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APPROVAL SHEET

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Christine Baumann

Author

Approved, February 1978

Stewart Ware

Stewart Ware

Mitchell Byrd

Mitchell Byrd

Gene M. Silberhorn

Gene Silberhorn

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ABSTRACT

The vegetation of a washover-dominated area on Cedar Island, Virginia was sampled with meter square quadrats placed along 24 cross-island transects. Transacts were divided into three categories, Least, Intermediate, and Most Overwash Influence, based on values for number of species, cover/m^2, maximum dune elevation and overwash/m^2.

Dune, grassland, slough, panne marsh and salt marsh communities are described. Ammophila breviligulata, Solidago sempervirens, Spartina patens, and Spartina alterniflora play a dominate role in the vegetation. Species diversity and cover was highest in the communities of the Least Overwash group. Only two of the six communities, the dune and salt marsh, were present in the Most Overwash group.

Spartina alterniflora marshes bordering the study area were predominatly tall form with a standing crop in early September of 1050 g/m^2.

THE EFFECTS OF OVERWASH ON THE VEGETATION OF A VIRGINIA BARRIER ISLAND

INTRODUCTION

Barrier islands are a significant feature of the North American coastline stretching from New England south along the Atlantic coast to Florida and continuing around the Gulf coast to the Mexican border. These islands and the salt marshes they protect represent one of the most dynamic and productive ecosystems in the world. Because of their position at the land-sea interface, the islands are shaped and continually influenced by the coastal environment. From their inception to the present, barrier islands are shaped by a rising sea and the forces of ocean currents, wind, and storms. The profound effects exerted by these environmental processes give the entire barrier island chain a common geological and ecological character (Godfrey 1976).

Considering the continually shifting nature of the barrier islands and the powerful physical forces acting upon them, the vegetation on these islands might be expected to play only a minor role in the functioning of the ecosystem. While the stresses placed on the vegetation by the coastal environment cannot be denied, research has shown that the vegetation plays an important role in tempering and modifying the effects of environmental stress on the island (Oosting 1954; Wagner 1964; Godfrey & Godfry 1973).

The extensive literature on coastal strand vegetation in the southeast has been summarized by Oosting (1954). Higgins et al (1971) includes a review of the literature on coastal vegetation of the mid-Atlantic states. Major barrier island vegetation studies since these reports include Au's (1969) study of Shackleford Banks, North Carolina, Art's (1976) work in the Sunken Forest of Fire Island, New York and two studies concerning the Georgia sea islands (Johnson et al.1974; Hillestad et al. 1975).

The coastal strand is characterized by vegetation whose life form and community structure is adapted to the rigors of the coastal environment. Because the environmental factors responsible for vegetation are similar on all coasts, similar life form and zonation are shared by strand vegetation all over the world (Oosting 1954). Strand vegetation occurs in zones beginning at the beach and changing with increasing distance from the ocean. The generalized pattern is beach, dune, grassland, thicket or shrub zone, woodland and salt marsh. The entire sequence does not develop on all coasts but depends in part upon the width of the island (Higgins 1971). The ecotone between zones may vary in width depending upon the degree of topographic change between the zones (Martin, 1959).

Although many factors such as soil moisture, temperature, sand deposition and distance to water table interact to influence vegetation, salt spray is the dominate environmental factor controlling plant zonation in coastal areas (Oosting & Billings 1942; Oosting 1945, 1954; Boyce 1954; Wells 1938). Because of its influence on the interception of salt spray and sand movement and its modifying effect on all other limiting factors, topography is also important in determining coastal plant zonation (Martin 1959).

Vegetation zonation on a barrier island does not necessarily reflect a successional sequence (Burk 1962). The successional stage reached in each zone is a function of the environmental factors operating in that area and may not progress past a given state regardless of the time factor. Changes in topography, however, can lead to changes in successional stage (Martin 1959).

Despite the attention given to coastal processes and vegetation, it wasn't until 1970 that overwash was focused upon as an important coastal process (Godfrey 1970). Overwash, occurs when a high energy surge generated by a storm forces water and sand up the beach and back onto the landward side of the island. The washover may pass between existing dunes or flatten dunes as it carries sediments and salt water back onto the island. Because of its apparent effects of dune erosion and vegetation burial, overwash has been viewed as being detrimental to the ecological health of a barrier island. Attempts at stabilization of such dynamic overwashed areas on the Outer Banks of North Carolina have met with less than successful results (Dolan, Godfrey & Odum 1973). The work of Godfrey & Godfrey (1971, 1973, 1974) pointed out the role of overwash as a natural geomorphic process essential to the long term stability of the barrier island. While chronic overwash could indeed be detrimental, overwash tempered by existing dunes and vegetation was actually functioning as a sand conserving process.

In studying overwash in relation to inlet dynamics Godfrey and Godfrey (1974) found that sediments from inlets and overwash deposits provided substrate for later development of salt marshes. The standing crop of marshes growing on this new substrate was more than twice that of nearby non-overwashed sites. These new marshes also served to widen the island and contributed to the landward migration of the island.

With the recognition of the overwash process as an integral part of the barrier island ecosystem, increased attention has been focused on the responses and role of vegetation in the process. In his comprehensive studies of the effects of overwash on the vegetation of Core and Shackleford Banks, North Carolina, Hosier (1973) describes community structure as well as ecological tolerances of some plants to the effects of overwash. He views the primary vegetational effects of overwash as burial by sand and salt water flooding.

Recent studies of the effects of overwash on coastal vegetation have been carried out along the Massachusetts coast at Cape Cod (Godfrey 1976; Godfrey _et al_. 1976). In comparing the results of these studies with the data from North Carolina, there appears to be a difference in the role of overwash in the two areas. In the south, overwash is a frequent process exerting a dominant effect on the vegetation. In the north, where overwash is less frequent, most plants are killed by sand burial when overwash does occur. _Spartina patens_, a dominant plant in the southern overwashed sites, occurs in the north only in the salt marsh and is not a significant component of the dune and beach flora which receives the effects of overwash. Vegetation recovery from an overwash event in the north involves the sprouting of _Ammophila breviligulata_ rhizome fragments disrupted by overwash. Subsequently, dune building occurs around these fragments.

Based on his observations of the overwash process, Godfrey (1976) considers the Delmarva Coast a transition zone with ecological conditions and vegetation intermediate between that found to the north and south. A similar concept of the vegetation of the Delmarva coast is held by

Art (1976) who views the entire Atlantic coast barrier island chain as a vegetational continuum. Changes in species composition are attributed to gradual changes in edaphic and climatic factors along the chain. Along this continuum, the Delmarva coast occurs near the mid-point and serves as a meeting ground for northern and southern species. Further evidence of Delmarva as a transition zone for coastal plant species is provided by Higgins _et al_. (1971) in their studies on Assateague Island.

When compared to the extensive studies along the North Carolina coast, the Virginia coast has received surprisingly little attention. A checklist of species and classification of communities of Cape Henry was prepared by Egler (1942). Brief visits by Harvill (1965, 1967) and Clovis (1968) to the barrier islands resulted in short papers delineating major communities and the more conspicuous species on Parramore, Assateague, and Smith Islands. A more detailed study of Assateague Island was made by Higgins _et al_. (1971).

Two recent studies have focused on the vegetation of the Virginia coast. In a study for the Nature Conservancy, McCaffrey (1975) surveyed 13 of the 16 Virginia barrier islands and recorded major vegetational communities and their species composition. A study of Fisherman's Island by Boulé (1976) correlated geomorphic features with vegetational succession and traced the development of the island from a sand bar in the 1800's to its present form.

The primary objective of the present study was to describe the vegetation of a Virginia barrier island in an area that is heavily influenced by overwash. A secondary objective was to measure the standing crop of <u>Spartina alterniflora</u> marshes adjacent to the overwashed area. It is hoped that both of these objectives will provide useful baseline information regarding overwash processes as they function in relation to the vegetation of the Delmarva transition zone.

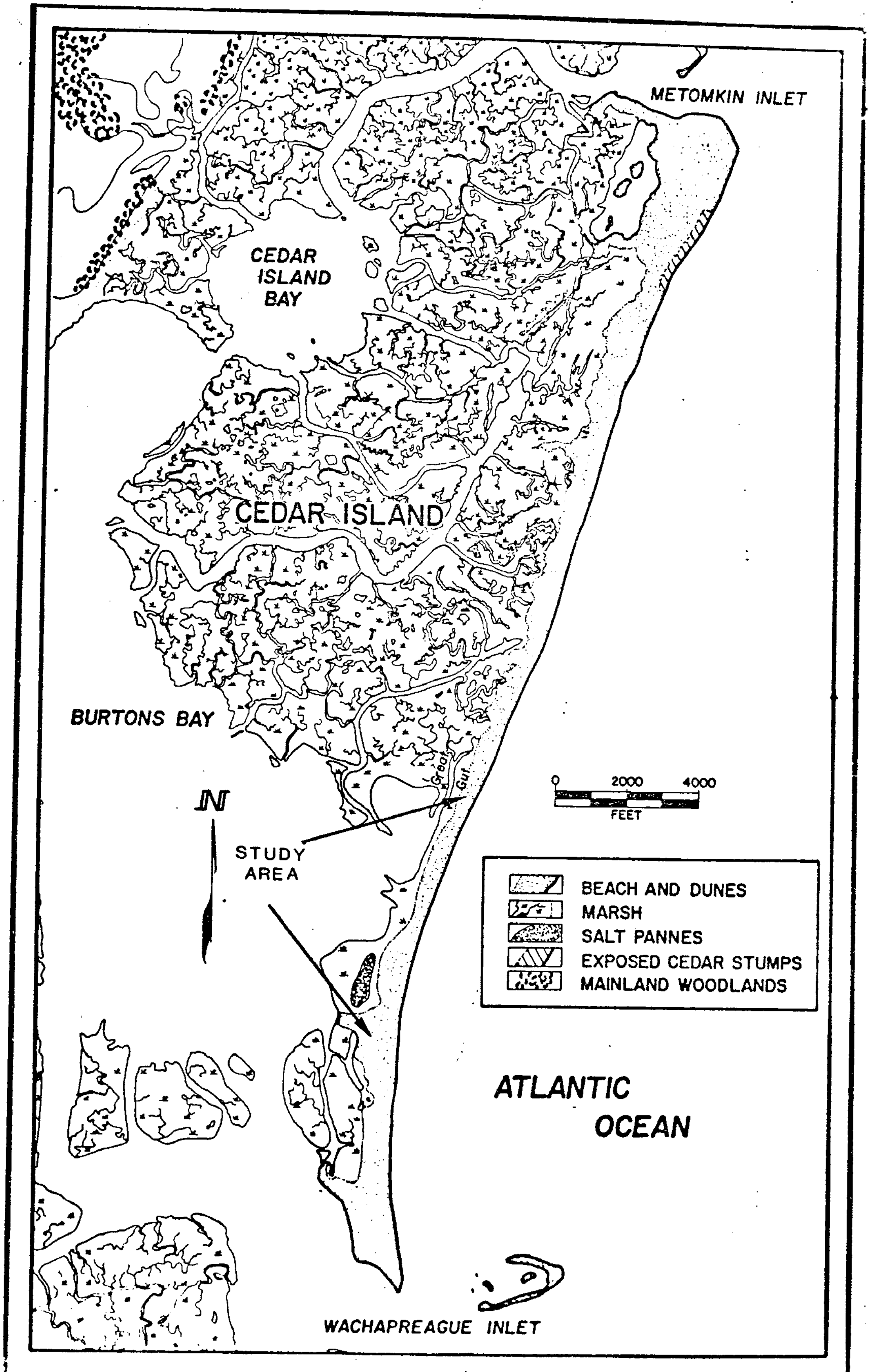
Usage of the terms "overwash" and "washover" in this paper will follow that of Hosier (1973). Overwash refers to the process of water and sand movement across the island. A washover is a specific site or event where the overwash process has occurred.

THE STUDY AREA: CEDAR ISLAND

Cedar Island is a 10.4 km long barrier island located approximately 6.4 km from the Virginia mainland east of Wachapreague. Cedar Island is separated from Metompkin Island to the north by Metompkin Inlet. Wachapreague Inlet to the south separates Cedar from Parramore Island (Figure 1). The island varies in width from 120 m near its southern end opposite Burton's Bay to 765 m at its northern end. Along the southern half of the island dunes are low, from 1 to 2 m, and scattered. A continuous dune line borders the beach along most of the northern half of the island. Dune ridges reaching a height of 6 m occur on the northern end of the island.

From analysis of core samples and C^{14} dating of peat, Newman and Munsart (1968) estimate the age of Cedar Island at 5500 years before present. Since its inception, the shoreline of Cedar Island has changed repeatedly as a result of fluctuations in sea level and movement of the earth's crust (Kemerer 1972). Shoreline changes within the past 100 years have been analyzed and documented (Kemerer 1972; Rice et al. 1975). Brief mention of these changes will be made here only as they relate to the current study. For a more thorough treatment of shoreline

FIGURE 1. MAP OF CEDAR ISLAND



METOMKIN INLET
CEDAR ISLAND BAY
CEDAR ISLAND
BURTONS BAY
Great Gut
0 2000 4000
FEET
N
STUDY AREA
BEACH AND DUNES
MARSH
SALT PANNES
EXPOSED CEDAR STUMPS
MAINLAND WOODLANDS
ATLANTIC OCEAN
WACHAPREAGUE INLET

changes and historical geomorphology of the island the reader is referred to the papers cited above.

Between 1852 and 1968, the seaward face of the island retreated westward almost 612 m. Evidence of the island's migration is visible in the surf zone approximately 3.2 km north of Wachapreague Inlet. For a distance of about .8 km an impressive layer of marsh peat including rhizomes and oyster and mussel shells lines the shore just below the low water mark (Figures 2 & 3). C^{14} dating has placed the age of this marsh at about 200 years (Newman & Munsart 1968). This indicates that at least 200 years ago at this location, the body of the island was east of its present position and the peat was part of a salt marsh bordering the western edge of the island. Even more recent migration is evidenced by the remains of a series of telephone poles in the surf zone near the peat layer. These poles were part of a telephone line which in the 1940's ran the length of the island behind the primary dune (Richard D. White pers. comm.) (Figure 3).

Cedar Island has been breached at least once in recorded history. Sometime between 1955 and 1957 an inlet was created about 3.2 km north of Wachapreague Inlet opposite Burton's Bay (Figures 4 & 5). The inlet acted as a sediment trap for sand being transported southward by longshore current. The constant movement of sand into the inlet was responsible for its eventual closure in 1961 (Kemerer 1972).

FIGURE 2. MARSH PEAT IN THE SURF ZONE ON CEDAR ISLAND

FIGURE 3. REMAINS OF TELEPHONE LINE IN SURF ZONE ON CEDAR ISLAND.

