, IL.

Simmons, R.C., A.J. Gold, and P.M. Groffman. 1992. Nitrate dynamics in riparian forests: groundwater studies. J. Environ. Qual. 21: 659-665.

Simpson, R.L., R.E. Good, R. Walker, and B.R. Frasco. 1983. The role of Delaware River freshwater tidal wetlands in the retention of nutrients and heavy metals. J. Environ. Qual. 12: 41-48.

Tiner, R.W. 1997a. Atlas of National Wetlands Inventory Maps for the Watersheds of the New York City Water Supply System. U.S. Fish and Wildlife Service, Hadley, MA. Prepared for the New York City Department of Environmental Protection, Bureau of Water Supply, Quality, and Protection, Valhalla, NY.

Tiner, R.W. 1997b. NWI Maps: What They Tell Us. National Wetlands Newsletter 19(2): 7-12. (Copy available from USFWS, ES-NWI, 300 Westgate Center Drive, Hadley, MA 01035)

Tiner, R. W. 2000. Keys to Waterbody Type and Hydrogeomorphic-type Wetland Descriptors for U.S. Waters and Wetlands (Operational Draft). U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA. November 2000.

Tiner, R.W. 1998. In Search of Swampland: A Wetland Sourcebook and Field Guide. Rutgers University Press, New Brunswick, NJ.

Tiner, R.W. and J.C. Anderson. 1986. Current Status and Recent Trends in Wetlands of the Lake Erie Coastal Zone of Pennsylvania. U.S. Fish and Wildlife Service, Newton Corner, MA.

Tiner, R.W., J.C. Anderson, and W. Zinni. 1987. Current Status and Recent Trends in Wetlands of the Delaware Estuary Coastal Zone of Pennsylvania. U.S. Fish and Wildlife Service, Newton Corner, MA.

Whigham, D.F., C. Chitterling, and B. Palmer. 1988. Impacts of freshwater wetlands on water quality: a landscape perspective. Environ. Manag. 12: 663-671.

Whiting, P.J. 1998. Bank storage and its influence on streamflow. Stream Notes July 1998. Stream Systems Technology Center, Rocky Mountain Research Station, Fort Collins, CO.

Yarbro, L.A., E.J. Kuenzler, P.J. Mulholland, and R.P. Sniffen. 1984. Effects of stream channelization on exports of nitrogen and phosphorus from North Carolina Coastal Plain watersheds. Environ. Manag. 8: 151-160.