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Classification and Structures of the Tidal Marshes of the Poropotank River, Virginia

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CLASSIFICATION AND STRUCTURE OF THE TIDAL MARSHES OF THE POROPOTANK RIVER, VIRGINIA

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ABSTRACT

A random quadrat sampling plan was employed to analye the community structure of the tidal marshes of the Poropotank River, a tributary of the York River, Virginia. A classification of four marsh types was made: fresh, slightly brackish, brackish, and salt water marshes. The mean range in salinities recorded from river waters adjacent to the marsh types were, respectively, 0.33-0.79 ‰, 0.79-4.11 ‰, 4.11-9.38 ‰, and 9.38-14.72 ‰. Although several marsh types exist within the 1000-acre system, the tidal marshes of the river apparently function as a salt water marsh or an *Spartina alterniflora* Loisel. association.

Dominant species for the entire system were *S. alterniflora*, *Spartina patens* (Ait.) Muhl., *Distichlis spicata* (L.) Greene, *Scirpus robustus* Pursh, and *Juncus roemerianus* Scheele. The saltmarsh cordgrass, *S. alterniflora*, was a dominant in at least one community of each of the four marsh types. The distribution of this species is apparently not governed by salinity, but by an ability of the plant to compete successfully with other phanerogams growing in fresh water.

The Poropotank River marshes exhibit greater affinity in flora with marshes to the north of the Chesapeake Bay than with those to the south; conspicuous differences appear in associations of the dominant plants at the community level of organization.

CLASSIFICATION AND STRUCTURE OF THE TIDAL MARSHES OF THE POROPOTANK RIVER, VIRGINIA

INTRODUCTION

Extensive estuarine systems occur in the coastal plain bordering the western North Atlantic. One of the most important of these is the Chesapeake Bay which, together with the surrounding land mass, comprises the Tidewater area of Virginia and Maryland. This dynamic system, in which fresh and saline waters mix, is important for its unusual and transitional associations of flora and fauna. The objectives of the present study are concentrated on the floral structure of a particular tidal marsh within this estuarine system.

The role of tidal marshes in estuarine production is not completely understood but, several hypotheses have been offered suggesting that these wetlands are extremely important in nutrient release or organic fertilization of adjacent waters, as sediment traps, and as border areas of nursery grounds of fish. It is beyond the scope of the present study to determine the role of tidal marshes in the estuarine production of Virginia's resources, however it is essential that a quantitative analysis of marsh structure be provided to serve as a foundation for future studies of a functional nature. Ultimately both approaches will allow for the development of ecological concepts pertinent to and in keeping with the dynamic approach in wetland research.

Several studies of tidal marshes along the Atlantic coast of North America have dealt with floral description and community zonation. Johnson and York (1915) and Yapp and Johnson (1917) described the tidal marshes of New England and related the development of plant zonation to tidal inundation. More recently, Miller and Egler (1950) characterized the tidal marshes of Connecticut and emphasized plant succession. Nicholson and VanDeusen (1953) described the tidal marshes of Maryland on the basis of community structure. Martin (1959) was concerned primarily with plant zonation within tidal marshes, while Redfield's (1965) study concerned itself with the ontogeny of the Barnstable estuarine marshes in Massachusetts. Wells (1928) described the saline influenced intercoastal marshes on the Outer Banks of North Carolina and since then several similar studies of Carolinian marshes have been conducted. Reed (1947) and Jackson (1952) related the development of plant zonation to edaphic factors. Bourdeau and Adams (1956), Beal, et al. (1962), and Adams (1963) studied zonation, while Brown (1959) considered succession and marsh structure. In the southeastern coastal states, Penfound (1952) characterized the swamps and marshes, Kurz and Wagner (1957) made extensive studies on plant zonation, while Odum (1961) and his students emphasized trophic-energy relationships in the salt marsh. Generalized classifications of the tidal marshes of the western Atlantic coast were made by Martin, et al. (1953), Oosting (1954), and Chapman (1960). Current studies are placing emphasis on the production of tidal marshes and their contribution to the estuarine system energetics.

