A FLORISTIC AND ECOLOGICAL SURVEY OF ASSATEAGUE ISLAND, VIRGINIA-MARYLAND

by
Elizabeth Ann Thornthwaite Higgins

Elizabeth Ann Thornthwaite Higgins

Thesis submitted to the Faculty of the Graduate School
of the University of Maryland in partial fulfillment
of the requirements for the degree of
Master of Science
1969

APPROVAL SHEET

Title of Thesis: A Floristic and Ecological Survey of Assateague Island, Virginia-Maryland

Name of Candidate: Elizabeth Ann Thornthwaite Higgins
Master of Science, 1969

Thesis and Abstract Approved: Russell G. Brown
Dr. Russell G. Brown
Associate Professor of Botany
Department of Botany

Date Approved:
Jan. 9, 1969

VITA

Name: Elizabeth Ann Thornthwaite Higgins

Permanent address: 6902 Wake Forest Drive
College Park, Maryland 20740

Degree and date to be conferred: Master of Science, 1969

Date of birth: November 17, 1927

Place of birth: Oklahoma City, Oklahoma

Secondary education: McKinley High School
Washington, D. C.

Collegiate institutions attended:	Dates	Degree	Date of Degree
University of Maryland	1945-1950	B.S.	1950
University of Maryland	1963-1969	M.S.	1968

Major: Taxonomy

Minor: Botany

Positions held:

Dates	Position	Institution	Address
1950-51	Payroll Clerk	U.S. Dept. of Interior Bureau of Mines	College Park, Md
1961-62	Supervisor of Cottage Life	Vineland State School	Vineland, N. J.
1963-present	Teaching Assistant	Botany Department University of Maryland	College Park, Md

ACKNOWLEDGEMENTS

The author wishes to thank Dr. Russell G. Brown for the initial suggestion of this project, for aid in taxonomic determinations and preparation of the manuscript; to Dr. F. J. Hermann of the U. S. Department of Agriculture Forest Service, for determination of *Carex* and *Juncus*; and to Mr. Neil Hotchkiss of the U. S. Department of Interior, Patuxent Wildlife Refuge, for his great enthusiasm and aid in determinations.

Appreciation is acknowledged to Dr. Thomas Fairchild, University of Maryland, and Mr. James Koch, U. S. Department of Agriculture, Biometrics Service, for invaluable assistance with the statistical analysis; and to Mr. Anthony Norcio for his patience with the computer program. Computer time for this project was supported completely by the University of Maryland Computer Science Center facility.

The author is grateful for the cooperation of the staff of the U. S. Department of Interior, Chincoteague Wildlife Refuge, and of the National Park Service on Assateague; and to the personnel of the Maryland Department of Forests and Parks, Assateague; and of Mr. Tom Reed, Chincoteague, Virginia.

Much gratitude is expressed to Dr. Robert D. Rappleye for his procurements and patience and most of all his perserverance.

And to my husband Joe, heartfelt thanks for encouragement, understanding, loyalty, and company, without whose help this study would have been impossible; and to Jay, Jenny, Jody and Louise for both their tolerance and intolerance.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS ii

INTRODUCTION 1

LITERATURE REVIEW 3

MATERIALS AND METHODS 13

Floristics 13

Transects 14

Soil and Water Samples 15

RESULTS 18

Zonation 18

Zonal Floristics 19

1. Dune Herbaceous Zone 20

2. Shrub Zone 22

3. Arborescent Zone 24

4. Marsh Herbaceous Zone 28

Transects 37

Soil and Water Samples 39

DISCUSSION 41

Floristics 41

1. Dune Herbaceous Zone 44

2. Shrub Zone 47

3. Arborescent Zone 49

4. Marsh Herbaceous Zone 53

Transects 55

Soil and Soil Water Samples 56

Succession 58

APPENDIX I. Historical and Geological Aspects 61

APPENDIX II. Topographic and Ecological Notations 68

APPENDIX III. Catalog of the Vascular Plants of Assateague Island, Maryland-Virginia 70

LITERATURE CITED 103

LIST OF TABLES

Table

1. Species common to two or more zones indicating their relative ecological frequencies 36

2. Comparative density and frequency of species in three strand communities (dunegrass, transition and mesic shrub) 38

3. Variation in soil salinity, pH, Mg, P_2O_5, and K_2O at the three soil depths; water salinity and pH; and water table depth for samples taken in dunegrass, transition and mesic shrub communities in areas where transects were made 40

Appendix Table

1. Number of transects, and distance (in decimeters) occupied by given species along 47 twenty meter line transects in the dunegrass community 99

2. Number of transects, and distance (in decimeters) occupied by given species along 59 twenty meter line transects inthe transition zone 100

3. Number of transects, and distance (in decimeters) occupied by given species along 58 twenty meter line transects in the mesic shrub community 101

4. Data on variation in soil salinity, pH, Mg, P_2O_5, and K_2O at three soil depths; water salinity and pH; and water table depth for samples taken at sites of transects: 9 in dunegrass, 10 in transition zone and 11 in mesic shrub community 102

LIST OF FIGURES

Figure

1. A comparison of the vascular plant families on four barrier bars of the Atlantic Coast 43

LIST OF MAPS

Appendix Map

1. Assateague and Vicinity 67

INTRODUCTION

Assateague Island is an offshore bar comprising the southeastern coast of Maryland and the northeastern coast of Virginia. It is part of the system of discontinuous barrier reefs or bars which occupy most of the Atlantic shoreline from Florida to Massachusetts. These are unstable bars, continuously influenced by storm winds and tides which provide a distinct and rigorous habitat for the vegetation there.

Studies in other disciplines, and some botanical collections, have been made on Assateague (Tatnall, 1942; Lems, 1966; Harvill, 1967), but there has been no extensive botanical survey. General floras of the Delmarva Peninsula do not mention Assateague Island specifically. Island Beach, New Jersey (Small and Martin, 1958; and Martin, 1959); Cape Henry, Virginia (Egler, 1942); and The Outer Banks of North Carolina (Burk, 1961) have been subjects of plant taxonomic and ecological studies. There are two brief taxonomic investigations of Virginia islands south of Assateague: Parramore (Harvill, 1965) and Smith (Clovis, 1968).

This survey will partially fill the void in literature concerning the Delmarva Peninsula. The objectives of the present study are to prepare a catalog of the vascular plants of Assateague Island, and to describe the communities in which they are found, in the hope that it will add to the knowledge of barrier reef vegetation.

LITERATURE REVIEW

The strand from New Jersey to South Carolina consists of three distinct bars, separated by the Delaware and Chesapeake Bays, and includes the transition between northern and southern floras. This literature survey is concerned with these three bars.[1] Small (1929) describes southern New Jersey and the Delmarva Peninsula as floristically similar and a meeting ground for southern and northern plants. North Carolina is included here although Oosting (1954) considers it part of the southern strand.

The early papers concerning strand vegetation along the middle Atlantic Coast describe plant explorations--often reporting only new or unusual species. Such investigations of the New Jersey strand were made by Knieskern (1857), Harshberger (1901, 1903, 1909), and Chrysler (1930). Early trips to Cape Henry, Virginia, are reported by

---

1. Inasmuch as there is considerable literature concerning world dune and marsh vegetation, both floristic and ecological, this review of dune vegetation is limited to that of the middle Atlantic coastal states, North Carolina to New Jersey, inclusive. Oosting (1954) prepared a comprehensive review of the literature of the southern strand including North Carolina.

The marsh habitat literature review here includes works primarily of the eastern United States. Many studies are available on marshes of the Pacific Coast, and Chapman (1960) has published an all inclusive Salt Marshes and Salt Deserts of the World.

Latrobe (1799) and Chickering (1878). Kearney (1900) made a careful study of the vegetation there.

The bulk of literature, both early and current, concerns North Carolina where the barrier reef extends along most of the coastline of the state. The northern portion, the Outer Banks , is composed of three islands from the North Carolina boundary southward about 80 miles. Early floristic surveys of these islands were made by Johnson (1900), Kearney (1900), Harper (1907), Lewis (1917).

Several visits to the Delmarva Peninsula are recorded. Canby (1864) noted species observed on a brief collecting trip to the Maryland eastern shore. Chickering (1878) collected at Ocean City, Maryland, which adjoined Assateague at that time. Rusby (1891) published A botanical excursion to Assateague Bay. Although it is difficult to determine just where he traveled, it is doubtful that he was on Assateague Island. Chrysler (1910) prepared a rather complete list of plants growing in the coastal zone of Maryland. Snow (1902, 1913) compared changes in the vegetation around Rehoboth, Delaware, over a ten-year period. Harper (1909, 1919), made two excursions to the center of the peninsula, but did not visit the coast. Tidestrom (1913) and McAtee (1918) recorded unusual species. Small (1929) made notes on the peninsula, comparing it with southern New Jersey, but did not study coastal vegetation.

The recent literature is generally more detailed, including ecological investigations in addition to plant species lists. Small and

Martin (1958) published a catalogue of vascular plants of Island Beach, New Jersey. It enumerates 267 species representing 63 plant families found on this ten-mile strand. In conjunction with that, Martin (1959) considered environmental and vegetational relationships on the strand.

Brown (1959) listed about 400 species observed on the Outer Banks from the Virginia border south to Ocracoke Island, but made no voucher specimens. Burk (1961) made sixteen collecting trips during two growing seasons on the Outer Banks and published a list of 546 species representing 109 families collected there.

The first complete flora of any given area on the Delmarva Peninsula was the Flora of Worcester County, Maryland, Redmond (1932). It was based on collections made from 1930 to 1932, and probably includes what is now Assateague Island. Fernald (1935, 1936) collected in Accomac County, which includes Chincoteague and the Virginia portion of Assateague, but failed to specify visits to either. Tatnall (1942) published the Flora of Delaware and the Eastern Shore. Although not specifying Assateague, he used the term "dune" as a habitat, and cites two specimens from the island, deposited in the University of Pennsylvania Herbarium, collected in 1928 by Rodney True. A Catalog of the Vascular Plants of Maryland, Norton and Brown (1946) included specimens collected by Norton in Ocean City and vicinity before 1932.

After a single day on Assateague, Lems (1963) compiled a list of 80 plant species he collected. Harvill (1965) published a brief survey of plant communities on Parramore Island, Virginia, and in 1967, The Vegetation of Assateague Island, Virginia. The later paper included a brief description of the pine and salt marsh communities, and a list of 123 species on the island. The area he visited is the widest portion with the richest flora. Despite the fact that this area contains at least ninety per cent of the species present on the island, he lists only a third of them. Clovis (1968) surveyed the vegetation on Smith Island, Virginia, south of Assateague.

Analysis of any barrier reef vegetation inherently includes marsh vegetation, as the leeward or bayside of the reef is a tidal salt marsh. Marsh floristics and distribution were described by Ganong (1903), Harshberger (1909), Johnson and York (1915), and Fernald (1935, 1936), among others. They all recognized the species change resulting from a slight change in marsh elevation, often of a few inches, which produces a zonal pattern of plant distribution (Vogl, 1966). Wells (1928) divided the marsh associes into four socies by tide levels. Johnson and York (1915) stated that species are related to a specific submergence to emergence ratio, each species growing where its own ratio occurs. More recent papers, Reed (1947), Miller and Egler (1950) and Bourdeau and Adams (1956), have attempted to correlate vegetational zonation in marshes with elevation and other environmental factors. The difficulty here, as with any other environmental problem, is to determine which factor is limiting while dealing with all factors concurrently. High tides bring about change in salinities and cause poor aeration.

In studying zonation within the marsh, it is generally agreed that salinity and inundation are the two most important factors, but there is little agreement as to which is the more limiting. Adams (1963) showed that the distribution of species is controlled presumably by tide-elevation factors, but other factors must be included: poor drainage and aeration, and, at upper marsh levels, competition with other angiosperms. Anderson, et al. (1968) demonstrated zonation of species, similar to that of a marsh, in an estuary, moving upstream along a decreasing salinity gradient.

Chapman (1960) described the zonation of marsh vegetation and stated that it represents biotic succession as the marsh fills in. Hinde (1954) assumed aggradation in marshes and stated succession occurs by less hydric species replacing the more hydric ones. Marmer (1948) demonstrated that the east coast has been sinking in relation to sea level at a rate of about 0.02 feet per year since 1930. Adams (1963) stated, "At the present time, the evidence shows that subsidence is occurring in the marshes of the east coast at a faster rate than aggradation in many areas (Kurz and Wagner, 1957). Thus succession may be occurring in a pattern opposite that suggested by (other) authors." Generalizations must be limited to specific coastlines.

Oosting (1954) stated, "The sand strand is a distinctive habitat and as such supports a characteristic vegetational cover whose zonation and life forms are repeated around the world." The zonation is described repeatedly in strand literature and is obvious to the most casual observer. Strand vegetation occurs in bands, the life form changing with distance away from the ocean. The zones or bands have been classified topographically (Cowles, 1899), and Snow, 1902) by describing vegetation along successive dune ridges parallel to the ocean. The band adjacent to the beach is grassland, followed landward by a band of shrubs, a band of woodland, and salt marsh at bayside. These bands, or zones, are not homogenous nor continuous along a strand. The width and development of any given zone varies with the width of the strand--their presence being a function of the width of the island. Vegetation within each zone varies distinctly with topography. A distinct change in vegetation--a mosaic--accompanies a distinct change in topography, whereas a gradual change in vegetation--an ecotone--occurs where the topographychanges gradually.

Oosting (1954) categorized the strand vegetation as follows:

I. Sand strand vegetation
   1. Treeless (open)
   2. Trees and Shrubs (closed)

II. Marsh vegetation
   1. Salt marsh
   2. Creek marsh
   3. Dune marsh
   4. Tidal flat

These marsh communities may occur within any of the broad life-form bands on a barrier reef. In much of the literature, considerable difficulty is expressed in categorizing marshes or mesic habitats on the strand.

Egler (1942) listed seven zones on Cape Henry, Virginia:

1. Ocean zone
2. Beach zone
3. Salt-spray grassland zone
4. Salt-spray Scrub zone
5. Forest zone
6. Tidal marsh zone
7. Bay zone

He described several vegetative communities within each of these zones except the two which are aquatic. Martin (1959), on Island Beach, New Jersey, mapped or described 46 plant communities within six structural vegetation types:

1. Herbaceous communities
2. Low thickets
3. High thickets
4. Herb-shrub mixtures
5. Transitional thickets
6. Woodland

Historically, in dune studies, as in marsh studies, there are many theories to explain the cause of zonation of the plant communities. Wells and Shunk (1931) stated that low water and nutrient content of the soil prevent development of mesic vegetation and maintain the relatively stable communities of the zones. By 1938, they suggested "that the distinctive composition of the dune community is based primarily upon the species adaptations to the (salt) spray factor". Martin and Clements (1939), working in Southern California, studied many environmental factors and concluded that the available water and nutrients determine vegetation. They also conducted salt spray tests, spraying solutions of "table salt" on plants transplanted to a control garden, and found little damage to strand plants; however, inland species were seriously injured. Their conclusion was that salt spray prevents species from becoming established in a foredune area.

In what is now considered a classic ecological study, Oosting and Billings (1942) studied soil moisture, osmotic concentration, pH and temperature; atmospheric temperature, evaporation and relative humidity, but could not relate the variation to zonation across the strand. Oosting (1954) summarized their significant findings, stating that, when they measured salt transported and deposited by wind,

> "regardless of weather, the highest catches (of salt) were on the windward side of the foredune, the crest of the foredune showed the next highest values, and the crest of the rear dune was next in order, with the depression between receiving much less."

Boyce (1954) confirmed these observations. Thus, all three authors concluded that salt spray is the one environmental factor which controls zonation.

Martin (1959) agreed that salt spray determines zonation, but that the interception of salt spray and sand movement are determined by the topography of an area--hence topography is also a prime factor. He described a three-way interaction of topography, vegetation, and environment, and considered environmental factors to be primarily salt spray and sand moved by wind. Perhaps the crux of causes of dune zonation are summarized in his statement, "Sand and salt spray determine vegetation, vegetation influences topography, topography influences deposition of sand and salt."

Zonation across the strand gives the appearance of ecological succession--herbacouous to shrub, to pine woodland, to deciduous forest communities. Many authors accept zonation as succession of a prisere; however, two opposing opinions are expressed in the literature. Chapman (1964) called it succession--a prisere--and presents a diagram of the stages. Chadwick and Dalke (1965) referred to the Idaho inland dune vegetation as a succession. Oosting (1954) did not accept the concept of biotic succession as applicable to zones of the maritime strand, since there is no proof that the zonation indicates either the direction or existence of succession. He believed that apparent successional relationships are primarily physiographic. Without a change in physiography the zones are relatively stable. Martin (1959) stated that the environment inhibits autogenic succession; the pioneer communities are stable or long persistent. Nobuhara (1967) "admits of no doubt that sand becomes more stable by the presence of coastal vegetation and consequently the vegetational succession advances, but there is no reason that the so-called seres of the coastal communities, arranged depending on the environmental gradient, should be regarded as succession."

The floristics of many strands have been catalogued, the vegetation zones have been classified, and a cause of zonation presented, but very little work has been done on adaptation and function of the individual species which inhabit them. Two grasses, known as primary dune builders, have been the subjects of notable autecological studies.

Wagner (1964) conducted an environmental study of *Uniola paniculata* L., a southern strand plant. He found maximum growth occurred where new layers of sand, coated with salts providing nutrients, were available. Laing (1958) has determined the reproduction of *Ammophila breviligulata*, the ubiquitous sand binder, to be primarily vegetative. Agnew (1961) described the plant species associations of *Juncus effusus*, in English marshes. There is a large body of literature, partly cytological, concerning *Spartina* species in English marshes (Ranwell *et al.*, 1964; and others). Burk (1961) studied hybridization of oaks on the North Carolina strand and morphological variation of *Heterotheca subaxillaris* in relation to its taxonomy. Sweitzer (1968) determined the effects of shading on *Salicornia Biglovii* growing on Assateague Island. Salt tolerance determinations on a number of plant species have been made by Taylor (1939), Oosting and Billings (1942), Kurz and Wagner (1957), Martin (1959), Chapman (1960, 1964), and others.

It is clear that a relatively few plant species are able to survive on the strand and, of those, no one species appears able to adapt to all strand habitats. Although the above is only a partial listing of autecological studies, it indicates the strand is an area available for more detailed study of specific plant taxa and their adaptation to a particular environment.

MATERIALS AND METHODS

Floristics. Assateague Island is an offshore barrier bar on the southeastern coast of the Delmarva Peninsula, located just south of Ocean City, Maryland, in Worcester County, extending southward to Chincoteague, Virginia, in Accomac County. It is separated from the mainland by the Sinepuxent and Chincoteague Bays.

Assateague was part of a continuous peninsula extending from South Bethany Beach, Delaware, to Chincoteague, Virginia. A storm in 1933, cut an inlet, since designated Ocean City Inlet, through the bar just south of Ocean City, Maryland, making Assateague a separate island, about 32 miles long, 23 miles in Maryland, and the remainder in Virginia. The width varies from one-half to three miles. Lack of access and low elevation have deterred development, and Assateague remains one of the last relatively undisturbed shoreline areas along the Atlantic Coast.[2]

An annotated check list of vascular plants of Assateague Island was prepared from observations of thirty collecting trips made during the growing seasons (April to November) from 1965 through 1967.

---

2. For additional information concerning the historical and geological aspects of the island, see Appendix I.

Approximately 2,000 specimens were collected, pressed, identified, and labeled.

For identification, The New Britton and Brown Illustrated Flora of Northeastern United States and Adjacent Canada by Gleason, and Gray's Manual of Botany by Fernald were used. Nomenclature in the check list follows Fernald unless otherwise noted. Other manuals which were also useful include: Daubs, A Monograph of Lemnaceae; Fassett, A Manual of Aquatic Plants; Gleason and Cronquist, Manual of Vascular Plants of Northeastern United States and Adjacent Canada; Hitchcock, Manual of the Grasses of the United States; Hotchkiss, Underwater and Floating-leaved Plants of the United States and Canada; Redmond, The Flora of Worcester County, Maryland; and Tatnall, The Flora of Delaware and the Eastern Shore. Voucher specimens are deposited in the Herbarium of the University of Maryland, College Park, Maryland. A duplicate set is to be deposited at the Headquarters of the U. S. Department of Interior Fish and Wildlife Service on Assateague.

Transects. An ecological study of two vegetational zones and the transition zone between them was conducted in June and July, 1967. Line transects, twenty meters long, were taken in the three floristic areas--47 in the dunegrass community, 58 in transition zone, and 59 in the shrub community for a total of 164. Transect sites were selected randomly within the three communities. However, the dunegrass community transects purposefully included those in front and behind the artificial barrier dune, and some located where there is no barrier dune.

Transects rather than quadrats were used in this study because some of the areas surveyed are almost impenetrable, dense shrub thickets. Oosting (1948) notes that transects are particularly useful in dense stands of scrubby vegetation, and give reasonably accurate information. Kershaw (1964) discussed sample size, or number of transect samples required in any given study. He concluded that with a sample size of less than 100, only gross differences in speciation are detectable. Since, in this study, approximately 50 transectswere made in each of the three communities, species occurring with a frequency of less than five are not considered significant.

