CHARACTERIZATION OF CATEGORY I NON-TIDAL WETLAND COMMUNITIES IN DELAWARE: INTERDUNAL WETLANDS

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PART I

INTERDUNAL WETLANDS IN DELAWARE

COMMUNITY CLASSIFICATION AND MAPPING CRITERIA FOR CATEGORY I INTERDUNAL WETLANDS IN DELAWARE

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INTERDUNAL WETLANDS IN DELAWARE

INTRODUCTION

Human threats to unique and significant wetland habitats in the state of Delaware (e.g. draining and filling) have prompted the Wetlands and Aquatic Protection Branch (WAPB) of the Division of Water Resources and the Delaware Natural Heritage Inventory (DNHI) of the Division of Parks and Recreation, Department of Natural Resources and Environmental Control (DNREC), Dover, Delaware, to locate, identify and map these sites for purposes of regulation and protection. Unique and significant wetland types, such as bald cypress and Atlantic white cedar swamps, interdunal wetlands and coastal plain ponds (i.e. Carolina/Delmarva Bays) have been classified as Category I wetlands. This classification is assigned based on their limited extent in the state, the assemblage of rare plant species that they often contain, their unique geological origins, and their distinctive physiognomic characteristics. Category I wetlands will receive the highest priority for protection.

Mapping of Category I wetlands is critical to the process of protection and regulation, and will be accomplished through interpretation of aerial photography. The procedure begins with ground reconnaissance: characterizing specific wetland communities through detailed, and intense biological surveys during the growing season. Classification of natural communities entails complex field studies which ultimately give a complete, over-all description of a community. Data collected will aid interpreters in locating Category I wetlands on aerial photographs so that boundaries can be drawn and maps produced.

The WAPB has contracted a two year study with the Delaware Natural Heritage Inventory to locate Category I wetlands, to develop community classifications of Category I wetlands, and to recommend criteria to be used for mapping of Category I wetlands. The first year of the study began in January of 1992 and its focus was on bald cypress and Atlantic white cedar wetlands. The second year of study (1993), concentrated on interdunal wetlands and coastal plain ponds. Base-line data for Piedmont stream valley wetlands and sea-level fen wetlands were also collected to determine their Category I potential (a separate report summarizing preliminary studies for these wetlands types has been completed).

This study will also provide the Delaware Natural Heritage Inventory with important information to be used in the development of a state-wide natural community classification. This work will contribute to protection and management efforts of Delaware's most significant and unique wetland communities.

MATERIALS AND METHODS

In-depth surveys of interdunal wetlands and coastal plain pond wetlands in Delaware were undertaken during the 1993 season. Preliminary work involved gathering known information on the occurrence of these habitat types in Delaware: from published reports, unpublished data (primarily from the DNHI database), and conversations with knowledgeable individuals. This step was critical to subsequent field investigations of these wetlands.

A study of aerial photography (1988 CIR at 1:24000 and 1992 CIR at 1:40,000) was undertaken. First, photographs of known interdunal wetlands and coastal plain pond sites were studied to determine a characteristic "signature" for each of the two habitat types. This information was then used to identify additional sites. Photographs from all areas in the state that were suspected to contain interdunal wetlands and coastal plain ponds were studied.

Once areas of known or suspected occurrence of the two habitat types were identified, field surveys were undertaken to verify the presence of the two communities and to assess their structure and species' compositions. At most sites, cover values were estimated, information on soils were recorded, habitat disturbances were noted, and a list of associated species for each site was made. Several "reference" interdunal wetland and coastal plain pond sites were selected, in which detailed surveys were undertaken for comparative purposes to other sites.

For each interdunal wetland and coastal plain site visited, a detailed description of the site was made (see discussions for each habitat type below), its location in the state noted on a U.S.G.S. topographic map, site boundaries were indicated, size of the natural community estimated, and any other pertinent information about the site (e.g. presence of rare species, adjacent land use, threats, etc.) discussed.

INTRODUCTION - INTERDUNAL WETLANDS

The focus of this study was descriptive in nature and botanically and ecologically based. Data collected are presented in a systematic, narrative way and a review of the literature is summarized within each discussion. Criteria and justification for Category I wetland mapping are based on field observations and data collected.

Interdunal wetland sites chosen to be sampled were selected by review of the DNHI database files, two aerial surveys done by plane, and by review of aerial photographs (1988 CIR at 1:24000 and 1992 CIR at 1:40,000).

Forty sites were sampled. For each site visited, all vegetation present were identified, hydrology was noted (surface water and groundwater measurements), soil characteristics were indicated, size and shape of a site was approximated, casual observations were transcribed, physical position on the landscape was noted and the approximate location was recorded onto a U.S.G.S. topographic map (1:24,000). Sampling was done randomly from May to December, 1993.

GENERAL DESCRIPTION OF AN INTERDUNAL WETLAND IN DELAWARE

Interdunal wetlands in Delaware, occur exclusively along the Atlantic coastal strand and barrier islands from Cape Henlopen south to the Delaware-Maryland state line (all within Sussex County). They are found as low, shallow depressions behind primary dune ridges of the shoreline. They are variable in size (none greater than 1 acre in area covered) and irregular in shape (see Fig. 1, Appendix B for a profile of an interdunal wetland). They are non-tidal, freshwater systems that are primarily groundwater driven. Water levels fluctuate seasonally and annually reflecting changes in groundwater levels. Soils are coarse textured sands and a very thin layer of organic matter, or peat is typically found at the soil surface. Interdunal wetlands are floristically diverse systems and the major vegetative groups represented are sedges (Cyperaceae), grasses (Poaceae), asters (Asteraceae) and rushes (Juncaceae). A suite of characteristic "signature" plant species (i.e. an assemblage of species that are frequently found) have been determined for Delaware interdunal wetlands, and a number of rare plant species have also been identified. Interdunal wetlands as ecological communities are also quite diverse, and five community variants have been identified for Delaware. Interdunal wetlands provide habitat for wildlife and also serve as a source for freshwater for animals utilizing coastal dune systems.

Through review of the literature, a number of synonyms were found for interdunal wetlands: dune meadow, dune slack, mesic meadow, dune marsh, dune swale, maritime wet grassland, and dune sedge. The terminology of interdunal wetland is suggested, to cover the broad

range of variation within the community type.

OVERALL DISTRIBUTION

Interdunal wetlands have been identified in the Atlantic coastal states of Massachusetts, Long Island, New York, New Jersey, Delaware (from Cape Henlopen south to the DE-MD state line), Maryland, Virginia, North Carolina, Georgia, and Florida (Odum and Harvey 1988, Jones 1992).

FORMATION/GEOLOGY

It has been theorized that interdunal wetlands are formed by "blowouts," in the loose, unvegetated sand of the inner dunes. These blowouts, resulting in the formation of depressions, lower the soil surface to groundwater levels and are therefore considered to be "windows" of the groundwater table (Ranwell 1959, Jones 1992). Many of the interdunal wetlands that have been identified are found on coastal barrier islands. These islands have developed what is called a ridge and swale topography (Odum and Harvey 1988), which consists of a high foredune or ridge, and low depressional areas or swales within the inner dunes. This accurately describes the geologic setting of Delaware's interdunal wetlands. The question has been asked, does this wetland type occur on the Delaware Bay coastline? Efforts to locate examples of this wetland community type through aerial surveys and review of aerial photographs, have been unsuccessful. Physical characteristics and natural processes of the Delaware Bay region do not appear to be favorable for interdunal wetland formation. For more detailed discussions of the geology of coastal interdunal wetlands, see Ranwell (1959, 1960) and Odum and Harvey (1988).

DYNAMICS/SUCCESSION

Interdunal wetlands occur within a dynamic environment, and may be subject to disturbance or modification by natural processes, such as shifting sand dunes, salt spray, oceanic overwash and storm erosion. Such disturbances appear to be important in preventing succession of interdunal wetlands to palustrine shrub, or dry dune shrub communities (Schafale and Weakley 1990). Field observations indicate that areas that are more sheltered than others (e.g. high, intact primary dunes with vegetative cover) are not subjected to the degree of disturbance that more open, unvegetated areas are. Sheltered areas are likely to succeed, while open, unvegetated areas are more conducive to wetland formation.

From studies of interdunal wetlands in Great Britain, Ranwell (1960) offers this possible cycle of succession: bare, moist sand of inner dune depressions are first colonized by germinating seeds,

carried by birds or wind from surrounding areas; perennial plants later become established; as sand deposition and dune movement takes place, interdunal wetlands become drier and dunes are eventually formed; over time, the process of shifting dunes and storm erosion continues to occur, and new depressions are formed, once again bare moist sand is suitable for colonization by seedlings. Ranwell predicts approximately 80 years for this cycle to take place. A review of early aerial photographs to the present, may reveal indications of this phenomenon occurring along Delaware's Atlantic coast.

Over the short term, water level fluctuations drive community dynamics. During periods of drought, shrubs and trees may become established and shade and out-compete the characteristic herbaceous plants, but most woody plants will likely be eliminated by later periods of prolonged flooding (Schafale and Weakley 1990). Dead, standing stems of *Acer rubrum* (red maple) and *Myrica cerifera* (bayberry) were often observed within many of the wetlands sampled during this study.

HYDROLOGY

Survey work completed for the Category I wetland project during 1993, as well as field observations made in previous years, indicate that interdunal wetlands are a reflection of the groundwater table. Ecological studies of interdunal wetlands done by other researchers also suggest this (Snow 1902, Ranwell 1959, 1960, Odum and Harvey 1988, Seliskar 1986, Jones 1992, Whittecar and Emery 1992). It has been found through Category I wetland surveys, that surface water levels of interdunal wetlands in Delaware will fluctuate through the seasons. A typical water regime may be as follows: maximum surface water depths occurring in the winter and spring, and minimum depths in mid to late summer, with occasional periods of random flooding after intense storm events. Observations made during this study show that interdunal wetlands will flood and remain flooded long after a severe storm. Although standing water was not typically found in interdunal wetlands in mid and late summer, and also between storm events, soils were always moist or saturated. During ecological surveys of Delaware's Atlantic coastal habitats from Cape Henlopen to Rehoboth Beach, Snow noted the same hydro regime as above; she described "swampy, dune-meadows" that flooded in winter and were dry in summer. Water table fluctuations in interdunal wetlands appear to be primarily associated with precipitation. Direct correlations have been found between the rise and fall of coastal groundwater tables and regional and local climatic cycles (Odum and Harvey 1988). The range of water table fluctuation throughout the year is dependent on rainfall, rate of sub-surface drainage and soil permeability, evapotranspiration, and infiltration by rainfall (Ranwell 1959).

The National Wetlands Inventory (NWI) program of the U.S. Fish and Wildlife Service were able to locate and map many of the larger interdunal wetlands along Delaware's Atlantic coast.