Floristic studies of the saline marshes of Virginia are few in comparison to the number conducted in other coastal states. Egler (1942) briefly described the marshes of the Seashore State Park at Cape Henry. More recently, Weiss (1963 and unpublished) described a marsh of Lynnhaven Bay near Virginia Beach, while Kerwin and Pedigo (1965) provided a quantitative description of the community zonation representative of the salt marshes of the western side of lower Chesapeake Bay.

The objectives of the present study are twofold. The primary objective is to characterize qualitatively and quantitatively the changes in marsh structure which occur as one proceeds from a fresh water through a brackish water sere. The secondary objective is to develop synthetic factors that pertain to the succession of plant communities.

The study area is the Poropotank River, a small tributary, which enters the York River on the northeastern side approximately 7 miles below the confluence of the Pamunkey and Mattoponi rivers (Fig. 1). The last six miles of the Poropotank River system contains a condensed series of marsh types which are particularly suitable for studying community structure. Not only are there longitudinal differences in the marsh vegetation (i. e. from fresh to salt water), but

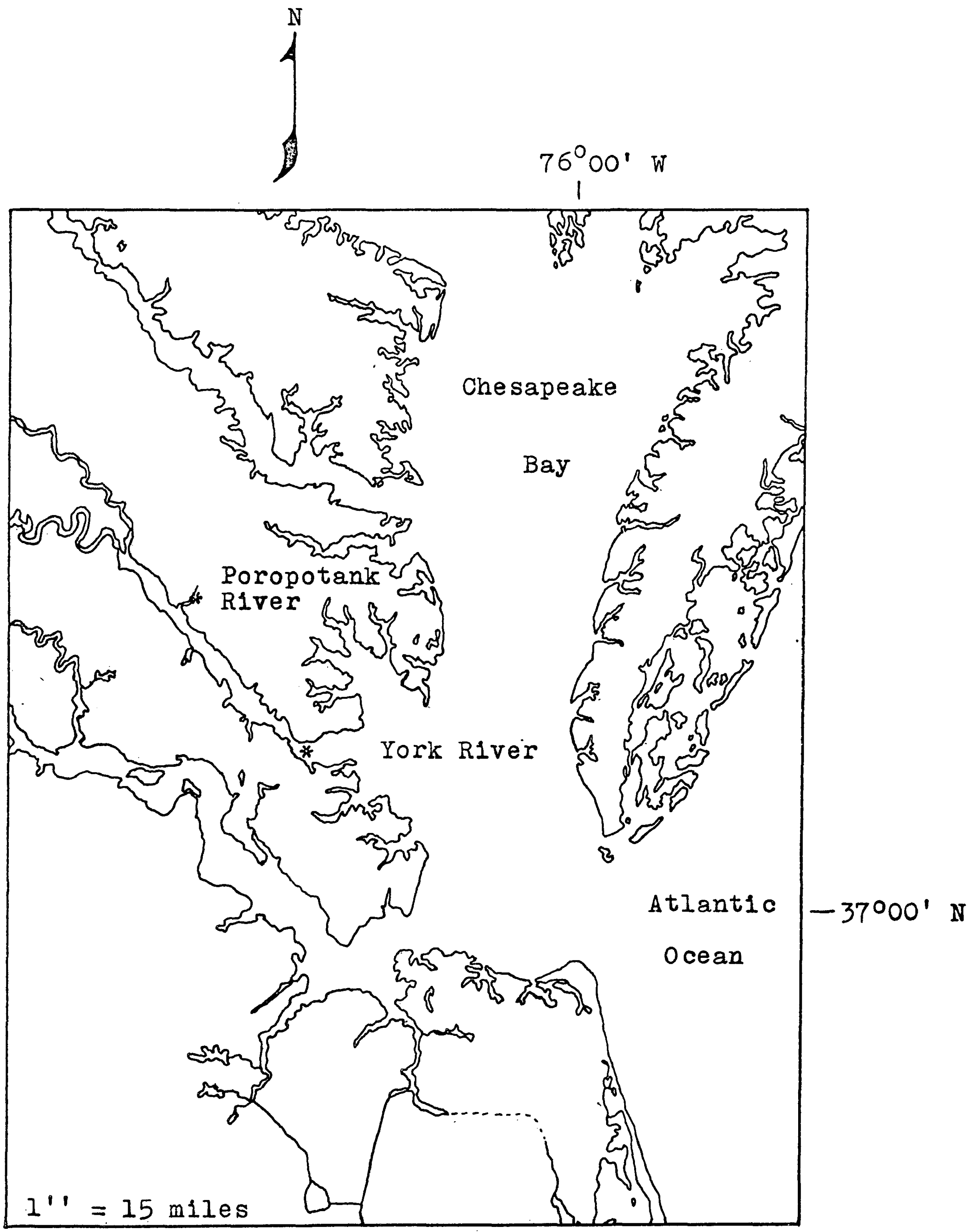

Fig. 1. Map of Tidewater, Virginia indicating the location of the study area.

also present are differences in the lateral plant zonation (i. e. from the water's edge to the woodland border).

The marshes occupy approximately 1000 acres and vary in width from one-quarter mile at the fresh water end to one mile at the river's mouth. Numerous tidal creeks and ditches form dendritic patterns within the marsh communities.

Human activity in the area apparently has had little effect in altering marsh development. A few homes, including summer cabins and permanent residences, border the river. Crop farming and coniferous lumbering are the chief economic activities supported by the adjoining lands. Some commercial fishing is done in the deeper waters of the river. One private boat landing and a waterfowl hunt club are located at the river's mouth.