A twenty meter tape, marked in decimeters, was laid across the vegetation. Number and coverage of each species touching the tape was recorded. From this, density and frequency of species were determined. Density reported here is the average number of individuals per decimeter. Frequency is the percent of the total samples in which the species occur. Together these values give an estimate of cover of individuals and their distribution.

Topographic and ecological frequency terminology is included in Appendix II.

Soil and water samples. Inasmuch as the causes of zonation are generally accepted to be an interrelation of topography and salt deposition, these factors were not tested in this study. The soils and soil water of the transect areas were sampled to determine variations between the three communities.

Soil samples were collected at the sites of the transects, nine sited in the dunegrass community, ten in the transition zone and eleven in the shrub community. At each sample area a pit was dug to the water table. Water samples were taken from the watertable; soil samples at the surface, 20 centimeters below the surface, and at the water table. The soil samples were air dried and analyzed by the Soil Testing Laboratory, University of Maryland, using methods described by Miller et al. (1963). pH, magnesium, potassium as K_20, and phosphorous as P_20_5, content were determined. The reliability of the data is as follows:

pH $\pm$ .05
Mg $\pm$ .125 ppm.
P_20_5 $\pm$ .625 ppm.
K_20 $\pm$ .375 ppm.

Soil salinity determinations were made using the method described by Miller et al. (1963) on an Industrial instruments conductivity bridge, Model RC-BC. Soil water samples, collected from the watertable were measured for salinity directly, on the same conductivity bridge. Their pH was measured immediately after collection in the field using a Beckman pocket pH meter, Model 180. Buffered solutions of known pH were used in the field to check the meter. Statistical analysis was carried out at the University of Maryland Computer Science Center, using Analysis of Variance for one-way design, version of June 15, 1966, Health Sciences Computing Facility, University of California, Los Angeles. A transformation to logarithms was required on some data where the variance varied with the mean. Duncan's Multiple Range Test (Steele and Torrie, 1960) was applied to determine significant differences of variable means between communities.

RESULTS

The vascular plants of Assateague Island, collected in this study number 441 species representing 88 families. (The annotated list of species appears as Appendix III.) This does not include two species collected on Assateague by Rodney True in 1928 (Tatnall, 1942), *Plantago major var. intermedia* Dcne. and *Oenothera perennis* L., or two species listed by Harvill (1967), *Lobelia siphilitica* L. and *Plantago maritima* L. These species have been sought but not found by the author.

Zonation. Vegetation bands or zones on Assateague are the same as those described on other barrier strands. From the ocean toward the bay they proceed in order from the beach, dunegrass, shrub, arborescent, and marsh running in bands parallel to the ocean but often interrupted. Occasionally the communities comprising the zones are distinctly separated one from another by a sharp topographic change--forming a mosaic. Generally, however, the floristic composition gradually changes from one community to the next--producing a floristic ecotone which is difficult to describe.

A factor more striking than the mosaic pattern, although part of it, is the xeric and mesic situation within each zone--each with a distinct vegetational society. Within any zone, a depression which brings the soil surface closer to the water table, also brings a change in floristic composition. In the dunes these may be small and provide a minor component of the zonal floristics, or, as in the shrub zone, they may be extensive. The mesic shrub community composes one-third of the entire shrub zone area.

Zonal floristics. A brief description of vegetational zones--their major communities and the distinct minor communities within them follows. The communities discussed are: dunegrass; xeric and mesic shrub; pine and pine deciduous mixed woodland; fresh and salt marshes. Included within these are typical minor communities: beach, Hudsonia dunes, pans and washes, impoundments and ponds, and one atypical site by the Light house. Also described is the transition zone or ecotone between the dunegrass and mesic shrub communities, where transects were made. Included with the description of the major communities is a list of species occurring primarily in that one community. The minor communities within the zones are described and species found in them are listed.

A compilation of species occurring across the strand in two or more zones or communities is shown in Table 1. The species list and frequency values are observations of the author, except in dunegrass and mesic shrub, where transect data are included with observations. Ecological frequency notations apply only to the one habitat; general frequencies for the entire island are included in the Annotated Check

List in Appendix III.

1. Dune Herbaceous Zone

Beach. Plant cover above the high tide line (the upper beach) is not over 1%. Beach pioneers appear only occasionally--often in the shelter of driftwood. Cakile edentula is the most frequent species, producing many seedlings, but few adult plants. The seed source is apparently from plants of the foredune or barrier dune where it matures under slightly more stable conditions than on the beach. Salsola Kali and Amaranthus pumila also occur on the beach, but rarely. There are two mounds, about two meters in diameter, covered with Arenaria peploides in Virginia, where this species approaches its southern limit.

Dunegrass Community. This is, floristically, the most uniform of the vegetation zones on Assateague, extending continuously the length of the island behind the beach, a band seventy meters or more in width. The habitat is of unstable, low rolling dunes, exposed to strong winds and much sand movement. Here an artificial barrier dune has been constructed. Cover in this community is 20% or less. Ammophila breviligulata, American Beach Grass, is the dominant species. Spartina patens is most commonly associated with it. The presence of Panicum amarum and P. amarulum ranges from rare in Virginia to frequent northward. The only forb occurring commonly is Solidago sempervirens.

Species occurring in the dunegrass zone and not generally found in other communities are listed below:

Frequent

- Cenchrus tribuloides
- Euphorbia polygonifolia
- Oenothera humifusa
- Xanthium Strumarium

Infrequent

- Cyperus strigosus
- Erigeron pusillus
- Solidago sempervirens var. mexicana
- Spergularia marina
- Triplasis purpurea

Rare

- Digitaria sanguinalis
- Panicum meridionale var. albemarlense

Local

- Amaranthus pumilus
- Polygonum glaucum
- Sesuvium maritimum

The dunegrass community gradually changes into the shrub zone, where *Ammophila breviligulata* is replaced by *Andropogon virginicus* as the dominant grass. In a few isolated areas where the dunegrass and shrub zones are wide, there is a tension zone containing low, scattered *Myrica cerifera*, *Ammophila breviligulata* and *Andropogon* spp., with the following herbs which are not often found elsewhere: *Chenopodium ambrosioides*, *Datura Stramonium*, *Erigeron pusillus*, *Oenothera humifusa* and *Solanum nigrum*.

Dunegrass-Shrub Transition zone. Between each of the vegetative bands along the strand is a transition or tension zone--an ecotone--where floristics change from one community to another. The widest, most apparent of these, is that between the dunegrass and shrub communities. This zone is continuous the length of the island behind the dunegrass community. Elevation is consistently low, varying gradually from one to two meters above sea level. Cover provided by herbaceous plants is 60 to 70%, while shrub cover is 20 to 30% of the total. Where blowouts have occurred and elevations are close to the water table, a marsh community similar to that present in blowouts in the dunegrass zone appears. The species of this zone, found in 58 transects are listed in Table 2.

2. Shrub Zone

Xeric Shrub Community. The shrub community is the second band of vegetation parallel to the ocean extending the length of the island except in pans and impoundments. This zone must be considered as two communities, because of the large size of both xeric and mesic shrub communities. The xeric shrub zone extends over secondary dunes where elevations vary from one to three meters. At lower elevations where the land is flat, the dominant shrubs are low--about one meter; lianas are very abundant, and herbaceous cover is 80% or more. On the dune ridges and slopes, where elevations are over one meter, shrubs are taller and provide more cover; lianas are few, and the herbaceous cover is 30% or less. The species collected only in this community are listed below:

Frequent

Amelanchier canadensis
Pyrus angustifolia var. spinosa

Infrequent

Argostis hyemalis
Eragrostis spectabilis

Infrequent (cont'd.)

Polygonella articulata
Pyrus arbutifolia

Rare

Aralia spinosa
Prunus maritima
Sambucus canadensis

Species from swales within the xeric shrub community:

Frequent

Juncus marginatus var. biflorus
Pteridium aquilinum
Juncus Gerardi

Rare

Galium pilosum
Paspalum leave

Infrequent

Osmunda regalis
Solidago fistulosa
Panicum sphaerocarpon

Hudsonia Dunes. Interspersed within the xeric shrub community are flat, open dune ridges from two to three meters high, which have an herbaceous dominant, Hudsonia tomentosa. Cover on these secondary dunes is less than 40%, composed of the following species:

Abundant

Andropogon virginicus
Hudsonia tomentosa
Lecchea maritima

Common

Bulbostylis capillaris
Hypericum gentianoides
Polygonella articulata
Rumex Acetocella

Frequent

Aristida tuberculosa
Linaria canadensis

Infrequent

Cynodon dactylon
Mollugo verticillata
Opuntia humifusa

Occasionally another herbaceous community occurs in small, open areas within the shrub zone--less frequently than the Hudsonia society. Frequency values are low for all species.

Andropogon virginicus
Aristida tuberculosa
Hypericum gentianoides
Krigia virginica
Opuntia humifusa
Polygonella articulata

Mesic Shrub Community. Interspersed within the shrub zone are extensive mesic sites where elevations are very low--less than one meter above the water table. The mesic shrub community occurs here. The shrub cover varies from 90 to 100% and forms a dense thicket. The herbaceous cover varies from 10 to 80% and includes numerous seedlings of the dominant shrubs. Species of this community are shown in Tables 1 and 2. Species collected only in this community are listed below:

Infrequent

- Cyperus filiculmis
- Eupatorium pilosum
- Ilex glabra
- Juncus coriaceous
- Panicum lanuginosum
- Sagina decumbens

Rare

- Cassia nictitans
- Smilax Walteri
- Vaccinium ceasariense
- Viburnum recognitum

3. Arborescent Zone

Pine Woodlands. Pine woodlands form the third band of vegetation landward from the ocean. It is not continuous, but broken intermittently by the salt marsh where the island narrows. The cover varies from 50 to 90% on dune ridges and swales, and elevation ranges from three to ten meters. The dominant species is *Pinus Taeda*. *Pinus virginiana* is also present in three small stands. Pine woodlands range from thickets composed of many species, generally representing the xeric shrub community, to an open, pure stand of mature *P. Taeda*.

Species occurring only in pine woodlands follow:

Infrequent	Local
Agrostis alba	Cypripedium acaule
Cyperus retrorsus	Pinus virginiana
Helianthemum canadense	
Hieracium Gronovii	

Pine-deciduous mixed woodland. The highest, oldest dunes on Assateague, located at the widest portion, are in the area around the Light house near the southern tip of the island. Here the dunes reach a height of sixteen meters. The elevation and distance from the ocean provide maximum protection from salt spray. According to Oosting (1954) such dunes are shifting landward; hence vegetation is subjected to coverage by moving sand; however, there is little evidence of that in this area on Assateague.

It is here, behind the pine woodland zone, that a deciduous woodland is expected, but it is not present as a generally homogenous community. Most of what probably was deciduous woodland has been cut over recently and is nowtypical pine woodland. This is in the area around the Light house where there was a village until the 1930's.

To the north of the pine woodland, on the same dune ridge, occurs one small area of deciduous woodland. It is limited to the lee-ward slope of the highest dunes (known as the White Hills). The cover is 100%, provided by a high canopy of Quercus falcata, with Ilex opaca, Vaccinium atrococcum, and Gaylusaccia baccata.

In the low behind the dune ridge is a large depression with standing water most of the year. The deciduous species change abruptly here. The dominant is Acer rubrum with Salix nigra.

The foreslopes of the White Hills are almost devoid of vegetation. Only an occasional plant of the Hudsonia association appears.

South of the pine woods around the Light house, extending to the beach at Tom's Cove, is a series of dune ridges and hollows, where the dominant is still Pinus Taeda, but it is mixed with large numbers of deciduous species. Here is the most dramatic evidence of change in vegetation with change in topography. The dune ridges are covered with open woodlands of large P. Taeda, often over thirteen meters tall, and Quercus nigra--also old trees, but rarely reaching over ten meters. Although the cover here is close to 80%, it is a low canopy--not over eight meters high. Ground cover is less than 20%. Along the edges where there has been some soil disturbance, Phytolacca americana and Rubus cuneifolia occur.

In the lows between the dunes are dense thickets formed by species the same as those in Myrica shrub thickets, but here they are taller and apparently older. The cover is 100%--a dense tangle of trees, shrubs, and lianas about seven meters tall.

In larger swales between dunes is a mixture of Myrica spp. and deciduous tree species (Acer rubrum, Quercus nigra, Q. falcata, Salix nigra, and Sassafras albidum.) The tree canopy is open, ten to twelve meters high, with a dense shrub layer below, covered with lianas. Juiperus virginiana is rare in this area, and each plant is completely covered by lianas.

The bayside of this forest is eroding visibly at this time. At high tide water covers the base of dead trees which are still standing, and the sandy shore is littered with dead trees and stumps which are remnants of the forest now in the bay. The beach materials being cut away here is deposited further south along the sheltered beach in Tom's Cove. The dunes receiving the deposits are encroaching on the forest, and covering trees with sand seven to ten meters high. The new dunes are barren, with the exception of Solidago sempervirens, Myrica cerifera and Prunus serotina which have survived burial.

Species found in the mixed woodlands and not elsewhere are listed below:

Local

Berchemia scandens
Cornus florida
Monarda punctata
Quercus stellata
Xanthoxylum Clava-Herculis

The Lighthouse stands on a dune ridge in the pine-deciduous woodland. The leeward slope is unusual in that it has an herbaceous cover of 100%, where other large dune slopes have almost none. Species found here, with one exception, are not found elsewhere on the island. Some are relics of cultivation, but the origin of others on Assateague is in question. Species on the slope are shown below. Frequencies are not given because there are so few representative plants of each species present.

Arenaria serpyllifolia

Akebia quinata

Ligustrum vulgare
also found near hunters cabin in Maryland

Althaea rosea

Asparagus officinalis

Aster dumosus var. cordifolius

Boehmeria cylindrica

Chrysanthemum Leucanthemum

Commelina communis

Crataegus crus-galli

Geum canadense

Helianthus petiolaris

Lamium amplexicaule

Nepeta cataria

Oxalis europaea var. Bushii

Parietaria floridana

Portulaca oleracea

Robina Pseudo-Acacia

Sanicula canadensis

Verbena officinalis

Xanthoxylum Clava-Herculis
frequent on sand strands
south of Assateague

4. Marsh Herbaceous Zone

Salt marsh. Covering the bayside of Assateague is the second herbaceous zone of the four major vegetative zones which occur on barrier bars. This is the salt marsh where Spartina patens is the dominant species. Spartina marshes line the bay shore for the length of island, except at the widest portion where the pine-deciduous woodland adjoins a sandy beach at bayside and along Tom's Cove. Generally they are narrow where the backdunes are high and well wooded, and wide where the island is low and narrow. Salinities vary from low to high marsh. Low marsh, inundated daily by tides, have salinities lower than the bay--about 23 ppt. The high marsh, inundated only by exceptionally high tides, shows higher salinities, up to 30 ppt. Estimated elevations are seldom over half a meter above sea level. Herbaceous cover is 100%, forming a mosaic within the low and high marsh.

Within the extensive marshes are hummocks--raised areas one to two meters above the marsh level and twenty to thirty meters in diameter. It was not determined whether these are remains of once larger dunes or whether they are building up in the marsh. Since they are covered with a well developed xeric shrub community, the same as found in the shrub zone, it appears that the hummocks were once continuous with the dunes.

At some time previous to this study, drainage ditches were dug in many of the marshes for mosquito control. The ditches and the mosquitoes are still there, just as they are on Island Beach (Martin, 1959). The ditch edges, where sand was piled, now support the shrubby Iva frutescens, forming narrow rows of plants visible for long distances through the marsh.

Species occurring in salt marshes are listed below. No attempt was made to gather quantitive data as simple transects or quadrats would not show the mosaic. A detailed vegetative map would be required to give the spatial relationships of species.

Frequent

A. tenuifolius
Bassia hirsuta
Juncus biflorus
Limonium carolinianum
Pluchea purpurascens
Salicornia spp.

Infrequent

Aster pilosus var. demotus
Polygala verticillata var. isocycla

Rare

Borrichia frutescens
Ludwigia alternifolia

Fresh Marsh. A marsh as defined by Webster is "a tract of soft wet land, usually characterized by monocotyledons." The connotation is a large tract. On Assateague, the large marshes are salt marshes adjacent to the bay. Fresh marshes are limited in size and occur in areas within the vegetative zones where ground level approaches water table--generally in dune swales or sites of blowouts. Species composition varies with the size of the depression and the broad zone in which it is located.

Blowouts supporting fresh marshes in the dunegrass and transition zones are unshaded; herbaceous species provide 100% cover. Eleocharis parvula with few associates covers areas where there is standing water part of the year, and has a remarkable ability to invade these areas on Assateague as well as in North Carolina (Burk, 1961). Pools present in the spring are ringed with a narrow band of this species. As the pool dries out, E. parvula follows the water table until no water remains, which results in a solid mat of vegetation. If the site remains dry, Juncus bufonius and Spergularia marina appear in association with it. In other sites with a shallow water table, but apparently better drained, Scirpus americanus and Juncus biflores occur--often in large areas.

The small fresh marshes within the mesic shrub community are densely shaded by the Myrica thicket, but herbaceous cover here is still 90 to 100% and composed of Dryopteris Thelypteris, Festuca rubra, Spartina patens, and Vulpia octoflora.

The marshes in the xeric shrub and Hudsonia communities are often only small sinks in the dunes. These show much species variation.

Polypogon monspeliensis, Scirpus americanus and Spartina patens are most often present, but species found in association with them vary widely from one marsh to the next. In one large marsh near Ragged Point, between Hudsonia dunes, Vaccinium macrocarpon was found. This is the only station where it occurs, although it was expected to be prevalent. In this same area Drosera intermedia occurs in a dense stand, and this is one of the few places where it is found. Fresh marshes within the arborescent zone are similar to those within the shrub zone.

Species found in fresh marshes are listed below:

Common

- Eleocharis rostellata
- Juncus dichotomus
- Polygonum punctatum

Frequent

- Argostis alba var. palustris
- Cyperus filicinus
- Galium obtusum
- Hypericum boreale
- H. mutilum
- H. virginicum
- Linum medium
- Lycopodium inundatum
- Polygonum pensylvanicum
- Samolus parviflorus
- Spergularia marina
- Viola lanceolata

Infrequent

- Carex hormathodes
- Cyperus esculentus
- Dioda virginiana
- Eclipta alba

Infrequent (cont'd.)

- Eupatorium serotinum
- Fuirena pumila
- Gnaphalium obtusifolium
- Heterotheca subaxillaris
- Ludwigia alternifolia
- Lythrum linare
- Panicum columbianum var. oricola
- Rhynchospora capitellata
- R. gomerata
- Scirpus cyperinus
- Setaria geniculata
- Spiranthes spp.
- Xyris spp.

Local

- Drosera intermedia
- Typha angustifolia
- T. latifolia

Rare

- Ammania teres
- Bacopa Monnieri
- Vaccinium macrocarpon

Washes and salt pans. A wash is a low area open to both the bay and the ocean, and inundated with salt water at exceptionally high tides. They are present on sites of inlets. One such wash is just south of Green Run. Another, farther north has been closed to the ocean by the artificial barrier dune. A third, south of Ragged Point in Virginia, has been closed by a dike at bayside and the barrier dune along the beach--forming a salt pan.

These three are low, flat expanses of sand, not over a meter above sea level, sided by low dunes, and lying perpendicular to the ocean. Salinities here are higher than in the bay due to accumulation of salt as evaporation takes place. They are barren; vegetation is restricted to the edges in the shelter of the dunes, or on an occasional low, actively forming dune within the wash. The same micro-zonation occurs here as in the tidal marshes. Species are specific to one level and rarely traverse topographic change.

Pioneers on the wash or pan level are only the most salt tolerant and are listed below: (* Asterisk denotes species which bridge two or more societies within this community.)

Amaranthus pumillus
* Atriplex arenaria
* Cakile edentula
Polygonum glaucum
Salicornia Biglovii
Salicornia europaea
Salsola Kali
Sesuvium maritimum
Spergularia marina

The dunes along the edge of washes and pans progress from low sand mounds to dunes a meter high with swales between. Moving out of the wash or pan level to the dunes, the vegetation changes as shown below:

First dune ridge (less than a half meter high)

* Aster subulatus var. euroauster
Bacopa Monnieri - Virginia only
Bassia hirta
Cyperus filicinus
* Distichlis spicata
Juncus bufonius
* Scirpus americanus
* Solidago sempervirens
* Spartina patens

Behind the first dune ridge is often a depression--a flat area which possibly was part of the salt pan at one time. The vegetation here is typical of fresh marsh communities within the shrub zone:

Erigeron pusillus
Gerardia purpurea
Leptochloa filiformis
Linum medium
Polypogon monspeliensis
Panicum capillare
P. virgatum
Pluchea purpurascens
Rhexia virginica
Sabatia stellaris
Spartina patens - most common
Spiranthes spp.