A range of water regimes were mapped during the National Wetlands Inventory (1977, 1981):

temporarily flooded	(A regime)
saturated	(B regime)
seasonally flooded	(C regime)
seasonally flooded/saturated	(D regime)

Past and present studies have shown that coastal interdunal wetlands are truly non-tidal, freshwater systems (Kearney 1904, Kelly 1925, Martin 1958, Ranwell 1959, Odum and Harvey 1988, Priestley pers. comm. 1994,). Ranwell has found that groundwater levels of interdunal wetlands in Great Britain are not affected by spring high tides, and no penetration of seawater beneath dunes has been measured or correlated with tide cycles. Kelly, during studies of soil water of the New Jersey coast, found that sub-surface lateral movement of groundwater is towards the sea, and there is no measurable passage of salt landward. Kearney, while studying sea beach vegetation, also determined that soil water of the inner dunes contains no appreciable amounts of soluble salts. Martin, during studies of the vegetation of Island Beach State Park, New Jersey, found that salinity measurements indicate no more than a negligible amount of salt in the groundwater. Salinity measurements taken of surface water in eight separate interdunal wetlands in Delaware (January 1994), revealed zero levels of salinity. However, interdunal wetlands may be found at times to be somewhat brackish, which is likely a result of salt spray (Kelly 1925), or maritime overwash during storm events (Odum and Harvey 1988). The eight interdunal wetlands mentioned above that were sampled for salinity levels in January of 1994, were also sampled in March of 1994, following an intense storm event where the primary dune ridge was breached by oceanic overwash, salinity levels were measured as high as 15 parts/thousand. A few sites sampled during this survey contained plant species tolerant of high levels of salinity (e.g. *Spartina patens*, salt hay; *Distichlis spicata,* spike grass; *Eleocharis parvula,* saltmarsh spike-rush; and *Baccharis halimifolia*, high-tide bush). Salt tolerant plant species were also found in interdunal wetlands in Virginia (Jones 1992). These sites should eventually be flushed by fresh groundwater and rainfall, and salt tolerant species will either become much less important, or be altogether eliminated (Odum and Harvey 1988). Odum and Harvey suggest that rainfall, infiltrating directly into the groundwater aquifer, displaces saline water and forms a lens of freshwater which may float on top of a layer of brackish water beneath.

SOILS

Soils of the interdunal wetlands sampled during this study were found to be predominately composed of coarse textured sand, with a thin layer (1-5mm) of humus at the surface. No true soil horizons were noted, indicating a lack of soil development. Similar observations have been made by other researchers studying the ecology of coastal interdunal wetlands (Kearney 1904, Oosting and Billings 1942, Martin 1958, Odum and Harvey 1988, Tyndall and Levy 1978, Jones 1992). Tyndall, in sampling interdunal wetlands of the Virginia coast, found the texture of all soil samples to be 98% sand. Odum and Harvey speculated that the periodic drying of interdunal wetlands and subsequent oxidation of their accumulated bottom sediments, may be a reason for low amounts of organic matter build-up and lack of soil development. The Sussex County Soil Survey (1974) maps the interdunal region of Delaware's Atlantic coast as either coastal sand (co), or tidal marsh (Tm).

Odum and Harvey (1985) suggest that interdunal depressional wetlands are underlain by confining mixed layers of sand, silt, clay and organic matter. In this case, groundwater exchange would then likely be most important around the edge of the wetland, with lesser amounts moving through the wetland bottom. In studies along the New Jersey coast, it was found that shallow layers of peat occurred under interdunal "cranberry bog" wetlands (Martin 1959).

The literature, as well as the species composition of interdunal wetlands sampled, suggests that the soil of coastal interdunal wetlands tends to vary from nutrient poor to nutrient rich (Oosting and Billings 1942, Ranwell 1959, Tyndall and Levy 1978, Jones 1992). A few sites sampled during this study contained plant species that are often found growing in eutrophic wetlands, such as *Echinochloa walterii* (Walter's millet), *Hibiscus moscheutos* (marsh mallow), *Ludwigia palustris* (water purslane), *Pluchea odorata* (flea-bane), *Polygonum* spp. (smartweeds), and *Proserpinaca palustris* (mermaid weed). The frequent occurrence of the carnivorous plant *Drosera intermedia* (sundew) in the majority of the interdunal wetlands sampled however, may indicate nutrient poor conditions in those wetlands where it was found. Due to the extreme sandy texture of the soils and the lack of organic material, primary sources of nutrients are from precipitation, salt spray, and groundwater (Oosting and Billings 1942, Jones 1992).

Although soil pH was not measured during this study, the vegetative composition of the majority of interdunal wetlands sampled (e.g. *Drosera intermedia; Sphagnum* sp., sphagnum moss; *Utricularia subulata,* zig-zag bladderwort; *Viola lanceolata,* lanceleaf violet; *Vaccinium macrocarpon,* cranberry; and *Xyris* spp., yellow-eyed grasses), indicate low levels of soil pH. Tyndall (1978) found a range of pH measurements from 5.0 to 5.7. Odum and Harvey have measured soil pH as low as 4.5.

Salt content of interdunal wetland soils is barely measurable (Oosting and Billings 1942). Kearney (1904) found only .003% salt in samples taken, and concludes that any salt measured is likely from salt spray or oceanic overwash. Such low levels of soil salinity are not enough to affect freshwater vegetation (Oosting and Billings 1942).

VEGETATION

Interdunal wetlands in Delaware are highly diverse plant communities, that typically contain herbaceous vegetation with varying degrees of emergent and prostrate growth forms. A mixture of wetland and mesic species are found, which are primarily perennial, and includes grasses, sedges, rushes, forbs, ferns, fern allies and mosses. The major plant families represented are: Cyperaceae (sedge family), 23 species; Poaceae (grass family), 14 species; Asteraceae (aster family), 13 species; Juncaceae (rush family), 7 species. The orchid family (Orchidaceae) is also fairly well represented with 5 species. Arborescent and frutescent vegetation are also encountered, but usually on the edges of moist perimeters, or in stunted forms if found in standing water. Many of the species found are persistent, allowing for identification throughout the year.

In Appendix A, a list of plant species associated with interdunal wetlands in Delaware can be found. Scientific and common names are given, as well as state ranks (ranks are a measure of a species rarity in the state), frequency class (based on the number of occurrences out of 40 survey sites), and wetland indicator status (Reed 1988).

Fourteen characteristic signature plant species have been determined for interdunal wetlands in Delaware (listed below). This determination is based on frequency classes of 3 and 4 (frequency class 3 = 14-26 occurrences, frequent; frequency class 4 = 27-40 occurrences, common). Frequency classes are calculated from 40 survey sites.

This suite of taxa represents the typical community assemblage of interdunal wetland plants to be found in Delaware (wetland indicator status is also given):

Andropogon virginicus	broom-sedge grass	FACU
Cladium mariscoides	twig-rush	OBL
Drosera intermedia	sundew	OBL
Eupatorium leucolepis	white-bract thorough-wort	FACW+
Euthamia tenuifolia	slender fragrant goldenrod	NOT LISTED
Juncus biflorus	grass-leaf rush	FACW
Juncus canadensis	Canada rush	OBL
Juncus dichotomus	forked rush	FACW
Juncus scirpoides	sedge rush	FACW
Lycopodium appressum	southern bog-clubmoss	FACW+

Scirpus pungens	three square sedge	OBL
Sphagnum sp.	sphagnum moss	NOT LISTED
Xyris difformis var. *difformis*	yellow-eyed grass	OBL
Vaccinium macrocarpon	cranberry	OBL

Several of the above listed signature species were also noted during Snow's survey of Delaware Atlantic coastal habitats in 1902: *Andropogon virginicus, Juncus scirpoides, Lycopodium appressum, Vaccinium macrocarpon,* and *Xyris flexuosa* (syn = *X. caroliniana, flexuosa* was likely misapplied and is treated here as *X. difformis* var. *difformis*).

Although a consistent assemblage of interdunal wetland plants are usually found, vegetational differences, or floristic variations between sites are often encountered. This is likely due to such factors as hydrology, soils, natural and unnatural disturbances, and randomness of plant dispersal events.

There is a wide variety of arenaceous species (plants growing in sand) of the surrounding dry dunes, that grade towards the wetter soils of the interdunal wetlands. Xeric vegetation, such as *Hudsonia tomentosa* (sand heather), *Solidago sempervirens* (seaside goldenrod), *Cyperus grayi* (Gray's nut-sedge), *Ammophila breviligulata* (American beach grass), *Panicum amarum* (a panic grass), *Prunus maritima* (beach plum), *Pinus thunbergii* (Japanese black pine), and *Juniperus virginiana* (red cedar) grade into a typical assemblage of mesic, wetland edge species that includes: *Rhus copallina* (winged sumac), *Toxicodendron radicans* (poison ivy), *Myrica cerifera, Ilex glabra* (inkberry), *Vaccinium corymbosum* (highbush blueberry), *Aronia arbutifolia* (chokecherry), *Acer rubrum, Prunus serotina* (black cherry), and *Liquidambar styraciflua* (sweetgum).

The following 23 plant species identified during this study are considered to be rare in the state of Delaware by the Delaware Natural Heritage Inventory (five ranked as S1, extremely rare; eleven ranked as S2, very rare; six ranked as S3, rare to uncommon; and one ranked as SU, status uncertain; (see Appendix A for further ranking criteria):

Calopogon tuberosus	grass-pink orchid	S1
Carex longii	Long's sedge	S1
Hypericum boreale	northern St. Johnswort	S1
Platanthera blephariglottis	white-fringe orchis	S1
Sabatia campanulata	slender marsh pink	S1
Bidens coronata	tickseed sunflower	S2
Centella erecta	erect coinleaf	S2
Eryngium aquaticum	button snakeroot	S2
Fuirena pumila	small umbrella sedge	S2
Panicum roanokense	a panic grass	S2
Pogonia ophioglossoides	rose-pogonia	S2

Rhynchospora gracilenta	slender beak-rush	S2
Spiranthes vernalis	spring ladies tresses	S2
Utricularia geminiscapa	hidden-fruit bladderwort	S2
Utricularia subulata	zig-zag bladderwort	S2
Xyris torta	slender yellow-eyed grass	S2
Vaccinium macrocarpon	cranberry	S3
Eleocharis quadrangulata	four-square sedge	S3
Eleocharis robbinsii	Robbin's spike-rush	S3
Fuirena squarrosa	umbrella sedge	S3
Juncus pelocarpus	brown-fruited rush	S3
Rhynchospora alba	white-bract sedge	S3
Pluchea foetida	marsh flea-bane	SU

To date, there does not appear to be any plant species that are endemic to interdunal wetlands in Delaware, however 19 of the 21 known Delaware populations for *Vaccinium macrocarpon* (cranberry) occur within interdunal wetlands along the Atlantic coast. Cranberry occurs in northern boreal bogs, Atlantic white cedar swamps, and mountain bogs of the southern Appalachians (Gleason and Cronquist 1991). Its natural range is from Newfoundland to Virginia, and in the mountains of North Carolina and Tennessee (Gleason and Cronquist 1991).

The assembly of signature plant species listed above, is actually a rather unique collection of plants for Delaware. I know of no other habitat in Delaware that consistently contains all of the species listed. A consideration of endemism to interdunal wetlands in Delaware could be given to this assemblage.