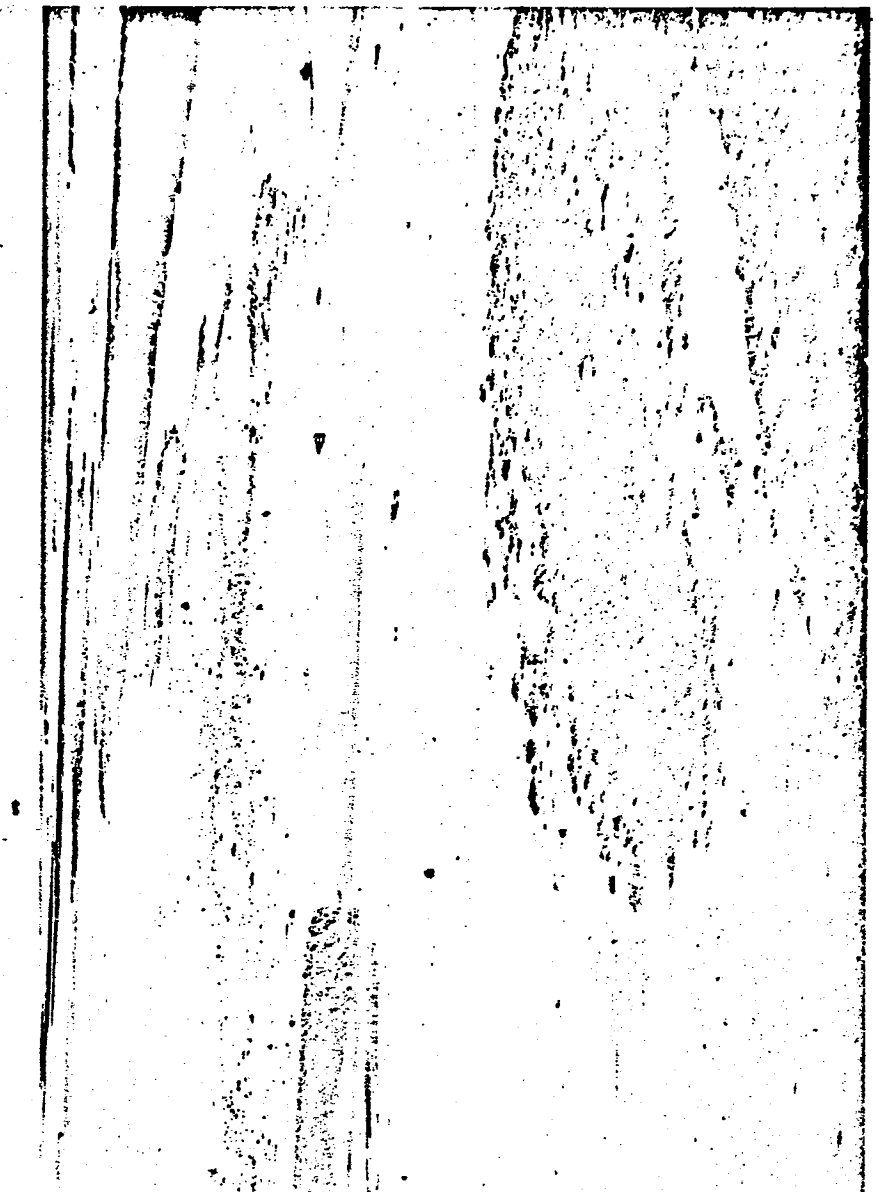
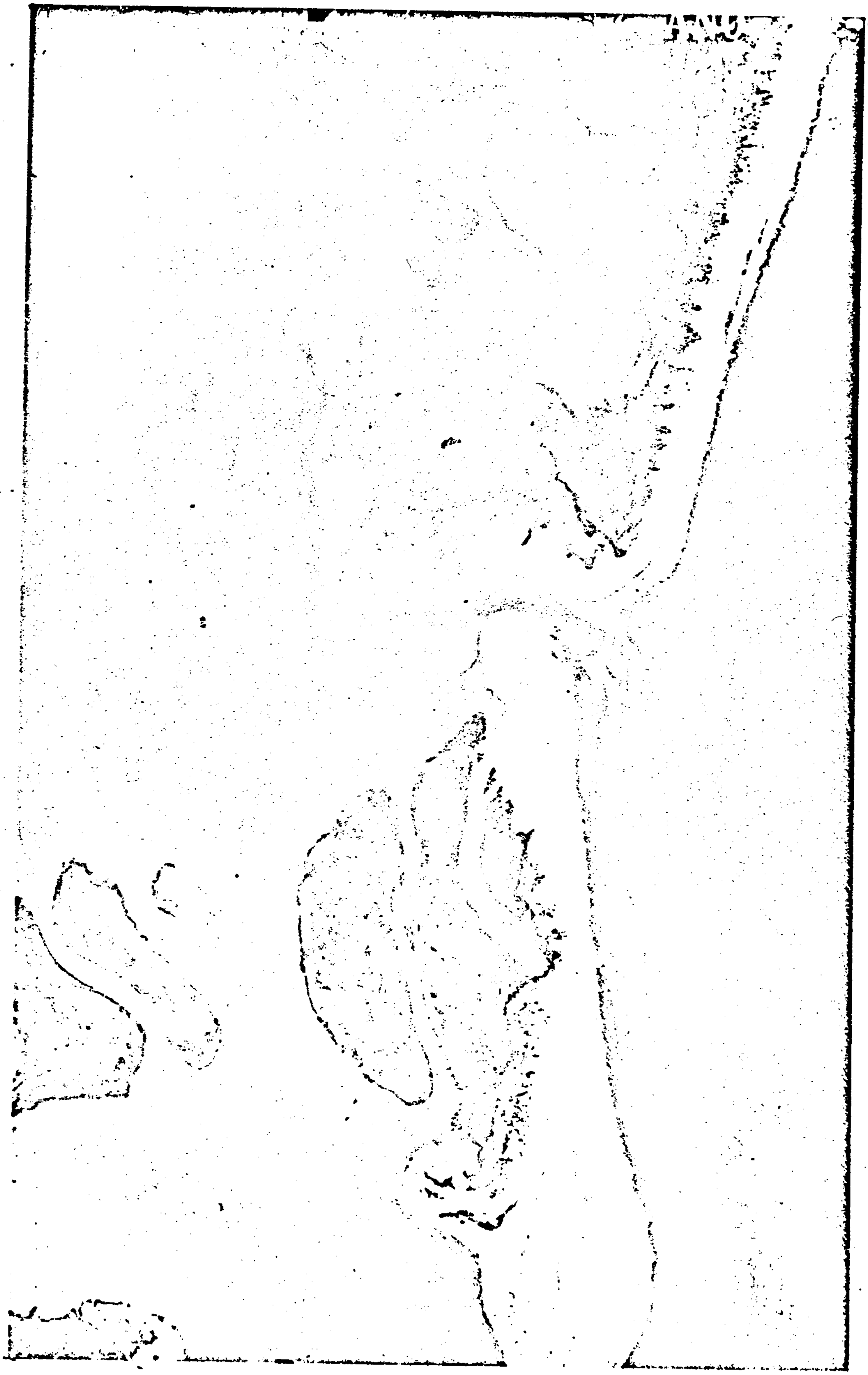


FIGURE 4. AERIAL PHOTOGRAPH OF SOUTHERN CEDAR ISLAND MAY, 1949 BEFORE THE OPENING OF THE INLET

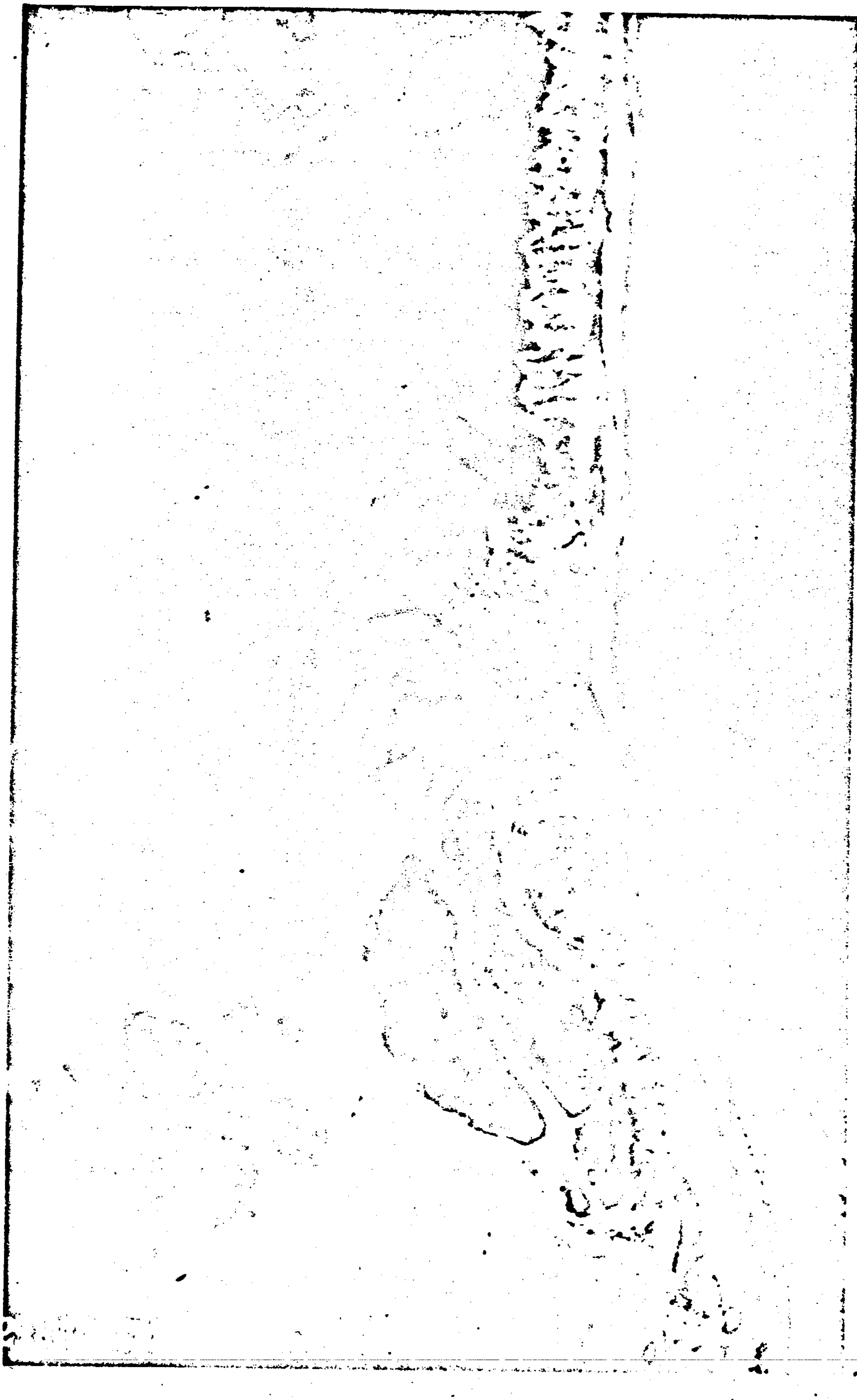
FIGURE 5. AERIAL PHOTOGRAPH OF SOUTHERN CEDAR ISLAND
NOVEMBER, 1957 - INLET OPEN



The most recent event to have a major effect on the geomorphology and vegetation of Cedar Island was the Ash Wednesday storm of March, 1962. Extremely high tides and waves caused extensive overwash on the island (Figure 6). The inlet which was opened in 1955 was reopened and extensive overwash sediments created a large fan on the western side of the island (Newman & Munsart 1968). The effects of overwash were most severe on the southern half of the island where the dunes were flattened and the vegetation was completely removed. A more substantial dune system to the north acted as a buffer and lessened the effects of the storm.

Human influence on Cedar Island has not had significant impact in comparison to the changes caused by the natural environment. The island was first patented in 1681 to William Burton (Whitelaw 1951). Early use of the island included grazing by horses and cattle. In the late 1800's Cedar Island, like many of the other Virginia barrier islands, became a popular recreation spot. A branch of the Wachagreague Hotel was constructed on the south end of the island. The hotel and a nearby Coast Guard station were both washed away in a severe storm in 1933. A Coast Guard station constructed after the 1933 storm on the north end of the island is still standing. In the 1950's a large portion of the island was owned by Richard Hall of Accomack, Virginia. He subdivided his holdings and sold

FIGURE 6. AERIAL PHOTOGRAPH OF SOUTHERN CEDAR ISLAND MARCH, 1962 AFTER THE ASH WEDNESDAY STORM



parcels of land with hopes of developing an area on Cedar Island similar to Ocean City, Maryland. Approximately three hundred lots were sold but development was thwarted when continual efforts to have a causeway constructed to the island failed.

At present there are over a dozen summer homes on the island. Most houses have at least one passageway to the beach through the dunes. These breaks in the dunes may function as washover channels during storms. The large salt panne near the southern end of the island is laced with tire tracks and this same area has been used as an airstrip for a small plane. In the spring and early summer Skimmers and Terns nest in colonies on the beaches of Cedar Island. Oversand vehicles driven indiscriminantly through these areas are disruptive to the bird's breeding efforts.

THE STUDY SITES

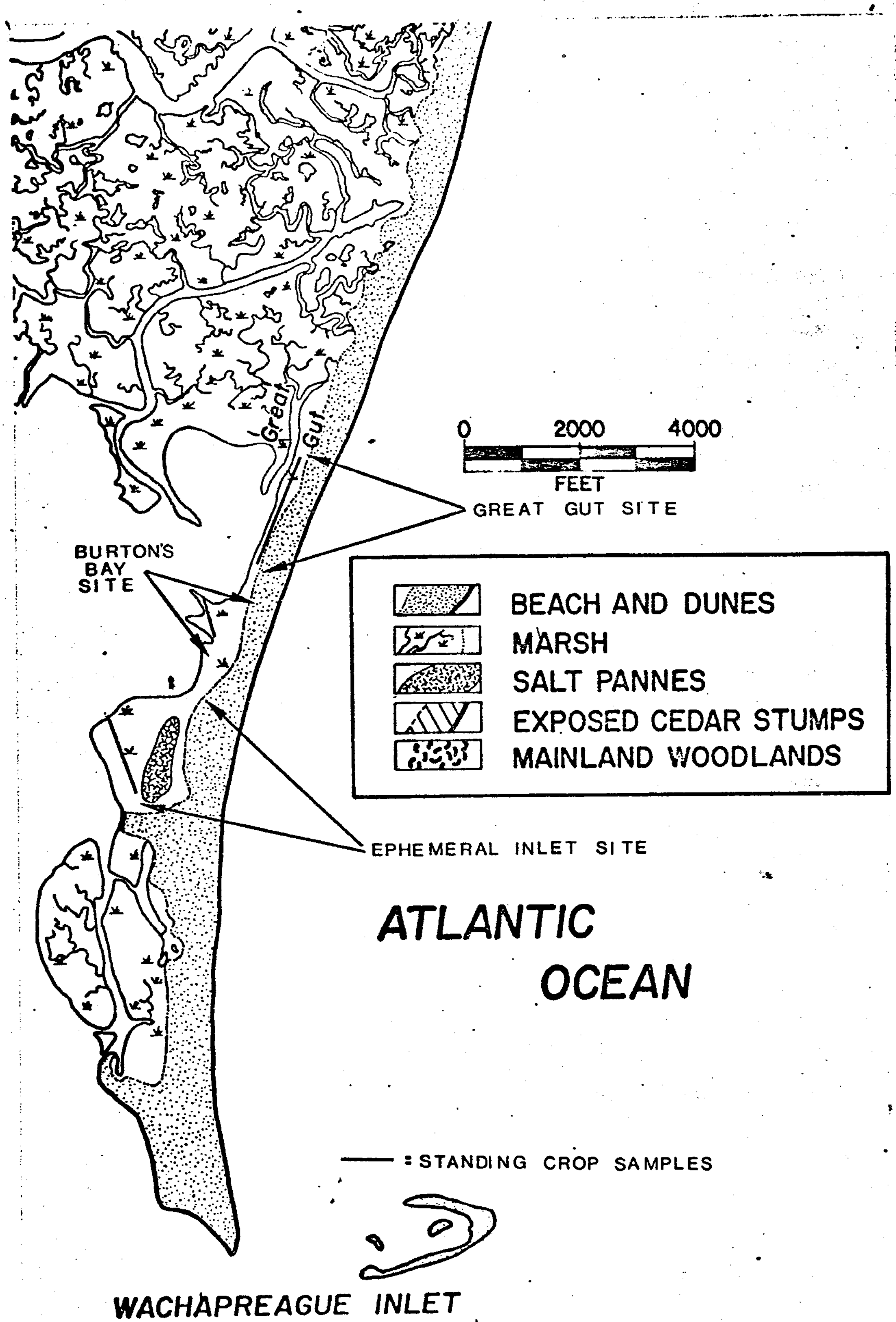
A 2 km section of Cedar Island beginning 3.2 km north of Wachapreague Inlet and extending north was selected for intensive study because of the presence of extensive washovers. Evidence of overwash in this area is apparent in photos from 1949 to the present and was no doubt a predominate feature even earlier than that, as evidenced by the rapid rate of retreat of the shoreline in the area during the past 100 years. The area studied included the narrowest parts of the island. The dunes in this region are low and scattered with numerous washovers throughout.