The washes and pans on Assateague would provide interesting sites for permanent ecological study, since the initial stages of dune building and associated vegetation development are most active there. Of the three, only one, just south of Green Run, is still open to flooding from the ocean and bay. The northernmost pan is exposed to flooding only from the bay. The largest of the three, located south of Ragged Point, within the Wildlife Refuge, was completely enclosed in 1963. Although salt water no longer floods this areas, standing water develops a high salt content from the soil.

Changes have occurred in the large pan during the course of this study. One area about fifty meters square directly behind the barrier dune was a Salicornia-Bassia flat of about 20% cover in 1965. In 1968, it is a grass community with 80% cover, chiefly of

Ammophila breviligulata and Spartina patens.

Impoundments. Impoundments have been established by the Fish and Wildlife Service to create conditions suitable for plants which serve as food for waterfowl. These habitats are unusual to the barrier strand, and are restricted to the Wildlife Refuge. They are located in the shrub or dunegrass-shrub transition zone and vary in size from shallow "watering holes", three or four meters across, to one which covers over a square mile. These impoundments are filled with water at least part of the year, and support an aquatic vegetation. The most extensive one is east and extending north of the Fish and Wildlife headquarters. As the water evaporates during the summer and the shoreline recedes, vegetation typical of the fresh marsh appears.

Along the edge of the large impoundment, seeds of Peltandra virginica, were introduced by a Chincoteague resident in 1965. Two plants appeared that year. By 1968, the number increased to about twenty-five plants and it now appears to be well established. In this same area is a small clump of Lobelia cardinalis. As far as has been determined, this was a natural introduction. Tatnall (1946) reported that neither of these species occurred in Accomac County in 1946.

Only a few small, naturally-occurring ponds have been found on the island. The Fish and Wildlife Service also maintains plowed fields of Millet for waterfowl food. No study of these fields was made.

Shallow impoundments dry out in the summer. Species in them are different from those in the deep impoundments, where there is water all year, as shown below:

Deep impoundments	Shallow impoundments
Lemna minor	Lobelia cardinalis
Spirodela polyrhiza	Peltandra virginica
Callitriche heterophylla	Scirpus robustus
Myriophyllum pinnatum	

Table 1 shows species occurring in two or more floristic zones or major communities. Species occurring in a single community are listed in the previous discussion. Species listed under fresh marsh include those occurring in swales and blowouts within every major zone, and also include those in impoundments and ponds. Species occurring only rarely are generally omitted.

Table 1. Species common to two or more zones indicating their relative ecological frequencies.*

	Dune Herbaceous Zone	Shrub Zone		Arborescent Zone		Marsh Herbaceous Zone	
	Dunegrass	Shrub		Woodland		Marsh	
Species		Mesic	Xeric	Pine	Mixed	Fresh	Salt
Sabatia stellaris						5	5
Atriplex patula var. hastata						4	5
Hibiscus palustris						4	5
Juncus Roemerianus						4	5
Aster subulatus						4	4
Juncus Torreyi						4	4
Kosteletzkya virginica						4	4
Rhexia virginica						4	4
Gerardia purpurea						4	4
Eleocharis palustris						5	3
Eleocharis parvula						5	3
Fimbristylis castanea						5	3
Lycopus americanus						4	3
Ludwigia alternifolia						3	2
Proserpinaca palustris						5	
Juncus bufonius						4	
Lippia lanceolata						4	
Ranunculus sceleratus						4	

Species	Dunegrass	Shrub		Woodland		Marsh	
		Mesic	Xeric	Pine	Mixed	Fresh	Salt
Centella erecta						4-3	
Ludwigia palustris						4-3	
Ruppia maritima						3	
Potomogeton pectinatus						2	
Potomogeton pusillus						2	
Ascyrum Hypericoides				4		4	
Elephantopus tomentosus				4	3		
Liquidambar Styraciflua				3	3		
Persea Borbonia				3	3		
Habenaria cristata				2	2		
Myrica cerifera		5-6	5	5	5		
Myrica pensylvanica		5-6	4	5	4		
Smilax glauca			5	5	5		
Andropogon virginicus		2	5	4	3		
Prunus serotina			5	3	4		
Pinus Taeda		2	4	6	5		
Sassafras albidum		2	3	4	4		
Smilax rotundifolia			4	5	5		
Rhus copellina		4	4	5	4		
Parthenosiccus quinquefolia		4	4	4	4		
Ilex opaca		4	4	4	3		
Eupatorium rotundifolium		4	4	4	3		
Rubus cuneifolia			4	4	3		

Species	Dunegrass	Shrub Mesic	Shrub Xeric	Woodland Pine	Woodland Mixed	Marsh Fresh	Marsh Salt
Vitis rotundifolia			4	3	5		
Quercus nigra		3	3	4	5		
Quercus falcata			3	4	4		
Uniola laxa			3	4	2		
Acer rubrum		3	2	3	4		
Juniperus virginiana		2	3	3	2		
Nyssa sylvatica			3	3	2		
Cirsium horridulum		3	3	3	2		
Salix nigra		3		2	4		
Magnolia virginica			2	4	3		
Campsis radicans			2	3	3		
Gnaphalium purpureum		3	5	3			
Eupatorium capellifolium			5	3			
Lonicera japonica			5	3			
Aristida tuberculosa			4	4			
Krigia virginica			4	4			
Panicum scoparium		4	4	4			
Andropogon scoparius			3	4			
Eupatorium hyssopifolium			3	4			
Gaylussacia baccata		3	3	4	3		
Vaccinium atrococcum		2	3	3	2		
Smilax Bona-nox			3	4	2		
Lechea Leggettii			3	3	2		

Species	Dunegrass	Shrub: Mesic	Shrub: Xeric	Woodland: Pine	Woodland: Mixed	Marsh: Fresh	Marsh: Salt
Hypericum gentianoides			4	3			
Linaria canadensis			4	3			
Polygonella articulata			4	3			
Opuntia humifusa			3	3			
Osmunda regalis			3	2			
Mitchella repens			2	2			
Vaccinium corymbosum		3	5	3			
Distichlis spicata		3	4-5				
Festuca rubra		4	4-5				
Festuca ovina var. duriuscula		4	4				
Rumex Acetocella		3	4	3			
Vulpia octaflora		4	4				
Holcus lanatus		3	2				
Panicum dichotomiflorum var. dichotomiflorum		2	3				
Rubus flagellaris		3	3				
P. lanuginosum var. Lindheimeri		2	3				
Ammophila breviligulata	6		2				
Solidago tenuifolia	4	4	4				
Mollugo verticillata	3		3				
Polypogon monspeliensis	3	3					

Species	Dunegrass	Shrub Mesic	Shrub Xeric	Woodland Pine	Woodland Mixed	Marsh Fresh	Marsh Salt
Cakile edentula	5						3
Salsola Kali	3						3
Suaeda linearis	2						3
Atriplex arenaria	3					4	4
Panicum amarulum and P. amarum	2-3					3	
Hydrocotyle umbellata	2					4	
Scirpus americanus	4	3	3			5-6	4
Solidago sempervirens	5	5	3-5			3	3
Spartina patens	5-6	4	3-4			5-6	6
Strophostyles helvola	2	3				3	
Rhus radicans	3	5-6	5	3	4		
Panicum virgatum	3	3	4	3			
Baccharis halimifolia		5	5	4		3	3
Iva frutescens		4	4	3		5	4
Teucrium canadense		3				2	4
Juncus acuminatus		1	3-4			4	
Oenothera fruticosa			3			4	
Convolvulus sepium			2			3	
Carex Longii		3				2	
Juncus dichotomus		4				5	
Juncus scirpoides		3				5	
Ptilimnium capillaceum		3				5	

Species	Dunegrass	Shrub Mesic	Shrub Xeric	Woodland Pine	Woodland Mixed	Marsh Fresh	Marsh Salt
Hydrocotyle verticillata		3				4-5	
Dryopteris Thelypteris		3				3-4	
Eupatorium pubescens		3				3	
Mikania scandens		3				4	
Setaria geniculata		3				3	
Sisyrinchium atlanticum		3	3			3	
Pluechea foetida		2				4-5	
Phragmites communis		1				3	

*** 6 - abundant. 5 - common, 4 - frequent, 3 - infrequent, 2 - rare, 1 - local. See Appendix II.**

Transects. Species frequency and density, as determined by line transects in dunegrass, transition and shrub communities, are shown in Table 2. A total of seventeen species occur in the dunegrass community--most of them with a density of less than one individual per decimeter. This reflects the low cover value of the entire community. Rarely is the total cover in this zone over 20%. Of the seventeen species here, fourteen, or 82% are also present in the transition zone.

The transition zone has forty-nine species. Of these, 77% occur in the dunegrass or mesic shrub zones; the remainder are typical of the xeric shrub community. Mesic shrub zone species number forty-five; of these 68% also occur in the transition or dunegrass zones.

The species which show the highest density also provide the most cover. Of the sixty-eight species making up the three zones, only seventeen species, or 25%, have a density greater than one plant per decimeter--two in the dunegrass community, seven in the transition zone, and eight in the shrub community. A mere five species provide most of the total cover for the three zones: *Ammophila breviligulata*, *Myrica cerifera*, *M. pensylvanica*, *Solidago sempervirens*, and *Rhus radicans*. These species also have the greatest frequency values. In these transects, species that occur in only one zone provide little cover. They all have a density of less than one with two exceptions: *Vitis rotundifolia* in the transition zone, and *Festuca ovina* in the shrub community.

Table 2. Comparative density and frequency of species in three strand communities (dunegrass, transition, and mesic shrub).

	Community transect totals					
	Dunegrass		Transition		Shrub	
Species	Density plants/dm.	Freq.*	Density plants/dm.	Freq.*	Density plants/dm.	Freq.*
Cakile edentula	<1	38				
Salsola Kali	<1	8				
Hudsonia tomentosa	<1	2				
**Panicum amarum & P. amarulum	<1	42	<1	13		
P. meridionale	<1	21	<1	3		
Euphorbia polygonifolia	<1	17	<1	7		
Cenchrus tribuloides	<1	15	<1	5		
Oenothera humifusa	<1	11	<1	7		
Linaria canadensis	<1	5	<1	10		
Smilax glauca	<1	2	<1	8		
Ammophila breviligulata	3	100	8	100	<1	2
Rhus radicans	1	5	10	58	11	64
Solidago sempervirens	<1	23	3	61	3	86
Erigeron pusillus	<1	21	<1	2	<1	2
Spartina patens	<1	17	<1	40	3	38
Myrica cerifera	<1	5	12	63	52	95
Vitis rotundifolia			2	15		
Prunus serotina			<1	5		

Species	Dunegrass Density plants/dm.	Dunegrass Freq.*	Transition Density plants/dm.	Transition Freq.*	Shrub Density plants/dm.	Shrub Freq.*
Aristida tuberculosa			>1	3		
Pinus Taeda			>1	3		
Echinochloa Walteri			>1	2		
Quercus falcata			>1	2		
Salix nigra			>1	2		
Sassafras albidum			>1	2		
Senecio tomentosus			>1	2		
Vaccinium atrococcum			>1	1		
Ilex opaca			>1	1		
Smilax Walteri			>1	1		
Myrica pensylvanica			7	46	21	60
Rubus cunefolia			1	25	>1	27
Baccharis halimifolia			>1	20	21	18
Eupatorium rotundifolium			>1	19	>1	7
Parthenocissus quinquefolia			>1	17	>1	21
Oenothera fruticosa			>1	15	>1	7
Rumex Acetocella			>1	10	>1	17
Festuca rubra			>1	8	4	52
Andropogon virginicus			>1	7	>1	7
Scirpus americana			>1	7	>1	7
Rosa palustris			>1	7	>1	5
Panicum virgatum			>1	5	>1	34

Species	Dunegrass Density plants/dm.	Dunegrass Freq.*	Transition Density plants/dm.	Transition Freq.*	Shrub Density plants/dm.	Shrub Freq.*
Juncus dichotomus			<1	5	<1	27
Helianthemum canadense			<1	5	<1	7
Rhus copallina			<1	5	<1	2
Panicum scoparium			<1	3	<1	29
Solidago tenufolia			<1	3	<1	17
Teucrium canadense			<1	3	<1	8
Vulpia octoflora			<1	3	<1	2
Carex longii			<1	2	<1	10
Phragmites communis			<1	2	<1	7
Iva frutescens			<1	1	<1	3
Pyrus angustifolia var. spinosa			<1	1	<1	2
Festuca ovina var. duriuscula					2	2
Mikania scandens					<1	13
Panicum lanuginosum var. fasciculatum					<1	8
Cirsium horridulum					<1	7
Gnaphalium purpureum					<1	7
Panicum lanuginosum var. Linderimeri					<1	7
Chenopodium ambrosioides					<1	5
Polypogon monspeliensis					<1	5
Ptilimnium capillaceum					<1	5

Species	Dunegrass Density plants/dm.	Dunegrass Freq.*	Transition Density plants/dm.	Transition Freq.*	Shrub Density plants/dm.	Shrub Freq.*
Elymus virginica					<1	3
Gaylussacia baccata					<1	3
Phytolacca americana					<1	3
Apocynum cannabinum					<1	2
Dioda virginiana					<1	2
Juniperus virginiana					<1	2
Strophostyles helvola					<1	2

* Frequency - per cent of total transects of community (Total transects: dunegrass, 47; transition, 58; and shrub, 59).

** Counts of Panicum amarum and P. amarulum are combined due to difficulty in field identification of the two.

<u>Soil and water samples</u>. Variation in data means for soil salinity, pH, Mg, P_2O_5, K_2O at three soil depths; water salinity, and pH; and watertable depth for samples taken in dunegrass, transition, and shrub communities; and tests of significant differences are given in Table 3. A comparison of the variables between the three zones shows the dunegrass and transition zones to be generally homogenous. The only significant differences were in soil pH at all levels. However, the mesic shrub zone was significantly different from the other zones in five variables--depth of water table was more shallow, while soil pH, salinity, magnesium and potassium content were higher.

Table 3. Variation in soil salinity, pH, Mg, P_2O_5, and K_2O at the three soil depths; water salinity and pH; and water table depth for samples taken in dunegrass, transition, and mesic shrub communities in areas where transects were made. (See Appendix Tables 1, 2, 3.)

Variables	Communities					
	data means			logarithmic transformation		
	dunegrass	transition	shrub	dunegrass	transition	shrub
Watertable Depth cm.	88.8	81.5	46.9	1.8850 a	1.8953 a	1.6126 b
Water Samples (Watertable)						
Salinity ppt.	3.19 a	0.15 a	0.78 a			
pH	7.0 a	6.3 a	6.5 a			
Soil Samples						
Salinity ppt.						
Surface	0.14	0.12	1.66	-2.1103 a	-2.4059 a	-0.6707 b
20 cm.	0.26 a	0.04 a	0.16 a			
Watertable	0.36 a	0.06 a	0.18 a			
pH						
Surface	7.0 a	6.1 b	5.2 c			
20 cm.	7.3 a	6.4 b	5.9 b			
Watertable	7.4 a	6.5 b	5.5 b			
Mg ppm						
Surface	21.3	6.5	143.4	1.3701 a	0.8912 a	2.1703 b
20 cm.	20.5	13.9	40.3	1.4229 a	1.2943 a	1.6861 a
Watertable	32.4	7.1	33.7	1.4350 ab	1.0060 b	1.6599 a
P_2O_5 ppm						
Surface	5.0 a	4.3 a	7.7 a			
20 cm.	4.7 a	4.3 a	5.2 a			
Watertable	5.5a	4.5 a	5.4 a			
K_2O ppm						
Surface	10.3	7.8	47.0	1.2220 a	1.1662 a	1.7935
20 cm.	11.5 a	8.8 a	15.7 a			
Watertable	14.5 a	8.5 a	15.6 a			

Means followed by letter in common between communities are not significantly different at the 1% level--Duncan's Multiple Range Test.

* Logarithmic transformations of mineral content are from original lbs/acre data. ($\frac{\text{lbs/acre}}{2}$ = ppm.)

DISCUSSION

The timing of the study proved to be fortuitous. At the beginning, in 1965, the island was essentially deserted. Only an occasional fisherman or the few cottage owners were there. By the spring of 1968, the entire island, with the exception of the Wildlife Refuge, was open to the public and generally accessible by automobile. It is now a camper's haven and tourist's delight. However, the direct effect people will have on the vegetation generally will be limited to the dunegrass zone. The other zones are protected during frost-free months by a population of voracious mosquitoes.

Floristics. Interzonal and intrazonal floristics and vegetational zones in dune and salt marsh habitats have been documented many times. Oosting (1954) notes that the world's seacoasts are covered with a vegetation of similar life form--often of the same genera and occasionally of the same species. This is true of the area studied, Assateague Island,and its neighboring strands. Catalogues of the vegetation of the Outer Banks of North Carolina (Burk, 1961), Cape Henry, Virginia (Egler, 1942) and Island Beach, New Jersey (Martin, 1959) are cited to represent floras to the north and south of Assateague. Earlier papers are of little value as they list only isolated or notable species.

A comparison of the vascular plant families collected on the four barrier beaches is shown in Figure 1. Of 108 families represented, 50 are present in all four areas. Assateague is a transition bar between the southern and northern strand floras; however, it inccludes more southern families than northern. The one family found only on Assateague, and not on the others, Lardizabalaceae is represented by one species, Akebia quinata. This plant is a native of Asia, and undoubtedly was introduced on the island where it is now well established at one station near the Light house.

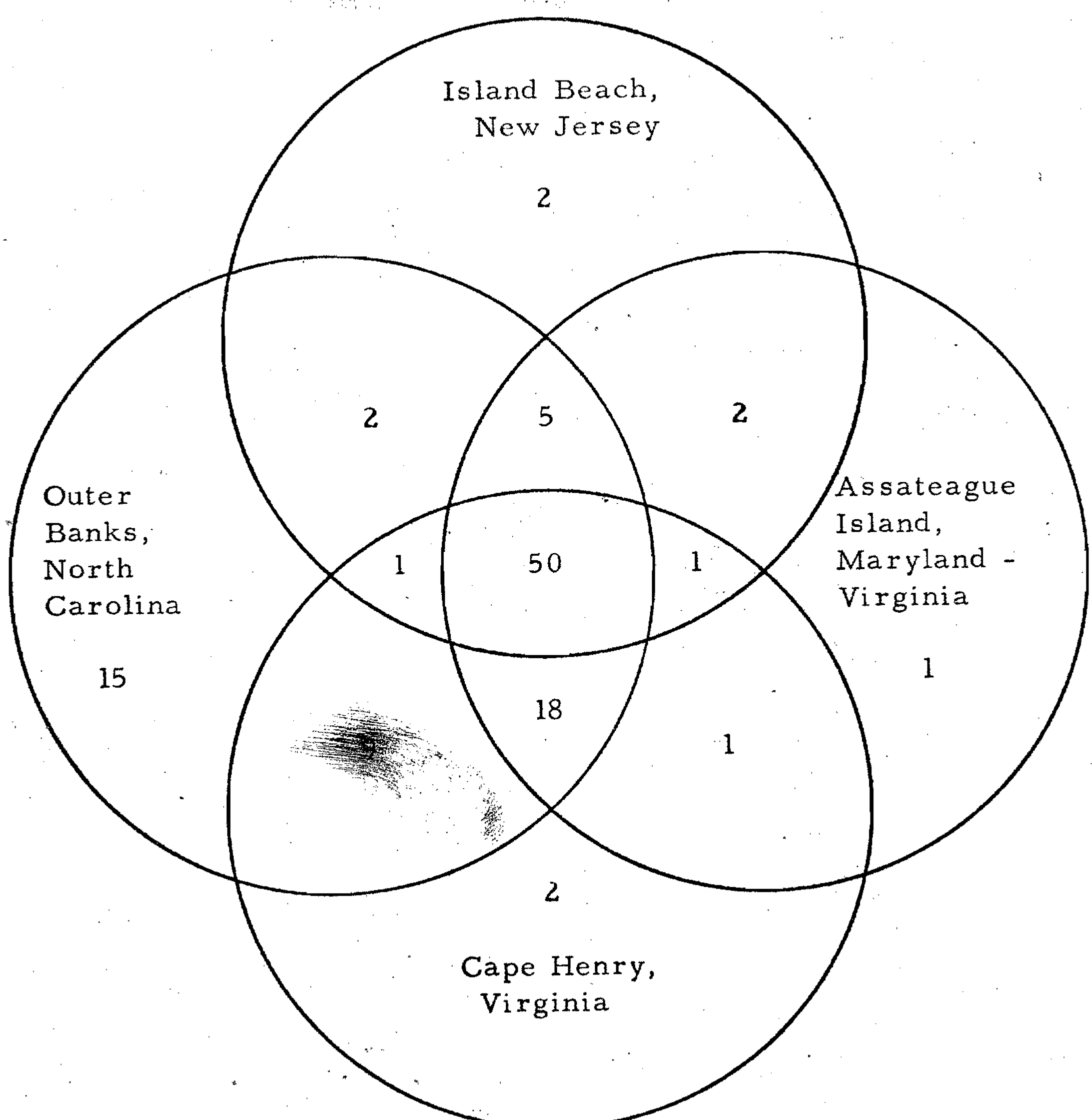


Figure 1. A comparison of the vascular plant families on four barrier bars of the Atlantic Coast. (Nine families common to Assateague Island and the Outer Banks not included.)