There is a high prevalence of *Juncus* species found in intedunal wetlands in Delaware, the most frequently occurring species are: *Juncus biflorus, Juncus canadensis, J. dichotomus,* and *J. scirpoides*. *J. acuminatus* (sharp-fruited rush), *J. effusus* (smooth rush), and *J. pelocarpus* (brown fruited rush) have also been recorded, but only rarely. A similar assemblage of rushes is also found in interdunal wetlands in Virginia (Jones 1992).

Interdunal wetlands in Delaware are closely related floristically to interdunal wetlands found in Virginia. Twelve characteristic signature species have been determined for Virginia (Jones 1992), of that twelve, five are also on the Delaware list shown above: *Andropogon virginicus, Drosera intermedia, Juncus biflorus, J. scirpoides,* and *Scirpus pungens*. In addition, of the 47 associated interdunal wetland species listed for Virginia (Jones 1992), 29 also occur in interdunal wetlands in Delaware. Further south of Virginia, plant species composition of interdunal wetlands change considerably, to the point where floristic relationships with Delaware are insignificant (Schafale and Weakley 1990). Plant species of interdunal wetlands of Long Island, New York, are also closely allied with Delaware. Many of the characteristic species described from Long Island (Reschke 1990) also occur in Delaware interdunal wetlands: *Cladium mariscoides, Cyperus* spp. (nut-

sedges), *Rhynchospora capitellata* (small headed beak-rush), *Juncus canadensis*, *Drosera* spp., *Vaccinium macrocarpon*, *Vaccinium corymbosum*, *Utricularia subulata*, and *Xyris torta*. North of Long Island, other than Cape Cod, Mass., dune activity is limited, and coastal wetlands are of different forms than what are usually found further south (Jones 1992).

NATURAL COMMUNITY DESCRIPTIONS

Interdunal wetlands are a broad community category with a great deal of diversity, diversity expressed in floristic associations. Diversity within the community type is primarily a result of hydroperiod. It is considered by many that depth to ground water table is the major selection factor influencing the interdunal wetland environment. Ranwell (1959), after recognizing distinct differences in the vegetation which accompanied changes in the water table depth, separated sites into "wet-vegetation" associations and "dry-vegetation" associations. Wet-vegetation associations are those in which the water table never falls below one meter from the surface throughout the season; dry-vegetation associations are those where the water table in summer, lies between one and two meters below the surface. Similar observations were made during this study; overall plant species richness and % cover were quite low when the groundwater table was measured below 15" from the surface. When the groundwater table was measured at 6-12," overall species richness and % cover increased.

To date, based on dominant vegetation present, five interdunal wetland variants are recognized in Delaware (future inventory work may identify additional community variants):

1) *Juncus scirpoides-Scirpus pungens* interdunal wetland association.

This association is the most common community variant to be found along Delaware's Atlantic coast. This type is distributed from Cape Henlopen, south to the DE-MD State line (Fig. 3, 4, 6, 7, Appendix B). Some of the best examples of this community type can be found on the Assawoman Bay quadrangle north of Fenwick Island, and on the Cape Henlopen quadrangle within Cape Henlopen State Park. The assemblage of characteristic signature plant species listed above are typically found, as well as rare plants such as *Panicum roanokense* (S2), *Spiranthes vernalis* (S2), *Utricularia subulata* (S2), *Vaccinium macrocarpon* (S3), and *Xyris torta* (S2). Where identified, NWI maps this wetland type as either: scrub/shrub, broad-leaved evergreen or narrow-leaved evergreen, or emergent, narrow-leaved persistent. Water regimes vary: saturated, temporarily flooded, seasonally flooded, and seasonally flooded/saturated.

2) *Scrub-shrub/mixed herbaceous* interdunal wetland association.

This interdunal wetland variant has been identified from three separate sites, all on the Bethany Beach quadrangle (Fig. 5, Appendix B). All three are of fairly large size (up to one acre) and are floristically diverse in regards to variations in life forms (i.e. woody and herbaceous growth). This wetland type contains scrub-shrub vegetation (woody shrubs and stunted trees) on its perimeter, which will often grade into herbaceous openings. Scrub-shrub vegetation includes the following: *Pinus rigida* (pitch pine), *Acer rubrum, Liquidambar styraciflua* (sweetgum), *Ilex glabra, Vaccinium corymbosum, Myrica cerifera, Rosa palustris* (swamp rose) and *Aronia arbutifolia*. Some of the more prevalent herbaceous vegetation that were common to all three sites includes: *Cladium mariscoides, Scirpus pungens, Euthamia tenuifolia, Juncus scirpoides, J. canadensis, Andropogon glomeratus* (bushy broomsedge), *Panicum scoparium* (velvet panic grass), *P. virgatum* (switch grass), *Prosperpinaca palustris, Lycopus virginicus* (Virginia bugleweed), *Hypericum mutilum* (dwarf St. Johns-wort), *Viola lanceolata* (lanceleaf violet), *Osmunda regalis* (royal fern), *Triadenum virginicum* (marsh St. Johns-wort), *Spartina patens,* and *Rhynchospora capitellata* (small headed beak-rush). Rare plant species identified from this community type were: *Bidens coronata* (S2), *Centella erecta* (S2), *Fuirena squarrosa* (S3), *Panicum roanokense* (S2), *Rhynchospora gracilenta* (S2) and *Vaccinium macrocarpon* (S3). These three sites have been identified by NWI, and have been mapped as scrub-shrub, broad-leaved evergreen/needle-leaved evergreen, temporarily flooded (PSS3/4A).

3) *Cladium mariscoides-Eryngium aquaticum* interdunal wetland association.

Only one site was identified for this community type; located on the Bethany Beach quadrangle, west of Rt. 1 (Fig 6, Appendix B). This site, which still lies within the ridge and swale topography of the Atlantic coast and is only interrupted by highway Rt. 1, is situated within a sandy, pitch pine (*Pinus rigida*) woodland of high quality. This wetland is an open depression, that is more concave than the typical *Juncus scirpoides-Scirpus pungens* variant. In addition to the dominant species of *Cladium mariscoides* and *Eryngium aquaticum*, the following associates are also found: *Juncus canadensis, Rhynchospora chalarocephala* (a beak-rush), *Drosera intermedia, Lycopus* sp., *Hypericum* sp., *Thelypteris palustris* (marsh fern), *Hibiscus moscheutos, Viola lanceolata, Myrica cerifera, Toxicodendron radicans* and *Rosa palustris*. Rare plant species identified included: *Eryngium aquaticum* (S2), *Sabatia campanulata* (S1), *Rhynchospora gracilenta* (S2), *Panicum roanokense* (S2) and *Pluchea foetida* (SU). This site has not been identified or mapped by NWI.

4) *Vaccinium macrocarpon-Mixed Orchid/Sphagnum* interdunal wetland association.

This interdunal wetland variant, the only one identified of its kind during this survey, is a rather small (ca 10x12 meters) site, and is located on the Cape Henlopen quadrangle within Cape Henlopen State Park (Fig. 3, Appendix B). A dense carpet of sphagnum moss and a variety of rare orchids are found; cranberry is also a common associate at this site. The rare orchids found here are: *Platanthera blephariglottis* (S1), *Calopogon tuberosus* (S1), and *Pogonia ophioglossoides* (S2). This site may have been much larger in the past; sand movement and woody plant establishment appear to have constricted the size of this wetland. A review of early aerial photographs may confirm this. This site has been mapped by NWI as emergent, narrow-leaved persistent, seasonally flooded (PEM5C).

5) *Emergent, mixed sedge/mixed scrub-shrub-mixed herbaceous peatmats* interdunal wetland association.

This site, located on the Cape Henlopen quadrangle, within Cape Henlopen State Park (Fig. 3, Appendix B), is one of the more unique wetland variants identified. The site is relatively large in area (up to one acre), is bordered by palustrine forest and dry dunes, appears to have a permanently flooded to semi-permanently flooded water regime, and has an unusual occurrence of floating peatmats on its perimeter. Data from previous field seasons (1991-92), as well as multiple visits in 1993, indicate flooded conditions year round, although surface water levels do appear to drop through the dry summer. Growing from the wetlands bottom substrate, and in standing water, are found such plants as *Cladium mariscoides, Juncus canadensis,* and *Nymphaea odorata* (fragrant waterlily). Rare plants of standing water include *Rhynchospora scirpoides* (S2), *Eleocharis quadrangulata* (S3), and *E. robbinsii* (S3). Floating mats of organic matter, or peat are found on the wetlands perimeter, which contain a mixture of scrub-shrub and herbaceous vegetation. Scrub-shrub vegetation includes *Acer rubrum, Cephalanthus occidentalis* (buttonbush), and *Decodon verticillatus* (water willow). Herbaceous plants found are *Eleocharis olivacea* (spike-rush), *Rhynchospora macrostachya* (horned rush), *R. chalarocephala* (a beak-rush), *Drosera intermedia, Sphagnum* sp., *Xyris difformis* var. *difformis*, and *Hydrocotyle umbellata* (pennywort). Rare plant species found growing on the floating peatmats include *Fuirena pumila* (S2), *Juncus pelocarpus* (S3), *Rhynchospora alba* (S3), *Hypericum boreale* (S1), *Vaccinium macrocarpon* (S3), and *Panicum roanokense* (S1). On the wetlands northern edge, an advancing sand dune is creeping into the site. A small stand of *Phragmites australis* has become established on this dune and control will be needed. NWI maps this wetland as a palustrine forested, broad-leaved deciduous wetland (PFO1C). This wetland, as delineated by Greenhorne and O'Mara Inc. (1991), is mapped as an interdunal wetland with a water regime of

intermittently exposed (HASG). Review of the DNHI database files, revealed that there are 3 similar sites immediately east of the above referenced site. Site survey summaries describe ditches leading from all three sites, and woody vegetation and *Phragmites australis* are established in all. Due to lack of time, these sites were not field checked.

WILDLIFE

Interdunal wetlands provide habitat and serve as a source of freshwater for animal species associated with coastal dune ecosystems. Brief zoological inventories have recorded frequent occurrences of the southern leopard frog (*Rana utricularia*) and the Fowler's toad (*Bufo woodhousii* var. *fowleri*) utilizing interdunal wetlands. A suite of damselfly and dragonfly species have also been collected: forktail damselfly (*Ischnura ramburi*), saltmarsh dragonfly (*Erthrodiplax berenice*), common green darner dragonfly (*Anax junius*), and the red saddlebag dragonfly (*Tramea carolina*). A variety of birds, which utilize coastal dune systems to feed and nest, were observed drinking from interdunal wetlands (terns, swallows, common night hawks, oyster catchers and shore birds). Interdunal wetlands may also be used by migrating waterfowl. Small depressions, void of vegetation, found within interdunal wetlands were noted in a few sites sampled. This observation suggests rooting by waterfowl for underground plant rhizomes and tubers. Deer and rabbit tracks have also been noted in the moist sand of interdunal wetlands, an indication that these species are using the wetlands as a source for freshwater. More zoological inventory work is certainly needed in interdunal wetlands to assess the full extent of wildlife use.