The entire study area was subdivided into three study sites, Great Gut, Burton's Bay, and Ephemeral Inlet. The study area and each of the study sites is delineated in Figure 7.

Great Gut Study Site

The Great Gut study site is located 5 km north of Wachagreague Inlet. This site is 1 km long and ranges in width from 124 to 200 m. The dunes vary from low and scattered at the southern end of the area to a continuous line approximately 2 m high in the north. The area is broken by numerous washover channels of varying severity. In two locations a large washover traverses the entire island. Salt marsh development is restricted to a narrow band

FIGURE 7. MAP OF THE STUDY AREA SHOWING THE THREE STUDY SITES AND LOCATION OF STANDING CROP SAMPLES


Great Gut
0 2000 4000
FEET
GREAT GUT SITE
BURTON'S BAY SITE
BEACH AND DUNES
MARSH
SALT PANNES
EXPOSED CEDAR STUMPS
MAINLAND WOODLANDS
EPHEMERAL INLET SITE
ATLANTIC OCEAN
= STANDING CROP SAMPLES
WACHAPREAGUE INLET

along the western edge of the island. The width of the island and the height and continuity of the dunes increases in the northern section of the study site. During the 1962 storm, overwash was extensive in the Great Gut site (Figure 6).

Burton's Bay Studv Site

The Burton's Bay study site is located 4.4 km north of Wachapreague Inlet. The dunes in this area are scattered and average 1 to 2 m in height. The area has four major washovers, and sand from recent washovers was observed in the salt marsh bordering the site. The pattern of the salt marsh in this area suggests that it may have grown up on old overwash deposits; however, the marsh appears on photos as early as 1949 and its exact age is uncertain. Only the eastern edge of the marsh was buried by overwash sediments during the 1962 storm.

Ephemeral Inlet Study Site

The Ephemeral Inlet site is located in the area where an inlet existed from 1957 to 1961 and reopened during the 1962 storm. The site is approximately 3.2 km north of Washapreague Inlet. Only one washover crosses the site. Other than this, the dunes form a generally continuous line and range in height from 1 to 2 m. The beach is wide, possessing a pronounced berm. This area was significantly altered by the 1962 storm. Dunes were flattened and almost all vegetation was either buried or undermined (Newman & Munsart 1968). The reopening of the inlet allowed large quantities of sediment to be deposited in the form of a large washover fan burying completely the salt marsh that had grown on this section of the island. The sediments deposited by the storm have subsequently been colonized on the western side by Spartina alterniflora. A large portion of the washover deposit remains as an unvegetated salt panne. Water from spring tides fills the panne periodically and, as it evaporates, hypersaline conditions are created. This phenomenon, failure of the panne area to drain, has been attributed to the presence of an underlying peat layer hindering percolation of water through the soil (Chapman 1960). The marsh buried by the overwash sediments is probably creating the impermeable layer in the study area. Hosier (1973) reported a similar area created in his North Carolina study area in 1962 which has remained unvegetated since.

METHODS

Field Methods

The initial selection of the study area was made in April, 1975. Visits were made to the island at least once a month from April through October, 1975. Work in May and June was devoted to a general reconnaisance of the entire island as well as a more detailed survey of the proposed study area. Notes on topography, species composition, and major vegetational patterns were supplemented with sketches and slides in an effort to develop a basic familiarity with the island. Intensive vegetational sampling was carried out in July at Great Gut and in September at Ephemeral Inlet. Standing crop samples were collected in early September from Great Gut, Burton's Bay and Ephemeral Inlet.

During 1976, visits were made to the island in April, July and October. Notes and slides taken during these visits were used to assess seasonal changes in vegetation patterns and the effects of minor storms on the study area.

Voucher specimens were collected periodically throughout the study and are on file in the College of William & Mary Herbarium. Nomenclature follows Radford et al. (1968) except where noted.

Cross-island transects were used at Great Gut and Ephemeral Inlet to determine major vegetational patterns and species composition of communities. The transects were spaced at 50 meter intervals and oriented along a line perpendicular to the beach based on a reading from a hand held bearing compass.

The Great Gut site was sampled in July, 1975 with 19 transects running from the top of the berm to the bay, or, in the case of the northernmost transects, to the edge of Great Gut. Transects were numbered consecutively beginning with #1 at the south end and ending with #18 in the north. Transect 19 was later added between transects 11 and 12 in order to sample directly a major washover.

In September, 1975 five transects, numbers 20 - 24, were run in the Ephemeral Inlet site. Transect 20 was located near the northern border of the only washover in this area. Transects 21 and 22 were located 50 and 100 meters, respectively, north of 20. Transects 23 and 24 were located 50 and 100 meters to the south of transect 20. Transects began at the berm but because of time limitations were extended only as far as the eastern edge of the salt marsh. Despite the exclusion of the salt marsh from these transects, they were still twice as long as transects in the Great Gut area.

A series of sample points were taken along each transect. In the Great Gut site, sampling points were taken at 5 meter intervals along the transects, resulting in 670 plots for the area. For the five Ephemeral Inlet transects

340 sampling points were taken. Intervals between sampling points at Ephemeral Inlet were 5 or 10 meters depending upon the degree of topographic relief. For example, when crossing the salt panne, sampling points were expanded to 10 meter intervals.

At each sampling point a square meter plot was placed along the transect with its lower right corner at a sample point. At each plot the following parameters were measured:

1. General community type
2. Elevation relative to the berm
3. Evidence of recent overwash
4. Species present
5. Percent cover of species present

General Community Type

This classification was possible because of the distinct life form and topography on a barrier island. Initially the plots were classified according to the community types described by Hosier (1973) in his classification of washover vegetation in North Carolina. This was later modified to allow for differences in the vegetation of Cedar Island. The order of communities that follow reflects the sequence in which they would be encountered moving landward from the ocean.

Hosier (1973)	This Study
1. Active Beach	1. Beach
2. Dunes	2. Dunes
3. Grassland	3. Grassland
4. Tidal Marsh	4. Slough
a. high marsh	5. Panne Marsh
b. salt flat	6. Salt Marsh
c. salt marsh	

Elevation Relative to the Berm

A modified Emery Method (1961) was used to measure changes in elevation along the transect. An explanation of this method appears in Appendix I.

Evidence of Recent Overwash

A plot was counted as having evidence of recent overwash if it was located in, or adjacent to, the throat or fan of a washover that had received sediment within the past year (Figure 8).

Species Present and Percent Cover

Any plant rooted inside the quadrat was counted. Percent cover for each species was estimated based on a six cover class method described in Daubenmire (1959).

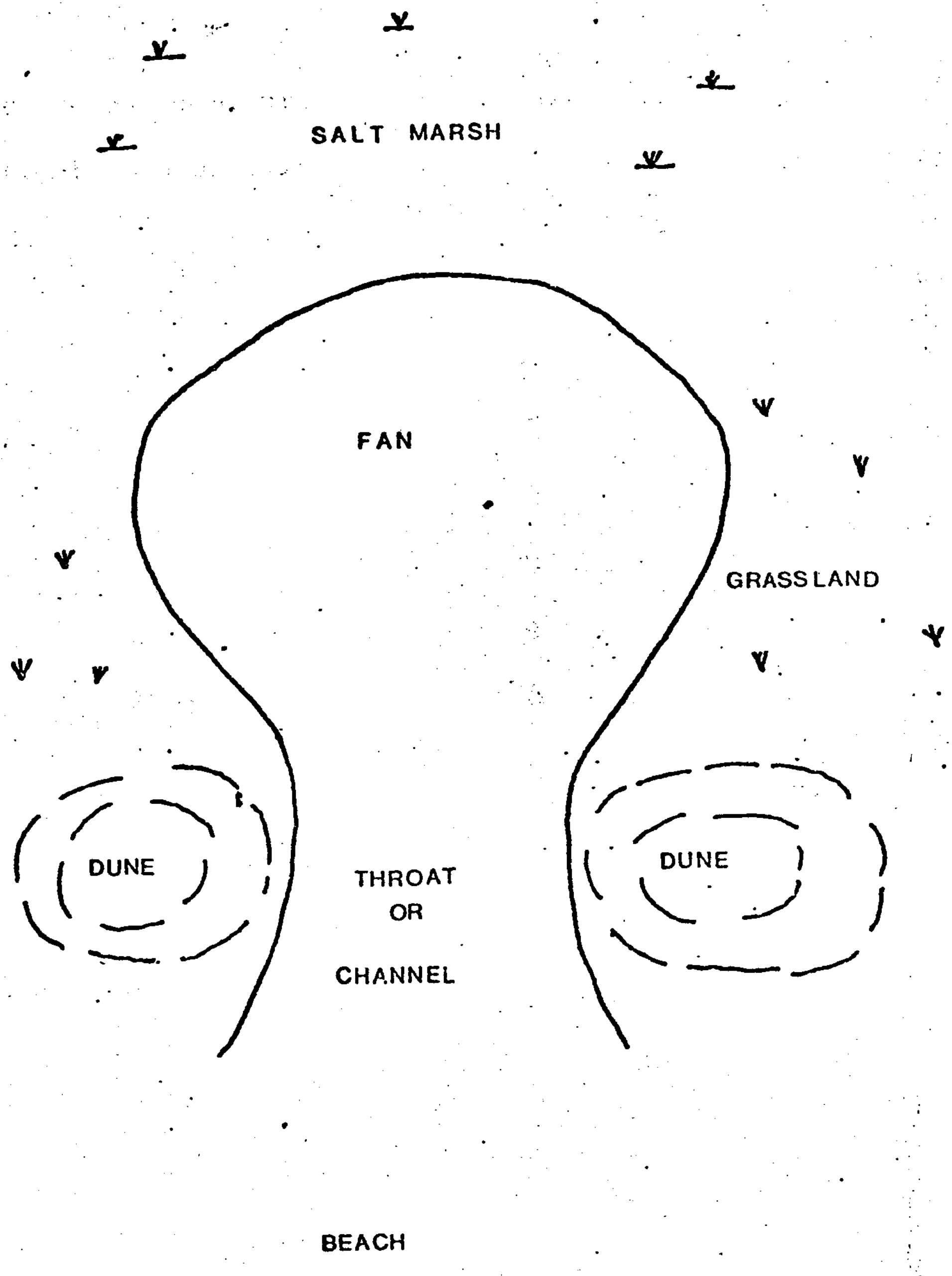


FIGURE 8. DIAGRAM OF THE ANATOMY OF A WASHOVER

The classes used are listed below. The midpoint is recorded as the percent cover for that species at that point.

		midpoint
no vegetation	-	0
less than 5%	1	2.5
5 - 25%	2	15.0
26 - 50%	3	37.5
51 - 75%	4	62.5
76 - 95%	5	85.0
greater than 95%	6	97.5

Transect Analysis

Based on the data collected in each plot, the transects were characterized by four parameters,

1. overwash/m^2
2. maximum elevation of dunes
3. cover/m^2
4. number of species

Parameters 1 and 2 reflect variations in the environment and topography of the transect. The other parameters are indicative of variation in the vegetation.

1. Overwash/m^2

This value represents the percentage of total plots along a transect with evidence of recent overwash.

$$\text{overwash/m}^2 = \frac{100 \times \#\ \text{plots with recent overwash}}{\text{total number of plots}}$$

2. Maximum elevation of dunes

Because of the role of dunes in moderating the effects of salt spray and overwash, the height of the dunes was selected as an important aspect of the topography along the transect.

3. Cover/m^2

Percent cover for each species in a plot was taken as the midpoint of the cover class into which the plant had been placed. Total cover was determined for each transect by summing the values for cover for all species in the transect. Cover/m^2 could then be determined using the following equation,

$$\text{cover}/m^2 = \frac{\text{total cover}}{\text{total number of plots}}$$

In the Ephemeral Inlet study site as many as one third of the plots were located in the unvegetated salt panne. In order to make the cover/m^2 of the vegetated portions of these transects comparable to those in the Great Gut site, the plots in the salt panne were excluded from the calculations of cover/m^2. For transects 20 - 24:

$$\text{cover}/m^2 = \frac{\text{total cover}}{\text{total plots} - \text{plots in salt panne}}$$

4. Number of Species

This parameter is a reflection of the species diversity of the section of the island crossed by the transect. All species encountered in plots were counted regardless of frequency or cover.

Vegetational Analysis

Along any transect or group of transects, and for each community type, relative cover and relative frequency were determined by combining all plots of the transect(s) or community type and applying the following formulae:

Relative cover for species x =

$$100 \times \frac{\text{total cover for species x in the transect(s) or community}}{\text{total cover for all species in the transect(s) or community}}$$

Relative frequency for species x =

$$100 \times \frac{\text{frequency of species x in the transects or community}}{\text{frequency of all species in the transect(s) or community}}$$

Standing Crop Methods

Standing crop samples were taken from the *Spartina alterniflora* marsh bordering the Ephemeral Inlet, Burton's Bay and Great Gut study sites on September 3, 4 and 5, 1975 respectively. These dates were chosen based on Keefe and Boynton's (1973) estimation of peak standing crop for the Chincoteague Bay marshes 50 kilometers to the north.

A total of 40, 0.25m^2 samples were taken. Of these, 16 were from Ephemeral Inlet, 10 from Burton's Bay and 14 from Great Gut. At 50 m intervals a 50cm x 50cm quadrat was tossed into the marsh on alternating sides of a transect through the marsh. The approximate location and orientation of these transects is shown in Figure 7.

The average height of grass in each quadrat was measured and the vegetation was clipped to the level of the marsh surface. The clipped sample was separated into living and dead components and placed in plastic bags in the field. Upon return to the lab, samples were refrigerated until they could be dried. Samples were dried to constant weight in a 38°C oven and weighed on a Sartorius pan balance.

Mean height and mean standing crop of living and dead material was computed for each site and for the sample as a whole. The ratio of living to dead standing crop was calculated.

RESULTS

Floristics

A total of 54 species representing 21 families were encountered in the study area. Species of the family Poaceae were dominant both floristically and vegetationally. Other important families floristically were Cyperaceae, Chenopodiaceae and Asteraceae. Species from these families comprised 69% of the total flora. A complete list of species found in the overwash study area appears in Appendix II.

Table I is a comparison of the flora of overwashed areas on Cedar Island with the flora of neighboring islands studied by other researchers. Since the flora from overwashed areas represents only a portion of the total island flora it is depauperate in comparison to the flora of entire islands.

Of the 79 species listed by McCaffrey (1975) for Cedar Island 40 were found in the study area. Fifteen additional species were found in the study area that do not appear on the list. Eight of these are listed for other barrier islands, but seven species are new to the list for the Virginia barrier islands included in McCaffrey's (1975) study.