1. Dune Herbaceous Zone.

Beach. Pioneers along the upper beach are the same species, noted for salt tolerance, found in the low salt marshes and pans. Most prominent is *Cakile edentula*--the only indigenous Crucifer on the strand. The reproductive survival mechanism of these species is an extravagant seed production, although seedling survival rate is low. This is in marked contrast to the dune grasses which reproduce primarily by vegetative means.

Beach plants survive only in the shelter of driftwood or small dunes which build up along the upper beach. The habitat is very unstable; species are continually covered and uncovered by shifting sand, and subjected to wind-driven salt spray resulting in few mature individuals. Along the artificial barrier dune bordering the upper beach, the same species grow luxuriantly. This dune has been planted with *Ammophila breviligulata* and fertilized, and thus provides a more stable habitat at a higher nutrient level.

Dunegrass Community. *Ammophila breviligulata* is dominant in the dunegrass zone behind the open beach. It is common to all barrier bars on the Atlantic Coast, together with its associate, *Spartina patens*. While the latter is common in marshes and pans also, *A. breviligulata* is restricted to the dunegrass zone. *Solidago sempervirens* is prevelant along the coast in this zone, providing 10% of the total community cover. From North Carolina southward, *S. sempervirens* var. *mexicana* is more common. *Panicum amarulum* and P. amarum are both widespread members of the dunegrass community on Assateague and the more southerly bars. P. amarulum apparently approaches its northern limit here since Martin (1959) reports only P. amarum in New Jersey, in association with Hudsonia tomentosa on stable dunes, not in the dunegrass zone. Arenaria peploides, found at two stations in Virginia, approaches its southern limit on Assateague. It has been recorded as far south as Cape Henry, but colonies are few (Smith, 1940). Several species are conspicuously absent. Artemisia Stelleriana Bess., which is frequent on the neighboring strands does not occur on Assateague. Carex kobomugi Ohwi, present on Cape Henry and successfully introduced on Island Beach does not occur. Two common southern species reported at Cape Henry apparently reach their northern limit just south of Assateague. Uniola paniculata L., an important dune binder, is not present, nor is Iva imbricata Walt., a forb frequent from Cape Henry south.

Man now recognizes the importance of holding sand on the barrier beaches against erosion, and the importance of vegetation as a sand stabilizer. On Cape Cod attempts were made to stabilize dunes with plantings as early as 1892, but only recently has there been construction of artificial barrier dunes along the shoreline, particularly since a disastrous storm in 1962. These dunes are built parallel to the ocean, landward of the high tide line, thus, within the dunegrass zone.

The dune reduces sand accretion and salt spray behind it and increases both factors on the windward side. The community landward will show the first effects of this barrier dune--particularly the broad expanses of Ammophila breviligulata. Wagner (1964) has shown that this species requires sand accumulation in order to survive. When this is reduced, the dunegrass community will be replaced, probably by the shrub community of stable secondary dunes. Long-range studies of areas behind the new barrier dunes would provide some evidence of the direction of, or factors affecting, succession on dunes.

One general characteristic of the dominant members of the dunegrass community, previously noted, is that these species reproduce most successfully by underground vegetative means--not by seed. The perennating organs overwinter underground where they are protected from salt spray during the period of highest salt deposition. Most of the species have deep rhizomes which spread under the sand or, as in the case of Solidago sempervirens, immature lateral underground shoots. Laing (1958) showed that Ammophila breviligulata, which reproduces effectively by runners and fragmentation, also produces large numbers of seeds of which only 5% are viable. Oosting (1954) found that Quercus virginiana, growing where salt spray is highest in the arborescent zone, has low seedling survival.

In a comparison study of four populations of Polygonum bistortoides Pursh., Mooney (1963) found that the coastal population reproduced only by rhizome proliferation, while the alpine populations set viable seeds, and showed no vegetative reproduction. Salinity conditions of the coastal population were not reported. Nobuhara (1967) stated that "coastal plants cannot live on the coast without the power of developing new overground shoots when covered by sand". The most successful plant species in regions of high salt spray generally over-winter and reproduce vegetatively underground, where the effects of salt spray are minimal.

The few species in the dunegrass zone which reproduce by seed are also found in low salt marshes and pans. In the two latter communities, seed reproduction is more common. One may postulate that the inability of seeds or seedlings to survive is a factor limiting the number of species in areas of high aerial salt spray, whereas it is not a factor where the salt is in the soils and ground water alone.

2. Shrub Zone.

On Assateague, Myrica cerifera is dominant in the shrub zone, more plentiful in mesic situations than in xeric. It is one of the few plants Latrobe (1798) listed as present on Cape Henry; however, it is not included in Egler's (1942) list. Snow (1913) reported that, although Maryland is considered the northern limit of M. cerifera, it had been recorded in Delaware by Williamson (1909) and in New Jersey by Stone (1910). Martin (1959) did not locate it on Island Beach. However, Stoesz and Brown (1957) stated that M. cerifera has been successfully planted on Cape Cod, Massachusetts, in dune stabilization work. The Myrica cerifera community on Assateague is perhaps peculiar to the coast north of the Outer Banks. The description of the shrub zone of the Outer Banks did not separate mesic and xeric shrub communities, but the dominants of the zone, M. cerifera and M. pensylvanica, are "fairly common" (Burk, 1961). Other species of the Outer Banks are predominantly southern species: Quercus virginiana and Ilex vomitoria Ait. Although M. cerifera does not occur at Cape Henry, M. pensylvanica is common but not dominant there, associated with Quercus virginiana.

Vaccinium corymbosum dominates the Island Beach mesic thickets and M. pensylvanica occurs as a subdominant. Other than these principal differences from the Assateague thickets, the subdominant shrubs and lianas are the same in both places. On Island Beach there are tangles composed entirely of Smilax spp.. Although Smilax is prevalant on Assateague, it has not made a community excluding other species.

Juniperus virginiana is a subdominant on the two southern bars; in New Jersey it is abundant and forms extensive forests. According to Martin (1959) it is the "most abundant tree on Island Beach". Although it is present in all vegetative zones on Assateague, except the marshes, mature plants are infrequent to rare. Numerous seedlings occur--particularly in one pan edge which was recently dyked to prevent flooding. Since Juniperus virginiana is a major species in the other three bars, it seems strange it is not so on Assateague. Another species, Chamaecyparis thyoides (L.) BSP. is common on strands both north and south, but not found on Assateague.

The xeric shrub community frequently includes Pinus Taeda and deciduous tree species found in the woodlands; more than are common to both the mesic shrub and woodland communities. Table 2 shows that few species are present both in the transition zone and mesic shrub community. More of the transition zone species are common to the xeric shrub community. If succession is taking place, the progression is probably from dunegrass to xeric shrub to woodland. The mesic shrub community represents a variance from the normal topographic up-building process of secondary dunes.

3. Arborescent Zone

Maritime forest. The maritime forest as described by Oosting and Bourdeau (1959) has not been defined on Assateague. No community similar to the live oak forest on the Outer Banks or the cedar thickets on Island Beach occurs here.

Pine woodland. The pine woodlands on Assateague, on high secondary dunes, occurs between the shrub zone and the salt marsh, but much elevated above the latter. The dominant is unquestionably Pinus Taeda--often in pure stands, but occasionally mixed with oaks. It is dominant also on strands to the south, but not present to the north on Island Beach. P. rigida Mill. is the dominant pine in New Jersey, but, as previously mentioned, Juniperus virginiana is generally the more common tree.

Egler (1942) postulates fire as the most important single factor prepetuating pine, indicating it is a subterminal stage of succession.

Burk (1961) believes the presence of pine forests is due to excess logging of hardwoods, and the difficulty of small animals in traversing the Banks which consequently prevents reforestation by seed they carry. The pine woodlands in the Maryland portion of Assateague, including sites of previous logging, are in areas where the island juts out into the bay. They are made up of old trees on stable dunes. The progression of pine to deciduous woodland is difficult to determine, but it appears these trees will be undercut from the bayside and the woodlands become salt marsh before conditions change sufficiently to permit formation of a pine-deciduous mixture, or a deciduous woodland. The presence of shrub and pine vegetation in hummocks within the salt marsh demonstrates the possible advance of the marsh into a woody community.

The Virginia portion of the island is generally wider and the woodlands more extensive than at the northern end. At the widest point, the pine woodland is much the same composition as that described on Cape Henry (Egler, 1942). The understory is composed of _Magnolia virginiana_, _Persea Borbonia_, _Ilex opaca_, and _Vaccinium_ spp.. The fact that this pine woodland was cut over and farmed until 1930, may account for it being the only such association on the island.

Pine Deciduous Mixed Woodland. The pine deciduous mixed woodland on Assateague occurs on the high dunes in the area of the Light house. Three species in this woodland were not found elsewhere on the island: _Cornus florida_ (one specimen), _Xanthoxylum clava-herculis_ (one specimen - it is frequent on bars to the south and

and possibly reaches its northern limit here), and Berchemia scandens (an extensive growth in one small area).

Oaks associated with the pines vary along the coast. In North Carolina and Virginia, the major species are Quercus falcata, Q. nigra, and Q. virginiana. On Assateague, Q. virginiana is not present, but the other two are common. In New Jersey, neither Q. nigra or Q. virginiana are present, while Q. falcata is still common (probably at its northern limit), in association with Q. ilicifolia Wang. and Q. marilandica Muench.. Carya spp. range from present to dominant on the southern bars, but are not present on Assateague or Island Beach.

Acer rubrum is an important species in mesic situation on all bars except the Outer Banks. In New Jersey, it is dominant in woodlands on the mainland where the water table is high (Bernard, 1963). Presence of A. rubrum in swales of the most stable pine-deciduous community indicates it may be the terminal or subterminal stage of succession in the mesic community. Harvill (1967) described the A. rubrum community on Assateague as an association of A. rubrum, Quercus nigra and Nyssa sylvatica. However, this author found but one specimen of Nyssa sylvatica in the area, hardly enough to qualify it as a major component of a community. The most frequent associate with A. rubrum and Quercus nigra is Sassafras albidum.

On all barrier islands, the arborescent zone occurs on the largest stable secondary dunes and intervening swales farthest away from the ocean. The dunes are formed from sand carried by the onshore prevailing winds. Oosting (1954) states, "Often highest dune ridges in an area are the result of an extensive blowout which piles quantities of sand above the already established surface level. These are important because of the protection provided leeward." This protection permits conditions suitable to forest development, but then the forests are continually being covered by dunes pushed landward by the onshore winds.

Latrobe (1798) described a swamp overgrown with aquatic trees and shrubs on Cape Henry as follows: "Of these, many thousand are already buried in the sand, which overtops their summits, and threatens the whole forest with ruin. Their destruction is slow but inevitable." The same phenomenon is still occurring on bars all along the coast, and has been recorded often.

Evidence of previous vegetative zones is difficult to discern. The presence of Quercus falcata in dunegrass and transition zones may indicate forests which have been covered by encroaching sand. Q. falcata here is very low (often not over one meter), but spreading, covering an area of two-meter diameter--possibly the crown of an old tree. The fact that there are no similar pines may indicate pine does not survive sand coverage.

Oosting (1954) and Burk (1961) reported "ghost forests"--stumps surviving in the ocean intertidal zone--on the Outer Banks. One such "forest" occurs on the surf at Green Run on Assateague. The presence of these "forests" clearly indicate that woodlands were located farther eastward than they are now. One can only judge by our present knowledge of zonation, that the dunegrass and shrub zones were present east of the beach where the stumps are now located. Material from one stump on Assateague has been identified as a "hard pine"*, presumably P. Taeda. In light of the present vegetation of the island, it seems logical that this was a pine forest rather than cedar (as the stumps are called by local residents), and would eliminate the possibly of an extensive cedar forest on Assateague within recent time.

Martin's postulation (1959) of succession is applicable on Assateague. He states that the terminal stage of succession is determined by environmental limitations of the area. The northern portion of Assateague is neither wide enough, nor the dunes high enough to provide the protection from salt spray required to permit establishment of a hardwood forest. The pine-deciduous mixture at the widest portion in Virginia demonstrates that hardwood forests can establish themselves on Assateague where conditions permit. The presence of deciduous tree species in zones closer to the ocean indicate isolated areas affording enough protection for them to survive.

4. Marsh Herbaceous Zone.

Salt marsh. The present study of the salt marsh verifies the

* Personal communication W. L. Stern, Wood Anatomist, University of Maryland.

findings of other investigators. The marshes of Assateague show the same mosaic pattern described in earlier literature. Species are separated generally into the low marsh and high marsh, but any change in elevation is sufficient to alter the edaphic conditions, including daily inundation, and produce a distinct change in species within either marsh.

Spartina alterniflora, characteristic of low marsh on other strands, is not common on Assateague. It occurs as a narrow band on the marsh bayside. Spartina patens, a high marsh species, covers many acres in pure stands--providing the "salt hay" on which the Assateague ponies graze. Species common to the pans appear also in the low marsh: Atriplex patula, Cakile edentula, Salicornia spp., and Suaeda linearis.

Borrichia frutescens, common on southern strands, was found along the shore of Tom's Cove--two stations only. A single specimen in the University of Maryland Herbarium is labeled "North Beach ferry landing, Assateague Island, Maryland," and dated 1948. A specific search in this vicinity and other similar sites failed to reveal its presence in 1967. This may indicate the limits of the range are decreasing. The northern limit of the species on Assateague is probably now Virginia.

There is insufficient evidence to indicate biotic succession in the salt marsh. The hummocks within the marsh having xeric shrub floristics might indicate succession, but it is more probable that they are relics of a former shrub zone which has been replaced by marsh. The theory advanced by Burk (1961) that the last successional stage in tidal marshes is the Myrica cerifera shrub community is applicable here.

Transects. Transects in the dunegrass zone show only 17 species. Two of the three species occurring only in the dunegrass zone are well-known halophytes, Cakile edentula and Salsola Kali. These are also found in salt pans and salt marshes. The third species (Hudsonia tomentosa), which is rarely found in the dunegrass zone, is a dominant on stable secondary dunes. Possibly this one is a relic of a former secondary dune. Ammophila breviligulata is the dominant in both the dunegrass community and the transition zone. The fact that density is higher in the transition zone may indicate more favorable growing conditions.

When this transect study was initiated, it was assumed that the shrub zone was represented by Myrica cerifera or M. pensylvanica. The presence of one of these was used as a criterion for locating shrub areas for transect sampling. It is now recognized that, although both Myrica species are represented in the shrub zone, they are dominant only in the hydrosere, although also present in the xerosere. Thus, shrub zone transects do not represent the entire shrub zone, but only the mesic community within the shrub zone.

The Myrica species in the mesic shrub zone obviously grow under conditions more favorable than those in either the transition zone or the xeric shrub community. The <u>Myricas</u> in the mesic community are taller and more vigorous, forming dense thickets, than those of more xeric habitats which grow singly and generally smaller.

The presence of many species typical of the xeric shrub zone in the transition zone, and the absence of those same species in the <u>Myrica</u> thicket may indicate that the <u>Myrica</u> thicket is an interruption of orderly transition between the transition zone and the xeric shrub community. On the other hand, it may be argued that the two progressions are occurring simultaneously, one in xeric and one in mesic habitats. The xeric communities dominate any zone.

<u>Soil and soil water samples</u>. The present study demonstrates the fact that significant differences exist between the dunegrass and mesic shrub communities, and the transition zone between them. The data indicate a difference in soil nutrients between the xeric and mesic communities, in addition to the difference in moisture conditions. The wide variation in the edaphic factors measured within each community indicates that the species of that community tolerate a wide range of these factors. At least in the dunegrass and transition zones, species exist at fertility levels which are agriculturally very low.

The presence of minerals in the dunegrass zone soil is not unexpected with the ocean constantly resupplying the dunes. The low level of nutrients in the transition zone may be assumed due to the position farther away from the ocean. However, the high levels of magnesium and potassium in the mesic shrub zone were not expected.

The position of this community is behind the transition zone away from the ocean and topographically low, thus making ocean supply unlikely.

The high magnesium and potassium content may be the interaction of two factors. There is considerably more organic matter on the surface of the mesic shrub zone than the other two zones studied here. Organic material has a tendency to hold both magnesium and potassium, but not phosphorous. There must be a source of minerals, however. Presumably it is from the bay, rather than the ocean. Many of the mesic shrub communities are adjacent to salt marshes, or contain inlets from the bay so that water may flow directly into them, bringing into the community a regular source of minerals. Even if the community is not directly connected to the bay, the water table is high and soil surface subject to flooding. Flooding provides a means of circulating the minerals from the surface to the water table and vice versa.

More work is required to support this hypothesis. Originally the thought behind taking soil and water samples was merely to demonstrate the differences between what was assumed to be three homogeneous zones. However, samples for each parameter within each zone showed such wide variation, it is difficult to explain. Sites of transects and pits were selected by the appearance of the community present. Floristically, within each zone the samples were relatively homogeneous. It was assumed that also edaphically they would be relatively homogeneous. However, this is not the case. A wide difference in samples for each parameter within each floristic zone indicates much variation of conditions within each zone. A more careful selection of sites within zones, reflecting their developmental stage, rather than the floristics could possibly shed light on this anomylous situation. Such differences as those between salinity of soil water in the dunegrass zone (3.19 ppt.) and soil at the same point (0.36 ppt.) certainly deserves additional attention.

Succession. Martin (1959) in a studious consideration of succession concludes:

> "In its broader aspects, plant succession on Island Beach is controlled by oscillations in the interaction between physical and biotic forces. A more precise description of successional patterns must necessarily await the accumulation of more precise data concerning the environmental and vegetational processes involved. Even at this stage of knowledge, however, it seems reasonable to conclude that plant succession of Island Beach, and perhaps on barrier beaches in general, is largely an intrazonal phenomenon. The herbaceous, shrubby, and arborescent zones do not necessarily represent seral stages in biotic (autogenic) succession. The herbaceous zones (Dunegrass and Salt Marsh) are structurally and compositionally stable under the environmental conditions which characterize them. Within the environmentally less severe shrubby, and arborescent zones, several sere - xerosere, hydrosere, and halosere - are recognizable, and the structure of terminal stages is determined by environmental limitations--especially salt spray intensity."

This study of the vegetation of Assateague supports his conclusion. The evidence of biotic succession on Assateague is inconclusive, but the same zonal pattern occurs here. However, the presence of distinctly different xeric and mesic sere within each vegetative zone indicate two lines of succession. The vegetative zones are commonly described by the dominants of the xeric communities (dunegrass - Ammophila; shrub - Vaccinium-Myrica; arborescent - Pinus-Quercus) because these occupy most of the strand.

The mesic society is often no more than a minor mosaic within the xeric community, but it also ranges from herbaceous to shrub to woodland (fresh and salt marsh - Scirpus and Spartina; shrub - Baccharis-Myrica; arborescent - Acer-Salix). The arborescent mesic community is probably as stable as that of the xerosere under the prevailing environmental limitations. This mesic line of progression across the strand, although of lesser importance than the xeric progression, should not be ignored; indeed it should be investigated further.

In his discussion of causes of zonation on the strand, Oosting (1954) accepts wind-borne salt spray as the major factor, and lists other potential causative factors. In this study, two other factors, topography (as depth of water table) and minerals in the soil are considered between two vegetative zones. It is shown that the depth of the water table is significantly closer to the surface in the mesic shrub than in the dunegrass and transition zones, and that magnesium and potassium are significantly higher in the mesic shrub zone. Although the differences are significant, more study is required before declaring these factors limiting or causative in zonation.

It is generally accepted that on barrier bars successional relationships between vegetative zones is stable if there is no physiographic change. However, any successional trend on a barrier bar must be temporary, as it is subjected to sand burial. Oosting (1954) states: "Although materials may be added to the beach, there is a tendency for materials to be removed and either to be carried inland or carried away. Most banks, therefore, tend to become narrower or to be shifted inland under the influence of waves, current and wind." The effect of the artificial barrier dunes constructed along the Atlantic coastline remains to be seen. Physiographic changes such as reduced sand burial, and salt spray will result. The changes which follow may indicate successional trends in a shorter time than would be required naturally.

On the dune strand habitat, zonation and succession cannot be separated. The causative factors of zonation and those limiting succession are the same. Any physiographic change on the strand brings about a change in the plant community, and it has been shown that new communities may be of lower successional status as often as one of successional advance.