Goode (1953) states that the climate of Tidewater Virginia is a "humid mesothermal" or "humid subtropical" type with warm summers and cool winters. The average dates of the first and last killing frosts are respectively the 30th day of October and the 30th day of March (U. S. Weather Bureau, Williamsburg, 1959-1963), thus, the mean length of the growing season is 214 days. The five-year annual mean for air temperature is 58.2^{o}F, with an annual range of 6-100^{o}F (Ibid.). The five-year annual mean for precipitation is

49.2 inches, with an annual variation of 44.8-57.7 inches, (Ibid.).

The coastal plain of Virginia is composed of five terraces to the west of Chesapeake Bay (Clark, 1916). These terraces, beginning within the coastal plain and proceeding to the coast, are known as the Brandywine, Sunderland, Wicomico, Talbot, and Recent. They are of recent origin and were developed in the Mesozoic and Cenozoic eras. Absence of unsorted sediments indicates that the coastal plain of Virginia has not been glaciated (Williams, 1962). The sea is now encroaching upon the land due to a slow subsidence of the Eastern Shore (Marmer, 1948, 1951). Evidence supporting this hypothesis may be found in the recent core analyses, pollen studies, and carbon-14 dating reported by Harrison, et al. (1965).

The natural climax of the tidewater area is a mixed deciduous and evergreen forest (Braun, 1950). Common hardwoods are the white and red oaks (Quercus spp.) and frequently encountered evergreens are the loblolly pine (Pinus taeda L.) and the poverty pine (P. virginiana Mill.).

The most typical soil type is a well-leached, relatively infertile, gray-brown podzol (Lyon and Buckman, 1937).

MATERIALS AND METHODS

A checklist of many of the marsh plants found in the Poropotank River area was compiled by Uhler and McCartney (Unpublished data, 1958). Employing this list and data from a preliminary survey in July of 1964, I tentatively classified the marsh system as being composed of fresh, brackish, and salt water marsh types. The preliminary survey involved walking through the marsh types, collecting plants, and recording the community associations.