The comparison of dominant families in Table II demonstrates the floristic dominance of Poaceae and Asteraceae in each area. Of the areas listed, the overwashed area has the smallest number of families contributing the highest percentage of the total flora.

A list of all species encountered in the study area and their frequency appears in Table III. Dominant species include Spartina patens, Spartina alterniflora, Solidago sempervirens and Ammophila breviligulata. These are the only species occurring in more than 20% of the vegetated quadrats. Only one annual, Strophostyles helvola, appears in the group of species occurring in more than 10% of the vegetated quadrats.

Table I. Comparison of overwash flora of Cedar Island with flora of other Virginia barrier islands

Location	Families	Species
Assateague Island (Higgins et al. 1971)	88	441
Fisherman's Island (Boulé 1976)	47	139
Virginia Barrier Islands (McCaffrey 1975)	62	211
Cedar Island (McCaffery 1975)	34	79
Cedar Island Overwash (This study 1978)	21	54

Table II. Comparison of dominant families of the overwash flora of Cedar Island and other Virginia barrier islands

Assateague Island (Higgins 1971)		Virginia Barrier Islands (McCaffery 1975)		Fisherman Island (Boulé 1976)	
Family	# Species	Family	# Species	Family	# Species
Asteraceae	67	Poaceae	39	Poaceae	24
Poaceae	65	Asteraceae	26	Asteraceae	21
Cyperaceae	23	Cyperaceae	17	Chènopodaceae	10
Fabaceae	19	Chenopodaceae	10	Cyperaceae	10
Rosaceae	17	Juncaceae	10		
Juncaceae	16				
47% of total flora		48% of total flora		47% of total flora	

Table II. continued

Cedar Island (McCaffery 1975)		Cedar Island Overwash (This study 1978)	
Family	# Species	Family	# Species
Poaceae	13	Poaceae	12
Asteraceae	13	Asteraceae	9
Chenopodaceae	8	Chenopodaceae	8
Cyperaceae	5	Cyperaceae	7
Juncaceae	5		
56% of total flora		69% of total flora	

Table III. Frequency of species encountered in 682 vegetated quadrats in the study area

Species	Frequency	
Spartina patens	265	
Spartina alterniflora	259	
Solidago sempervirens	220	
Ammophila breviligulata	201	
		20%
Panicum amarum	86	
Strophostyles helvola	85	
Scirpus americanus	73	
Fimbrystylis spadicea	69	
		10%
Salicornia europaea	66	
Distichlis spicata	53	
Cakile edentula	47	
Euphorbia polygonifolia	44	
Erigeron canadensis	42	
Salicornia bigelovii	40	
Iva frutescens	39	
Pluchea purpurascens	39	
Suaeda linearis	37	
Cyperus esculentus	36	
		5%
Limonium nashii	25	
Cyperus filicinus	22	
Gnaphalium obtusifolium	20	

Table III. continued

Species	Frequency
Triplasis purpurea	17
Salsola kali	16
Cenchrus tribuloides	15
Salicornia virginica	14
- -	- - - - - - 2%
Bassia hirsuta	13
Sabatia stellaris	12
Borrichia frutescens	11
Euphorbia supina	8
Eragrostis spectabilis	7
Andropogon virginicus	6
Atriplex patula	5
Calystegia sepium	5
Oenothera humifusa	5
Baccharis halimifolia	4
Linum virginianum	4
Myrica cerifera	3
Cyperus retrorsus	3
Teucrium canadense	2
Phragmites australis	2
Aster subulatus	1
Cynodon dactylon	1
Eupatorium capillifolium	1
Kosteletskya virginica	1

Table III. continued

Species	Frequency
Parthenocissus quinquefolia	1
Rhus radicans	1
Samolus parviflorus	1
Atriplex arenaria	
Cyperus odoratus	
Eleocharis sp.	= Species found in study area not included in quadrats
Hypericum gentianoides	
Juniperus virginiana	
Lythrum lineare	
Panicum capillare	

Analysis of Vegetation of Transects

Observations made in the field suggested a relationship between overwash/m^2 and each of the other three variables. This relationship is represented graphically in Figures 9, 10 and 11. Based on their position on the graphs, the transects were placed into one of three groups. Transects 1, 2, 3, 11, 12, 14 and 19 fall consistently in the lower right section of the graphs. Transects 17, 18, 21, 22, 23 and 24 are grouped consistently in the upper left of the graphs. The remaining transects lie in the center with the exception of 4, 9, 20, and 10 which each occur once in the upper area. Based upon the graphs and observations in the field, the transects were grouped as above into three categories: Most Overwash Influence, Least Overwash Influence, and Intermediate Overwash Influence.

Titling the groups in relation to overwash is not meant to suggest that overwash is the sole determinant of the other factors. Overwash, along with cover, number of species, and dune height, are all a part of the island profile at a given location. The primary function of the categories is a means of combining similar sections of the island for analysis. Further, the terms least, intermediate and most are relative ones used to compare

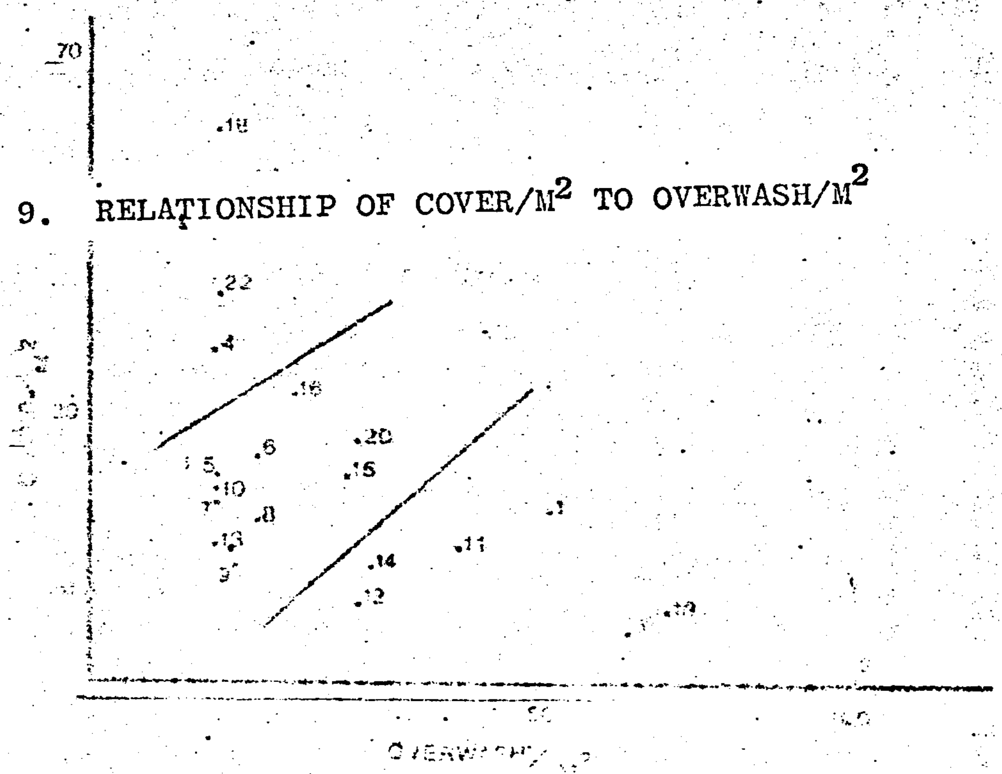


FIGURE 9. RELATIONSHIP OF COVER/M^2 TO OVERWASH/M^2

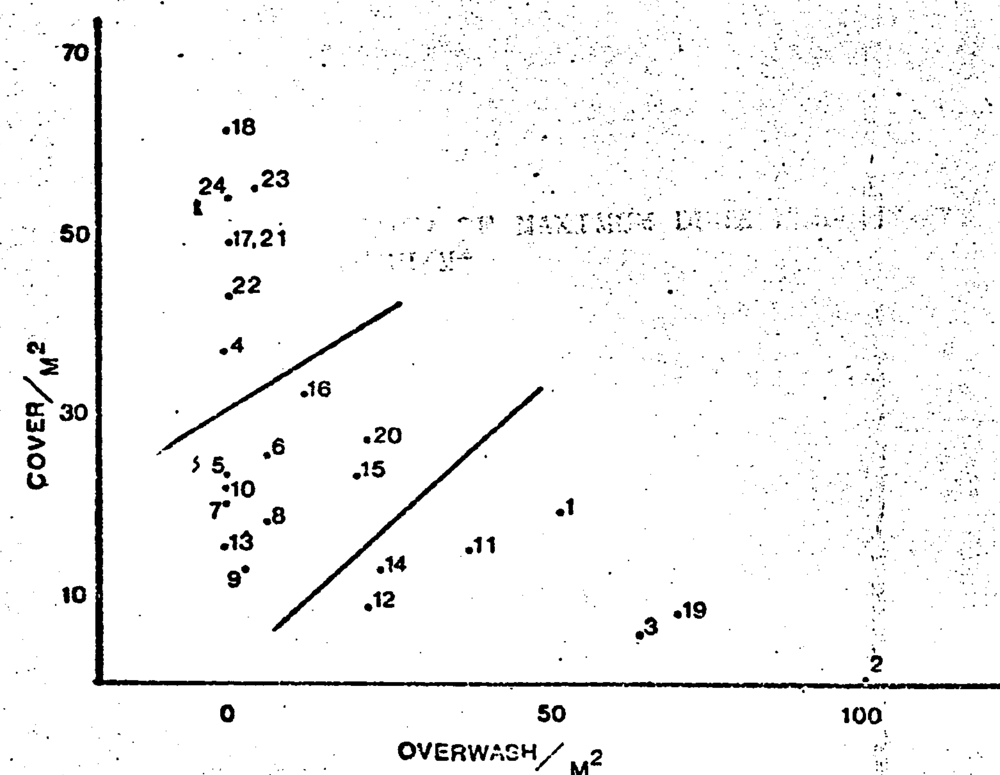

70
50
30
10
COVER/M²
0
50
100
OVERWASH/M²
18
24
23
17,21
22
4
16
20
6
5
15
10
7
8
1
13
11
14
9
12
19
3
2

FIGURE 10. RELATIONSHIP OF MAXIMUM DUNE ELEVATION TO OVERWASH/M^2

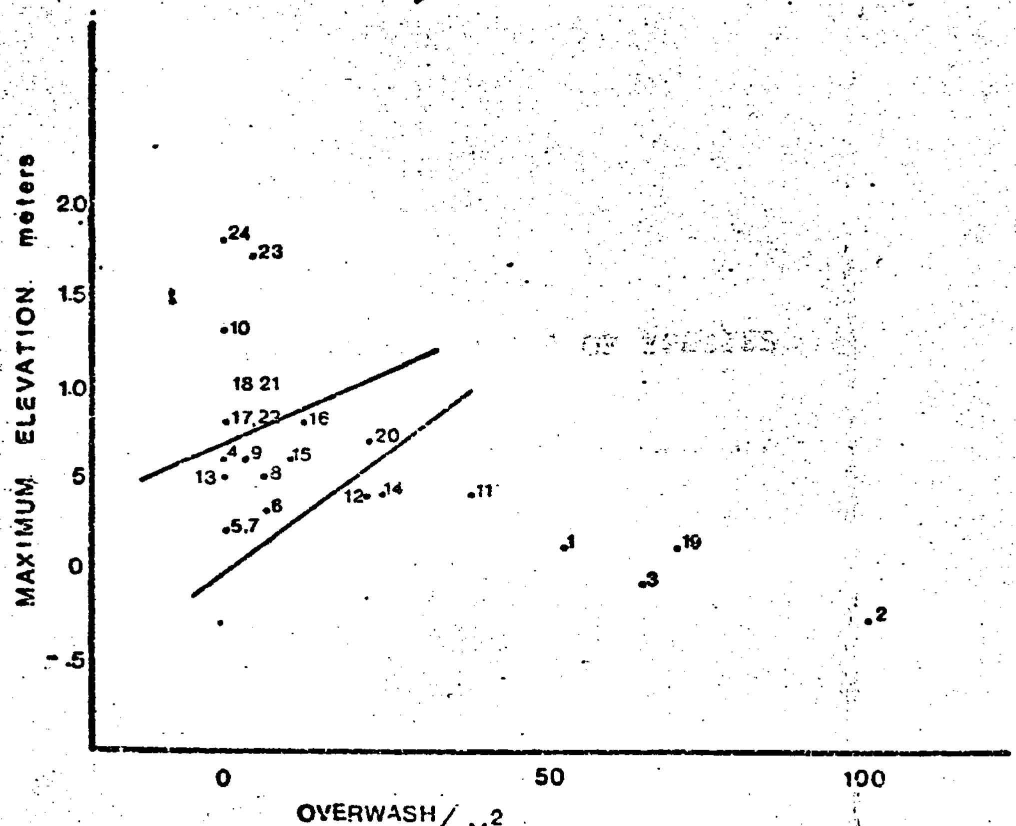

MAXIMUM ELEVATION meters
2.0
1.5
1.0
5
0
-.5
0
50
100
OVERWASH / M2
24
23
10
18 21
17,22
16
20
4
9
15
13
8
12
14
11
6
5,7
1
19
3
2

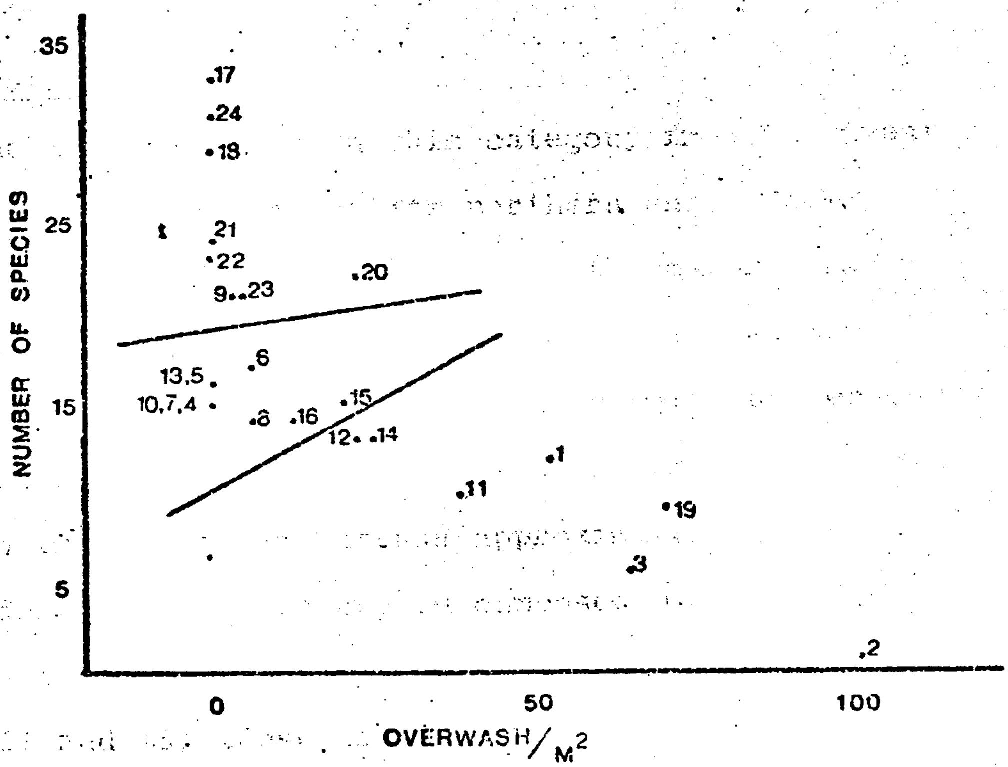
FIGURE 11. RELATIONSHIP OF NUMBER OF SPECIES TO OVERWASH/M^2

the [illegible] to each other, and although [illegible] in the [illegible] Overwash Influence category, it shows [illegible] influence than other sections of the [illegible] included in the study.