THREATS

Threats to fragile dune ecosystems are many, but one that has caused the greatest amount of habitat loss is development. Delaware's Atlantic coast is a popular and attractive area to live, and the leveling of dunes for homes has been, and continues to be, the major threat to intact natural dune systems.

Hydrologic studies have shown that excessive ground water pumping can result in serious negative impacts to interdunal wetlands (Whittecar and Emery 1992). Large groundwater withdrawal from aquifers connected to interdunal wetland systems will cause these wetlands to gradually dry-out, or become saline if brackish water intrudes into the freshwater lens (Odum and Harvey 1988, Whittecar and Emery 1992).

Ditching, and attempts at draining interdunal wetlands is another serious threat to their ecological integrity. Parallel ditches were found at each of the three *scrub-shrub/mixed herbaceous* community

variants on the Bethany Beach quadrangle. It is difficult to determine from only one year of study what impacts may have resulted from ditching, but negative impacts to hydrology have likely occurred.

The construction of dune crossings, from parking areas to the beach, have been documented as a real threat to interdunal wetlands. A pedestrian crossing at Cape Henlopen State Park was discovered to be bisecting through the center of an interdunal wetland. Fortunately, with the help of park personnel, the crossing was rerouted to eliminate impacts. Mapping of Delaware's Category I coastal dune wetlands is critical, so that agencies involved in beach and dune activities can be made aware of their locations.

Dune restoration is also a potential threat to interdunal wetlands. Depending on the location, dune ridges breached or destroyed during severe storms are often rebuilt. If bulldozers are used in restoration efforts, there is high potential for severe disturbance to interdunal wetlands. Again, this is clearly another example of why the mapping of interdunal Category I wetlands is important.

A series of interdunal wetlands found on the Rehoboth Beach quadrangle, were modified by the Delaware Division of Fish and Wildlife, Mosquito Control during the years of 1980 and 1981 (Saveikis pers. comm. 1994). As part of Mosquito Controls Open Marsh Water Management (OMWM), existing interdunal wetlands were dredged deeper (ca 2-2.5ft.) to create perennial "ponds" for mosquito eating fish to reside in. Shallow, blind ditches leading from these wetlands were also constructed, to allow fish to swim up them and devour mosquitos; these activities have changed the ecology and community structure of the wetlands involved. Some levels of standing water are usually found year round now, and weedy taxa have become established. Overall plant diversity is lower within these wetlands and *Phragmites australis* has invaded several of them. The salt tolerant plant species *Spartina patens, Eleocharis parvula* and *Distichlis spicata* have also been found in a few sites sampled. This may indicate possible brackish water intrusion into the freshwater lens due to dredging. Although modification and disturbance has taken place within these wetlands, they should still be considered and mapped as Category I wetlands, although OMWM practices within interdunal wetlands should be discontinued. Category I consideration is still given, because of their physiographic position on the landscape (i.e. Atlantic coastal ridge and swale topography), they continue to function as interdunal wetlands (i.e. groundwater recharge, habitat for wildlife), many still contain some of the characteristic signature plant species, as well as state rare species, which include *Fuirena pumila* (S2) and *Utricularia subulata* (S2). The possibility also remains that natural, dynamic processes involved in the formation and serial stages of succession of interdunal wetlands will "naturally restore" these sites. Wetlands that have been disturbed by OMWM practices are lumped into the *Juncus scirpoides-Scirpus*

pungens community variant. Undisturbed examples of this community type are still found within the area, and OMWM sites were likely of this wetland type before modification. These wetlands can be identified and located on aerial photographs by their relatively regular shape, and by the straight, blind ditches which radiate from them.

The invasion and establishment of the aggressive plant species *Phragmites australis* is also a serious threat to interdunal wetlands. Several wetlands sampled either contained some degree of infestation, or were completely dominated by *P. australis*. Invasion of *P. australis* usually follows a disturbance, such as dredging and filling, or artificial changes to the groundwater table, usually from withdrawal from the aquifer. *P. australis* will also find favorable conditions for establishment if an increase in salinity levels of a wetland occurs. As mentioned above, excessive groundwater pumping can lead to brackish water intrusion. Control measures such as chemical treatment or burning should be applied to any interdunal wetland found to be infested with *P. australis*.

JUSTIFICATION FOR CATEGORY I RANKING

As presented here, there are many reasons to justify the designation of interdunal wetlands in Delaware as Category I.

Interdunal wetlands may be relatively common when considering their overall, regional distribution (Massachusetts to Florida), but like all coastal and barrier island natural communities, they are limited in their local extent (Shafale and Weakley 1990). In Delaware, interdunal wetlands have a very narrow and local county distribution (limited to the Atlantic coastal strand and barrier islands of Sussex County, Cape Henlopen south to the DE-MD state line).

Interdunal wetlands are situated within the geologically unique ridge and swale topography of the fragile Atlantic coast.

Complex, dynamic natural processes work to form and create interdunal wetlands, and are an integral part of coastal dune ecosystems.

Interdunal wetlands are significant, in that they are primarily groundwater driven, and community structure is a function of groundwater level fluctuations.

Interdunal wetlands are unique, in that they are freshwater, non-tidal wetland systems, that are geographically bordered by tidal, saline wetland systems.

Interdunal wetlands in Delaware harbor numerous state rare plant species; 23 plant species considered to be rare by DNHI have been

identified: five ranked as S1, extremely rare; eleven ranked as S2, very rare; six ranked as S3, rare to uncommon; and one ranked as SU, status uncertain.

Interdunal wetlands in Delaware contain a unique assemblage of characteristic "signature" plant species. An assemblage that may be restricted to interdunal wetlands in the State.

Interdunal wetlands at the community level are variable, but their variation is distinct. Five community variants have been recognized and two could be considered rare in the state, with only a single occurrence for both.

Interdunal wetlands provide habitat and serve as a source of freshwater for animal species associated with coastal dune systems.

Interdunal wetlands in Delaware are vulnerable to a number of defined threats, which are listed in detail above.

CATEGORY I MAPPING CRITERIA

Maps provided in Appendix B will direct aerial interpreters to known, field documented interdunal wetlands, so that a "signature" can be developed for identification. Symbols designating interdunal wetlands found on site maps are only an approximation of their location and are not meant to be their exact location.

When a signature for interdunal wetlands has been determined, any area identified with such a signature, that is found within the Atlantic interdunal ecosystem from Cape Henlopen, south to the DE-MD state line, should be mapped as Category I.

The Atlantic coastal interdunal ecosystem in Delaware, is here defined as: an area approximately 0.5 mile inland, behind primary dune ridges of the Atlantic coastal region, from Cape Henlopen south to the DE-MD state line. However, there are active dune areas (vegetated and unvegetated) beyond the ca 0.5 mile boundary on the Cape Henlopen quadrangle, where interdunal wetlands have been identified (Fig. 3, Appendix B). This area is also considered to be within the Atlantic coastal interdunal ecosystem.

The Delaware highway Rt. 1 only artificially interrupts the interdunal system and does not delineate a boundary; interdunal wetlands have been identified west of Rt. 1.

Interdunal wetlands appear as dark, glossy spots on aerial photographs that can sometimes be difficult to distinguish from island clumps of scrub-shrub vegetation. Interdunal wetlands that are surrounded by woody vegetation may also be difficult to identify.

Aerial interpreters must be aware that some interdunal wetlands may be dominated by *Phragmites australis,* which may present problems in identification.

Wetlands that have been modified by OMWM practices (see above discussion under Threats) can be identified and located on aerial photographs by their relatively regular shape, and by the straight, blind ditches which radiate from them.

The mapping of interdunal wetlands should be a dynamic process of updating (i.e. adding and deleting), just as the interdunal wetland is a dynamic system in itself. The discussion found above dealing with the dynamics and succession of interdunal wetlands should be seriously considered. Unvegetated, or sparsely vegetated moist areas, may be missed by aerial interpreters (as well as by field investigators), but they may be interdunal wetlands in very early stages of formation. Conversely, interdunal wetlands initially mapped as Category I, may disappear due to natural disturbance processes.

It is recommended that field verification of interdunal wetlands be done before the mapping process is completed. As implied above, potential exists for misidentification during aerial interpretation. The community classifications, descriptions, and list of characteristic signature plant species described within, should be used as guidelines for field determinations.

It has been found, in the field, that specific areas possessing an interdunal wetland photographic signature (i.e. flooded conditions), may lack or even be completely devoid of characteristic interdunal wetland vegetation. These areas would likely not meet jurisdictional criteria as a wetland (since wetland vegetation is not present) and should not be mapped as a Category I wetland at this time. However, as recommended above, aerial interpretation and future ground verification, may find that sites such as these have succeeded to mature interdunal wetlands and should then be mapped accordingly.

It is also recommended that before wetland maps are made public, the DNHI should be given the opportunity to refine Category I boundaries, or to include known sites that may have been missed through aerial interpretation.

A freshwater wetlands map of an area of the Cape Henlopen quadrangle (produced by Greenhorne and O'Mara Inc., 1991), identifies many of the interdunal wetlands located in this area during this survey, as well as from previous surveys. However, many were misidentified, or were missed entirely. This is likely due to the fact that a community description for interdunal wetlands was not yet developed, and mapping criteria had also not been determined.

LITERATURE CITED AND RELATED SCIENTIFIC REFERENCES

Breden, T.F. 1989 A preliminary natural community classification for New Jersey. New Jersey's rare and Endangered Plants and Animals. E.F. Karlin, editor. Institute for Environmental Studies, Ramapo College, Mahwah, NJ. 280 pp.

Brown M.L. and R.G. Brown. 1984. Herbaceous plants of Maryland. University of Maryland, College Park, Maryland.

Clemants, S.E. 1990. Juncaceae (Rush Family) of New York State. Contributions to a Flora of New York State VII, R. Mitchell, Editor. Bulletin No. 475. New York State Museum, Albany, New York.

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, Biological Services Program. FWS/OBS-79/31, 103 pp.

Delaware Natural Heritage Inventory database. 1988-1992.

Gleason, H.A. 1952. The new Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. Vol. I-III. Hafner Press, New York.

Gleason, H.A. and A. Cronquist. 1991. Manual of vascular plants of the Northeast and adjacent Canada, second edition. The New York Botanical Garden, New York.

Greenhorne and O'Mara. 1991. State of Delaware Freshwater Wetlands Inventory Pilot Project. Prepared for Delaware Department of Natural Resources and Environmental Control, Dover, DE.

Godfrey, R.K. and J.W. Wooten. 1979. Aquatic and wetland plants of the Southeastern United States, monocotyledons. The University of Georgia Press, Athens, Georgia.

Jones, H.A. 1992. A vegetational analysis of interdunal swale communities of False Cape State Park, Currituck Spit, Virginia. Masters Thesis. The College of William and Mary, Virginia.

Kelly, A.P. 1925. Soil water of the New Jersey coast. Ecology 6(2):143-149.

Kearney, T.H. 1904. Are plants of sea beaches and dunes true halophytes?. Botanical Gazette June:424-436.