The area was then divided into six strata, proceeding from fresh to salt water (Fig. 2). The purpose of these subdivisions was to provide a logical basis for a stratified random quadrat sampling plan whereby the major marsh types (i. e. fresh, brackish, and salt water) and the transitional marsh types (i. e. fresh to brackish, and brackish to salt water) could be analyzed. One stratum was designated in each of the three major marsh types, one in the fresh to brackish marsh transition, and two in the brackish to salt marsh transition. The brackish to salt water marsh interchange consisted of two strata, as the area was large and species associations appeared to differ within the community types. No attempt was made to subdivide the strata from the water's edge to the woodland border. However, the lateral succession of plant

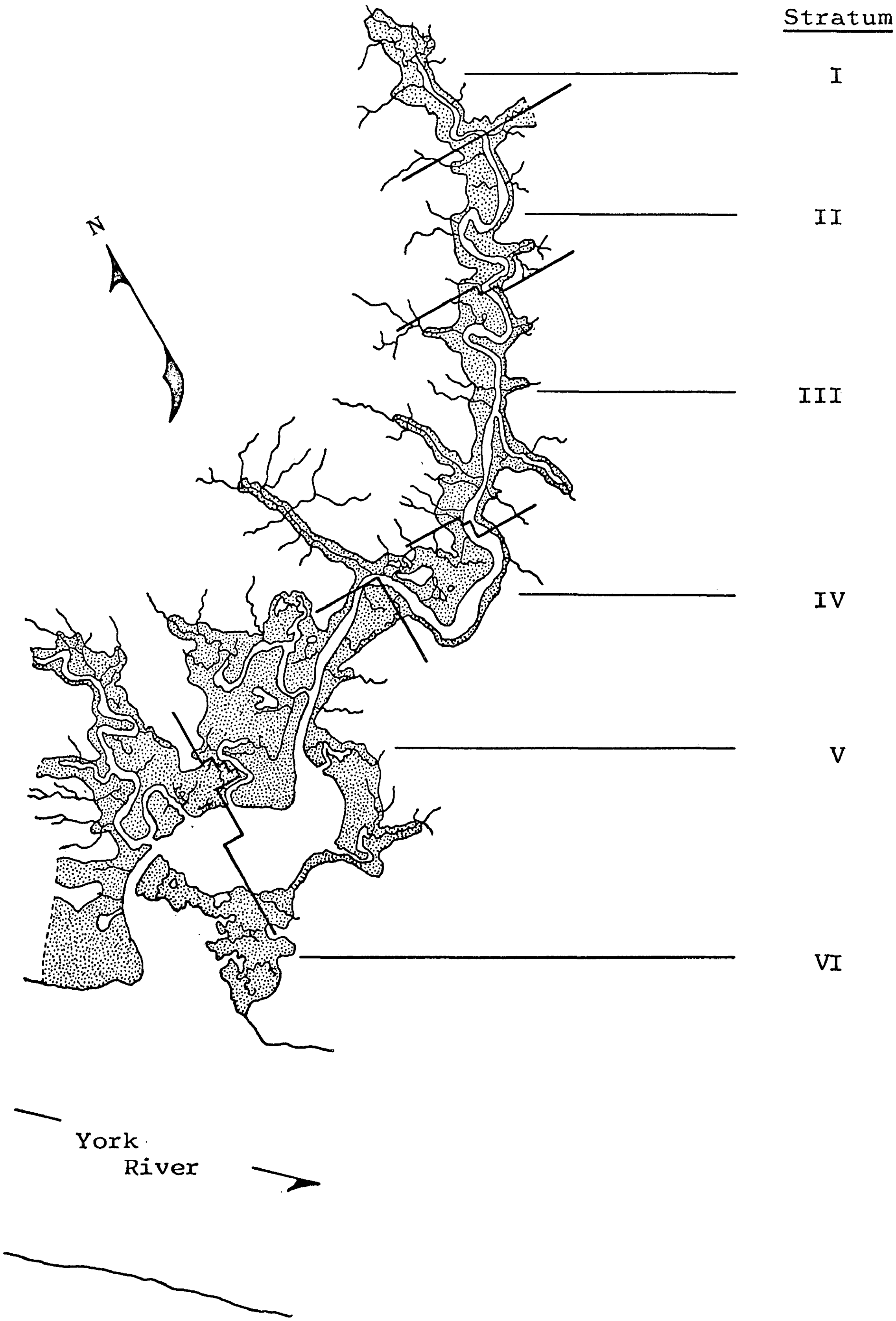

Fig. 2 . Delineation of the strata employed in sampling.

communities, as correlated with differences in elevation, was determined by walking from the river's edge to the marsh border in each major marsh and transitional type. In other words, quantitative random sampling was conducted to evaluate linear marsh structure, while qualitative analyses were employed to reveal the lateral plant zonation.