APPENDIX I

HISTORICAL AND GEOLOGICAL ASPECTS

Assateague Island is part of the barrier island system along the North American shore of the Atlantic Ocean. These islands are initially composed of sand, although silt and organic matter are accumulated later. Sands are thrown up by ocean waves. As a wave rolls shoreward across the ocean, the oscillating water eventually touches the bottom in shallow water, slowing the wave and creating a drag. This moves the bottom materials shoreward, initially creating the bar. Due to the fact that the prevelant wave action is not continually at right angles to the beach, there is littoral drift - that is - a net long-shore movement of material, primarily sand. On Assateague the direction is south, hence a hook formed on the southern tip of the island, south of Assateague Cove, commonly known as Tom's Cove.

Between the barrier islands and the mainland are lagoons, designated locally and on charts as bays. These bodies of water are by Pritchard's (1952) definition, estuaries--specifically bar-built estuaries. The bay between Assateague and the mainland to the north is the Sinapuxent Bay. To the south is the Chincoteague bay, one of the largest (five miles at its widest part) and most important of the Atlantic Coast (Vokes, 1961).

The Maryland barrier beaches are of Miocene series, presently in an interglacial period when the ocean is rising and the coastline subsiding (Vokes, 1961). Erosion and the subsiding coastline have produced changes in the island size and location within historic time. The presence of a "ghost forest", i.e., stumps of coniferous trees in the surf at Green Run, now indicates the island has been wider there, and probably along its entire length. Truitt (1968) postulates that Assateague consisted of a series of small islands which have coalesced, forming the present bar.

> In 1837, Ducatel described a feature of "that part of Maryland which lies on the Atlantic Ocean. It embraces the eastern side of the lowest Eastern Shore county, (Worcester) the main land of which is separated and protected from the surf, by a sandy beach, at present, extending unbroken the whole length of the Maryland sea-coast. The intervening sheet of water is known as the Sinepuxent sound;. . . Here the process of filling up is gradually going on, the more rapidly since the inlets of the ocean into it have become obstructed. . . Until lately the sandy beach just referred to consisted of a series of islands, some of which were tolerably well wooded, as those on the Virginia coast now are. . . ."

At present, Assateague Island is a continuous bar extending from southeast of Chincoteague Island, Virginia, to Ocean City, Maryland. Until 1932, the bar extended into Delaware; however, a narrow inlet was cut just south of Ocean City in 1929. A storm in 1933 enlarged the inlet making it navagable. Since then the Federal Government has maintained the inlet with stone jetties. These jetties have two effects. They keep the inlet open, and they increase the sand accumulation at Ocean City beach, while depriving the northern tip of Assateague of sand (Sieling, 1960).

Inlets between barrier islands provide a source of salt water into the bays. Salinities in the bays behind Assateague are highest at the inlets during most of the year. Seasonal fluctuations show lowest salinities--(24 °/oo)--in March and April and highest--(up to 38 °/oo)--due to evaporation in August and September. This is higher than the ocean which is generally 30.5 °/oo (Sieling, 1960).

When storm tides overrun low parts of the barrier beach, ocean waters enter the bays directly. On Assateague, the sites of previous inlets are most frequently inundated by abnormally high tides. However, with the construction of an artificial barrier dune in 1963, most of these were closed to the ocean. Two areas in the Maryland portion remain open to ocean storms: a low wash south of Green Run, and the northern tip, both of which are quite low, almost barren of vegetation and frequently flooded.

Sieling (1960) states that salinities in the bays increased with the opening of the Ocean City inlet in 1933. Although he is not specific, he mentions that this has changed the bayside flora of the upper portion of the barrier beach (Ocean City to Delaware). Presumably this would be true also of the lower portion (Assateague Island). Truitt (1968) has recorded opening and closing of five inlets across the present island since the eighteenth century.

With the exception of two small, isolated areas at Green Run and North Beach which are Norfolk sand, and the tidal marshes, the island soil is coastal beach sand--a white to light grey sand continuing down several feet. The tidal marsh soils are Elkton sandy loam--a grey medium sandy loam. The subsoil of the high tidal marsh is a heavy bluish-grey medium sandy loam where drainage is poor and the water table is near the surface. In the low tidal marsh, the top soil is mixed with muck, and the subsoil clay, covered with water almost continually (Perkins and Bacon, 1928).

The early effects of man on the present vegetation of Assateague are not apparent; however, the history of the island indicates these probably have been of some importance. Three villages were built at Green Run, Pope Island, and Assateague Light. These were small communities of fisherman, lumbermen and farmers which have disappeared in the last century. The subsequent effects of lumbering or farming are not easy to determine. Since a loblolly pine forest can mature in 25 years (Cope, 1926), areas changed by extensive cutting may have been obliterated since the last inhabitants left the island.

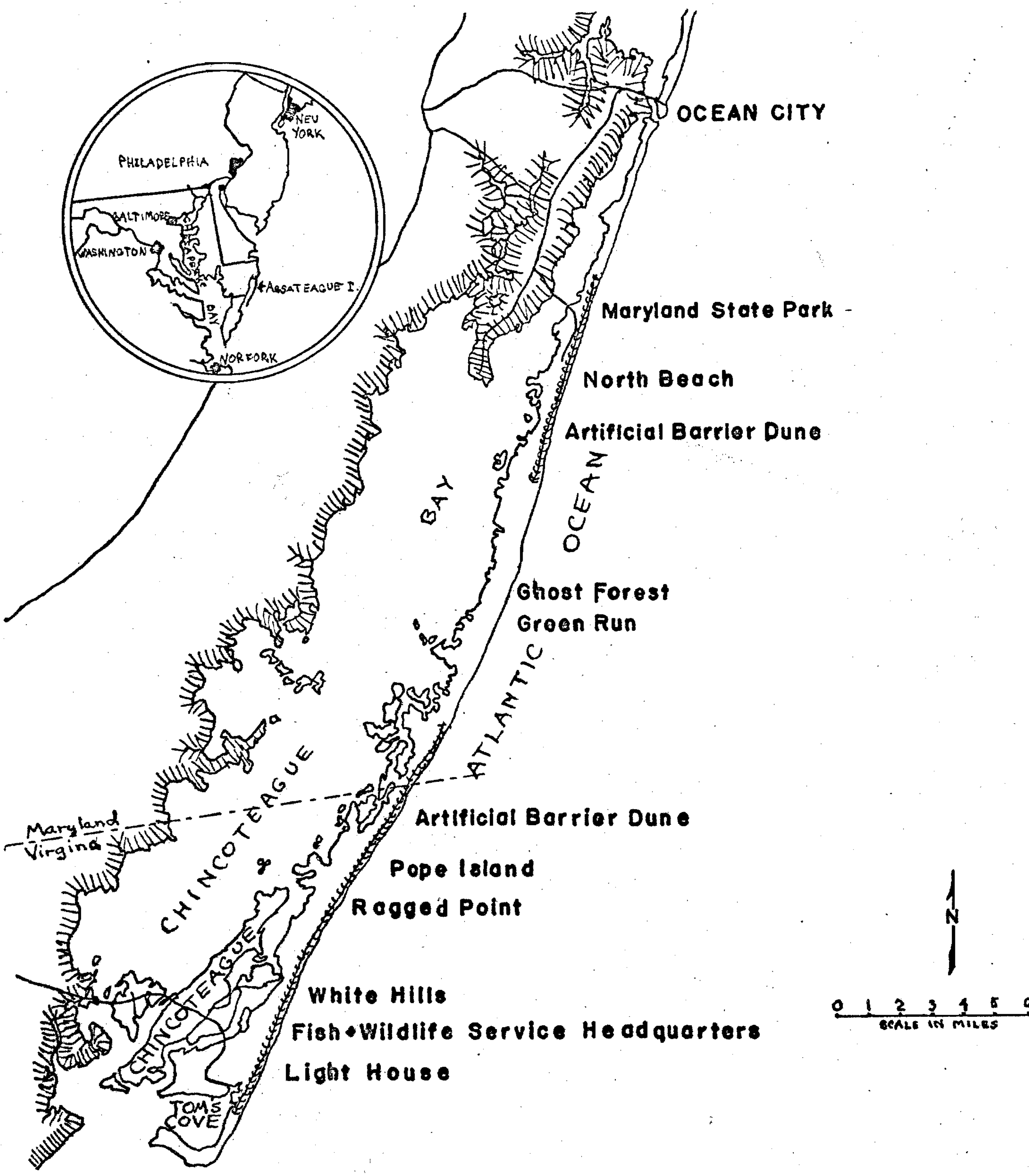
Grazing the salt meadows of barrier islands has been common since the 1800's. The Outer Banks of North Carolina, and Cape Cod, Massachusetts, were grazed continuously until they were made National Seashores recently by the Federal Government. The extent of grazing on Assateague has not been recorded. Ducatel (1837) reports that, when Assateague was a series of separate islands, the islands were inhabited by a race of horses called "Beach ponies". However, in 1836, "only a few of these Beach ponies remain on the Virginia islands, having been not many years back almost totally destroyed by an inroad of the ocean, to which these tracts of land are naturally exposed." Perkins and Bacon (1928) note that "the soil of the inner border of the island supports grasses which are forage for ponies, sheep, goats, hogs and cattle." A herd of about 150 ponies still graze the Spartina marshes and woodlands within the Wildlife Refuge. They are owned by the Chincoteague Volunteer Fire Department, are rounded up each July and the spring colts sold.

It is conceivable that lumbering and grazing, particularly grazing on the foredunes, removed sufficient vegetation to produce blowouts, permitting later inlet formation. One may wonder whether villages were built beside navagable inlets, or whether the activity of the villagers produced the inlets.

Barrier islands are subjected to harsh environmental conditions. The sands piled up by ocean waves are exposed to landward erosion by prevailing winds, particularly during ocean storms. The value of vegetation in holding sands against erosion was first recognized in the United States on Cape Cod as early as 1828. Lamson-Scribner (1898) described the planting of sand with Ammophila breviligulata (erroneously named Ammophila arenaria at that time) in 1895. By 1898 "no sand has moved" in the planted areas, and tree and shrub seeds planted since 1895 were growing--on sands encroaching on the town of Provincetown and its harbor. Since that time considerable dune building and stabilization has been carried out on Cape Cod. On numerous barrier bars along the Atlantic coast, the National Park Service has constructed artificial barrier dunes--these are bulldozed piles of sand, ten to fifteen feet high, reinforced with sand fence on top to collect drifting sands, and planted with Ammophila breviligulata. These dunes have proven effective in preventing the ocean from washing across the islands during storms.

On Assateague, since 1943, the United States Department of Interior Fish and Wildlife Service has maintained a Wildlife Refuge covering most of the Virginia portion of the island. In 1963, they constructed a barrier dune from Green Run to the southern tip of the island. Portions of the Maryland end are also protected by artificial barrier dunes, some built by private interests, three miles are maintained by the Maryland State Park Service. The National Park Service is currently acquiring the remainder of Assateague for a National Seashore. They undoubtedly will complete the barrier dune. The artificial dunes will reduce sand movement and salt spray carried across the strand. This should help stabilize the primary dunes behind them, and have an effect on the plant communities. Presumably the new conditions will permit species less salt tolerant and less able to withstand sand accretion to enter new areas.

The Wildlife Refuge management is primarily interested in migratory waterfowl. Within their area giant impoundments have been established to maintain aquatic plants, and large fields of millet have been planted as sources of duck food. The impoundments present a habitat unusual on the strand--large expanses of fresh to brackish standing water.



ASSATEAGUE AND VICINITY

U. S. Department of Interior 1963

APPENDIX II

Topographic descriptions follow Martin (1959)

Dune - windblown pile of sand

Hollow - low place between dunes or depression surrounded by higher ground

Dune Ridge - straight row of dunes

Swale - trough between primary and secondary dunes

Sandy flats - broad low-level areas between dunes

Primary dunes - relatively unstable dominated by physical forces with a history of continual change; open to catastrophe

Secondary dunes - stable dunes where vegetation shows slow change; dominated by biotic factors

Other terms are included here to describe areas on Assateague

Wash - low, flat expanse of sand, inundated by salt water during exceptionally high tides, leaving a salt deposit

Pan - a low, flat basin with an accumulation of salt due to evaporation. On Assateague, these have been created by closing sites of inlets or washes with dikes and barrier dunes.

Lagoon - "A lagoon is a body of relatively quiet shallow water, separated from the sea by a barrier beach, spit, or bar, which prevents wave energy from entering the lagoon. The lagoon receives fresh water and sediments from streams, and salt water from the sea through tidal inlets. These conditions develop a gradation from normal sea water at the inlets to brackish water in the body of the lagoon and fresh water near the stream mouths." (Krumbein and Sloss, 1951)

Blow-out - depression created by wind removal of sand

Ecological notations for all communities follow Allard and Leonard (1943)

Abundant: Occurring usually in large numbers where found (Dominant species of area)

Common: Plentiful throughout the area

Frequent: Evenly distributed over the area but not plentiful in any one given habitat

Infrequent: Occurring only occasionally

Rare: Not often found owing to its scarcity everywhere

Local: Restricted to a particular habitat or location

APPENDIX III

CATALOG OF THE VASCULAR PLANTS OF ASSATEAGUE ISLAND, MARYLAND-VIRGINIA

The following is a list of the vascular plants collected on Assateague Island during the growing seasons, 1964-67. Nomenclature following M. L. Fernald's Gray's Manual of Botany, 8th Ed. 1950, except as noted. Frequency notations follow Allard & Leonard (1943).

EQUISETACEAE (Horsetail Family)

1. Equisetum arvense L. Common horsetail. North of Maryland State Park, one station.

LYCOPODIACEAE (Club-moss Family)

2. Lycopodium inundatum L. var. Bigelovii Tuckerm. Bog club moss. Fresh marsh, three stations.

OSMUNDACEAE (Flowering fern Family)

3. Osmunda cinnamomea L. Cinnamon fern. Pine woodland, rare.

4. O. regalis L. Royal fern. Fresh marsh and pine woodlands, infrequent.

POLYPODIACEAE (Fern Family)

5. Asplenium platyneuron (L.) Oakes. Ebony Spleenwort. Two stations.

6. Dryopteris Thelypteris (L.) Gray. Shield fern. Fresh marsh, frequent.

7. Onoclea sensibilis L. Sensitive fern. Fresh marsh, Virginia, one specimen.

8. Pteridium aquilinum (L.) Kuhn var. pseudocaudatum (Clute) Heller. Bracken fern. Shrub and pine woodlands, infrequent.

9. Woodwardia areolata (L.) Moore. Netted Chain fern. Pine woodlands, one specimen.

10. W. virginica (L.) Sm. Virginian Chain fern. Fresh marsh and pine woodlands, infrequent.

PINACEAE (Pine Family)

11. Juniperus virginiana L. Red cedar. Shrub, infrequent.

12. Pinus echinata Mill. Yellow pine. Pine woodland, rare.

13. P. Taeda L. Loblolly pine. Pine woodland, abundant.

14. P. virginiana Mill. Jersey or scrub pine. Pine woodland, infrequent.

15. P. rigida Mill. Pitch pine. Pine woodland, rare. (Identification uncertain)

TYPHACEAE (Cat-tail Family)

16. Typha angustifolia L. Narrow-leaved cat-tail. Impoundment, rare.

17. T. latifolia L. Common cat-tail. Fresh marsh, rare.

ZOSTERACEAE (Pondweed Family)

18. Potamogeton pectinatus L. Sago pondweed. Impoundment, infrequent.

19. P. pusillus L. Pondweed. Impoundment, infrequent.

20. Ruppia maritime L. Ditch grass. Fresh marsh, rare.

GRAMINAE (Grass Family)

21. Agrostis alba L. Red top. Pine woodland, infrequent.

22. A. alba L. var. palustris (Huds.) Pers. Creeping bentgrass. Wet areas, woodlands, rare.

23. A. hyemalis (Walt.) BSP. Ticklegrass. Mesic shrub, infrequent.

24. A. perennans (Walt.) Tuckerm. Upland bent. Fresh marsh, one station.

25. Aira praecox L. Hair grass. Fresh marsh, pine woodlands, rare.

26. Ammophila breviligulata Fern. American beach grass. Dune-grass zone, abundant.

27. Andropogon scoparius Michx.
var. littoralis (Nash) Hitchc. Beard grass. Open secondary dunes, infrequent.

28. A. virginicus L. Broom-sedge. Open secondary dunes, infrequent.

29. A. virginicus L.
var. abbreviatus (Hack.) Fern. & Grisc. Bayside open secondary dunes, infrequent.

30. A. virginicus L.
var. glaucopsis (Ell.) Hitchc. Pine woodlands, infrequent.

31. Aristida tuberculosa Nutt. Sea-beach needle-grass. Open secondary dunes and pine woodland, infrequent.

32. Briza minor L. Quaking grass. Fresh marsh, Virginia, one station.

33. Bromus commutatus Schrad. Brome grass. Open secondary dunes, rare.

34. Cenchrus tribuloides L. Sandbur. Dunegrass zone, frequent.

35. Cynodon Dactylon (L.) Pers. Bermuda grass. Salt marsh and open secondary dunes, infrequent.

36. Digitaria filiformis (L.) Koel. Slender crabgrass. Fresh marsh, rare.

37. D. sanguinalis (L.) Scop. Finger grass. Dunegrass zone, infrequent.

38. Distichlis spicata (L.) Greene Spike grass. Salt marsh and pan, common.

39. Echinochloa pungens (Poir.) Rydb.
var. microstachya (Wieg.) Fern. & Grisc. Weed in cultivated field, one specimen.

40. E. Walteri (Pursh) Nash. Fresh marsh, infrequent.

41. Eleusine indica (L.) Gaertn. Goose grass. Pine woodland, rare.

42. Elymus virginicus L. Wild rye. Planted by Md. bridge.

43. Eragrostis sp. Undetermined introduced species. In clay fill - roadsides, infrequent.

44. E. pectinacea (Michx.) Nees. Love grass. Shrub, rare.

45. E. spectabilis (Pursh) Steud. Tumble grass. Salt marsh and open secondary dunes, infrequent.

46. Festuca arundinacea Schreb. Alta fescue. (from Hitchcock, not Fernald) Pan, one station.

47. F. arundinacea Schreb. Hort. var. K31. Planted along roadsides, Virginia.

48. F. ovina L.
var. duriuscula (L.) Koch Sheep's-fescue. Mesic shrub, infrequent.

49. F. rubra L. Red fescue. Shrub and open secondary dunes, frequent.

50. Glyceria pallida (Torr.) Trin. Manna-grass. Fresh marsh, rare.

51. G. septentrionalis Hitchc. Floating Manna-grass. Fresh marsh, rare.

52. Holcus lanatus L. Velvet grass. Roadsides, infrequent.

53. Leptochloa filiformis (Lam.) Beauv. Feathergrass. Pan, frequent.

54. Lolium multiflorum Lam. Italian rye-grass. Roadsides and pan, infrequent.

55. Muhlenbergia Schreberi J. F. Gmel.
var. palustris Scribn. Drop-seed. Fresh marsh, rare.

56. Panicum agrostoides Spreng. Fresh marsh, rare.

57. P. amarum Ell. Dunegrass and Marsh, frequent.

58. P. amarulum Hitchc. & Chase. Beach grass. Dunegrass and marsh, frequent.

59. Panicum capillare L. Old witch grass. Salt marsh and pan, infrequent (with Salicornia).

60. P. columbianum Scribn.
var. oricola (Hitchc. & Chase) Fern. Salt marsh, infrequent.

61. P. dichotomiflorum Michx.
var. dichotomiflorum. Wet areas in open secondary dunes, infrequent.

62. P. lanuginosum Ell.
var. fasciculatum (Torr.) Fern. Mesic shrub, infrequent.

63. P. lanuginosum Ell.
var. lanuginosum. Open secondary dunes, rare.

var. Lindheimeri (Nash) Fern. Shrub, infrequent.