The values for cover, number of species [illegible] tion, overwash/m² and length for the 24 transects [illegible] shown in Table IV. The three overwash categories [illegible] mean values for each of the parameters and [illegible]

Least Overwash [illegible]

[illegible] this category [illegible]



[illegible] 50 meters [illegible]

Transects in this category [illegible]

the transects to each other, and although transect 18 is in the Least Overwash Influence category, it shows more overwash influence than other sections of the island not included in the study.

The values for cover, number of species, elevation, overwash/m^2 and length for the 24 transects are shown in Table IV. The three overwash categories with mean values for each of the parameters appear in Table V.

Least Overwash Influence

The two transects in this category from the Great Gut study site are located at its northern end. These transects are the furthest removed from the major zone of washovers, and they cross the widest portion of the Great Gut site. The continuous dune line which borders the northern half of the island begins in the area covered by these two transects and extends approximately 4km north. The remainder of this category is composed of transects 21, 22, 23 and 24 at the Ephemeral Inlet site. As with transects 17 and 18, these transects cross an area with a continuous dune line. The island, at this point, is 500 wide, excluding salt marsh, and all transects are at least 50 meters from the only washover in the area.

Most Overwash Influence

Transects in this category go directly through a

Table IV. Values for the major parameters measured in all 24 transects

TRANSECT	COVER/ M^2	# SPECIES	MAX. DUNE ELEVATION(m)	OVERWASH/ M^2	LENGTH(m)
1	18.9	12	.1	52	138
2	.1	1	-.3	100	124
3	5.8	6	-.1	64	127
4	37.0	15	.6	0	142
5	22.7	16	.2	0	155
6	25.1	17	.3	6	147
7	20.3	15	.4	0	146
8	17.8	14	.5	6	156
9	13.0	21	.6	3	154
10	22.4	15	1.3	0	142
11	15.1	10	.4	38	147
12	9.3	13	.4	22	167
13	14.6	16	.5	0	183

Table IV. continued

TRANSECT	COVER/ M^2	# SPECIES	MAX. DUNE ELEVATION(m)	OVERWASH/ M^2	LENGTH(m)
14	12.7	13	.4	24	206
15	22.6	15	.6	20	202
16	32.4	14	.8	12	190
17	49.1	33	.8	0	183
18	61.2	29	1.0	0	200
19	7.9	9	.1	70	151
20	27.1	22	.7	22	527
21	48.8	24	1.0	0	517
22	42.9	23	.8	0	508
23	55.3	21	1.7	4	491
24	54.3	31	1.8	0	509

Table V. Values for the major parameters in the three overwash categories

CATEGORY	MEAN COVER/M^2	MEAN # SPECIES	MEAN ELEV.	MEAN OVERWASH/M^2	MEAN LENGTH
Least Overwash Influence					
Transects: 17, 18, 21, 22, 23, 24	51.9	27	1.2	.7	401
Range	42.9 - 61.2	21.33	.8-1.8	0-4	183-517
Intermediate Overwash Influence					
Transects: 4, 5, 7, 8, 9, 10, 13, 15, 16, 20	23.2	16	.6	6.3	195
Range	13.0 - 37.0	14-22	.2-1.3	0-22	142-527
Most Overwash Influence					
Transects: 1, 2, 3, 11, 12, 14, 19	10.0	9	.1	52.9	151
Range	.1 - 19.8	1-13	-.3-.4	22-100	124-206

major washover or lie immediately adjacent to one. Dunes are low and scattered, and in some transects, dunes are absent. The narrowest portion of the island, approximately 120 m, is included in these transects.

Intermediate Overwash Influence

The 10 transects in this category have varying values for overwash/m^2 including some transects with 0 overwash/m^2. Although they may not be located immediately adjacent to a washover, all of these transects, except 20, are in the Great Gut site where the frequency of overwash is high. Most of the transects are less than 30 m from a washover.

Although some of the dunes in this group reach heights over 1 m, the dune line consists of isolated dunes with frequent breaks caused by overwash. The narrowness of the island in this area acts as another limiting factor to the vegetation.

Even though transect 20 is located on a wide portion of the island, its position near the only washover at the Ephemeral Inlet site makes it more suited to this category.

Values for relative frequency and relative cover of species in the three overwash categories are listed in Table VI.

Table VI. Relative frequency and relative cover for species in each of the overwash categories

SPECIES	RELATIVE COVER			RELATIVE FREQUENCY		
	L*	I	M	L	I	M
Spartina patens	31	19	12	13	14	15
Spartina alterniflora	13	50	57	6	17	19
Strophostyles helvola	11	1	1	7	3	2
Fimbrystylis spadicea	7	0**	0	5	3	0
Salicornia europaea	7	1	0	5	3	1
Solidago sempervirens	6	4	5	12	11	10
Ammophila breviligulata	5	11	15	5	12	19
Distichlis spicata	5	4	0	3	4	0
Pluchea purpurascens	3	0	-	5	0	-
Iva frutescens	2	1	0	2	2	0
Erigeron canadensis	1	0	-	4	1	-
Scirpus americanus	1	2	3	3	5	3
Borrichia frutescens	1	1	-	1	1	-
Eragrostis spectabilis	1	-	-	1	-	-
Panicum amarum	0	1	4	1	6	8
Salsola kali	0	1	0	1	1	2
Limonium nashii	0	1	0	1	2	0
Cyperus filicinus	-	0	1	-	2	5

* L = Least Overwash Influence; I = Intermediate Overwash Influence; M = Most Overwash Influence

** 0 = species less than 1% cover; - = species absent

Table VI. continued

SPECIES	RELATIVE COVER			RELATIVE FREQUENCY		
	L	I	M	L	I	M
Euphorbia polygonifolia	0	0	1	2	2	3
Cakile edentula	0	0	1	1	2	7
Salicornia bigelovii	0	0	-	3	2	-
Suaeda linearis	0	0	0	3	1	1
Cyperus esculentus	0	0	0	3	1	0
Gnaphalium obtusifolium	0	0	-	2	0	-
Triplasis purpurea	0	0	0	1	1	1
Bassia hirsuta	0	0	-	1	1	-
Cenchrus tribuloides	0	0	0	1	1	0
Salicornia virginica	0	0	0	1	1	0
Atriplex patula	0	0	-	1	0	-
Sabatia stellaris	0	0	-	1	0	-
Andropogon virginicus	0	0	-	1	0	-
Oenothera humifusa	0	-	-	1	-	-
Euphorbia supina	0	-	-	1	-	-
Total number species	32	30	21	32	30	21
Total structurally significant species	14	13	10	32	25	14

Analysis of Community Types

Six major vegetation communities were found in the three overwash study sites. Three of these communities, the beach, dune and salt marsh occurred in each of the overwash categories. The grassland and panne marsh were found only in the intermediate and least overwash category. The contribution of each of these communities to the total vegetation cover in each category is presented graphically in Figure 12.

Numerical results of the community analysis appear in Tables VII-XII. Relative frequency and relative cover for species in each overwash category are grouped by community. The species contributing greater than 5% relative cover in each community are listed in Table XIII.

The cover/m^2 of each community in the three overwash categories is compared in Figure 13. A summary of values for number of species, cover/m^2, percentage of total cover and percentage of quadrats vegetated for each community appears in Table XIV.

The number of ruderal species present in the dune and grassland communities varied in the three overwash categories. Species occurring in a variety of habitats, for example, roadsides, old fields and disturbed areas, as well as in coastal environments, are considered ruderal. Dune and marsh species are those plants whose growth is restricted to these maritime habitats. The percentage of ruderal species is compared to the percentage of maritime species in the dunes and grassland in Table XV.

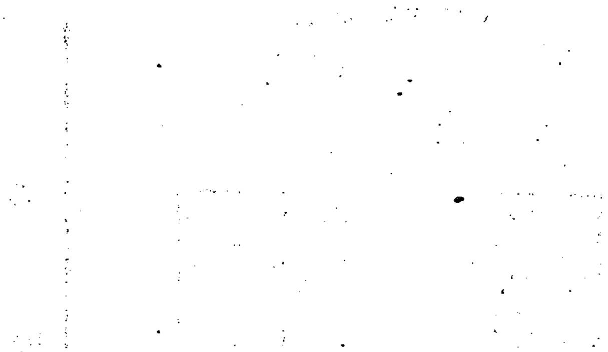


FIGURE 12. : CONTRIBUTION OF EACH COMMUNITY TYPE TO THE TOTAL COVER IN AN OVERWASH CATEGORY

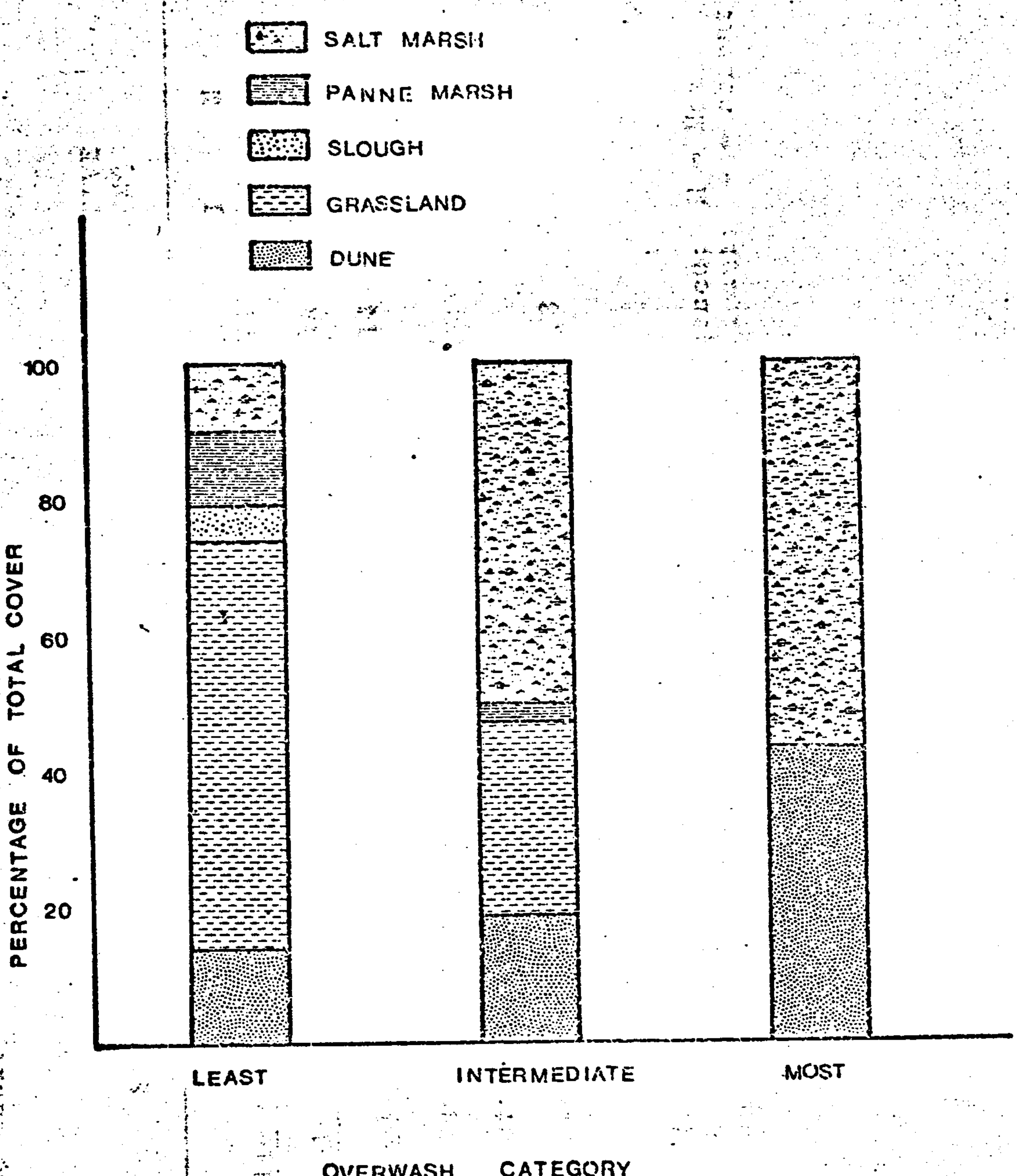

SALT MARSH
PANNE MARSH
SLOUGH
GRASSLAND
DUNE
PERCENTAGE OF TOTAL COVER
100
80
60
40
20
LEAST
INTERMEDIATE
MOST
OVERWASH CATEGORY

Table VII. Relative frequency and relative cover/m^2 of species in the Beach community*

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
BEACH -	*Cakile edentula*	71	100	-	71	100	-
	Salsola kali	14	-	-	14	-	-
	Ammophilia breviliqulata	14	-	-	14	-	-
	vegetated quadrats	17	2	0			
	total quadrats	42	72	47			
	cover/m^2				.3	.2	0

* For Tables VII - XII:
L = Least Overwash Influence; I = Intermediate Overwash Influence; M = Most Overwash Influence; O = present but structurally insignificant; - = absent

Table VIII. Relative frequency and relative cover/m^2 of species in the Dune community

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
DUNE	*Ammophilia breviligulata*	23	29	25	35	56	37
	Spartina patens	13	13	19	11	18	27
	Erigeron canadensis	11	0	-	3	0	-
	Strophostyles helvola	10	1	3	30	0	2
	Euphorbia polygonifolia	9	4	5	2	1	1
	Panicum amarum	8	14	12	3	4	10
	Solidago sempervirens	8	13	12	8	10	10
	Cenchrus tribuloides	5	1	1	2	1	1
	Cakile edentula	4	5	8	1	1	2
	Triplasis purpurea	3	1	2	1	0	0
	Eragrostis spectabilis	2	-	-	1	-	-
	Salsola kali	2	2	3	0	0	1
	Cyperus filicinus	1	-	-	0	-	-
	Fimbrystylis spadicea	1	0	-	1	0	-

Table VIII. continued

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
DUNE (cont.)	Gnaphalium obtusifolium	1	-	-	0	-	-
	Cyperus esculentus	-	5	7	-	2	2
	Scirpus americanus	-	8	4	-	4	5
	Iva frutescens	-	1	1	-	1	0
	Calystegia sepium	-	1	-	-	0	-
	Borrichia frutescens	-	1	-	-	0	-
	Suadea linearis	-	-	1	-	-	0
	Cynodon dactylon	-	-	1	-	-	1
	Spartina alterniflora	-	-	1	-	-	0
	Baccharis halimifolia	-	0	-	-	0	-
	vegetated quadrats	49	111	84			
	total quadrats	50	115	124			
	cover/m^2 community				38	31	19

Table IX. Relative frequency and relative cover/m^2 of species in the Grassland community

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
GRASSLAND	*Spartina patens*	18	23		45	52	
	Solidago sempervirens	16	16		7	9	
	Strophostyles helvola	9	5		11	8	
	Fimbrystylis spadicea	8	6		14	1	
	Pluchea purpurascens	6	1		2	0	
	Erigeron canadensis	4	2		1	1	
	Distichlis spicata	3	6		8	11	
	Iva frutescens	3	5		3	3	
	Scirpus americanus	3	5		1	3	
	Gnaphalium obtusifolium	3	0		1	0	
	Cyperus filicinus	3	-		0	-	
	Spartina alterniflora	2	7		1	3	
	Salicornia europaea	2	3		2	0	
	Sabatia stellaris	2	1		0	0	