Martin, W.E. 1958. The vegetation of Island Beach State Park, New Jersey. Ecological Monographs 29(1):1-46.

National Wetland Inventory Maps. 1977, 1981. 1:24,000. U.S. Fish and Wildlife Service, Washington, D.C.

Odum, W.E. and J.W. Harvey. 1988. Barrier island interdunal freshwater wetlands. ASB Bulletin 35(4):149-155.

Oosting, H.J., and W.D. Billings. 1942. Factors affecting vegetational zonation on coastal dunes. Ecology 23:131-142.

Ranwell, D. 1959. Newborough Warren, Anglesey. I. The dune system and dune slack habitat. Ecology 47:571-601.

Ranwell, D. 1960. Newborough Warren, Anglesey. II. Plant associes and succession cycles of the sand dune and dune slack vegetation. Ecology 48:117-141.

Reed, P.B. 1988. National list of plant species that occur in wetlands: Northeast (Region 1). U.S. Fish and Wildlife Service, Washington, D.C.

Reschke, C. 1990. Ecological communities of New York State. New York Natural Heritage Inventory Program. New York State Department of Environmental Conservation. Latham, New York.

Schafale, M. P. and A.S. Weakley. 1990. A classification of natural communities of North Carolina, 3rd Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation. North Carolina Department of Environment, Health, and Natural Resources.

Seliskar, D.M. 1986. Waterlogging and sand deposition in dune slack vegetation: plant morphology and ethylene production. Doctoral Thesis. University of Delaware, College of Marine Studies, Lewes, Delaware.

Snow, L.M. 1902. Some notes on the ecology of the Delaware coast. The Bot. Gaz. 34:284-306.

Stetzar, E.J. and L.A. Gelvin-Innvaer. 1992. Delaware bog turtle project, 1992 progress report. Nongame and Endangered Species Program, Division of Fish and Wildlife, DNREC, Dover, Delaware.

Tiner, R.W. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service, Region 5. Delaware Department of Natural Resources and Environmental Control, Dover, Delaware.

Tyndall, R. W. and G.F. Levy. 1978. Plant distribution and succession within interdunal depressions on a Virginia barrier dune system. J. Elisha Mitchell Scientific Society 49(1):1-15.

USDA Soil Conservation Service, Soil Survey, Sussex County, Delaware. 1974. Washington, D.C.

U.S.G.S. Topographical Maps, 1:24,000. Cape Henlopen (1984), Rehoboth Beach (1984), Bethany Beach (1984), Assawoman Bay (1967, photorevised 1981).

Whittecar, R.G. and J.S. Emery. 1992. Hydrogeology of a regressive barrier island segment, Bodie Island, North Carolina. Barrier Island Ecology of the Mid-Atlantic coast: A Symposium. National Park Service, Southeast Regional Office, Atlanta Georgia.

APPENDIX A

PLANT SPECIES ASSOCIATED WITH INTERDUNAL WETLANDS OF DELAWARE'S ATLANTIC COAST

PLANT SPECIES ASSOCIATED WITH INTERDUNAL WETLANDS OF DELAWARE'S ATLANTIC COAST 1993

This list is not meant to be comprehensive; further inventory work may result in additional species being added. This list is composed of **37** families of vascular plants (including **4** pteridophytes and **1** gymnosperm), **71** genera (including **3** mosses), **108** species (including **3** mosses), and **3** varieties. Herbaceous taxa includes **95** species and **3** varieties, and woody taxa comprise **15** species. Nomenclature generally follows Gleason and Cronquist's (1991) *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. Where this differs from the treatment in Gleason and Cronquist, the name used in that work is indicated in parentheses (see state ranking and frequency class criteria below).

Scientific Name	Common Name	State Rank	Frequency
Herbaceous Taxa:			
Ambrosia artemisifolia	rag-weed	S5	1
Ammophila breviligulata	American beach grass	S5	1
Andropogon glomeratus (*virginicus* var. *abbreviatus*)	bushy broom-sedge grass	S5	1
Andropogon virginicus	broom-sedge grass	S5	3
Bidens coronata	tickseed sunflower	S2	1
Calopogon tuberosus	grass-pink orchid	S1	1
Campylium sp.	a moss	?	1
Carex canescens	a sedge	S4	1
Carex longii	Long's sedge	S1	1
Centella erecta	erect coinleaf	S2	1
Cladium mariscoides	twig-rush	S4	3
Cyperus filicinus	nut-sedge	S4	1
Decodon verticillatus	water willow	S5	1
Diodia virginiana	virginia buttonweed	S4	1
Distichlis spicata	seashore salt-grass	S5	1
Drosera intermedia	sundew	S5	3
Dulichium arundinaceum	a sedge	S5	1
Echinochloa walterii	Walter's millet	S5	1
Eleocharis olivacea (*flavescens* var. *olivacea*)	spike-rush	S5	2
Eleocharis palustris	spike-rush	S5	1
Eleocharis parvula	saltmarsh spike-rush	S5	1
Eleocharis quadrangulata	four square sedge	S3	1
Eleocharis robbinsii	Robbin's spike-rush	S3	1
Eleocharis tuberculosa	tuberculed spike-rush	S4	1
Erianthus giganteus	giant plume-grass	S5	1
Eryngium aquaticum	button snakeroot	S2	1
Eupatorium hyssopifolium	hyssop-leaf thorough-wort	S5	1
Eupatorium leucolepis	white-bract thorough-wort	S4	3
Eupatorium rotundifolium	round-leaf thorough-wort	S5	1
Eupatorium rotundifolium var. *ovatum*	hairy thorough-wort	S5	1
Euthamia tenuifolia	slender fragrant goldenrod	S5	3
Fimbristylis autumnalis	fall fimbry	S5	1
Fimbristylis castanea	salt-marsh fimbry	S5	1
Fuirena pumila	small umbrella grass	S2	1
Fuirena squarrosa	umbrella grass	S3	1
Hibiscus moscheutos	marsh mallow	S5	1
Hydrocotyle umbellata	pennywort	S5	1
Hypericum boreale	northern St. Johnswort	S1	1
Hypericum canadense	Canada St. Johnswort	S5	2
Hypericum mutilum	dwarf St. Johnswort	S5	2
Hypericum stans	St. Peterswort	S4	1
Juncus acuminatus	sharp-fruited rush	S5	1
Juncus biflorus	grass-leaf rush	S4	3
Juncus canadensis	Canada rush	S5	3

Juncus dichotomus (*tenuis* var. *dichotomus*)	forked rush	S5	3
Juncus effusus	smooth rush	S5	1
Juncus pelocarpus	brown fruited rush	S3	1
Juncus scirpoides	sedge rush	S5	4
Leersia oryzoides	rice cut-grass	S5	1
Lindernia dubia var. *anagallidea*	slender false pimpernel	S4	1
Ludwigia alternifolia	common seedbox	S5	1
Ludwigia palustris	water purslane	S5	1
Lycopodium appressum	southern bog-clubmoss	S4	3
Lycopus virginicus	Virginia bugleweed	S5	1
Lysimachia terrestris	swamp candles	S4	1
Mikania scandens	climbing hempweed	S5	1
Nymphaea odorata	fragrant waterlily	S5	1
Osmunda regalis	royal fern	S5	2
Panicum longifolium	panic grass	S4	1
Panicum scoparium	velvet panic grass	S5	2
Panicm verrucosum	panic grass	S5	1
Panicum virgatum	switch grass	S5	2
Panicum roanokense (*dichotomum*)	panic grass	S2	1
Phragmites australis	common reed	S5	3
Platanthera blephariglottis	white-fringe orchis	S1	1
Pluchea foetida	marsh flea-bane	SU	2
Pluchea odorata	saltmarsh flea-bane	S5	2
Pogonia ophioglossoides	rose pogonia	S2	1
Polygonum caespitosum	long-bristled smart-weed	S5E	1
Polygonum hydropiperoides	mild water-pepper	S5	1
Polytrichum sp.	a moss	?	2
Proserpinaca palustris	mermaid weed	S5	2
Rhexia virginica	meadow beauty	S5	2
Rhynchospora alba	white-bract beak-rush	S3	1
Rhynchospora chalarocephala	a beak-rush	S4	1
Rhynchospora capitellata	small headed beak-rush	S5	2
Rhynchospora gracilenta	slender beak-rush	S2	1
Rhynchospora macrostachya	horned rush	S4	1
Rhynchospora scirpoides	long-beaked bald-rush	S2	1
Sabatia campanulata	slender marsh pink	S1	1
Scirpus cyperinus	wool grass sedge	S5	1
Scirpus pungens	three square sedge	S5	4
Solidago fistulosa	pine-barren goldenrod	S5	2
Solidago sempervirens	sea-side goldenrod	S5	2
Sphagnum sp.	sphagnum moss	?	3
Spartina patens	salt hay	S5	2
Spiranthes cernuua	nodding ladies-tresses	S4	1
Spiranthes vernalis	spring ladies-tresses	S2	1
Thelypteris palustris	marsh fern	S5	1
Triadenum virginicum	marsh St. Johns-wort	S5	2
Utricularia geminiscapa	hidden-fruit bladderwort	S2	1
Utricularia subulata	zig-zag bladderwort	S2	2
Viola lanceolata	lanceleaf violet	S5	2
Woodwardia virginica	Virginia chain-fern	S5	1
Xyris difformis var. *difformis*	yellow-eyed grass	S4	3
Xyris torta	slender yellow-eyed grass	S2	1

<u>Woody Taxa</u>:

Acer rubrum	red maple	S5	2
Aronia arbutifolia	chokeberry	S5	1
Baccharis halimifolia	high-tide bush	S5	1
Cephalanthus occidentalis	buttonbush	S5	1
Decodon verticillatus	water willow	S5	1
Ilex glabra	inkberry	S5	1
Liquidambar styraciflua	sweetgum	S5	1

Myrica cerifera	bayberry	S5	2
Pinus rigida	pitch pine	S4	1
Prunus serotina	black cherry	S5	1
Rhus copallina	winged sumac	S5	2
Rosa palustris	swamp rose	S5	1
Toxicodendron radicans	poison ivy	S5	1
Vaccinium corymbosum	highbush blueberry	S5	2
Vaccinium macrocarpon	cranberry	S3	3

Frequency Class: (based on 40 survey sites)

1 (1-5 occurrences, rare)
2 (6-13 occurrences, infrequent)
3 (14-26 occurrences, frequent)
4 (27-40 occurrences, common)

State Ranking Criteria:

S1 Extremely rare; typically 5 or fewer known occurrences in the state; or only a few remaining individuals; may be especially vulnerable to extirpation.

S2 Very rare; typically between 6 and 20 known occurrences; may be susceptible to becoming extirpated.

S3 Rare to uncommon; typically 21 to 50 known occurrences; S3 ranked species are not yet susceptible to becoming extirpated in the state, but may be if additional populations are destroyed.

S4 Common; apparently secure under present conditions; typically 51 or more known occurrences, but may be fewer with many large populations; usually not susceptible to immediate threats.