64. P. meridionale Ashe
var. albemarlense (Ashe) Fern. Dunegrass zone and open secondary dunes, infrequent.

65. P. scoparium Lam. Mesic shrub and fresh marsh, frequent.

66. P. sphaerocarpon Ell. Open secondary dunes and shrub, infrequent.

67. P. virgatum L. Switch grass. Marsh and pan, frequent.

68. Paspalum floridanum Michx. Pine woodland, one station.

69. P. laeve Michx. Shrub, infrequent.

70. P. setaceum Michx. Shrub, rare.

71. Phragmites communis Trin. Fresh marsh, infrequent.

72. Poa annua L. Annual blue-grass. Ruderal, rare.

73. Polypogon monspeliensis (L.) Desf. Beardgrass. Marsh and pan, common.

74. Pucinellia distans (L.) Parl. Alkali-grass. Pine woodland, rare.

75. P. fasciculata (Torr.) Bickn. Fresh marsh, rare.

76. Setaria geniculata (Lam.) Beauv. Bristly Foxtail. Salt marsh, frequent.

77. S. glauca (L.) Beauv. Foxtail. Roadside, rare.

78. Spartina alterniflora Loisel. Fresh marsh, frequent.

79. S. patens (Ait.) Muhl. Salt-meadow grass. Marsh and pan, abundant.

80. Sphenopholis obtusata (Michx.) Scribn. Mesic shrub, rare.

81. Triodia flava (L.) Smyth Tall Red-top. Tar grass. Light house, one station.

82. Triplasis purpurea (Walt.) Chapm. Sand-grass. Dunegrass zone, infrequent.

83. Uniola laxa (L.) BSP. Spike grass. Woodlands, infrequent.

84. Vulpia Elliotea (Raf.) Fern. Shrub, infrequent.

85. V. octoflora (Walt.) Rydb.
var. tenella (Willd.) Fern. Mesic shrub, frequent.

CYPERACEAE (Sedge Family)

86. Bulbostylis capillaris (L.) C. B. Clarke. Open secondary dunes, frequent.

87. Carex Emmonsii Dew. Sedge. Pine woodland, rare.

88. C. hormathodes Fern. Fresh marsh, infrequent.

89. C. Longii Mackenz. Pine woodland, infrequent.

90. Cladium mariscoides (Muhl.) Torr. Twig-rush. Fresh marsh, one station.

91. Cyperus esculentus L. Yellow nut-grass. Fresh marsh, infrequent.

92. C. filicinus Vahl. Galingale. Marshes and pan, infrequent.

93. C. filiculmis Vahl. Marshes, pan, bayside dune, frequent.

94. C. odoratus L. Galingale. Marshes, infrequent.

95. C. retrorsus Chapm. Galingale. Pine woodlands, infrequent.

96. C. strigosus L. Galingale. Open secondary dunes, frequent.

97. Eleocharis albida Torr. Spike-rush. Fresh marsh, one station.

98. E. palustris (L.) R. & S. Fresh marsh, common.

99. E. parvula (R. & S.) Link. Fresh marsh, common.

100. E. rostellata Torr. Marshes, common.

101. Fimbristylis autumnalis (L.) R. & S. Fresh marsh, infrequent.

102. F. castanea (Michx.) Vahl. Marshes, frequent.

103. Fuirena pumila Torr. (As F. squarrosa Michx. - National Herbarium) Umbrella-grass. Fresh marsh, rare.

104. Rhynchospora capitellata (Michx.) Vahl. Beak-rush. Wet areas in open secondary dunes, infrequent.

105. R. glomerata (L.) Vahl Wet areas in open secondary dunes, rare. (with Drosera)

106. Scirpus americanus Pers. Three-square rush. Dunegrass zone and marshes, abundant.

107. S. cyperinus (L.) Kunth Bulrush. Fresh marsh, infrequent.

108. S. robustus Pursh Impoundment edge, one station.

ARACEAE (Arum Family)

109. Peltandra virginica (L.) Schott & Endl. Arrow Arum. Impoundment, Virginia, one station.

LEMNACEAE (Duckweed Family)

110. Lemna minor L. Duckweed. Impoundment, one station.

111. Spirodela polyrhiza (L.) Schleid. Water-flaxseed. Impoundment, one station.

XYRIDACEAE (Yellow-eyed Grass Family)

112. Xyris caroliniana Walt. Yellow-eyed Grass. Fresh marsh, infrequent (with Drosera).

113. X. Torta Sm. Fresh marsh, infrequent.

COMMELINACEAE (Spiderwort Family)

114. Commelina communis L. Dayflower. Light house, one station.

JUNCACEAE (Rush Family)

115. Juncus acuminatus Michx. Rush. Fresh marsh and open secondary dunes, frequent.

116. J. biflorus Ell. Salt marsh, frequent.

117. J. bufonius L. Toad-rush. Marshes, pans, and impoundment, frequent.

118. J. canadensis J. Gay Rush. Fresh marsh, rare.

119. J. coriaceus Mackenz. Mesic shrub, infrequent.

120. J. dichotomus Ell. Fresh marsh, common.

121. J. dichotomus Ell.
var. platy phyllus (Wieg.) Fern. Salt marsh, rare.

122. J. effusus L.
var. solutus Fern. and Wieg. Soft rush. Fresh marsh, infrequent.

123. J. Gerardi Loisel. Black grass. Salt marsh, rare.

124. J. marginatus Rostk. Rush. Fresh marsh, rare.

125. J. marginatus Rostk.
var. biflorus (Ell.) Wood. Fresh marsh and woodlands, infrequent.

126. J. Roemerianus Scheele Salt marsh, frequent.

127. J. scirpoides Lam. Rush. Fresh marsh and open secondary dunes, common.

128. J. scirpoides Lam.
var. compositus Harper. Fresh marsh, rare.

129. J. tenuis Willd. Path rush. Fresh marsh, rare.

130. J. Torreyi Coville Fresh marsh and open secondary dunes, frequent.

LILIACEAE (Lily Family)

131. Allium vineale L. Field Garlic. Ruderal, rare.

132. Asparagus officinalis L. Garden asparagus. Ruderal, rare.

133. Smilax Bona-nox L. China-brier. Woodlands, frequent.

134. S. glauca Walt. Sawbrier. Shrub and pine woodland, common.

135. S. rotundifolia L. Common greenbrier. Shrub and pine woodland, common.

136. S. Walteri Pursh Red-berried greenbrier. Mesic shrub, frequent.

AMARYLLIDACEAE (Amaryllis Family)

137. Hypoxis hirsuta (L.) Coville Stargrass. Open secondary dunes, one station.

IRIDACEAE (Iris Family)

138. Sisyrinchium atlanticum Bickn. Blue-eyed grass. Fresh marsh, frequent.

ORCHIDACEAE (Orchid Family)

139. Cypripedium acaule Ait. Stemless (Pink) Lady's slipper. Pine woodland, local.

140. Habenaria cristata (Michx.) R. Br. Crested Yellow Orchid. Mixed woodland, rare.

141. Spiranthes cernua (L.) Richard Nodding Ladies'-tresses. Marshes and pan, infrequent.

142. S. praecox (Walt.) S. Wats. Ladies'-tresses. Marshes and pan, infrequent.

143. S. vernalis Engelm. and Gray Marshes and pan, infrequent.

SALICACEAE (Willow Family)

144. Populus alba L. White Poplar. Shrub, rare.

145. P. canescens (Ait.) Sm. Gray popular. Shrub, one station.

146. Populus deltoides Marsh. Cottonwood. Light house, one station.

147. Salix babylonica L. Weeping willow. Planted by cottage, one station.

148. S. nigra L. Black Willow. Fresh marsh, shrub and woodlands, infrequent.

MYRICACEAE (Wax-myrtle Family)

149. Myrica cerifera L. Wax-myrtle. Shrub and woodlands, abundant.

150. M. pensylvanica Loisel. Bayberry. Shrub and woodlands, common.

JUGLANDACEAE (Walnut Family)

151. Juglans nigra L. Black Walnut. Planted by Light house, one station.

FAGACEAE (Beech Family)

152. Quercus falcata Michx. Southern Red Oak. Shrub and woodlands, common.

153. Q. nigra L. Water Oak. Woodlands, common.

154. Q. palustris Muenchh. Pin Oak. Bayside open secondary dune, one station.

155. Q. Phellos L. Willow Oak. Shrub, rare.

156. Q. stellata Wang. Post Oak. Mixed woodland, rare.

URTICACEAE (Nettle Family)

157. Boehmeria cylindrica (L.) Sw. Bog-hemp. Light house, one station.

158. Parietaria floridana Nutt. Pellitory. Light house, damp wooded slope, one station.

POLYGONACEAE (Buckwheat Family)

159. Polygonella articulata (L.) Meisn. Jointweed. Fresh marsh and open secondary dunes, frequent. (sand on all dunes)

160. Polygonum amphibium L.
var. stipulaceum (Coleman) Fern. Water Smartweed. Fresh marsh, rare.

161. P. densiflorum Miesn. Smartweed. Virginia, Bridge roadside, one specimen.

162. P. glaucum Nutt. Seabeach Knotweed. Dunegrass and pan, frequent.

163. P. pensylvanicum L. Pinkweed. Salt marsh, infrequent.

164. P. punctatum Ell. Water Smartweed. Fresh marsh, common.

165. Rumex Acetosella L. Sheep sorrel. Shrub and open secondary dunes, common.

166. R. Crispus L. Yellow Dock. Ruderal, rare.

167. R. Patientia L. Patience Dock. Ruderal, one station.

CHENOPODIACEAE (Goose foot Family)

168. Atriplex arenaria Nutt. Seabeach Orach. Marshes and pan, abundant.

169. A. patula L.
var. hastata (L.) Gray Orach. Marshes, abundant.

170. Bassia hirsuta (L.) Aschers. Marshes and pan, frequent.

171. Chenopodium album L. Pigweed. Ruderal, rare.

172. C. ambrosioides L. Mexican Tea. Shrub, infrequent.

173. Salicornia Bigelovii Torr. Dwarf Saltwort. Marshes and pan, frequent.

174. S. europaea L. Chickenclaws. Marshes and pan, frequent.

175. S. virginica L. Perennial Saltwort. Salt marsh, infrequent.

176. Salsola Kali. L. Saltwort. Dunegrass zone and marshes, local.

177. S. Kali L.
var. caroliniana (Walt.) Nutt. Common saltwort. Salt marsh and pan, local.

178. Suaeda linearis (Ell.) Moq. Sea-blite. Salt marsh, rare.

AMARANTHACEAE (Amaranth Family)

179. Amaranthus hybridus L. Pigweed. Ruderal, rare.

180. A. pumilus Raf. Seabeach Amaranth. Pan, frequent.

NYCTAGINACEAE (Four-O'Clock Family)

181. Mirabilis Jalapa L. Four O'clock. Dump near Wildlife office, one station.

PHYTOLACCACEAE (Pokeweed Family)

182. Phytolacca americana L. Pokeweed. Disturbed areas, shrub and woodland, infrequent.

AIZOACEAE

183. Mollugo verticillata L. Carpetweed. Dunegrass zone and open secondary dunes, infrequent.

184. Sesuvium maritmum (Walt.) BSP. Sea-purslane. Dunegrass zone and pan, frequent.

PORTULACACEAE (Purslane Family)

185. Portulaca oleracea L. Common Purslane. Light house, one station.

CARYOPHYLLACEAE (Pink Family)

186. Arenaria peploides L. Seabeach Sandwort. Dunegrass, rare.

187. A. serpyllifolia L. Thyme-leaved Sandwort. Light house, one station.

188. Cerastium viscosum L. Mouse-ear Chickweed. Clay roadsides, infrequent.

189. C. vulgatum L. Common Mouse-ear Chickweed. Clay roadsides, infrequent.

190. Lychnis alba Mill. White Cockle. Clay roadsides, infrequent.

191. Sagina decumbens (Ell.) T. & G. Pearlwort. Mesic shrub, infrequent.

192. Scleranthus annuus L. Knawel. Clay roadsides, rare.

193. Spergularia marina (L.) Griseb. Sand-spurrey. Fresh marsh and pan, common.

194. S. rubra (L.) J.&C. Presl Pan, Maryland, one station.

195. Stellaria media (L.) Cyrillo Common Chickweed. Open secondary dunes, rare.

RANUNCULACEAE (Crowfoot Family)

196. Ranunculus Sardous Crantz Clay roadside, one specimen.

197. R. sceleratus L. Cursed Crowfoot. Fresh marsh and impoundment.

LARDIZABALACEAE

198. Akebia quinata Dcne. Light house, one station.

MAGNOLIACEAE (Magnolia Family)

199. Magnolia virginiana L. Laurel-Magnolia, Sweet Bay. Woodlands, infrequent.

LAURACEAE (Laurel Family)

200. Persea Borbonia (L.) Spreng. Red Bay. Pine woodland, infrequent.

201. Sassafras albidum (Nutt.) Nees. Sassafras. Shrub and woodlands, infrequent.

CRUCIFERAE (Mustard Family)

202. Arabidopsis Thaliana (L.) Heynh. Mouse-ear-cress. Clay roadside, rare.

203. Arabis glabra (L.) Bernh. Tower-mustard. Clay roadside, one specimen.

204. Barbarea verna (Mill.) Aschers. Early Winter-cress. Clay roadside, one specimen.

205. B. vulgaris R. Br. Common Wintercress. Clay roadside, one specimen.

206. Brassica Rapa L. Birds' Rape. Ruderal, one station.

207. Cakile edentula (Bigel.) Hook. (Pioneer on beach) dunegrass zone, pan and marshes, common.

208. Lepidium campestre (L.) R. Br. Pine woodland, one specimen.

209. L. virginicum L. Pepper Grass. Ruderal, infrequent.

210. Raphanus Raphanistrum L. Jointed Charlock. Ruderal, one station.

DROSERACEAE (Sundew Family)

211. Drosera intermedia Hayne Sundew. Fresh marsh, infrequent.

HAMAMELIDACEAE (Witch-hazel Family)

212. Liquidambar Styraciflua L. Sweet gum. Shrub and woodlands, infrequent.

PLATANACEAE (Plane-tree Family)

213. Platanus occidentalis L. Sycamore. Mixed woodland, rare.

ROSACEAE (Rose Family)

214. Amelanchier canadensis (L.) Medic. Shad bush. Xeric shrub and pine woodland, common.

215. Crataegus crus-galli L. Cock-spur Thorn. Light house, one station.

216. Geum canadense Jacq. Light house, one station.

217. Potentilla norvegica L. Roadside, rare.

218. P. recta L. Cinquefoil. Clay roadside, rare.

219. Prunus maritima Marsh. Beach Plum. Shrub, Maryland, one station. (possibly introduced, since not known south of north Ocean City, Maryland.

220. P. Persica (L.) Batsch Peach. Shrub, Maryland, one specimen.

221. P. serotina Ehrh. Black cherry. Shrub and pine woodland, common.

222. Pyrus angustifolia Ait.
var. spinosa (Rehd.) Bailey Wild crab. Shrub, common.

223. P. arbutifolia (L.) L. f. Red Chokeberry. Shrub, infrequent.

224. P. Malus L. Apple. Shrub, rare.

225. Rosa palustris Marsh. Rose. Mesic shrub, infrequent.

226. R. rugosa Thunb. Rose. Back slope of barrier dune, Wildlife Refuge, planted in 1966.

227. * Rubus argutus Link Bramble. Light house, one station.

228. R. cuneifolius Pursh Sand Blackberry. Shrub and open secondary dunes,

229. R. flagellaris L. Northern Dewberry. Disturbed areas, shrub and woodlands, infrequent.

230. R. pensilvanicus Poir. Shrub, rare.

<u>LEGUMINOSAE</u> (Pulse Family)

231. Baptisia tinctoria (L.) R. Br. Wild Indigo. Fresh marsh, one station.

232. Cassia fasciculata Michx. Partridge Pea. Clay roadside, one station.

233. C. nictitans L. Wild sensitive plant. Wet areas in open secondary dunes, infrequent.

234. Desmodium canescens (L.) DC. Tick Trefoil. Shrub, rare.

235. D. rigidum (Ell.) DC. Open secondary dunes, rare.

236. D. sessilifolium (Torr.) T. &G. Open secondary dunes, rare.

237. Lespedeza hirta (L.) Hornem. Bush Clover. Ruderal, rare.

238. Melilotus alba Desr. White sweet clover. Ruderal, one station.

239. M. officinalis (L.) Lam. Yellow sweet clover. Clay roadside, rare.

* Treatment of <u>Rubus</u> from Gleason, and Cronquist (1965).

240. Robina Pseudo-Acacia L. Black locust. Light house, one station.

241. Strophostyles helvola (L.) Ell. Wild bean. Dunegrass zone and marshes, infrequent.

242. S. umbellata (Muhl.) Britt. Wild bean. Dunegrass zone, infrequent.

243. Trifolium arvense L. Rabbit-foot clover. Clay fill along roadside, rare.

244. T. dubium Sibth. Clay fill along roadsides, rare.

245. T. pratense L. Red clover. Clay fill along roadsides, rare.

246. T. procumbens L. Hop Clover. Clay fill along roadsides, rare.

247. T. repens L. White clover. Clay fill along roadsides, rare.

248. Vicia angustifolia Reichard. Clay roadside, one station.

249. Vicia Cracca L. Vetch. Clay roadside, one station.

<u>LINACEAE</u> (Flax Family)

250. Linum medium (Planch.) Britt. Flax. Marshes and pan, frequent.

<u>OXALIDACEAE</u> (Wood-sorrel Family)

251. Oxalis europaea Jord.
forma villicaullis Wieg. Ruderal, rare.

252. O. europaea Jord.
var. Bushii (Small) Wieg. forma subglabrata Wieg. Light house, rare.

253. O. stricta L. Ruderal, rare.

<u>GERANIACEAE</u> (Geranium Family)

254. Erodium cicutarium (L.) L'Her. Stork's Bill. Wet clay roadside, local.

RUTACEAE (Rue Family)

255. Xanthoxylum Clava-Herculis L. Hercules'-club or Prickley Ash. Light house, one station.

POLYGALACEAE (Milkwort Family)

256. Polygala verticillata L. var. isocycla Fern. Milkwort. Salt marsh, infrequent.

EUPHORBIACEAE (Spurge Family)

257. Acalypha gracilens Gray Three-seeded Mercury. Pine woodlands, rare.

258. Euphorbia maculata L. Eyebane. Ruderal, two stations.

259. E. polygonifolia L. Seaside spurge. Dune grass zone, frequent.

260. E. supina Raf. Milk purslane. Ruderal, rare.

CALLITRICHACEAE (Water-starwort Family)

261. Callitriche heterophylla Pursh Water-starwort. Impoundment, one station.

ANACARDIACEAE (Cashew Family)

262. Rhus copallina L. Dwarf sumac. Shrub, and woodlands, frequent.

263. Rhus radicans L. Poison Ivy. Ubiquitous, except in salt marsh and pan.

AQUIFOLIACEAE (Holly Family)

264. Ilex glabra (L.) Gray Inkberry. Mesic shrub, infrequent.

265. I. opaca Ait. American Holly. Shrub and pine woodland, infrequent.

ACERACEAE (Maple Family)

266. Acer rubrum L. Red Maple. Mesic shrub and woodlands, frequent.

RHAMNACEAE (Buckthorn Family)

267. Berchemia scandens (Hill) K. Koch Supple-Jack. Mixed woodland, local, Virginia.

268. Rhamnus Frangula L. Alder Buckthorn. Mixed woodland, rare.

VITACEAE (Vine Family)

269. Parthenocissus quinquefolia (L.) Planch. Virginia creeper. Dunegrass and shrub, frequent.

270. Vitis aestivalis Michx. Summer grape. Pine woodland, frequent.

271. V. rotundifolia Michx. Muscadine. Shrub and pine woodland, common.

MALVACEAE (Mallow Family)

272. Althaea rosea Cav. Hollyhock. Escape, Light house, one station.

273. Hibiscus palustris L. Swamp Rose-mallow. (Includes H. Moscheutos L. and intermediate forms) Marshes, common.

274. Kosteletzkya virginica (L.) Presl Seashore-mallow. Marshes, frequent.

GUTTIFERAE (St. John's-wort Family)

275. Ascyrum Hypericoides L. St. Andrews Cross. Wet areas in pine woodlands and open secondary dunes, frequent.

276. Hypericum boreale (Britt.) Bickn. St. John's wort. Fresh marsh, frequent.

277. H. canadense L. Fresh marsh, rare.

278. H. gentianoides (L.) BSP. Orange Grass. Open secondary dunes, shrub and pine woodland, frequent.

279. H. gymnanthum Engelm. & Gray St. John's-wort. Fresh marsh, rare.

280. H. mutilum L. St. John's-wort. Fresh marsh, rare.

281. H. virginicum L. Fresh marsh, frequent.

CISTACEAE (Rockrose Family)

282. Helianthemum canadense (L.) Michx. Frostweed. Pine woodland, frequent.

283. Hudsonia tomentosa Nutt. Beach-heath. Open secondary dunes, common.

284. Lechea Leggettii Britt. & Holl. Pine woodlands, infrequent.

285. L. maritima Leggett Pinweed. Open secondary dunes, infrequent.

VIOLACEAE (Violet Family)

286. Viola cucullata Ait. Open secondary dunes, Maryland, one specimen.

287. Viola lanceolata L. Lance-leaved Violet. Fresh marsh, common.

CACTACEAE (Cactus Family)

288. Opuntia humifusa Raf. Prickly Pear. Open secondary dunes, infrequent. (with Andropogon)

LYTHRACEAE (Loosestrife Family)

289. Ammannia teres Raf. Fresh marsh, Virginia, rare.

290. Lythrum lineare L. Loosestrife. Fresh marsh, infrequent.

291. Rotala ramosior (L.) Koehne Fresh marsh, Virginia, one station.

NYSSACEAE (Sour Gum Family)

292. Nyssa sylvatica Marsh Black gum. Shrub and woodlands, infrequent.

MELASTOMATACEAE (Melastoma Family)

293. Rhexia virginica L. Meadow beauty. Marshes and pan, frequent.

ONAGRACEAE (Evening-primrose Family)

294. Ludwigia alternifolia L. Seedbox. Marshes, frequent.

295. Ludwigia palustris (L.) Ell.
var. americana (DC.) Fern. & Grisc. Water-purslane.
Fresh marsh, common.

296. Oenothera biennis L. Evening Primrose. Dunegrass zone, Virginia, one station.

297. O. fruticosa L.
var. humifusa Allen Sundrops. Fresh marsh, open secondary dunes and pine woodland, common.

298. O. fruticosa L.
var. linearis (Michx.) S. Wats Open secondary dunes, common.

299. O. fruticosa L.
var. unguiculata Fern. Disturbed areas, infrequent.

300. O. humifusa Nutt. Seabeach Evening Primrose. (Browsed selectively by Sika deer) Dunegrass zone, common.

<u>HALORAGACEAE</u> (Water-milfoil Family)

301. Myriophyllum pinnatum (Walt.) BSP. Water-milfoil. Impoundments, rare.

302. Proserpinaca palustris L. Mermaid-weed. Fresh marsh and impoundments, common.

<u>ARALIACEAE</u> (Ginseng Family)

303. Aralia spinosa L. Hercules'-Club. Shrub, infrequent.

<u>UMBELLIFERAE</u> (Parsley Family)

304. Centella erecta (L. f.) Fern. Fresh marsh, common.

305. Daucus Carota L. Wild carrot. Ruderal, rare.

306. Hydrocotyle umbellata L. Water-penny-wort. Fresh marsh, common.

307. H. verticillata Thunb. Water-penny-wort. Fresh marsh, common.

308. Ptilimnium capillaceum (Michx.) Raf. Mock Bishop's Weed. Fresh marsh, common.

309. Sanicula canadensis L. Black Snakeroot. Light house, one station.

CORNACEAE (Dogwood Family)

310. Cornus florida L. Flowering Dogwood. Mixed woodland, one specimen.

PYROLACEAE (Wintergreen Family)

311. Chimaphila maculata (L.) Pursh Pipsissewa. Pine woodland, rare.

312. Monotropa Hypopithys L. Pinesap. Pine woodland, Maryland, one station.

313. M. uniflora L. Indian-pipe. Pine woodland, Virginia, one station.

ERICACEAE (Heath Family)

314. Gaylussacia baccata (Wang.) K. Koch Huckleberry. Shrub and pine woodland, frequent.

315. Vaccinium atrococcum (Gray) Heller (Vacciniums include undetermined hybrids) Shrub, common.

316. V. caesariense Mackenzie. Mesic shrub, rare.

317. V. corymbosum L. (Includes V. marianum Wats. and V. australe Small which are separated by Camp, but not included in Fernald.) Shrub and pine woodland, common.