Table IX. continued

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
GRASSLAND (cont.)	Euphorbia supina	2	-		0	-	
	Ammophila breviligulata	1	4		2	2	
	Suaeda linearis	1	1		0	0	
	Limonium nashii	1	1		1	0	
	Borrichia frutescens	1	1		1	3	
	Euphorbia polygonifolia	1	1		0	0	
	Andropogon virginicus	1	0		0	0	
	Oenothera humifusa	1	-		0	-	
	Eragrostis spectabilis	1	-		0	-	
	Calystegia sepium	1	-		0	-	
	Baccharis halimifolia	1	-		0	-	
	Triplasis purpurea	1	1		0	0	
	Salicornia bigelovii	0	1		0	0	
	Bassia hirsuta	0	0		0	0	

Table IX. continued

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M²		
		L	I	M	L	I	M
GRASSLAND (cont.)	*Cyperus retrorsus*	0	0		0	0	
	Cenchrus tribuloides	0	0		0	0	
	Myrica cerifera	0	0		0	0	
	Linum virginianum	0	-		0	-	
	Teucrium canadense	0	-		0	-	
	Atriplex patula	0	0		0	0	
	Phragmites australis	0	-		0	-	
	Rhus radicans	0	-		0	-	
	Parthenocissus quinquefolia	0	-		0	-	
	Samolus parviflorus	0	-		0	-	
	Cyperus odoratus	0	-		0	-	
	Eupatorium capillifolium	0	-		0	-	
	Cyperus esculentus	-	1		-	0	
	Panicum amarum	-	0		-	0	

Table IX. continued

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
GRASSLAND (cont.)	Salsola kali	–	0		–	0	
	Cakila eduntula		0		–	0	
	Kosteletskya virginica	–	0		–	0	
	Aster subulatus	–	0		–	0	
	vegetated quadrats	102	84				
	total quadrats	102	84				
	cover/m^2				80	63	

Table X. Relative frequency and relative cover/m^2 of species in the Slough community

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
SLOUGH	<u>Pluchea</u> <u>purpurascens</u>	18			30		
	<u>Scirpus</u> <u>americanus</u>	18			5		
	<u>Salicornia</u> <u>europaea</u>	15			49		
	<u>Bassia</u> <u>hirsuta</u>	9			7		
	<u>Solidago</u> <u>sempervirens</u>	6			2		
	<u>Distichlis</u> <u>spicata</u>	6			2		
	<u>Cyperus</u> <u>filicinus</u>	6			1		
	<u>Strophostyles</u> <u>helvola</u>	3			0		
	<u>Salicornia</u> <u>virginica</u>	3			2		
	<u>Spartina</u> <u>patens</u>	3			0		
	<u>Iva</u> <u>frutescens</u>	3			0		
	<u>Sabatia</u> <u>stellaris</u>	3			0		
	<u>Salicornia</u> <u>bigelovii</u>	3			0		

Table X. continued

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
SLOUGH (cont.)	<u>Limonium</u> <u>nashii</u>	3			0		
	vegetated quadrats	7					
	total quadrats	7					
	cover/m^2 community				108		

Table XI. Relative frequency and relative cover/m^2 of species in the Panne Marsh community

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
Panne Marsh	Spartina alterniflora	27	29		56	61	
	Salicornia bigelovii	22	42		3	30	
	Suaeda linearis	17	17		3	5	
	Salicornia europaea	17	4		24	1	
	Bassia hirsuta	2	8		1	2	
	Pluchea purpurascens	2	-		6	-	
	Atriplex patula	2	-		0	-	
	Solidago sempervirens	2	-		0	-	
	Distichlis spicata	2	-		1	-	
	Spartina patens	1	-		2	-	
	Fimbrystylis spadicea	1	-		0	-	
	Cyperus filicinus	1	-		0	-	
	Limonium nashii	1	-		1	-	

Table XI. continued

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
Panne Marsh (cont.)	*Salicornia virginica*	1	-		0	-	
	vegetated quadrats	36	11				
	total quadrats	103	63				
	quadrats across panne	67	52				
	cover/m^2 community				67	52	

Table XII. Relative frequency and relative cover/m^2 of species in the Salt Marsh community

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
Salt Marsh	<u>Spartina</u> <u>alterniflora</u>	58	65	82	87	95	98
	<u>Salicornia</u> <u>europaea</u>	17	9	4	2	1	0
	<u>Salicornia</u> <u>virginica</u>	13	4	2	2	0	0
	<u>Limonium</u> <u>nashii</u>	4	7	2	0	1	0
	<u>Distichlis</u> <u>spicata</u>	4	7	2	1	1	0
	<u>Iva</u> <u>frutescens</u>	4	-	-	8	-	-
	<u>Suaeda</u> <u>linearis</u>	-	3	-	-	0	-
	<u>Spartina</u> <u>patens</u>	-	2	2	-	0	0
	<u>Solidago</u> <u>sempervirens</u>	-	1	4	-	0	1
	<u>Salicornia</u> <u>bigelovii</u>	-	1	-	-	0	-
	<u>Cakile</u> <u>edentula</u>	-	1	-	-	0	-
	<u>Cyperus</u> <u>filicinus</u>	-	1	-	-	0	-
	<u>Fimbrystyles</u> <u>spadicea</u>	-	-	2	-	-	0

Table XII.

COMMUNITY	SPECIES	RELATIVE FREQUENCY			RELATIVE COVER/M^2		
		L	I	M	L	I	M
Salt Marsh (cont.)	<u>Scirpus</u> <u>americanus</u>	-	-	2	-	-	0
	vegetated quadrats	15	122	45			
	total quadrats	15	123	49			
	cover/m^2 community				78	78	65

Table XIII. Species in each community with greater than 5 percent relative cover

Community	Species	Least Overwash	Intermediate Overwash	Most Overwash
BEACH	*Cakile edentula*	71	100	-
	Salsola kali	14	-	-
	Ammophila breviligulata	14	-	-
	mean percent cover of community	.3	.2	-
DUNE	*Ammophila breviligulata*	35	56	37
	Strophostyles helvola	30	0	0
	Spartina patens	11	18	27
	Solidago sempervirens	8	10	10
	Panicum amarum	-	-	10
	mean percent cover of community	38	31	19

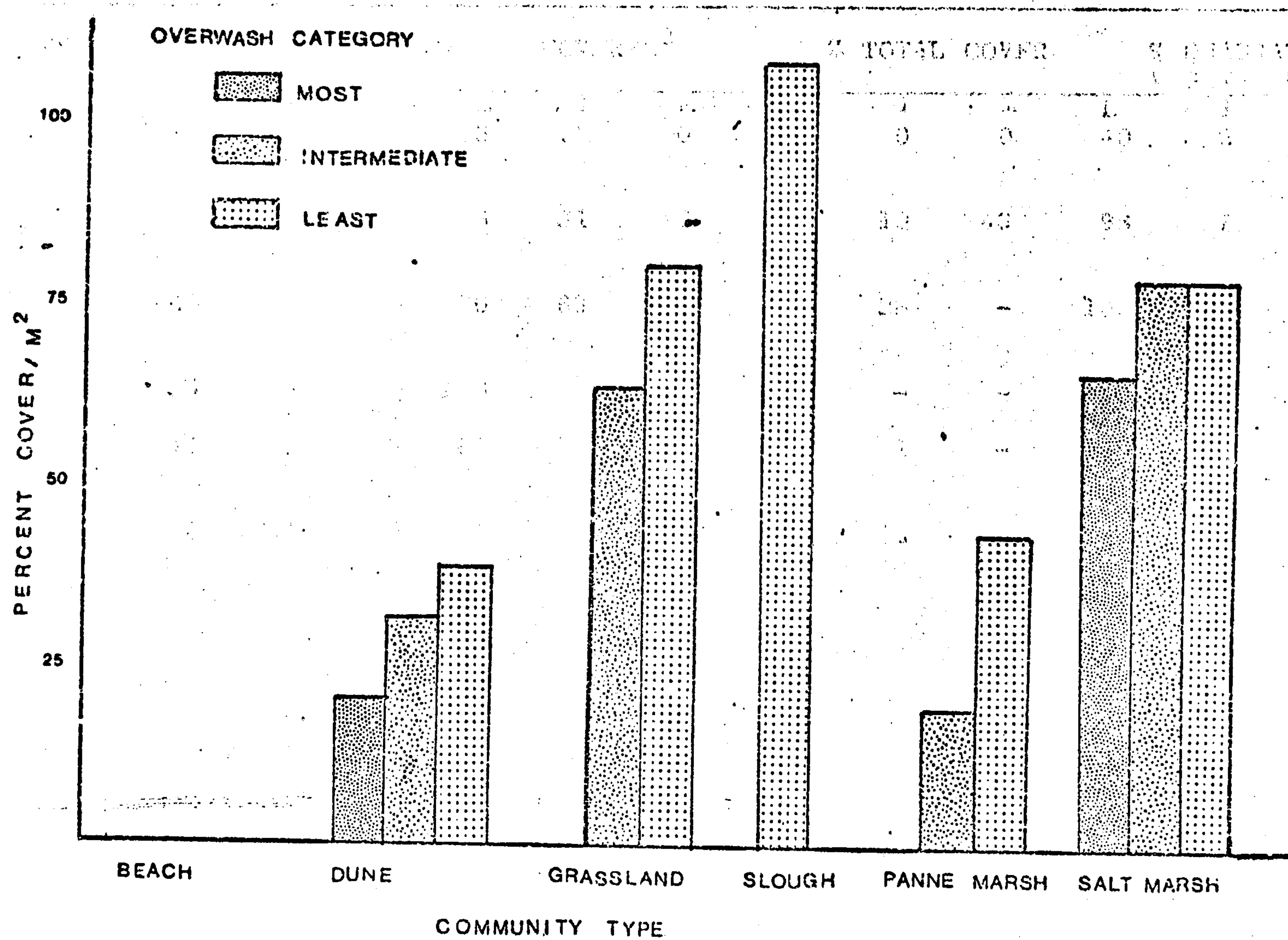
Table XIII. continued

Community	Species	Least Overwash	Intermediate Overwash	Most Overwash
GRASSLAND	*Spartina patens*	45	52	
	Fimbrystylis spadicea	14	-	
	Strophostyles helvola	11	8	
	Distichlis spicata	8	11	
	Solidago sempervirens	7	9	
	mean percent cover of community	80	63	
SLOUGH	*Salicornia europaea*	49		
	Pluchea purpurascens	30		
	Bassia hirsuta	7		
	mean percent cover of community	108		
PANNE MARSH	*Spartina alterniflora*	56	61	
	Salicornia europaea	24	-	
	Pluchea purpurascens	6	-	

Table XIII. continued

Community	Species	Least Overwash	Intermediate Overwash	Most Overwash
PANNE MARSH (cont.)	*Salicornia bigelovii*	-	30	
	mean percent cover of community	43	19	
SALT MARSH	*Spartina alterniflora*	87	95	98
	mean percent cover of community	78	78	65

FIGURE 13. COMPARISON OF COVER/M^2 OF EACH COMMUNITY IN THE THREE OVERWASH CATEGORIES



OVERWASH CATEGORY
MOST
INTERMEDIATE
LEAST
100
75
50
25
PERCENT COVER/ M2
BEACH
DUNE
GRASSLAND
SLOUGH
PANNE MARSH
SALT MARSH
COMMUNITY TYPE

Table XIV. Summary of major parameters for each community

COMMUNITY	# SPECIES			COVER/M²			% TOTAL COVER			% QUADRATS VEGETATED		
	L	I	M	L	I	M	L	I	M	L	I	M
BEACH	3	1	0	.3	.2	0	0	0	0	40	2	0
DUNE	15	18	16	38	31	19	14	19	43	98	97	68
GRASSLAND	40	32	-	80	63	-	60	28	-	100	100	-
SLOUGH	14	-	-	108	-	-	5	-	-	100	-	-
PANNE MARSH	14	5	-	67	52	-	11	1	-	35	17	-
SALT MARSH	6	11	9	78	78	65	9	52	57	100	99	92

Table XV. Comparison of species composition of Dune and Grassland communities of the three overwash categories

	TYPE OF SPECIES (percentage of total flora)		
	Dune	Ruderal	Marsh
DUNE			
Least	47	53	-
Intermediate	41	41	18
Most	50	31	19
GRASSLAND			
Least	15	63	23
Intermediate	25	44	31

The Beach

The beach is more a physiographic zone of the island than a particular plant community. Species adapted to extremes of salt spray and sand movement are able to survive in this zone. A total of 161 plots were located on the beach. Only 19 of these contained vegetation. Of the vegetated plots, 17 were on transects grouped in the least overwash category. The average cover/m^2 in this category was .3. The remaining 2 plots were in the intermediate overwash category with an average cover/m^2 of .2. *Cakile edentula* was the most frequently occurring species on the beach with minor contributions by *Salsola kali* and *Ammophila breviligulata*.

The Dune Community

The extent and type of dunes varied throughout the study areas as did the dune vegetation. In the most overwash category there were transects which traversed areas on the island where dunes were small and widely separated by washover channels. This zone of scattered low dunes extended over an average of 50% of the transect distance. Mean elevation of these dunes was .1 meter.

Dunes in the intermediate overwash category ranged from .2 m to 1.3 m in height with a mean elevation of .6 meters. These dunes formed more of a continuous line than those in the most overwash category but were still broken in numerous places by washover channels.

In the least overwash category the dunes had a mean elevation of 1.2 m and formed a continuous line between the beach and grassland.

Vegetation cover in the dunes varied among the three categories reaching its highest mean value of 38% in the least overwash category. Cover in the intermediate overwash category averaged 31% followed by 19% cover in the areas with the most overwash.

Ammophila breviligulata was the dominate species in the dunes of all three categories. Spartina patens was a codominant in all categories but contributed proportionately more to cover in the most overwash category. Solidago sempervirens, Panicum amarum and Euphorbia polygonifolia were also important in all three categories. In the least overwash influenced areas, two annuals achieved dominance in frequency and cover. Erigeron canadensis was the third most frequently occurring species on the dunes, and Strophostyles helvola was the second species in order of area covered. This plant contributed almost as much as Ammophila breviligulata to cover in the dunes of the least overwash category.

The Grassland

Grassland vegetation was found in the areas with intermediate and least overwash influence. The absence of grassland development in the most overwashed zone may have been a result of the width of the island in these areas as well as the disturbed overwash environment. The narrowest transects fall in this category with a mean length of 151m as compared to 195m in intermediate and 401m in the least overwashed areas. The development of grassland vegetation is also influenced by the dunes present in front of it. Differences in dunes and dune vegetation between the intermediate and least overwashed areas was mentioned in the previous section.

Cover/m^2 was again highest in the least overwashed category, 80% as compared to 63% in the intermediate category. Spartina patens was the dominant species in both categories. Species of secondary importance were Strophostyles helvola, Solidago sempervirens and Distichlis spicata. Fimbrystylis spadicea contributed a significant amount of cover in the least overwash category but was of minor importance in the intermediate category.

The greatest species diversity of all communities occurred in the grassland community. There were 40 and 32 species respectively in the least and intermediate grassland. Less than half of these species having made a significant structural contribution to the total vegetation.

The Slough

This community was sampled by only one transect yet was a conspicuous feature of the vegetation in areas where dune protection was adequate and the island was over 180m wide. Characteristically, the sloughs are low areas flanked on either side by grassland vegetation or shrubs. The ground on either side of the slough is noticably higher in elevation. Cover in the area sampled was over 100%. A similar degree of cover was observed in other slough areas.