S5 Very common; demonstrably secure under present conditions.

SU Status uncertain; an uncommon species, but data is inadequate to determine rarity.

E Exotic in the state, not a part of the native flora.

WETLAND INDICATOR STATUS OF PLANT SPECIES ASSOCIATED WITH INTERDUNAL WETLANDS OF DELAWARE'S ATLANTIC COAST
(based on National List of Wetland Plants, Reed 1988)

Scientific Name	Common Name	Wetland Indicator Status
Herbaceous Taxa:		
Ambrosia artemisifolia	rag-weed	FACU
Ammophila breviligulata	American beach grass	FACU
Andropogon glomeratus (*virginicus* var. *abbreviatus*)	bushy broom-sedge grass	FACW+
Andropogon virginicus	broom-sedge grass	FACU
Bidens coronata	tickseed sunflower	OBL
Calopogon tuberosus	grass-pink orchid	FACW+
Campylium sp.	a moss	NOT LISTED
Carex canescens	a sedge	OBL
Carex longii	Long's sedge	OBL
Centella erecta	erect coinleaf	FACW
Cladium mariscoides	twig-rush	OBL
Cyperus filicinus	nut-sedge	OBL
Decodon verticillatus	water willow	OBL
Diodia virginiana	virginia buttonweed	FAC
Distichlis spicata	seashore salt-grass	FACW
Drosera intermedia	sundew	OBL
Dulichium arundinaceum	a sedge	OBL
Echinochloa walterii	Walter's millet	FACW
Eleocharis olivacea (*flavescens* var. *olivacea*)	spike-rush	OBL
Eleocharis palustris	spike-rush	OBL
Eleocharis parvula	saltmarsh spike-rush	OBL
Eleocharis quadrangulata	four square sedge	OBL
Eleocharis robbinsii	Robbin's spike-rush	OBL
Eleocharis tuberculosa	tuberculed spike-rush	OBL
Erianthus giganteus	giant plume-grass	FACW+
Eryngium aquaticum	button snakeroot	OBL
Eupatorium hyssopifolium	hyssop-leaf thorough-wort	NOT LISTED
Eupatorium leucolepis	white-bract thorough-wort	FACW+
Eupatorium rotundifolium	round-leaf thorough-wort	FAC-
Eupatorium rotundifolium var. *ovatum*	hairy thorough-wort	NOT LISTED
Euthamia tenuifolia	slender fragrant goldenrod	NOT LISTED
Fimbristylis autumnalis	fall fimbry	FACW+
Fimbristylis castanea	salt-marsh fimbry	OBL
Fuirena pumila	small umbrella grass	OBL
Fuirena squarrosa	umbrella grass	OBL
Hibiscus moscheutos	marsh mallow	OBL
Hydrocotyle umbellata	pennywort	OBL
Hypericum boreale	northern St. Johnswort	OBL
Hypericum canadense	Canada St. Johnswort	FACW
Hypericum mutilum	dwarf St. Johnswort	FACW
Hypericum stans	St. Peterswort	FACU
Juncus acuminatus	sharp-fruited rush	OBL
Juncus biflorus	grass-leaf rush	FACW
Juncus canadensis	Canada rush	OBL
Juncus dichotomus (*tenuis* var. *dichotomus*)	forked rush	FACW
Juncus effusus	smooth rush	FACW+
Juncus pelocarpus	brown fruited rush	OBL
Juncus scirpoides	sedge rush	FACW
Leersia oryzoides	rice cut-grass	OBL
Lindernia dubia var. *anagallidea*	slender false pimpernel	OBL

Ludwigia alternifolia	common seedbox	FACW+
Ludwigia palustris	water purslane	OBL
Lycopodium appressum	southern bog-clubmoss	FACW+
Lycopus virginicus	Virginia bugleweed	OBL
Lysimachia terrestris	swamp candles	OBL
Mikania scandens	climbing hempweed	FACW+
Nymphaea odorata	fragrant waterlily	OBL
Osmunda regalis	royal fern	OBL
Panicum longifolium	panic grass	OBL
Panicum scoparium	velvet panic grass	FACW
Panicm verrucosum	panic grass	FACW
Panicum virgatum	switch grass	FAC
Panicum roanokense (dichotomum)	panic grass	FAC
Phragmites australis	common reed	FACW
Platanthera blephariglottis	white-fringe orchis	NOT LISTED
Pluchea foetida	marsh flea-bane	OBL
Pluchea odorata	saltmarsh flea-bane	NOT LISTED
Pogonia ophioglossoides	rose pogonia	OBL
Polygonum caespitosum	long-bristled smart-weed	FACU-
Polygonum hydropiperoides	mild water-pepper	OBL
Polytrichum sp.	a moss	NOT LISTED
Proserpinaca palustris	mermaid weed	OBL
Rhexia virginica	meadow beauty	OBL
Rhynchospora alba	white-bract beak-rush	OBL
Rhynchospora chalarocephala	a beak-rush	OBL
Rhynchospora capitellata	small headed beak-rush	OBL
Rhynchospora gracilenta	slender beak-rush	OBL
Rhynchospora macrostachya	horned rush	OBL
Rhynchospora scirpoides	long-beaked bald-rush	OBL
Sabatia campanulata	slender marsh pink	FACW
Scirpus cyperinus	wool grass sedge	FACW+
Scirpus pungens	three square sedge	OBL
Solidago fistulosa	pine-barren goldenrod	FACW
Solidago sempervirens	sea-side goldenrod	FACW
Sphagnum sp.	sphagnum moss	NOT LISTED
Spartina patens	salt hay	FACW+
Spiranthes cernuua	nodding ladies-tresses	FACW
Spiranthes vernalis	spring ladies-tresses	FAC
Thelypteris palustris	marsh fern	NOT LISTED
Triadenum virginicum	marsh St. Johns-wort	OBL
Utricularia geminiscapa	hidden-fruit bladderwort	OBL
Utricularia subulata	zig-zag bladderwort	OBL
Viola lanceolata	lanceleaf violet	OBL
Woodwardia virginica	Virginia chain-fern	OBL
Xyris difformis var. *difformis*	yellow-eyed grass	OBL
Xyris torta	slender yellow-eyed grass	OBL

<u>Woody Taxa:</u>

Acer rubrum	red maple	FAC
Aronia arbutifolia	chokeberry	FACW
Baccharis halimifolia	high-tide bush	FAC-
Cephalanthus occidentalis	buttonbush	OBL
Decodon verticillatus	water willow	OBL
Ilex glabra	inkberry	FACW-
Liquidambar styraciflua	sweetgum	FAC
Myrica cerifera	bayberry	FAC
Pinus rigida	pitch pine	FACU
Prunus serotina	black cherry	FACU
Rhus copallina	winged sumac	UPL
Rosa palustris	swamp rose	OBL
Toxicodendron radicans	poison ivy	FAC
Vaccinium corymbosum	highbush blueberry	FACW-
Vaccinium macrocarpon	cranberry	OBL