318. V. macrocarpon Ait. Cranberry. Fresh marsh, Virginia, one station. (with Drosera)

PRIMULACEAE (Primrose Family)

319. Anagallis arvensis L. Scarlet Pimpernel. Ruderal, rare.

320. Samolus parviflorus Raf. Water-Pimpernel. Fresh marsh, frequent. (with Ptilimnium)

PLUMBAGINACEAE (Leadwort Family)

321. Limonium carolinianum (Walt.) Britt. Sea-Lavender. Salt marshes, frequent.

EBENACEAE (Ebony Family)

322. Diospyros virginiana L. Persimmon. Shrub and pine woodland, infrequent.

OLEACEAE (Olive Family)

323. Ligustrum vulgare L. Privet. Ruderal, planted two stations.

LOGANIACEAE (Logania Family)

324. Polypremum procumbens L. Fresh marsh, rare.

GENTIANCEAE (Gentian Family)

325. Bartonia virginica (L.) BSP. Fresh marsh, Virginia, one station.

326. Sabatia stellaris Pursh Sea Pink. Marshes, common. (Highly variable species)

327. S. stellaris Pursh
forma albiflora Britt. Marshes, infrequent.

APOCYNACEAE (Dogbane Family)

328. Apocynum cannabinum L. Indian hemp. Shrub and pine woodland, infrequent.

ASCLEPIADACEAE (Milkweed Family)

329. Asclepias incarnata L.
var. pulchra (Ehrh.) Pers. Swamp milkweed. Fresh marsh, infrequent.

330. A. lanceolata Walt. Milkweed. Mixed woodland, infrequent.

331. A. tuberosa L. Butterflyweed. Pine woodland, Virginia, one station.

CONVOLVULACEAE (Convolvulus Family)

332. Convolvulus sepium L. Hedge Bindweed. Fresh marsh, infrequent.

POLEMONIACEAE (Polemonium Family)

333. Phlox Drummondii Hook. Clay roadside, one specimen.

VERBENACEAE (Vervain Family)

334. Lippia lanceolata Michx. Fog-fruit. Fresh marsh, Virginia, frequent.

335. Verbena officinalis L. European Vervain. Light house, one station.

LABIATAE (Mint Family)

336. Lamium amplexicaule L. Henbit. Light house, one station.

337. Lycopus americanus Muhl. Water-horehound. Marshes, frequent.

338. Monarda punctata L. var. villicaulis Pennell Horsemint. Open secondary dunes, rare.

339. Nepeta cataria L. Catnip. Light house, one station.

340. Prunella vulgaris L. Heal-all. Clay roadside, one station.

341. Teucrium canadense L. American Germander. Edges of mesic thickets and bayside marshes, frequent.

342. Trichostema dichotomum L. Blue curls. Roadside by Wildlife Office, local.

SOLANACEAE (Nightshade Family)

343. Datura Stramonium L. Jimson weed. Open stabilized dunes, infrequent.

344. Solanum carolinense L. Ruderal, two stations.

345. S. nigrum L. var. vulgare L. Black nightshade. Open secondary dunes, infrequent. (Gleason, 1952)

SCROPHULARIACEAE (Figwort Family)

346. Bacopa Monnieri (L.) Pennell Water-hyssop. Marshes and pan, frequent.

347. Gerardia maritima Raf. Gerardia. Pan, rare.

348. Gerardia purpurea L. Salt marsh and pan, frequent.

349. Linaria canadensis (L.) Dumont Old-field toadflax. Shrub and open secondary dunes, frequent.

350. Verbascum Blattaria L. Moth-mullein. Shrub, rare.

351. V. Thapsus L. Common mullein. Ruderal, rare.

352. Veronica arvensis L. Corn speedwell. Ruderal, rare.

353. V. peregrina L. Neckweed. Ruderal, rare.

BIGNONIACEAE (Bignonia Family)

354. Campsis radicans (L.) Seem. Trumpet-creeper. Shrub and pine woodland, infrequent.

OROBANCHACEAE (Broom-rape Family)

355. Orobanche minor Sm. Pine woodland, rare.

PLANTAGINACEAE (Plantain Family)

356. Plantago aristata Michx. Bracted plantain. Open secondary dunes, Virginia, one station.

357. P. lanceolata L. Buckhorn. Ruderal, rare.

358. P. Rugelii Dcne. Broad-leaved plantain. Pine woodland, rare.

359. P. virginica L. Hoary plantain. Ruderal, rare.

RUBIACEAE (Madder Family)

360. Dioda teres Walt. Buttonweed. Fresh marsh, rare.

361. D. virginiana L. Buttonweed. Fresh marsh, frequent.

362. Galium hispidulum Michx. Bedstraw. Fresh marsh, one specimen.

363. G. obtusum Bigel. Fresh marsh, frequent.

364. G. parisiense L. Fresh marsh, one station.

365. G. pilosum Ait. Mixed woodland, infrequent.

366. Houstonia nigricans (Lam.) Fern. Open secondary dunes, rare.

367. H. purpurea L. Fresh marsh, Virginia, one specimen.

368. Mitchella repens L. Partridge-berry. Pine woodland, rare.

CAPRIFOLIACEAE (Honeysuckle Family)

369. Lonicera japonica Thunb. Japanese Honeysuckle. Shrub and pine woodland, common.

370. L. sempervirens L. Trumpet honeysuckle. Shrub and pine woodland, infrequent.

371. Sambucus canadensis L. Common Elder. Shrub and open secondary dunes, infrequent.

372. Viburnum recognitum Fern. Arrow-wood. Mesic shrub, rare.

CAMPANULACEAE (Bluebell Family)

373. Lobelia Cardinalis L. Cardinal-flower. Impoundment, Virginia, one station.

374. Specularia perfoliata (L.) A. DC. Venus's looking-glass. Clay roadsides, local.

COMPOSITAE (Composite Family)

375. Achillea Millefolium L. Common Yarrow. Pine woodland, rare.

376. Ambrosia artemisiifolia L. Common ragweed. Ruderal, rare.

377. Anthemis arvensis L. Corn-chamomile. Clay roadsides, local.

378. Aster dumosus L.
var. coridifolius (Michx.) T. and G. Light house, one station.

379. A. ericoides L. Heath aster. Salt marsh, Maryland, one station.

380. A. pilosus Willd.
var. demotus Blake. Salt marsh, infrequent.

381. Aster simplex Willd.
var. ramosissimus (T. & G.) Cronq. Shrub, Virginia, one station.

382. A. spectabilis Ait. Pine woodland, one station.

383. A. subulatus Michx. Salt marsh, frequent.

384. A. subulatus Michx.
var. euroauster Fern. & Grisc. Marshes and pan, frequent.

385. A. tenuifolius L. Aster. Salt marsh and pan, frequent.

386. Baccharis halimifolia L. Sea-myrtle. Mesic shrub and open secondary dunes, frequent.

387. Bidens bipinnata L. Spanish needles. Open secondary dunes, frequent.

388. B. frondosa L. Bur-marigold. Fresh marsh, frequent.

389. B. laevis (L.) BSP. Marshes, infrequent.

390. Borrichia frutescens (L.) DC. Sea ox-eye. Salt marsh, Virginia, two stations.

391. Chondrilla juncea L. Skeleton-weed. Open secondary dunes, rare.

392. Chrysanthemum Leucanthemum L. Light house, one station.

393. Chrysopsis nervosa (Willd.) Fern Silkgrass. Pine woodland, two stations.

394. Cichorium Intybus L. Chicory. Pan, Virginia, one station.

395. Circium horridulum Michx. Yellow thistle. Mesic shrub and pine woodland, frequent.

396. C. vulgare (Savi) Tenore Bull Thistle. Pine woodland, rare.

397. Eclipta alba (L.) Hassk. Yerba-de-Tago. Fresh marsh, infrequent.

398. Elephantopus nudatus Gray Elephant's foot. Woodlands, infrequent.

399. E. tomentosus L. Devil's-grandmother. Woodlands, infrequent.

400. Erechtites hieracifolia (L.) Raf. Fireweed. Fresh marsh and mesic shrub, infrequent.

401. Erigeron canadensis L. Horseweed. Two disturbed, wet areas, rare.

402. E. pusillus Nutt. Fleabane. Dunegrass zone and shrub, frequent.

403. E. strigosus Muhl.
var. strigosus Daisy Fleabane. Ruderal, rare.

404. Eupatorium album L. Thoroughwort. Pine woodland, rare.

405. E. capillifolium (Lam.) Small Dog-fennel. Open secondary dunes and roadside, common.

406. E. hyssopifolium L.
var. hyssopifolium. Open secondary dunes, infrequent.

407. E. hyssopifolium L.
var. laciniatum Gray Pine woodlands, frequent.

408. E. leucolepis (DC.) T. & G. Pine woodlands, rare.

409. E. pilosum Walt. Mesic shrub, infrequent.

410. E. pubescens Muhl. Fresh marsh and mesic shrub, frequent.

411. E. rotundifolium L. Shrub and open secondary dunes, frequent.

412. E. rugosum Houtt. Ruderal, rare.

413. E. serotinum Michx. Fresh marsh, infrequent.

414. Gaillardia pulchella Foug. Gaillardia. Ruderal, Virginia, one station.

415. * Gnaphalium purpureum L.
var. falcatum (Lam.) T. & G. Purple cudweed. Shrub and pine woodland, frequent.

416. G. purpureum L.
var. purpureum Purple cudweed. Shrub and pine woodland, frequent.

* Treatment of Gnaphalium varieties from Gleason and Cronquist (1965).

417. Gnaphalium obtusifolium L. Catfoot. Fresh marsh, frequent.

418. Helianthus petiolaris Nutt. Light house, one station.

419. Heterotheca subaxillaris (Lam.) Britt. & Rusby Camphor weed. Fresh marsh and open secondary dunes, infrequent.

420. Hieracium Gronovii L. Hawkweed. Pine woodland, infrequent.

421. Hypochaeris radicata L. Cat's ear. Dunegrass zone, Virginia, one station.

422. Iva frutescens L. Marsh Elder. (Highwater shrub) Marshes and mesic shrub, common.

423. Krigia virginica (L.) Willd. Dwarf dandelion. Open secondary dunes, frequent.

424. Lactuca canadensis L.
var. longifolia (Michx.) Farw. Wild lettuce. Open secondary dunes, Maryland, one specimen.

425. L. canadensis L.
var. latifolia Ktze. Open secondary dunes, rare.

426. L. Scariola L. Prickly Lettuce. Roadside, one station.

427. Mikania scandens (L.) Willd. Climbing hempweed. Mesic shrub, frequent.

428. Pluchea foetida (L.) DC. Stinking fleabane. Fresh marsh, pan and mesic shrub, frequent.

429. P. purpurascens (Sw.) DC. Marsh fleabane. Marshes, frequent.

430. Pyrrhopappus carolinianus (Walt.) DC. False Dandelion. Roadsides, rare.

431. Senecio tomentosus Michx. Groundsel. Open secondary dunes, rare.

432. Solidago fistulosa Mill. Goldenrod. Open secondary dunes, infrequent.

433. S. graminifolia (L.) Salisb. Open secondary dunes, rare.

434. S. rugosa Ait.
var. aspera (Ait.) Fern. Fresh marsh, rare.

435. S. sempervirens L. Seaside Goldenrod. Dunegrass zone, shrub and marsh, common.

436. S. sempervirens L. var. mexicana (L.) Fern. Dunegrass zone, infrequent.

437. S. tenuifolia Pursh. Dunegrass zone and mesic shrub, frequent.

438. Sonchus asper (L.) Hill. Spiny-leaved Sow-thistle. Fresh marsh, rare.

439. S. oleraceus L. Common Sow-thistle. Open secondary dunes, rare.

440. Taraxacum officinale Weber. Common Dandelion. Ruderal, infrequent.

441. Xanthium Strumarium L. Cocklebur. Dunegrass zone, infrequent.

#####

APPENDIX TABLE 1

Number of transects, and distance (in decimeters) occupied by given species along 47 twenty-meter line transects in the dunegrass community.

Species	Number	Distance
Ammophila breviligulata	47	296
Rhus radicans	2	100
Solidago sempervirens	11	25
Cakile edentula	18	20
Myrica cerifera	2	16
Euphorbia polygonifolia	8	10
Oenothera humifusa	5	6
Diospyros virginiana	1	6
Panicum amarum	2	4
Cenchrus triuloides	7	2
Spartina patens	8	1
Erigeron pusillus	1	1
Smilax glauca	1	1
Linaria canadensis	2	>1
Salsola Kali	4	>1
Hudsonia tomentosa	1	>1
Panicum meridionale var. albemarlense	1	>1

APPENDIX TABLE 2

Number of transects, and distance (in decimeters) occupied by given species along 59 line transects in the transition zone.

Species	Number	Distance
Myrica cerifera	37	1426
Rhus radicans	34	1183
Ammophila breviligulata	59	940
Myrica pensylvanica	27	863
Solidago sempervirens	36	312
Parthenocissus quinquefolia	10	290
Vitis rotundifolia	9	205
Rubus cuneifolia	15	161
Baccharis halimifolia	12	103
Andropogon virginicus	4	103
Quercus falcata	1	99
Vulpia octoflora	2	89
Rhus copallina	3	65
Spartina patens	24	58
Pinus Taeda	2	45
Festuca rubra	5	40
Pyrus angustifolia var. spinosa	1	39
Panicum amarum	8	29
Rumex Acetosella	6	26

APPENDIX TABLE 2 con't.

Species	Number	Distance
Erigeron pusillus	11	22
Solidago tenuifolia	6	16
Vaccinium atrococcum	1	14
Ilex opaca	1	11
Eupatorium rotundifolia	2	10
Salix nigra	1	10
Oenothera humifusa	4	9
Panicum virgatum	3	9
Lonicera japonica	3	6
Scirpus americanus	4	5
Echinochloa Walteri	1	5
Prunus serotina	3	4
Oenothera fruticosa	9	2
Linaria canadensis	6	2
Rosa palustris	4	2
Diospyros virginiana	2	2
Smilax rotundifolia	1	2
Smilax glauca	5	1
Euphorbia polygonifolia	4	1
Helianthemum canadense	3	1
Panicum scoparium	2	1
Iva frutescens	1	1

APPENDIX TABLE 2 con't.

Species	Number	Distance
Sassafras albidum	1	1
Cenchrus tribuloides	3	<1
Juncus dichotomus	3	<1
Aristada tuberculosa	2	<1
Juncus acuminatus	2	<1
Panicum meridionale	2	<1
Teucrium canadense	2	<1
Carex Longii	1	<1
Phragmites communis	1	<1
Senecio tomentosus	1	<1
Smilax Walteri	1	<1

APPENDIX TABLE 3

Number of transects, and distance (in decimeters) occupied by given species along 58 line transects in the mesic shrub community.

Species	Number	Distance
Myrica cerifera	55	6010
Myrica pensylvanica	35	2434
Baccharis halimifolia	47	2385
Rhus radicans	37	1298
Festuca rubra	22	436
Solidago sempervirens	50	374
Spartina patens	22	331
Rhus copallina	7	299
Festuca ovina var. duriuscula	8	216
Andropogon virginicus	4	91
Rubus spp.	16	89
Panicum virgatum	20	73
Parthenocissus quinquefolia	12	36
Juniperus virginiana	5	32
Solidago tenuifolia	19	28
Pyrus angustifolia var. spinosa	1	23
Mikania scandens	8	19

APPENDIX TABLE 3 con't.

Species	Number	Distance
Rosa palustris	3	12
Panicum lanuginosum var. Lindheimeri	9	11
Pinus Taeda	1	8
Gaylussacia baccata	2	7
Iva frutescens	2	6
Rumex Acetocella	10	6
Helianthemum canadense	4	4
Ammophila brevigulata	1	4
Cirsium horridulum	4	3
Gnaphalium purpureum	4	3
Erigeron pusillus	1	3
Panicum scoparium	17	3
Phragmites communis	4	3
Phytolacca americana	2	3
Carex Longii	6	2
Teucrium canadense	5	2
Eupatorium rotundifolia	4	2
Scirpus americanus	4	2
Chen opodium ambrosiodes	3	2
Elymus virginica	2	2
Acer rubrum	1	2

APPENDIX TABLE 3 con't.

Species	Number	Distance
Apocynum cannabinum	1	2
Vulpia octaflora	1	2
Juncus dichotomus	16	1
Oenothera fruticosa	4	1
Polypogon monspeliensis	3	1
Ptilimnium capillaceum	3	1
Panicum lanuginosum var. fasiculatum	2	1
Strophostyles helvola	2	<1
Diodia virginiana	1	<1

APPENDIX TABLE 4

Data on variation in soil salinity, pH, Mg, P_2O_5, and K_2O at three soil depths; water salinity and pH; and water table depth for samples taken at sites of transects: 9 in dunegrass community, 10 in transition zone and 11 in mesic shrub community. (See Appendix tables 1, 2, 3.)