Salicornia europaea and *Pluchea purpurascens* were dominant. Other frequently occurring species were *Scirpus americanus*, *Bassia hirsuta*, *Solidago sempervirens*, *Distichlis spicata* and *Cyperus filicinus*.

While the author was familiar with the major environmental factors affecting the vegetation in the other communities, the factors that created and maintained the distinctive vegetation of the slough were at first unclear. Sketches of the location and shape of sloughs with respect to surrounding topography were compared to aerial photos of the island. The pattern of a series of adjacent overwash fans was similar to the pattern of sloughs and high areas. The high areas flanking the sloughs seemed to represent old overwash terraces. The slough vegetation was confined to low areas between the terraces. Since the terraces were fairly well vegetated with grassland vegetation (100% *Spartina patens* in many areas) or shrubs, they may have been the extensive overwash deposits from the 1962 storm.

Species composition of the slough suggests that the area is moister and perhaps more saline than the surrounding higher ground. The slough is open on the side facing the salt marsh and may receive water during storms and extreme high tides. Hosier (1973) correlated the number of seedlings and annuals present in grassland vegetation to the water content of the soil. The density of vegetation and large number of annuals in the slough may be related to moisture or distance to water table. When the slough areas were examined in April they were devoid of vegetation. In May, dense Salicornia sp. seedlings were observed through the area. By the time of sampling in August the vegetation described above had developed.

The Panne Marsh

The panne marsh of this study is similar to the tidal flats described by Hosier (1973). The panne marsh occurred only at the Ephemeral Inlet site bordering the large salt panne. As mentioned earlier, spring tides deposit salt water in the panne periodically. The standing water remains in the panne until it evaporates causing high salinity conditions. The central portion of the salt panne is devoid of vegetation. The edges of the panne are being colonized by halopytic species such as Salicornia bigelovii, Spartina alterniflora, Suaeda linearis, Salicornia europaea, and Bassia hirsuta. These are the dominate species in the panne marsh community.

Eleven plots from transects of the intermediate overwash group and 36 plots in the least overwash group were located in the vegetated panne marsh. Average cover was 19% in the intermediate group and 43% in the least overwash category. The five species mentioned above were the only ones to occur in the intermediate overwash samples. These five and nine other species of minor importance were found in the least overwashed panne marsh.

The Salt Marsh

Salt marsh vegetation occurred in a band fringing the Great Gut site and was sampled with 187 plots. Salt marsh vegetation comprised 57% of the total vegetated area in the most overwash category and 63% of the total vegetated area in the intermediate overwash category. Only 11% of the total vegetated area of the least overwash category consisted of salt marsh. This lower number is not a reflection of a lack of salt marsh development in these areas but results from the fact that four of the six transects in this category were not carried into the salt marsh. If the transects in the Ephemeral Inlet site had been extended through the salt marsh, roughly 50 - 75% of the transect distance would have been salt marsh vegetation.

Spartina alterniflora dominated the salt marsh in all three categories. Cover/m^2 was 78% in both intermediate and least overwash categories. Cover was 65% in the most overwash category.

Results of Standing Crop Determination

The results of the standing crop determination at Great Gut, Burton's Bay and Ephemeral Inlet are shown in Table XVI. The mean height of the grass in each area as well as in the sample as a whole falls in the range classified as tall form by Squiers and Good (1974). The ratio of living to dead standing crop is presented in the table. This ratio is an indication of how regularly a salt marsh is flooded. A regularly flooded Spartina alterniflora marsh at the peak of the growing season would be expected to have a high ratio of living to dead material. Comparison of data obtained from this study from marshes bordering an overwash dominated area are compared to results obtained from other mid-Atlantic areas in Table XVII.

e XVI. Results of standing crop analysis, ± standard error f the mean

ocation	# Samples	Mean Height (cm)	Mean Standing Crop g/m^2 (living)	S	Mean anding Crop g/m^2 (dead)	Ratio Living/ Dead S.C.
eral Inlet	16	123.2 ±25.5	939 ±236		87 ±57.6	9.2
n's Bay	10	127.8 ±13.0	1047 ±284		147 ±67.7	7.1
Gut	14	104.7 ±48.2	1178 ±748		159 ±114.2	7.4
area	40	117.9	1050		127	7.8

Table XVII. Standing crop of mid-Atlantic salt marshes.

Dominant species	Net production* or standing crop** g(dry) m^{-2} yr^{-1}	Locale	Source
S. alterniflora	427 - 558**	Assateague Island bordering Chincoteague Bay, Md., Va.	Keefe and Boynton, 1973
S. alterniflora (Tall) *S. alterniflora* (Short)	1592* 592	New Jersey at lower end of Mullica R., Great Bay estuary	Squiers and Good, 1974
S. alterniflora	362*	near Wachapreague, Va.	Mendelssohn & Marcellus, 1976
S. alterniflora (Tall) *S. alterniflora* (Short)	1,725** 920	Machipongo R., Eastern Shore, Va. (only 2 samples)	Wass and Wright, 1969
S. alterniflora	445*	Delaware	Morgan, 1961
S. alterniflora	300**	New Jersey	Good, 1965
S. alterniflora (Tall)	1050*	Cedar Island, Va. bordering overwash dominated area	This study

DISCUSSION AND CONCLUSIONS

The vegetation of overwashed areas on Cedar Island, dominated by perennial herbs, is similar to that found by Hosier (1973) for overwashed areas on the Outer Banks of North Carolina. The prominent role played by *Spartina patens* and *Solidago sempervirens* in overwash influenced areas both on Cedar Island and the Outer Banks is a reflection of their tolerance to flooding and sand burial. This tolerance was demonstrated by Hosier (1973).

Despite the general similarity, a notable difference between the vegetation in this study and Hosier's is the presence on Cedar Island of *Ammophila breviligulata* as a dominant species in the dune community. Though not present in North Carolina, *Ammophila* has been reported further north in overwash influenced areas on Cape Cod (Godfrey 1976). Godfrey (1976) found that the reaction of *Ammophila* to overwash involved the sprouting and subsequent vegetative spreading of *Ammophila* rhizome fragments disrupted and distributed by the washover. In the Cape Cod area, *Spartina patens* is restricted primarily to the high marsh, occurs rarely on dunes, and is destroyed by overwash. This *Spartina* is different from the southern form of the species, which Godfrey (1976) refers to as var. *monogyna*, a tall upright form which occurs as a component of dune and grassland flora beginning on the Delmarva peninsula and extending south. The *Spartina patens* of the dunes and grassland of Cedar Island, like that in North Carolina, can tolerate overwash.

During the course of this study, several storms occurred of sufficient magnitude to result in minor overwash. The severity of these storms was such that erosion of existing dunes was negligible and sand deposited in the dune and grassland communities was between 2 and 5cm. Plants growing on the beach in the direct path of the washover suffered the most damage and were uprooted or killed as a result of salt water flooding. *Cakile edentula* was the primary species affected in this manner. The effects of overwash on the dune vegetation, notably *Ammophila breviligulata* and *Spartina patens*, was not as severe. The only plants of these species destroyed by overwash were those growing in narrow washover channels. Plants growing in areas where the primary effect of overwash was burial by sand appeared to be growing more vigorously when observed approximately one week after the storm. *Ammophila* and *Spartina patens* plants in areas that received overwash deposits appeared more robust and were more intensely green than plants in surrounding non-overwashed areas. Minor overwash thus appeared to encourage the growth of *Ammophila breviligulata* and *Spartina patens*.

Spartina patens is able to survive in overwashed areas because of its ability to grow up through deposited sand (Godfrey 1970). Through formation of lateral rhizomes, this species is also able to spread into areas of freshly deposited sand following a washover (Hosier 1973). The response of Ammophila to shallow overwash burial may be similar to its response to gradual burial by wind blown sand. Deposits of wind blown sand stimulate the formation of adventitous roots and results in increased absorption

of water and nutrients (Laing 1958).

The presence of both Spartina patens and Ammophila breviligulata as dominant components of the dune vegetation of overwash influenced areas on Cedar Island is support for Godfrey's (1976) suggestion that the Delmarva coast is a transition zone where the role of overwash and response of vegetation to overwash is intermediate to that observed further north (Godfrey 1976) and south (Godfrey 1970; Hosier 1973).

The diversity and species composition of Cedar Island's overwash vegetation varied in relation to degree of overwash. Comparison of the dune and grassland flora of the three overwash categories showed an increase in number of species with decreasing overwash influence.

Many of the species occurring in the Least Overwash category were ruderal. Chapman (1976) has stated that with increasing age a greater proportion of non-maritime species enter the dune community. Change in species

Van der Valk's (1975) work on foredune plant communities on the Outer Banks. He found that on the front and top of the foredune where the environmental stresses of salt spray and sand movement were most severe the flora consisted primarily of characteristic dune plants. On the back of the foredune where environmental stress was less, ruderal species played a more important role in the vegetation.

Both age of the area and environmental stress are factors influencing the proportions of maritime and ruderal species present in the Grassland and Dune communities of the three overwash categories. Although this study was not conducted over a period of time sufficient to directly measure successional change, the three overwash categories can be interpreted as representing vegetation that is in varying stages of recovery from overwash. Overwash functions as an agent of physiographic change returning areas to a more primary stage of succession. The frequency and severity of overwash influences the degree to which species diversity and cover can develop in an area (Hosier 1973).

The role of overwash in maintaining an area in a primary successional stage is evidenced by vegetational patterns observed in the Most Overwash category. The severity of environmental conditions is reflected by the fact that an average of 78% of the transect distance in this category consists of beach or dune community. The beach in this category is essentially a physiographic feature and is unvegetated. The mean cover/m^2 in the dune community is only 19% and there is no development of a grassland community. Comparison of the number of species present in this dune community with that of the dune communities of the Intermediate and Least Overwash categories shows only minor differences. There are 16 species in the Most category and 18 and 15 respectively in the Intermediate and Least categories. The difference in species composition among the three groups lies in the proportion of maritime and ruderal species that make up the flora. The lowest proportion of ruderal species, 31%, occurs in the Most Overwash category and increases to 41% in the Intermediate and 53% in the Least Overwash category (Table XV). The lowest proportion of ruderal species in the Most Overwash category reflects a greater degree of environmental stress associated with recent overwash.

In this study the Least Overwash category is representative of the most advanced stage of overwash recovery. The areas included in this category experienced severe overwash during the Ash Wednesday storm of 1962 and probably for a period following that until a protective dune line developed. However, there was no observable evidence of recent overwash. Lack of overwash, the presence of a substantial dune system, and the width of the island have all contributed to the vegetation patterns described for this category. Six vegetation communities are present, the most extensive of which is the grassland. The cover/m^2 and number of species present in these communities was generally the highest of any of the categories. The role of ruderal species in the dune and grassland communities was greater in this category than in any other (Table XV). Two ruderal species, Erigeron canadensis and Strophostyles helvola, are important structural components of the dune community with a combined cover/m^2 of 33% and a combined relative frequency of 21%. The development of the vegetation in this category is an indication of both the greater age of the area as well as a decrease in environmental stress such as overwash, salt spray and sand blasting relative to that of the other categories.

Conditions intermediate to those of the previously described for the Intermediate Overwash category. Although overwash and its effects are in evidence, its severity and frequency are less than that found in the Most Overwash category. Dunes have developed to a greater extent than that found in the Most Overwash category. These dunes along with the increased width of the island in the areas of this category contribute to development of the existing vegetation. Five communities are present with cover/m^2 and number of species present generally

Even though evidence of recent overwash was lacking in the slough and panne marsh, these communities are physiographically influenced by the overwash process. During the 1962 storm a combination of inlet dynamics and overwash resulted in conditions that created and are operating to maintain the panne marsh. Burial by overwash sediments of an existing marsh created a barrier to downward percolation of salt water which floods the area on monthly spring tides. A large portion of the overwash sediment remains unvegetated. The panne marsh borders this unvegetated area and is composed of species such as _Spartina alterniflora_, _Salicornia bigelovii_, _Suaeda linearis_, and _Salicornia europaea_, which are tolerant of hypersaline conditions.

The physiographic area occupied by the slough community also appears to be a result of the extensive overwash of the 1962 storm. Sandwiched between the edges of two overwash terraces the slough vegetation sits in a depression. The habitat is moist and supports a cover of over 100%, the highest for this study. _Pluchea purpurascens_, _Scirpus americanus_, and _Salicornia europaea_ dominate this community along with other species typical of brackish marsh habitat.

When washover is of sufficient magnitude to carry sand all the way across the island, this sand can serve as substrate for the development of salt marshes. The marshes that develop on these overwash deposits attain a higher standing crop than marshes on surrounding areas. Godfrey and Godfrey (1974) in their studies of North Carolina barrier islands found that the standing crop of a 15 year old salt marsh that had grown up on overwash deposits was 1.9 kg/m^2. This value was compared to the standing crop of a nearby salt marsh which was older and consisted of short form *Spartina alterniflora*. The standing crop of the older marsh was .7 kg/m^2. The younger marsh was regularly flooded and, as a result, more material was exported from it into the surrounding waters.

In this study, the three marshes sampled received fresh overwash sediments as a result of the 1962 storm. The Ephemeral Inlet and Great Gut sites were totally overwashed and barren after the storm making the age of the salt marshes now growing there approximately 15 years. The Burton's Bay and the Great Gut marshes continue to receive overwash sediments during severe storms. Based on field observations, all three marshes are regularly flooded. Further evidence of this is the ratio of living to dead standing crop for the marshes which was 7.8. Tall form *Spartina alterniflora* dominated the marshes with a peak standing crop in early September of 1050 g/m^2.

While standing crop is not the most accurate means of assessing total marsh productivity, if taken when the vegetation is at the peak of its growth cycle it can serve as a useful tool (Wass & Wright 1969). Some of the limitations and problems with using peak standing crop as a measure of marsh productivity have recently been outlined (Kirby & Gosselink 1976). Bearing in mind the limitations of comparing results from separate studies, the value for standing crop obtained for the overwash influenced marshes of Cedar Island are in accord with values obtained from other locations on the Eastern Shore (Table XVII).

Wass and Wright (1969) calculated a peak standing crop for a *Spartina alterniflora* tall form marsh near the Machipongo River as 1,570 g/m^2. The major drawback in this study is that the value is based on only two samples. *Spartina alterniflora* short form marshes bordering Chincoteague Bay were found to have a peak standing crop of 558 g/m^2 (Keefe & Boynton, 1973). Based on samples taken over a year, Mendelssohn and Marcellus (1976) arrived at a value of 362 g/m^2 for the productivity of a salt marsh near Wachagreague. It was not stated if this marsh was tall form or short form *Spartina alterniflora*.