APPENDIX B

FIGURES

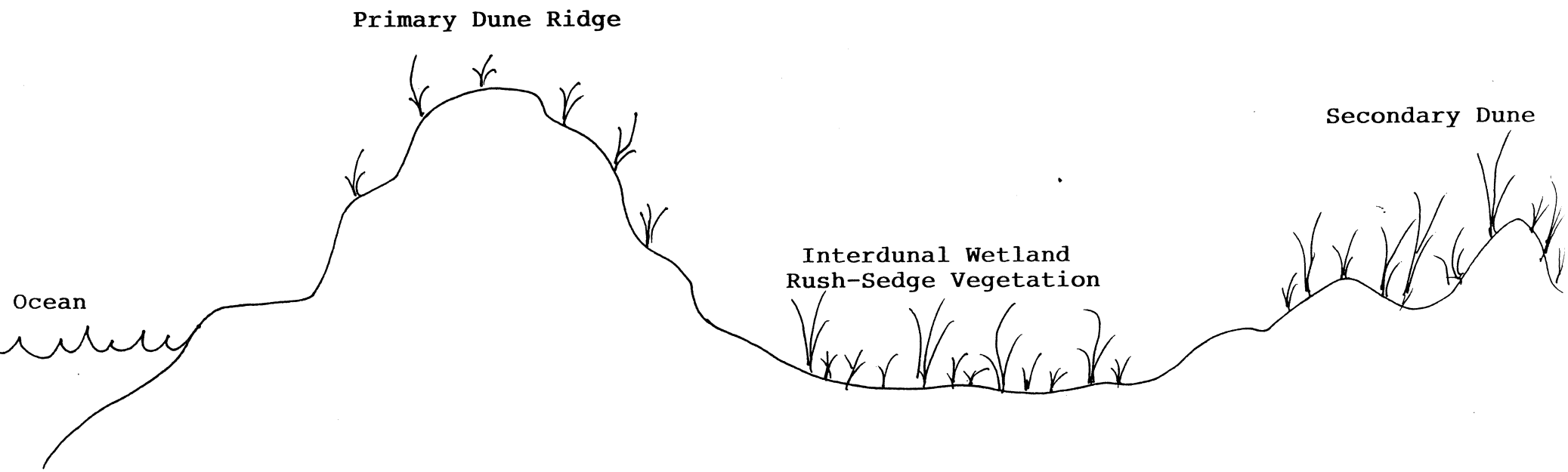

Figure 1: profile of a typcal iterdunal wetland in Delaware

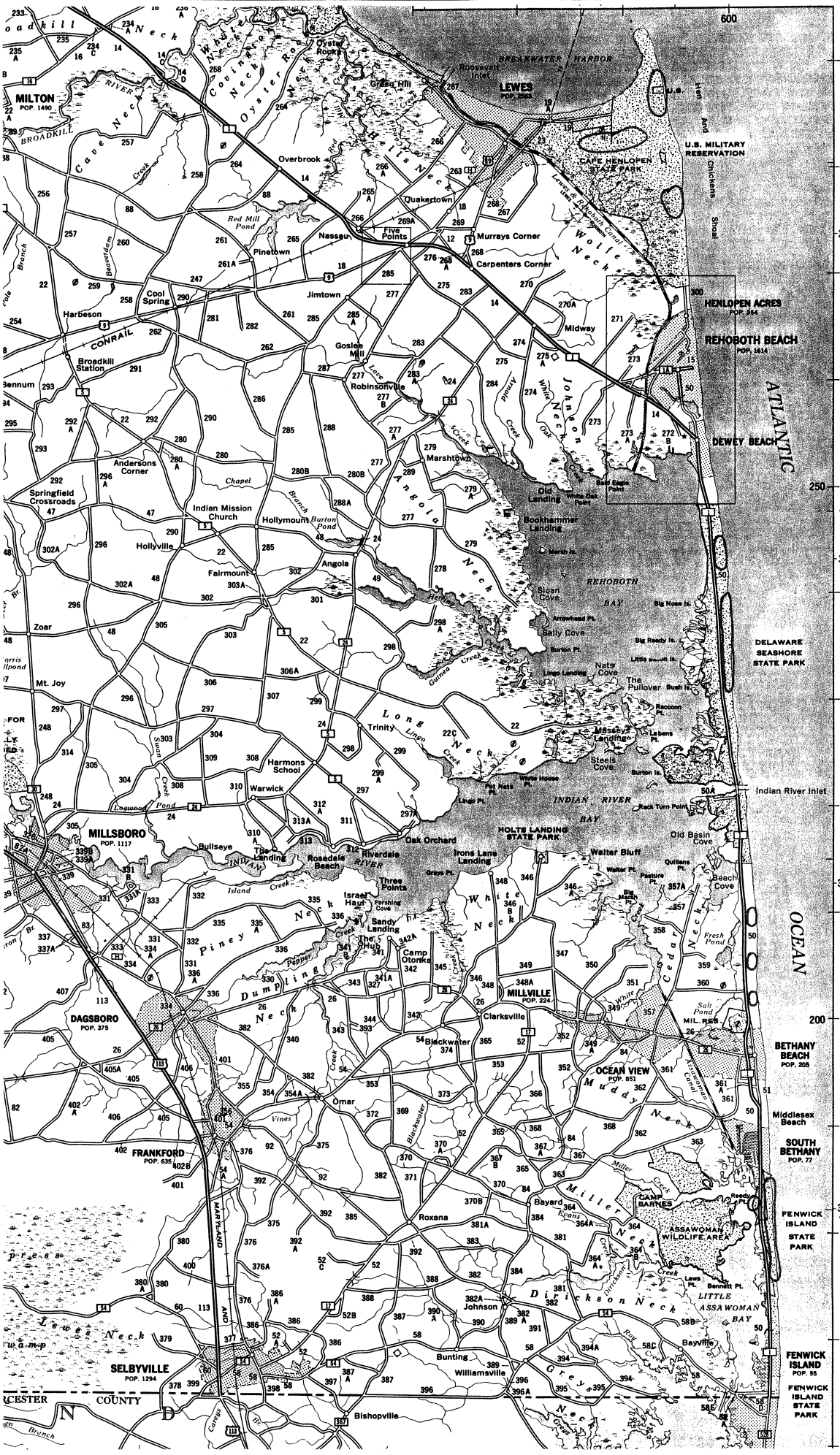

Figure 2: General, overall known distribution of interdunal wetlands in Delaware, 1993.

MAP LEGEND
(natural community variants)