The allocation of sampling effort in each stratum was determined by use of the estimated areal coverage and plant diversity of each. The estimate of diversity was obtained through an examination of the data from the preliminary survey. Strata were then gridded into units 80 meters square and numbered systematically. Sample grid locations were selected by use of a table of random numbers. One square meter sample plot was analyzed in each of the randomly selected grids. Size of the sample employed is that recommended by Cain (1932). The number of samples obtained in each major and transitional marsh type are as follows : 10 each in the fresh and slightly brackish water marshes (strata I and II), 35 in the brackish water marsh (15 in stratum III and 20 in stratum IV), and 70 in the salt water marsh (30 in stratum V and 40 in stratum VI). Specific sample sites were marked on an aerial photograph (USDA, 1960), which was used to facilitate the location of sample areas in the field. Sample sites, the grid system, and strata are shown in Figs. 3-5.

The sampling procedure consisted of examining the

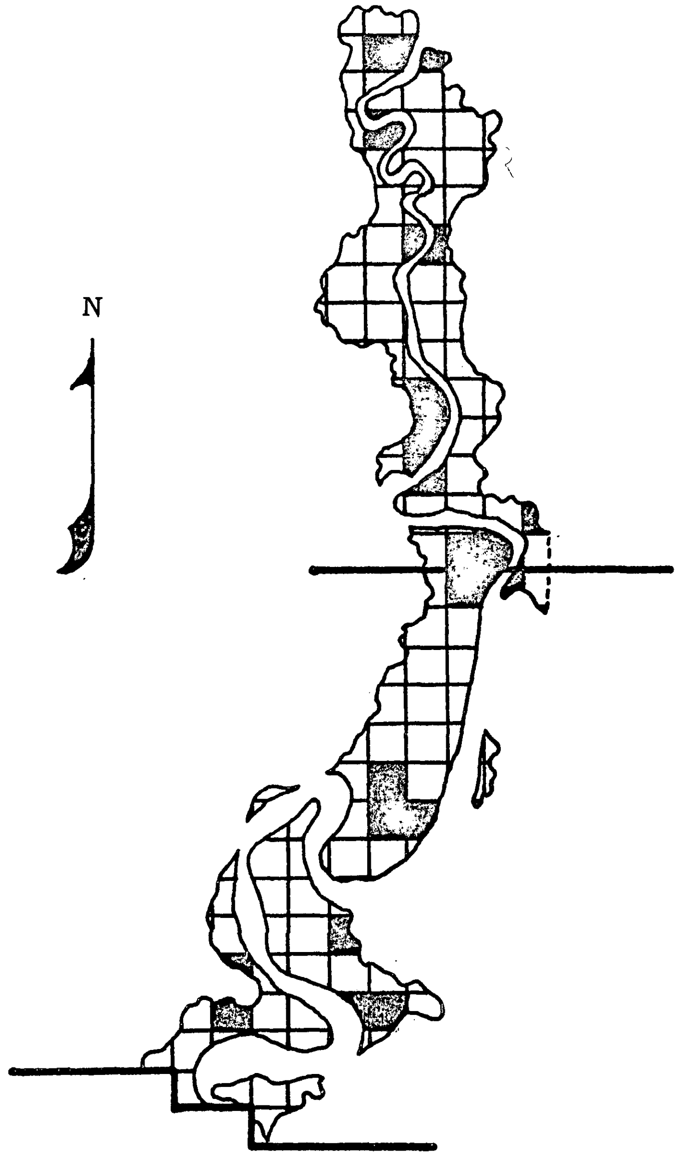

Fig. 3. Grid system and sample sites (Strata I-II).