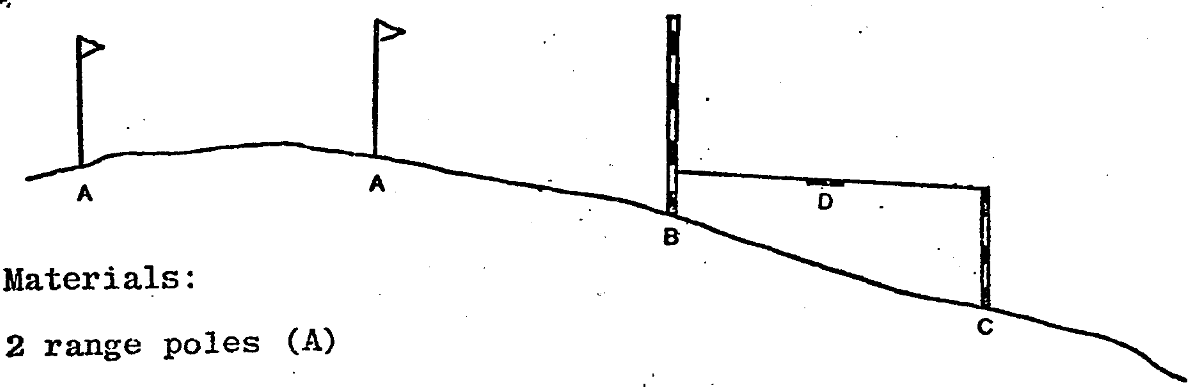
The variation in standing crop data seen in these studies may be just as much a result of differing sampling techniques as a reflection of actual differences in productivity. The marshes of the Eastern Shore are extensive and it is undeniable that productivity will vary from one location to another as well as from year to year. The marshes that are the most productive would be those that are regularly flooded or of a younger age. Marshes that fit these criteria would be those located near a major inlet, along creeks and channels, and growing on deposits from overwash or ephemeral inlets. Older marshes flooded less frequently would support a smaller standing crop and contribute less of their material to surrounding waters.

The overwash process along with salt spray, sand movement and topography is a significant determinant of coastal vegetation patterns. The stresses of salt water flooding and sand burial associated with overwash act as limiting factors influencing species composition and cover in areas where overwash occurs. Elements of vegetation response characteristic of overwashed areas in both the north and south were observed in the Cedar Island study area. The division of 24 cross-island transects into groups based on dune height, overwash/m^2, number of species and cover/m^2 resulted in three categories interpreted as representing varying successional stages of recovery from overwash. Maximum values for community diversity, number of species present, % of ruderal species in the dune and grassland, and mean % cover occurred in the Least Overwash Influence category. This represented the most successionally advanced stage. Minimum values for the same parameters were found in the Most Overwash Influence category where recent and frequent overwash maintained the vegetation in an early primary successional stage. This study confirms that on Cedar Island, as elsewhere on the east coast, overwash can provide sediment for the creation of new, highly productive salt marshes.

APPENDIX I

BEACH PROFILING

MODIFIED EMERY (1961) METHOD



Materials:

2 range poles (A)

1 - 8' stadia intercept pole (B)

1 - 5' stadia pole (C)

15' line

line level (D)

Methods:

1. The 15' line is stretched between the two poles which are lined up with the range poles.

2. The line is attached to the top of the 5' pole and is lined up along the stadia intercept pole using the line level to determine when the line is even. The reading taken on the stadia intercept pole is the difference in elevation between the two points.

3. The five foot pole is then moved to where the stadia intercept pole was located and the process is repeated until the transect is complete.

4. Elevation along the transect is obtained by summing stadia intercept values.

5. A profile can be drawn using the values for elevation and cumulative distance along the transect.

APPENDIX II

Species encountered in overwash study area
Cedar Island, Virginia

Gymnospermae

Cupressaceae
Juniperus virginia L. red cedar. dense grassland. rare.

Angiospermae

Poaceae
Ammophila breviligulata Fernald. beach grass. dune. abundent.

Andropogon virginicus L. broom sedge. grassland. infrequent.

Cenchrus tribuloides L. sandbur. dune. common.

Cynodon dactylon (L.) Pers. bermuda grass. dune. rare.

Distichlis spicata (l.) Greene. salt grass. grassland, upper salt marsh. common

Eragrostis spectabilis (Pursh) Steudel. love grass. dune. infrequent.

Panicum amarum Ell. panic grass. dune. common.

Panicum capillare L. panic grass. grassland. rare.

Phragmites australis (Cav.) Trin. reed grass. grassland. rare. (source, Silberhorn 1976).

Spartina alterniflora Loisel. salt marsh cordgrass. salt marsh. abundant.

Spartina patens (Ait.) Muhl. salt meadow cordgrass. dune, grassland, upper salt marsh. abundant.

Triplasis purpurea (Walter) Chapman. purple sand grass. dune. infrequent.

Cyperaceae
Cyperus esculentus L. dune. grassland. infrequent.

Cyperus filicinus Vahl, dune, grassland. infrequent.

Cyperus odoratus L. grassland. rare.

Cyperus retrorsus Chapman. grassland. rare.

Eleocharis sp. spike rush. moist grassland. rare.

Fimbrystylis spadicea (L.) Vahl. grassland, upper salt marsh. common.

Scirpus americanus Pers. three square bulrush. grassland, slough, upper salt marsh. common.

Myricaceae

Myrica cerifera L. wax myrtle. dense grassland. rare.

Chenopodiaceae

Atriplex arenaria Nuttall. sea beach orach. edges of overwash fan, salt marsh. rare.

Atriplex patula L. halberd leaved orach. panne-marsh, salt marsh. infrequent.

Bassia hirsuta (L.) Achers. panne-marsh, upper edge of salt marsh. infrequent. (source, Fernald 1950).

Salicornia bigelovii Torrey. dwarf glasswort. panne-marsh, salt marsh. common.

Salicornia europaea L. chicken claws. slough, panne-marsh, salt marsh. abundant.

Salicornia virginica L. perennial glasswort. salt marsh. infreqnent.

Salsola kali L. saltwort. dune, upper salt marsh, edge washover fan. infrequent.

Suaeda linearis (Ell.) Moq. seablite, panne-marsh, upper salt marsh. infrequent.

Brassicaceae

Cakile edentula (Bigel.) Hook. sea rocket. beach, dune. common.

Fabaceae

Strophostyles helvola (L.) Ell. wild bean. dune, grassland. common.

Linaceae

Linum virginianum var. floridanum Planchon. flax. grassland. rare.

Euphorbiaceae

Euphorbia polygonifolia L. seaside spurge. dune. common.

Euphorbia supina Raf. milk purslane. dune. infrequent.

Anacardiaceae

Rhus radicans L. poison ivy. grassland. rare.

Vitacea

Parthenocissus quinquefolia (L.) Planchon. Virginia creeper. grassland. rare.

Malvaceae

Kosteletskya virginica (L.) Presl. seashore mallow. grassland. rare.

Hyperidaceae

Hypericum gentianoides (L.) BSP. pineweed. grassland. rare.

Lythraceae

Lythrum lineare L. linear leaved loostrife. grassland. rare.

Onagraceae

Oenothera humifuse Nutt. seabeach evening primrose. dune, grassland. infrequent.

Primulaceae

Samolus parviflorus Raf. water pimpernel. moist grassland. rare.

Plumbaginaceae

Limonium nashii var. nashii Small. sea lavender. salt marsh. infrequent.

Gentianaceae

Sabatia stellaris Pursh. marsh pink. grassland, dune. infrequent.

Convolvulaceae

Calystegia sepium (L.) R. Br. hedge bindweed. grassland. infrequent.

Lamiacae

Teucrium canadense L. wood sage. grassland. rare.

Asteraceae

Aster subulatus Michaux. grassland. rare.

Baccharis halimifolia L. groundsel tree. grassland-salt marsh transition. infrequent.

<u>Borrichia</u> <u>frutescens</u> (L.) DC. sea ox-eye. grassland-salt marsh transition. locally abundant.

<u>Erigeron</u> <u>canadensis</u> var. <u>canadensis</u> L. dune, grassland. common.

<u>Eupatorium</u> <u>capillifolium</u> var. <u>capillifolium</u> (Lam.) Small. dog fennel. grassland. rare.

<u>Gnaphalium</u> <u>obtusifolium</u> L. rabbit tobacco. dune, grassland. locally abundant.

<u>Iva</u> <u>frutescens</u> L. marsh elder. grassland-salt marsh transition. common.

<u>Pluchea</u> <u>purpurascens</u> (Swartz) DC. camphorweed. grassland, slough, grassland-salt marsh transition. locally abundant.

<u>Solidago</u> <u>sempervirens</u> L. seaside goldenrod. dune, grassland, slough, upper salt marsh. abundant.

LITERATURE CITED

Art, H. W. 1976. Ecological studies of the Sunken Forest, Fire Island National Seashore, New York. NPS Scientific Monograph Series # 7. 237 pp.

Au, S. 1969. Vegetational and ecological processes on Shackleford Bank, North Carolina. Duke University Ph. D. 172 pp.

Boulé, M. E. 1976. Geomorphic interpretation of vegetation on Fisherman Island, Virginia. M.S. Thesis College of William and Mary. 125 pp.

Boyce, S. G. 1954. The Salt Spray Community. Ecol. Monog. 25:29 - 64.

Burk, C. J. 1962. The North Carolina Outer Banks. A floristic interpretation. Jour. Elisha Mitchell Soc. 78:21 - 28.

Chapman, V. J. 1960. Salt marshes and salt deserts of the world. Interscience Publishers, New York. 392 pp.

Chapman, V. J. 1976. Coastal vegetation, 2nd ed. Pergamon Press, Inc., New York. 245 pp.

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

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43 - 64.

Dolan, Godfrey & Odum. 1973. Man's impact on the barrier island's of North Carolina. American Scientist 61:152 - 162.

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

Emery, K. O. 1961. A simple method of measuring beach profiles. Limnol. & Oceanog. 6:90 - 93.

Fernald, M. L. 1950. Gray's Manual of Botany. 8th edition. American Book Co. New York. 1632 pp.

Godfrey, P. J. 1970. Oceanic overwash and its ecological implications of the outer banks of North Carolina. Annual Report 1969, Office of Natural Science Studies, National Park Service, U. S. Department of the Interior, 1 - 37.

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

Godfrey, P. J. 1976 Comparative ecology of east coast barrier islands: hydrology, soil, vegetation. In Technical Proceedings of the 1976 Barrier Islands Workshop: Barrier Islands and Beaches. The Conservation Foundation, Wash. D. C. pp. 5 - 34.

Godfrey, P. J. & M. M. Godfrey. 1971. Effects of oceanic overwash and inlet closure on barrier island succession and stability. Bull. Ecological Society of America, 52(2), p. 27.

Godfrey, P. J. & M. M. Godfrey. 1973. Comparison of ecological and geomorphic interactions between altered and unaltered barrier island systems in North Carolina. In Coastal Geomorphology. State University of New York, Binghamton, New York. pp. 239-258.

Godfrey, P. J. and M. M. Godfrey. 1974. The role of overwash and inlet dynamics in the formation of salt marshes on North Carolina barrier islands. In Ecology of Halophytes, Academic Press. pp. 407-427.

Godfrey, P. J., M. Godfrey, R. Nathhorst and B. Fullington. 1976. Vegetation and stratigraphy of Core Banks, Cape Lookout National Seashore, N. C., in comparison with northern barrier beaches. In Proc. of AIBS Symposium on Research in National Parks, Nov. 1976 New Orleans, La. pp. 99. (Abstract)

Good, R. E. 1965. Salt marsh vegetation, Cape May, New Jersey. Bull. New Jersey Acad. Sci. 10(1): 1-11.

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

Harvill, A. M. 1967. The vegetation of Assateague Island, Virginia. Castanea 32:105-108.

Higgins, E. A. T., R. D. Rappleye, and R. G. Brown. 1971 The flora and ecology of Assateague Island. Univ. Md. Ag. Exp. Sta. Bull. A-172. 70 pp.

Hillestad, H. O., J. R. Bozeman, A. S. Johnson, C. W. Berisford and J. I. Richardson. 1974. The ecology of Cumberland Island National Seashore Camden County, Georgia. University of Georgia Tech. Report series 75-5. 300 pp.

Hosier, P. E. 1973. The effects of oceanic overwash on the vegetation of Core and Shackleford Banks, North Carolina. Duke University Ph. D. 230 pp.

Johnson, A. S., H. O. Hillestad, S. F. Shanholtler and G. F. Shanholtler. 1974. An ecological survey of the coastal region of Georgia. National Park Service Scientific Monograph Series #3. 233 pp.

Keefe, C. W. and W. R. Boynton. 1973. Standing crop of salt marshes surrounding Chincoteague Bay, Maryland - Virginia. Ches. Sci. 14(2):117-123.

Kemerer, T. F. 1972. Barrier island origin and migration near Wachapreague, Virginia. West Virginia University MS thesis. 154 pp.

Kirby, C. J. and J. G. Gosselink. 1976. Primary production in a Louisiana gulf coast Spartina alterniflora marsh. Ecology 57:1052-1059.

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

McCaffrey, C. A. 1975. Major vegetation communities of the Virginia Barrier Islands; Metomkin Island through Smith Island inclusive. The Nature Conservancy, Washington, D. C.

Mendelssohn, I. A. and K. L. Marcellus. 1976. Angiosperm production of three Virginia marshes in various salinity and soil nutrient regimes. Ches. Sci. 17(1):15-23.

Morgan, M. H. 1961. Annual angiosperm production on a salt marsh. M. S. Thesis, Univ. Deleware. 34 p.

Newman, W. S. and C. A. Munsart. 1968. Holocene geology of the Wachapreague Lagoon, Eastern Shore Peninsula, Virginia. Marine Geol. 6:81-105.

Oosting, H. J. 1954. Ecological processes and vegetation of the maritime strand in the southeastern United States. Bot. Rev.:226-262.

Oosting, H. J. 1945. Tolerance to salt spray of plants of coastal dunes. Ecology 26:85-89.

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

Radford, A. E., H. E. Ahles and C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina, Chapel Hill. 1183 pp.

Rice, T. E., A. W. Niedoroda, and A. P. Pratt. 1975. The coastal processes and geology of the Virginia Barrier Islands. In the Virginia Coast Reserve Study, Ecosystem Description. The Nature Conservancy, Washington, D. C. pp. 107-285.

Silberhorn, G. M. 1976. Tidal Wetland plants of Virginia. VIMS. Educ. Series #19. 86 pp.

Squiers, E. R. and R. E. Good. 1974. Seasonal changes in the Productivity, caloric content, and chemical composition of a population of salt-marsh cord-grass (Spartina alterniflora). Ches. Sci. 15(2):63-71.

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

Wass, M. L. and T. D. Wright. 1969. Coastal wetlands of Virginia. Interim report to the Governor and General Assembly. VIMS. Spec. Rept. in Applied Marine Sci. and Ocean eng. #10. 154 pp.

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

White, R. D. pers. comm. 1975. Wallops Island, Virginia.

Whitelaw, R. T. 1951. Virginia's Eastern Shore, Va. Historical Society, Richmond Va. 2 volumes. 1511 pp.

Van Der Valk, A. G. 1975. The floristic composition and structure of foredune plant communities of Cape Hatteras National Seashore. Ches. Sci. 16(2):115-126.

VITA

Merry Christine Baumann

November 8, 1950 Washington, D. C.

Education

University of Maryland, College Park, Maryland
9/68 - 6/72, B. S. 6/72
Major: Zoology

College of William and Mary, Williamsburg, Virginia
9/74 - 5/78, M. A. 6/78
Major: Biology

Experience

Naturalist, Chincoteague National Wildlife Refuge, Virginia, Summer 1971, 1972
Instructor (coastal ecology), Wallops Island Marine Science Center, Virginia 9/72 - 9/74
Teaching Assistant, College of William and Mary, Virginia 9/74 - 5/75, 9/75 - 11/75
Naturalist, Everglades National Park, Florida 11/75-5/76
Naturalist, Assateague Island National Seashore, Virginia Summer 1975, 1976
Research Technician, Everglades National Park, Florida 11/76 - 6/77
Marine Life Instructor, Audubon Ecology Workshop, Maine Summer 1977
Naturalist, Cumberland Island National Seashore, Georgia 10/77 - Present