● - *Juncus scirpoides-Scirpus pungens* association

■ - *Scrub-shrub/mixed herbaceous* association

▼ - *Cladium mariscoides-Eryngium aquaticum* association

⬣ - *Mixed orchid/Sphagnum-Vaccinium marcrocarpon* association

▲ - *Emergent, mixed sedge/mixed scrub-shrub-mixed herbaceous* association

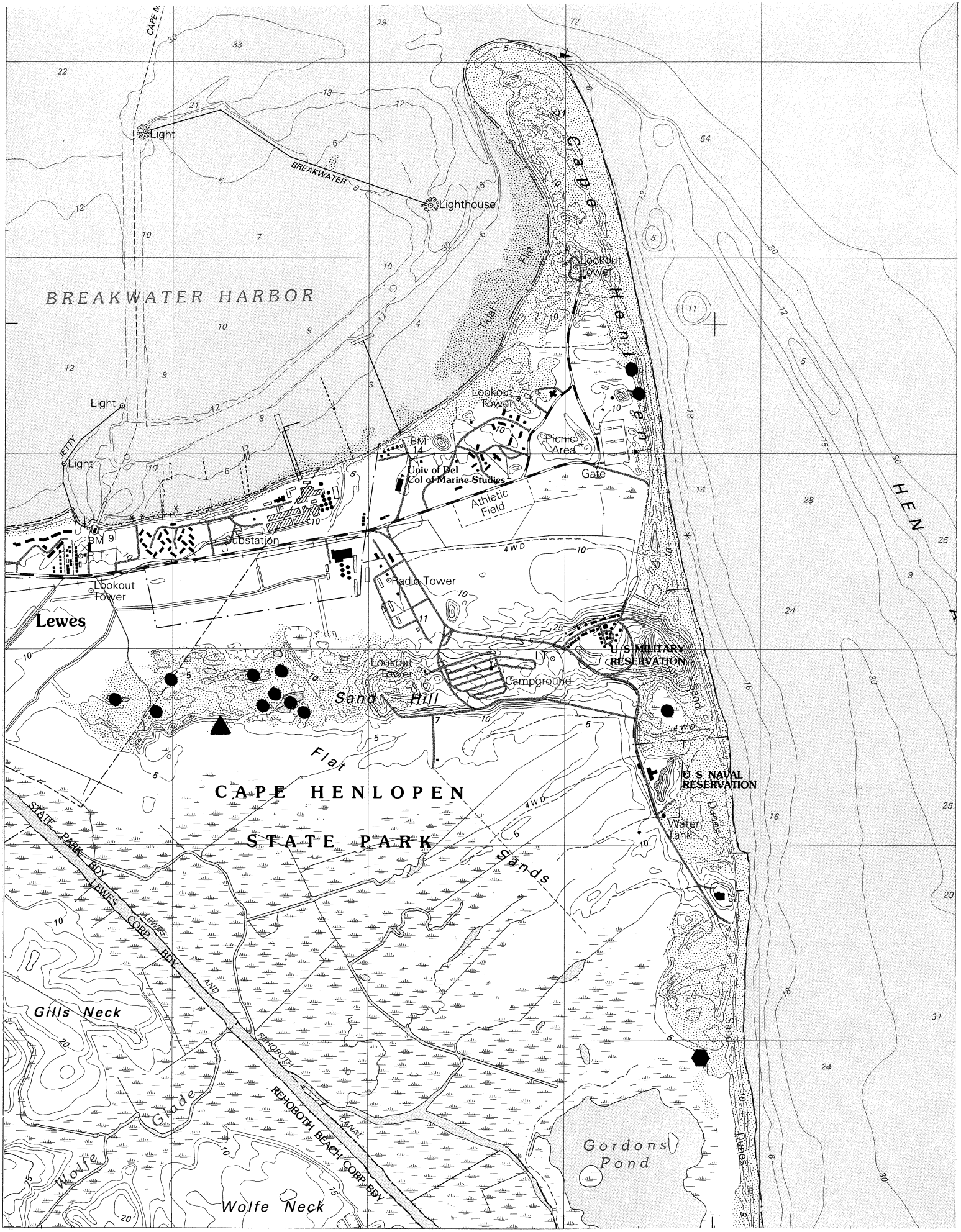

Figure 3: Cape Henlopen quadrangle

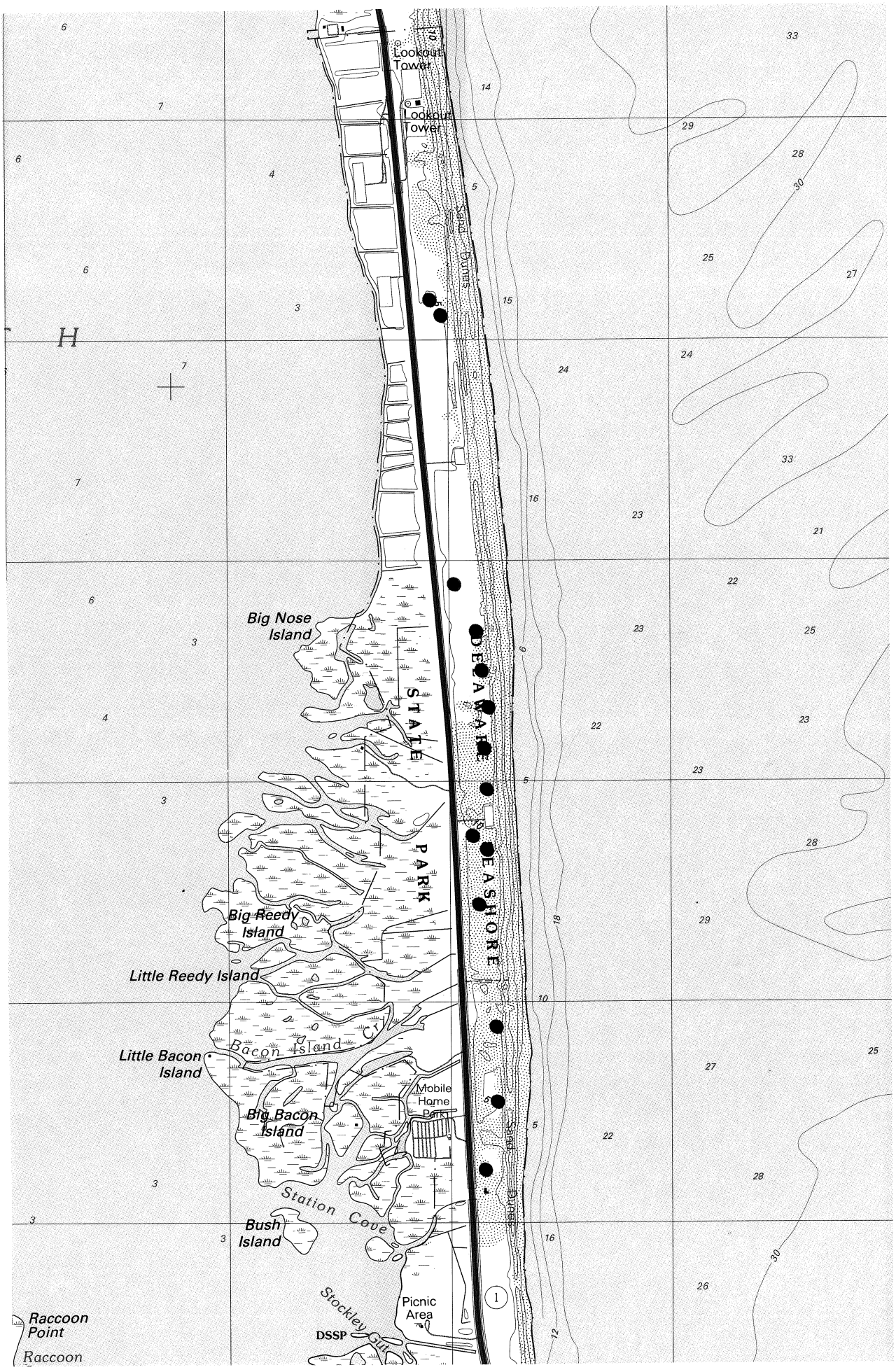

Figure 4: Rehoboth Beach quadrangle

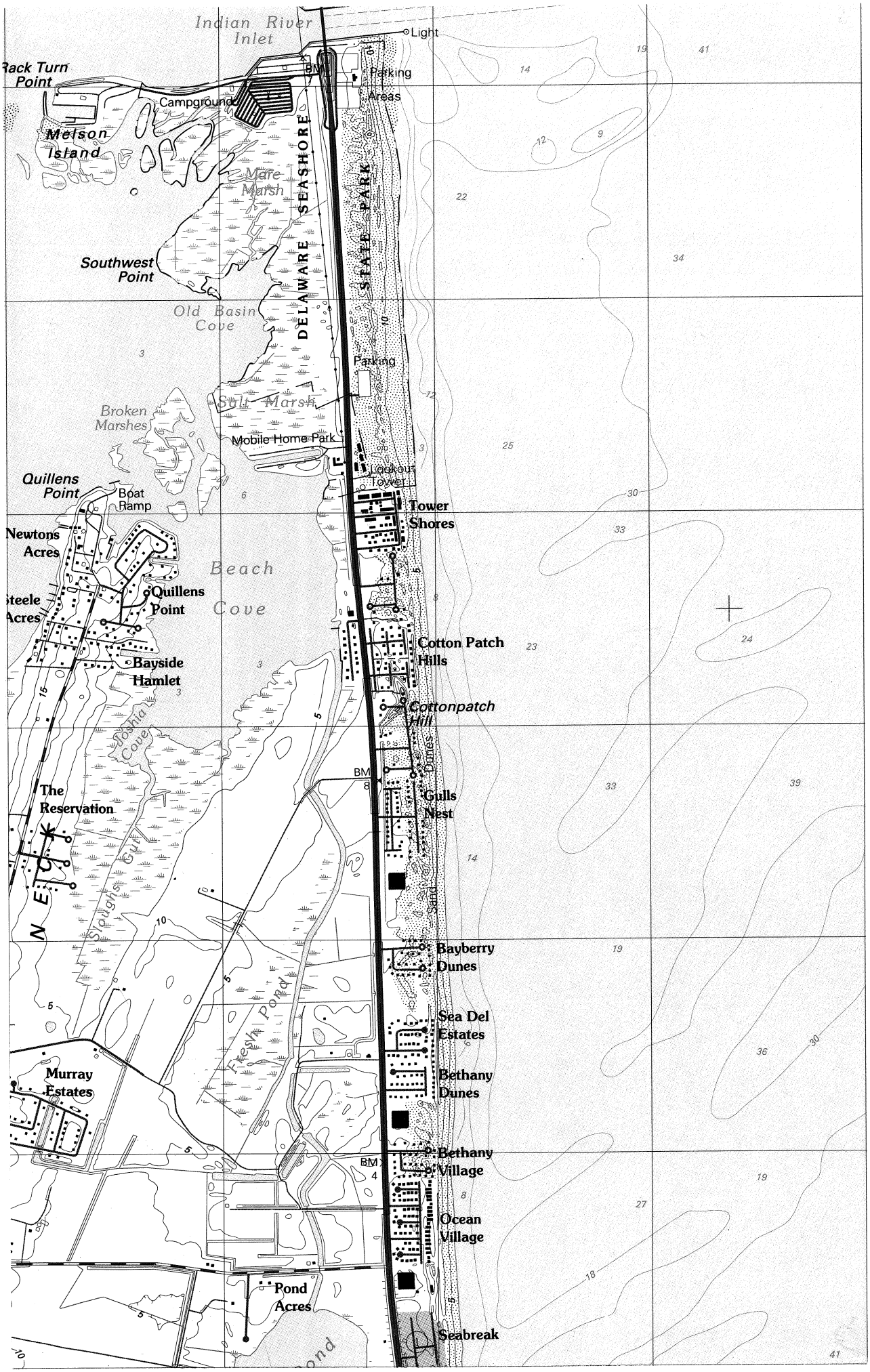

Figure 5: Bethany Beach quadrangle

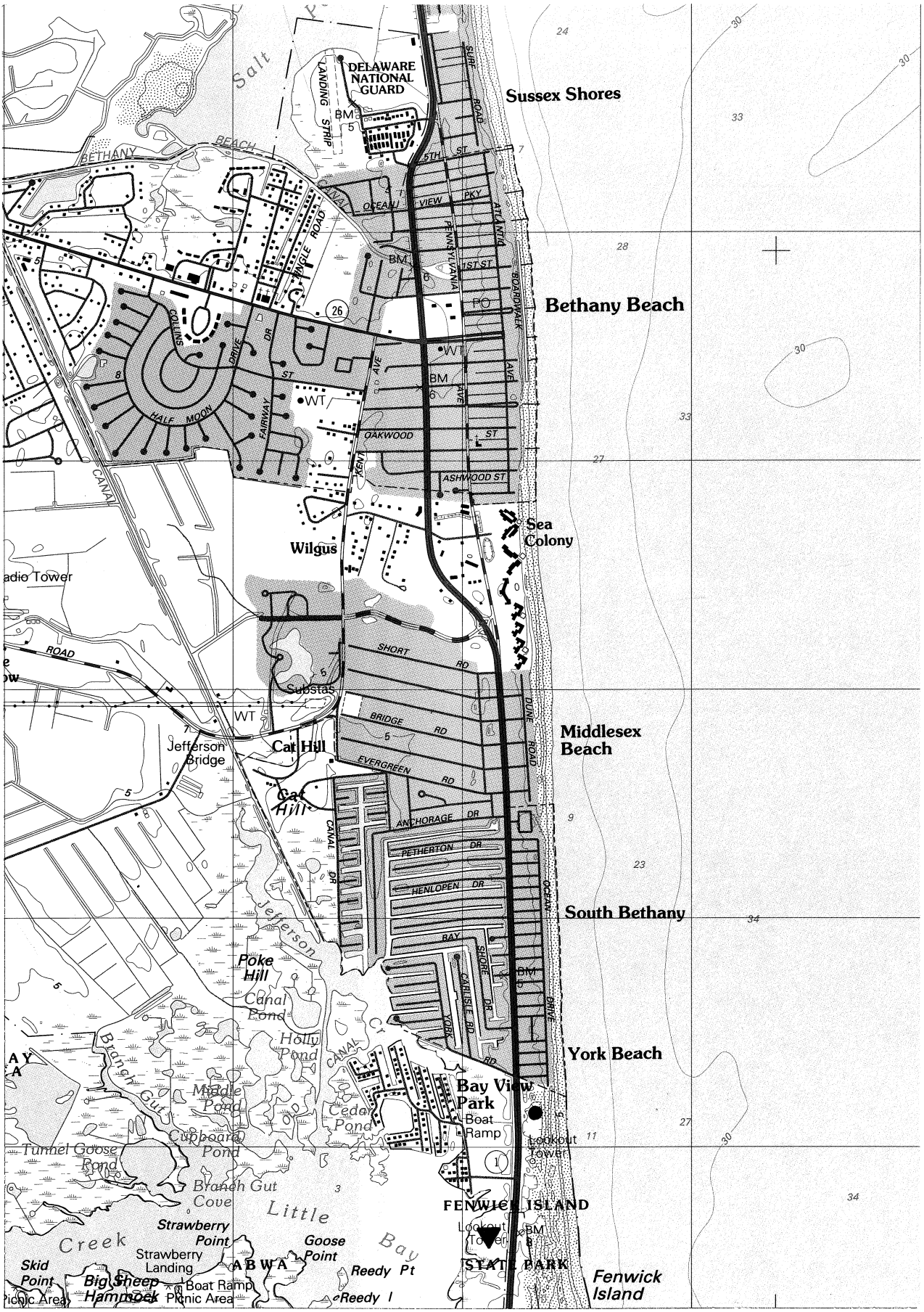

Figure 6: Bethany Beach quadrangle

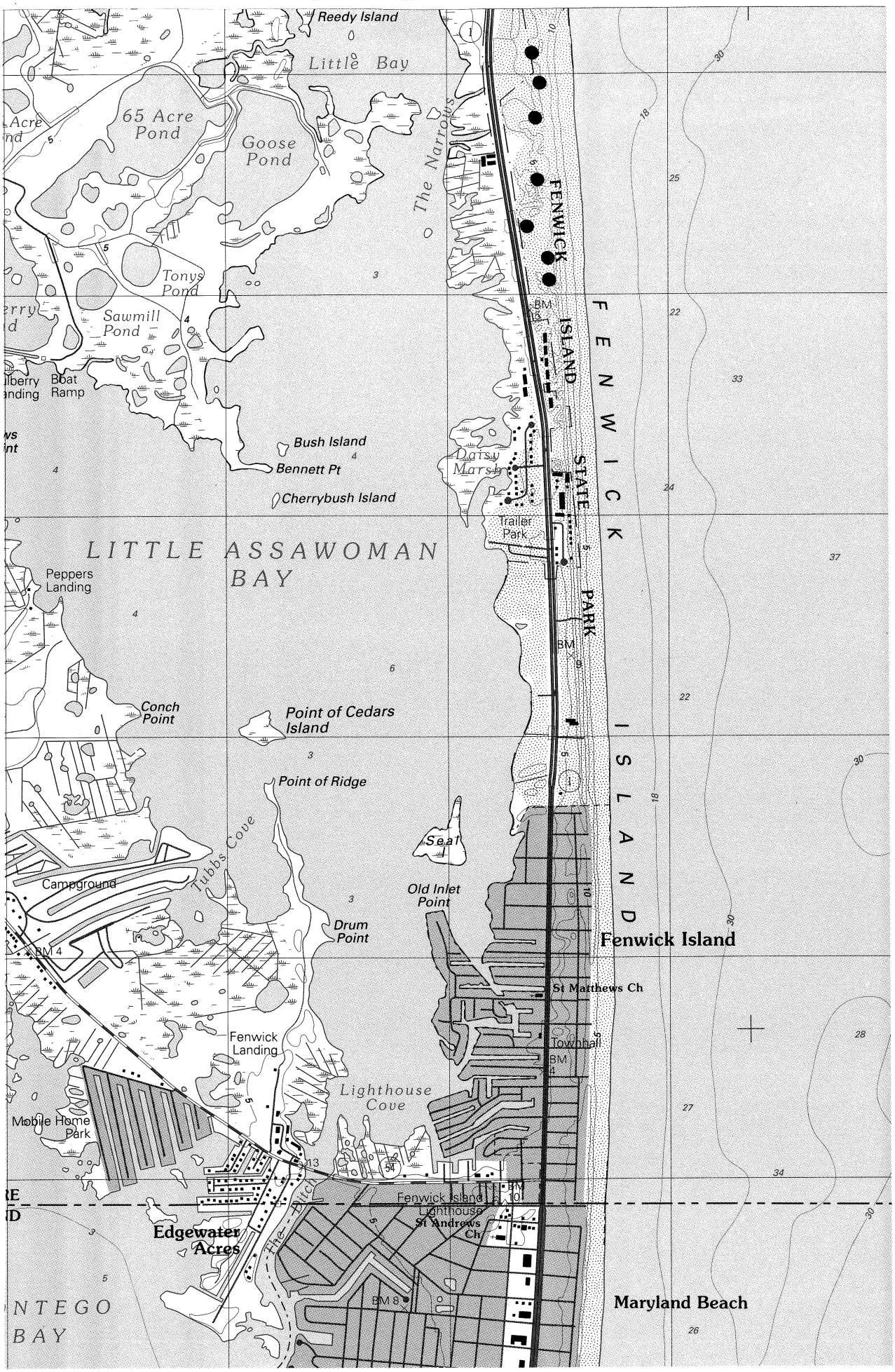

Figure 7: Assawoman Bay quadrangle