Community	Water Table Depth (cm.)	Salinity (0/00) Soil Water	Salinity Soil Surface	Salinity Soil 20 cm.	Salinity Soil Water Table	pH Soil Water	pH Soil Surface	pH Soil 20 cm.	pH Soil Water Table	Mg. (lbs./acre*) Surface	Mg. 20 cm.	Mg. Water Table	P_2O_5 (lbs./acre*) Surface	P_2O_5 20 cm	P_2O_5 Water Table	K_2O (lbs./acre*) Surface	K_2O 20 cm.	K_2O Water Table
Dunegrass	45	.145	.056	.032	.028	7.8	7.1	8.0	7.9	21	21	5	10	15	10	15	18	15
	53	.078	.054	.044	.214	6.4	6.0	6.1	6.7	5	5	44	5	5	10	6	3	6
	89	.270	.062	.024	.030	7.0	6.8	7.2	8.0	33	33	38	15	10	10	18	18	18
	47	1.570	.306	.532	.160	7.8	7.3	6.9	7.5	88	67	5	10	5	5	39	39	21
	150	.086	.076	.022	.032	5.4	6.5	7.4	7.3	5	5	38	10	10	15	6	6	12
	190	13.300	.106	.306	1.824	7.0	7.4	7.8	7.0	67	67	3.7	10	10	25	27	33	105
	47	12.690	.456	.896	.604	7.1	7.8	6.9	7.4	127	110	99	15	10	10	45	51	48
	90	.248	.106	.020	.064	7.8	7.0	8.1	7.1	5	44	33	10	10	10	12	18	21
		.351	.044	.060	.296	6.7	7.0	7.2	7.3	33	17	5	5	10	5	18	21	15
Mean	88.8	3.190	.140	.215	.361	7.0	7.0	7.3	7.4	42.6	41.0	64.8	10	9.	11.1	20.6	23.0	29.0
Transition zone	80	.144	.028	.020	.024	7.2	6.5	6.9	7.1	5	11	5	10	15	10	3	12	12
	80	.181	.046	.024	.044	6.5	6.5	6.6	6.9	5	21	5	10	5	15	12	12	15
	100	.124	.174	.106	.124	8.6	6.5	6.8	7.1	5	17	5	5	5	5	6	6	3
	65	.088	.038	.046	.020	6.7	6.8	7.0	7.4	5	5	5	5	5	5	18	21	18
	95	.170	.064	.024	.060	5.8	5.7	6.6	5.7	5	55	11	15	5	5	18	21	12
	135	.120	.062	.026	-	6.5	6.0	6.6	-	5	21	-	5	10	--	15	18	--
	60	.054	.038	.030	.130	5.5	5.9	6.4	6.2	5	21	17	5	5	10	18	10	21
	85	.095	.028	.026	.034	4.6	5.3	5.2	5.8	5	5	5	5	5	10	15	18	21
	55	.191	.048	.044	.048	5.8	6.0	6.1	6.1	38	67	44	10	15	10	36	36	36
	60	.343	.664	.036	.038	5.9	5.7	6.2	6.3	55	55	44	15	15	10	15	21	15
Mean	81.5	.151	.119	.038	.058	6.3	6.1	6.4	6.5	13.3	27.8	14.1	8.5	8.	8.9	15.6	17.5	17.0
Shrub zone	75	.098	.046	.028	.018	5.5	6.0	6.7	6.8	5	5	5	5	5	5	10	18	18
	34	.430	1.184	.142	.086	7.8	5.1	5.7	6.5	552	138	166	15	20	20	150	54	60
	25	.420	.498	.096	.044	7.8	5.0	6.0	6.4	552	99	88	40	5	10	105	39	30
	60	1.456	8.8	.48	.64	5.4	4.7	5.2	4.1	552	166	110	15	5	15	279	54	54

APPENDIX TABLE 4

Data on variation in soil salinity, pH, Mg, P_2O_5, and K_2O at three soil depths; water salinity and pH; and water table depth for samples taken at sites of transects: 9 in dunegrass community, 10 in transition zone and 11 in mesic shrub community. (See Appendix tables 1, 2, 3.).

Community	Water Table Depth (cm.)	Salinity (0/00) Soil Water	Salinity Soil Surface	Salinity Soil 20 cm.	Salinity Soil Water Table	pH Soil Water	pH Soil Surface	pH Soil 20 cm.	pH Soil Water Table	Mg. (lbs./acre*) Surface	Mg. 20 cm.	Mg. Water Table	P_2O_5 (lbs/acre*) Surface	P_2O_5 20cm	P_2O_5 Water Table	K_2O (lbs./acre*) Surface	K_2O 20 cm.	K_2O Water Table
Dunegrass	45	.145	.056	.032	.028	7.8	7.1	8.0	7.9	21	21	5	10	15	10	15	18	15
	53	.078	.054	.044	.214	6.4	6.0	6.1	6.7	5	5	44	5	5	10	6	3	6
	89	.270	.062	.024	.030	7.0	6.8	7.2	8.0	33	33	38	15	10	10	18	18	18
	47	1.570	.306	.532	.160	7.8	7.3	6.9	7.5	88	67	5	10	5	5	39	39	21
	150	.086	.076	.022	.032	6.4	6.5	7.4	7.3	5	5	38	10	10	15	6	6	12
	190	13.300	.106	.306	1.824	7.0	7.4	7.8	7.0	67	67	3.7	10	10	25	27	33	105
	47	12.690	.456	.896	.604	7.1	7.8	6.9	7.4	127	110	99	15	10	10	45	51	48
	90	.248	.106	.020	.064	7.8	7.0	8.1	7.1	5	44	33	10	10	10	12	18	21
		.351	.044	.060	.296	6.7	7.0	7.2	7.3	33	17	5	5	10	5	18	21	15
Mean	88.8	3.190	.140	.215	.361	7.0	7.0	7.3	7.4	42.6	41.0	64.8	10	9.	11.1	20.6	23.0	29.0
Transition zone	80	.144	.028	.020	.024	7.2	6.5	6.9	7.1	5	11	5	10	15	10	3	12	12
	80	.181	.046	.024	.044	6.5	6.5	6.6	6.9	5	21	5	10	5	15	12	12	15
	100	.124	.174	.106	.124	8.6	6.5	6.8	7.1	5	17	5	5	5	5	6	6	3
	65	.088	.038	.046	.020	6.7	6.8	7.0	7.4	5	5	5	5	5	5	18	21	18
	95	.170	.064	.024	.060	5.8	5.7	6.6	5.7	5	55	11	15	5	5	18	21	12
	135	.120	.962	.026	-	6.5	6.0	6.6	-	5	21	-	5	10	-	15	18	--
	60	.054	.038	.030	.130	5.5	5.9	6.4	6.2	5	21	17	5	5	10	18	10	21
	85	.095	.028	.026	.034	4.6	5.3	5.2	5.8	5	5	5	5	5	10	15	18	21
	55	.191	.048	.044	.048	5.8	6.0	6.1	6.1	38	67	44	10	15	10	36	36	36
	60	.343	.664	.036	.038	5.9	5.7	6.2	6.3	55	55	44	15	15	10	15	21	15
Mean	81.5	.151	.119	.036	.058	6.3	6.1	6.4	6.5	13.3	27.8	14.1	8.5	8.5	8.9	15.6	17.5	17.0
Shrub zone	75	.093	.046	.028	.018	6.5	6.0	6.7	6.8	5	5	5	5	5	5	10	18	18
	34	.430	1.184	.142	.086	7.8	5.1	5.7	6.5	552	138	166	15	20	20	150	54	60
	25	.420	.498	.096	.044	7.8	5.0	6.0	6.4	552	99	88	40	5	10	105	39	30
	60	1.456	8.8	.48	.64	5.4	4.7	5.2	4.1	552	166	110	15	5	15	279	54	54

APPENDIX TABLE 4 con't.

	Water Table	Salinity (0/00)				pH				Mg. (lbs./acre*)			P_2O_5 (lbs./acre*)			K_2O (lbs./acre*)		
	Depth	Soil Water	Soil			Soil Water	Soil											
	(CM.)		Surface	20 cm.	Water Table		Surface	20 cm.	Water Table	Surface	20 cm	Water Table	Surface	20 cm	Water Table	Surface	20 cm.	Water Table
Shrub zone con't.	20	2.616	5.0	.390	.306	5.5	5.1	5.7	4.2	469	94	35	5	10	10	219	42	21
	47	.130	.106	.028	.140	5.3	5.4	5.5	5.0	99	28	44	29	10	10	30	9	21
	55	.326	.142	.052	.286	5.7	4.7	5.3	4.7	38	21	94	20	5	5	27	9	30
	25	1.28	1.376	.140	.120	6.9	4.7	6.1	6.6	359	88	77	5	5	20	84	18	18
	18	1.33	.906	.150	-	7.5	5.9	6.9	-	386	77	-	10	10	--	42	24	--
	82	.220	.092	.052	.074	-	5.5	6.6	6.3	33	5	44	20	20	5	36	33	36
	75	.220	.148	.216	.108	-	5.3	5.8	4.7	110	166	11	5	20	20	54	45	24
Mean	46.9	0.775	1.663	.161	.182	6.5	5.2	5.9	5.5	286.8	80.6	67.4	15.4	10.4	10.9	94.1	31.4	31.2

* Soil analysis of mineral content by the University of Maryland Soil Testing Laboratory is in lbs./acre. This is converted to ppm. using the conversion factor: $\frac{\text{lbs./acre}}{2}$ = ppm. Lbs./acre values were used in the statistical analysis and logarithmic transformation reported in Table 3.

LITERATURE CITED

Adams, D.A. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology 44:445-455.

Agnew, A.D.Q. 1961. The ecology of Juncus effusus L. in North Wales. Jour. Ecol. 49:83-102.

Allard, H.A. and E.C. Leonard. 1943. The vegetation and floristics of Bull Run Mountain, Virginia. Castanea 8:1-64.

Anderson, R.R., R.G. Brown and R.D. Rappleye. 1968. Water quality and plant distribution along the upper Patuxent River, Maryland. Chesapeake Sci. 9:145-150.

Bernard, J.M. 1963. Lowland forests of Cape May formation in southern New Jersey. Bull. N.J. Acad. Sci. 8:1-12.

Bourdeau, P.F. and D.A. Adams. 1956. Factors in vegetational zonation of salt marshes near Southport, North Carolina. Ecol. Soc. Am. Bull. 37:68

Boyce, S.G. 1954. The salt spray community. Ecol. Monog. 24:29-67.

Brown, C.A. 1959. Vegetation of the Outer Banks of North Carolina. Louisiana State University Press. Baton Rouge. 179pp.

Burk, J.C. 1961. A floristic study of the Outer Banks of North Carolina. Unpublished PhD thesis. University of North Carolina, Chapel Hill. 123pp.

Canby, W.M. 1864. Notes of botanical visits to the lower part of Delaware and the eastern shore of Maryland. Proc. Acad. Nat. Sci. (Philadelphia). 16-19.

Chadwick, H.W. and P.D. Dalke. 1965. Plant succession on dune sands in Fremont County, Idaho. Ecology 46:765-779.

Chapman, V.J. 1960. Salt marshes and salt deserts of the world. Leonard Hill Books Ltd. London. 392pp.

__________. 1964. Coastal vegetation. The MacMillan Co. New York. 245pp.

Chickering, J.W. 1878. A season's botanizing. Field and Forest 3:154-155.

Chrysler, M.A. 1910. Ecological plant geography of Maryland; coastal zone; western shore district. Md. Weather Serv., Spec. Publ. 3:149-193.

_____________. 1930. The origin and development of the vegetation of Sandy Hook. Bull. Torrey Club 57:163-176.

Clovis, J.F. 1968. The vegetation of Smith Island, Virginia. Castenea 33:115-120.

Cope, J.A. 1926. Loblolly pine, a woodland crop. U. of Md. Ext. Ser. Bull. 41. College Park 49pp.

Cowles, H.C. 1899. The ecological relations of the vegetation on the sand dunes of Lake Michigan. Bot. Gaz. 27:95-117, 167-175.

Daubs, E.H. 1965. A monograph of Lemnaceae. Ill. Biol. Monog. 24. University of Illinois Press. Urbana. 118pp.

Ducatel, J.T. 1837. Outlines of the physical geography of Maryland embracing its prominent geological features. Trans. Md. Acad. Sci. & Lit. I:24-28.

Egler, F.E. 1942. Check list of the ferns and flowering plants of the Seashore State Park, Cape Henry, Virginia. Mimeo. Publ. New York State College of Forestry. Syracuse. 75pp.

Fassett, N.C. 1957. A manual of aquatic plants. The University of Wisconsin Press. Madison. 382pp.

Fender, F.A. 1938. The flora of Seven Mile Beach, New Jersey. Bartonia 19:23-41.

Fernald, M.L. 1935. Midsummer vascular plants of southeastern Virginia Rhodora 37:378-413, 423-454.

_____________. 1936. Plants from the outer coastal plain of Virginia. Rhodora 38:376-404, 414-452.

_____________. 1950. Gray's manual of botany. 8th edition. American Book Co. New York 1632pp.

Ganong, W.F. 1903. The vegetation of the Bay of Fundy salt and diked marshes. Bot. Gaz. 36:161-186, 280-302, 349-367, 429-455.

Gleason, H.A. 1952. The new Britton and Brown illustrated flora of northeastern United States and adjacent Canada. New York Botanical Gardens New York. 1726pp.

____________ and Arthur Cronquist. 1965. Manual of vascular plants of northeastern United States and adjacent Canada. D. Van Nostrand Co. Princeton. 810pp.

Harper, R.M. 1907. A midsummer journey through the coastal plain of the Carolinas and Virginia. Bull. Torrey Bot. Club 34:351-377.

____________. 1909. Car window notes on the vegetation of the Delaware Peninsula and southern Virginia. Torreya 9:217-226.

____________. 1919. A forest reconnaissance of the Delaware Peninsula. Jour. Forestry 17:546-555.

Harshberger, J.W. 1901. An ecological study of the New Jersey strand flora. Proc. Acad. Nat. Sci. Philadelphia 52:623-671.

____________. 1903. Additional observations on the strand flora of New Jersey. Proc. Acad. Nat. Sci. Philadelphia 54:642-669.

____________. 1909. The vegetation of the salt marshes and of the salt and fresh water ponds of northern coastal New Jersey. Proc. Acad. Nat. Sci. Philadelphia 61:373-400.

Harvill, A.M. Jr. 1965. The vegetation of Parramore Island, Virginia. Castanea 30:226-228.

____________. 1967. The vegetation of Assateague Island, Virginia. Castanea 32:105-108.

Hinde, H.P. 1954. The vertical distribution of salt marsh phanerogams in relation to tide levels. Ecol. Monog. 24:209-225.

Hitchcock, A.S. 1950. Manual of the grasses of the United States. U.S. Dept. Agri. Misc. Publ. 200. Washington, D. C. 1050pp.

Hotchkiss, Neil. 1967. Underwater and floating-leaved plants of the United States and Canada. U.S. Dept. Int. Res. Publ. 44. Washington, D.C. 125pp.

Johnson, D.S. and H.H. York. 1915. The relation of plants to tide levels. Carnegie Inst. Wash. Publ. 206. Washington, D.C. 162pp.

Johnson, E.S. 1900. Notes on the flora of the banks and sounds at Beaufort, North Carolina. Bot. Gaz. 30:405-410.

Kearney, T.H. 1900. The plant covering of Ocracoke Island. U.S. Nat. Herb. Contri. 5:261-319.

Kershaw, K.A. 1964. Quantative and dynamic ecology. Edward Arnold Pub. Ltd. London 183pp.

Knieskern, P.D. 1857. A catalogue of plants growing without cultivation in the counties of Monmouth and Ocean, New Jersey.

Krumbein, W.C. and L.L. Sloss. 1951. Strategraphy and sedimentation. W.H. Freeman and Co. San Francisco.

Kurz, Herman, and Kenneth Wagner. 1957. Tidal marshes of the Gulf and Atlantic coasts of northern Florida and Charleston, South Carolina. Florida State University Studies 24. Tallahassee. 168pp.

Laing, C.C. 1958. Studies in the ecology of Ammophila breviligulata Fern.; seedling survival and its relation to population increase and dispersal. Bot. Gaz. 119:208-216.

Lamsom-Scribner, F. 1898. Sand-binding grasses. U.S. Dept. Agri. Yearbook Washington, D.C. 405-420.

Latrobe, B.J. 1799. Memoir on sandhills of Cape Henry, Virginia. Trans. Am. Phil. Soc. 4:439-443.

Lems, Kornelius. 1963. Plants observed on Assateague Island, Virginia. Unpublished mimeo. Gaugher College. Baltimore. 1 p.

Lewis, I.F. 1917. The vegetation of Shackleford Bank. N.C. Geol. Econ. Surv. 46:1-40.

Marmer, H.A. 1948. Is the Atlantic coast sinking? The evidence from the tide. Geog. Rev. 38:652-657.

Martin, E.V. and F.E. Clements. 1939. Adaptation and origin in the plant world. I. Factors and functions in coastal dunes. Carn. Inst. of Wash. Publ. Washington, D.C. 107pp.

Martin, W.E. 1959. The vegetation of Island Beach State Park, New Jersey. Ecol. Monog. 29:1-46.

McAtee, W.L. 1918. Notes on the plants of Wallops Island, (Accomac Co.) Virginia. Torreya 18:70-71.

Miller, J.R., R.H. Seher, and N.R. Usherwood. 1963. Methods used for testing soil samples at the University of Maryland Soil Testing Laboratory. U. of Md. Agron. Mimeo. No. 37 College Park 16pp.

Miller, W.R. and R.E. Egler. 1950. Vegetation of the Wequetequock-Pawcatuck tidal marshes, Connecticut. Ecol. Monog. 20:143-172.

Mooney, H. A. 1963. Physiological ecology of coastal, subalpine and alpine populations of Polygonum bistortoides Pursh. Ecology 44:812-816.

Nicholson, W. R. and R. D. VanDeusen. 1954. Marshes of Maryland. Resource Study Report No. 6. Md. Dept. Res. and Educ. Solomons, Maryland

Nobuhara, Hajime. 1967. Analysis of coastal vegetation on sandy shore by biological types in Japan. Jap. Jour. Bot. 19:325-351.

Norton. J. B. S. and R. G. Brown. 1946. A catalog of the vascular plants of Maryland. U. of Md. Agri. Exp. Sta. College Park. 50pp.

Oosting, H. J. 1948. The study of plant communities. W.H. Freeman and Co. San Francisco. 389 pp.

____________. 1954. Ecological processes and vegetation of the maritime strand in the southeastern United States. Bot. Rev. 20:226-262.

____________ and W. D. Billings. 1942. Factors effecting vegetation zonation on coastal dunes. Ecology 23:131-142.

____________ and P. E. Bourdeau. 1959. The maritime live oak forest in North Carolina. Ecology 40:148-152.

Pritchard, D. W. 1952. The physical structure, circulation and mixing in a coastal plain estuary. The Johns Hopkins University Tech. Rep. 111. The Chesapeake Bay Inst. Ref. 52-2.

Perkins, S. O. and S. R. Bacon. 1928. Soil survey of Worcester County, Maryland. U.S. Dept. Agri., Bur. Chem. and Soils No. 11. Ser. 1924. 31pp.

Ranwell, E.S., E. C. F. Bird, J. C. E. Hubbard, and R. E. Stebbings. 1964. Spartina salt marshes in southern England. Jour. Ecol. 52:627. 641.

Redmond, P. J. 1932. A flora of Worcester County, Maryland. Contri. Biol. Lab. Catholic University of America 11. 99pp.

Reed, J. F. 1947. The relation of the Spartinetum glabrae near Beaufort, North Carolina, to certain edaphic factors. Am. Mid. Nat. 38:605-614.

Rusby, H. H. 1891. A botanical excursion to Assateague Bay. Bull. Torrey Bot. Club 18:250-255.

Sieling, F. W. 1960. The resources of Worcester County coastal waters. Md. Dept. Res. and Educ. Ref. No. 60-10. Solomons, Maryland 17pp.

Small, J.A. and W.E. Martin. 1958. A partially annotated catalogue of vascular plants reported from Island Beach State Park, New Jersey. Bull. Torrey Bot. Club 85:368-377.

Small, J.K. 1929. Peninsula Delmarva. Jour. N.Y. Bot. Garden 30:62-71.

Smith, A.V. 1940. Some plants recently found in the coastal plain of Maryland. Rhodora 42:276-281.

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

____________. 1913. Progressive and retrogressive changes in the plant association of the Delaware coast. Bot. Gaz. 55:45-55.

Steel, R.G.D. and J.H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co. New York 481pp.

Stoesz, A.D. and R.L. Brown. 1957. Stabilizing sand dunes. U.S. Dept. Agri. Yearbook. Washington, D.C. 321-326.

Stone, Witmer. 1910. The plants of southern New Jersey. Rep. N.J. State Museum.

Sweitzer. E.M. 1968. An anatomical and ecological study of Salicornia Bigelovii Torr. Unpublished Master's Thesis. University of Maryland, College Park. 30pp.

Tatnall, R.R. 1946. Flora of Delaware and the eastern shore. Soc. Nat. Hist. of Delaware. Lancaster, Pennsylvania 310pp.

Taylor, N. 1939. Salt tolerance of Long Island salt marsh plants. N.Y. State Museum Circ. 23. Albany.

Tidestrom, Ivar. 1913. Notes on the flora of Maryland and Virginia I. Rhodora 15:101-106.

Truitt, R.V. 1968. High winds...high tides. Nat. Res. Inst., Univ. of Md. Educ. Ser. 77. College Park. 35pp.

U.S. Dept. Interior. 1963. Assateague Island and vicinity. Study of recreation values and potential use. U.S. Dept. Int., Bur. Outdoor Recreation. Washington, D.C. 32pp.

Vogl, R.G. 1966. Salt marsh vegetation of upper Newport Bay,. California. Ecology 47:80-87.

Vokes, H.E. 1961. Geography and geology of Maryland. Md. Geol. Surv. Bull. 19 243pp.

Wagner, R.H. 1964. The ecology of Uniola paniculata L. in the dune strand habitat of North Carolina. Ecol. Monog. 34:79-96.

Wells, B.W. 1928. Plant communities of the coastal plain of North Carolina and their successional relationship. Ecology 9:230-242.

____________. 1938. Salt spray; an important factor in coastal ecology. Bull. Torrey Bot. Club 65:485-520.

____________ and I.V. Shunk. 1931. The vegetation and habitat factors of the coarser sands of the North Carolina coastal plain; an ecological study. Ecol. Monog. 1:465-520.

Williamson, C.S. 1909. Notes on the flora of central and southern Delaware. Torreya 9:160-166.