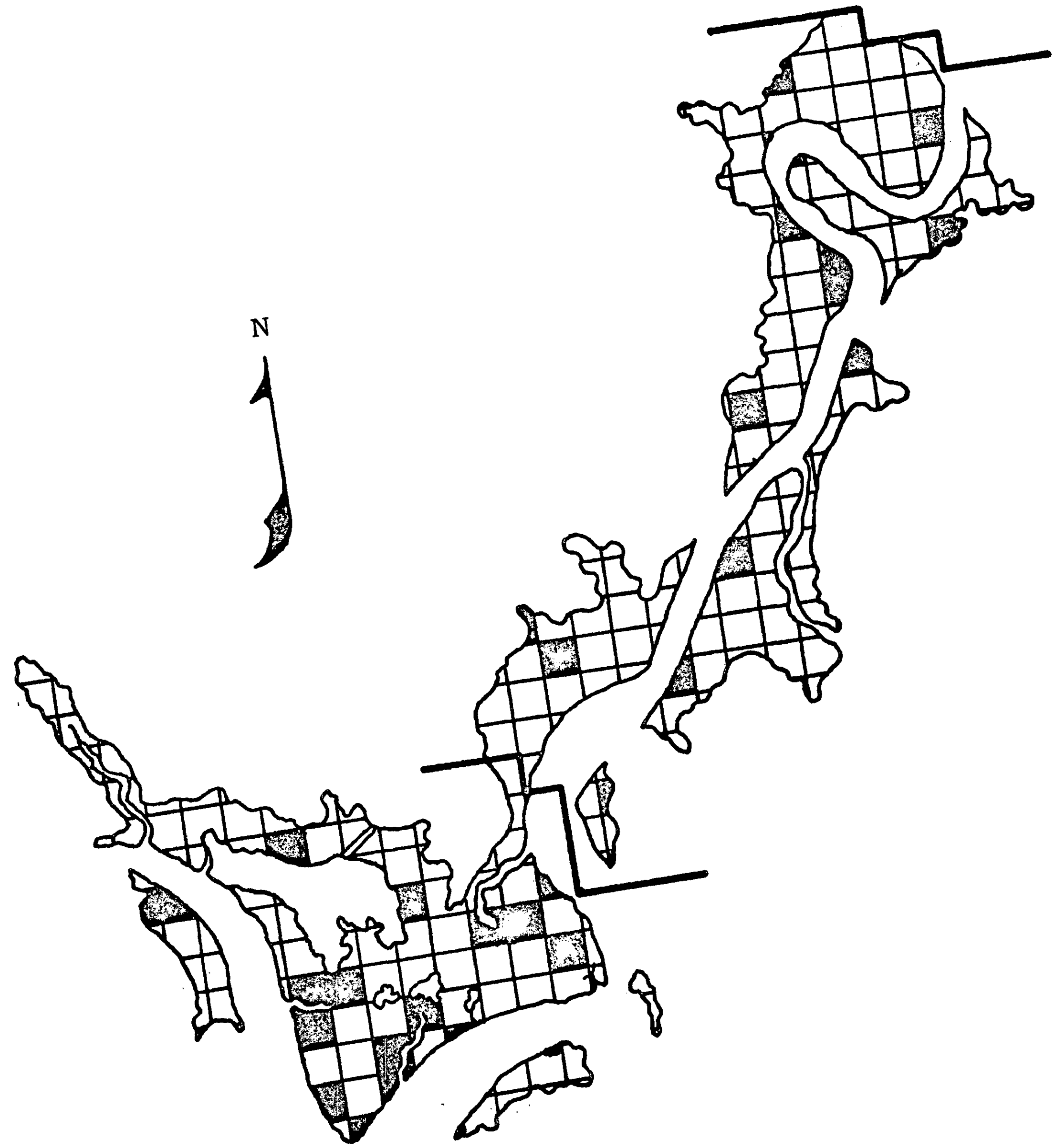

Fig. 4 . Grid system and sample sites (Strata III-IV).

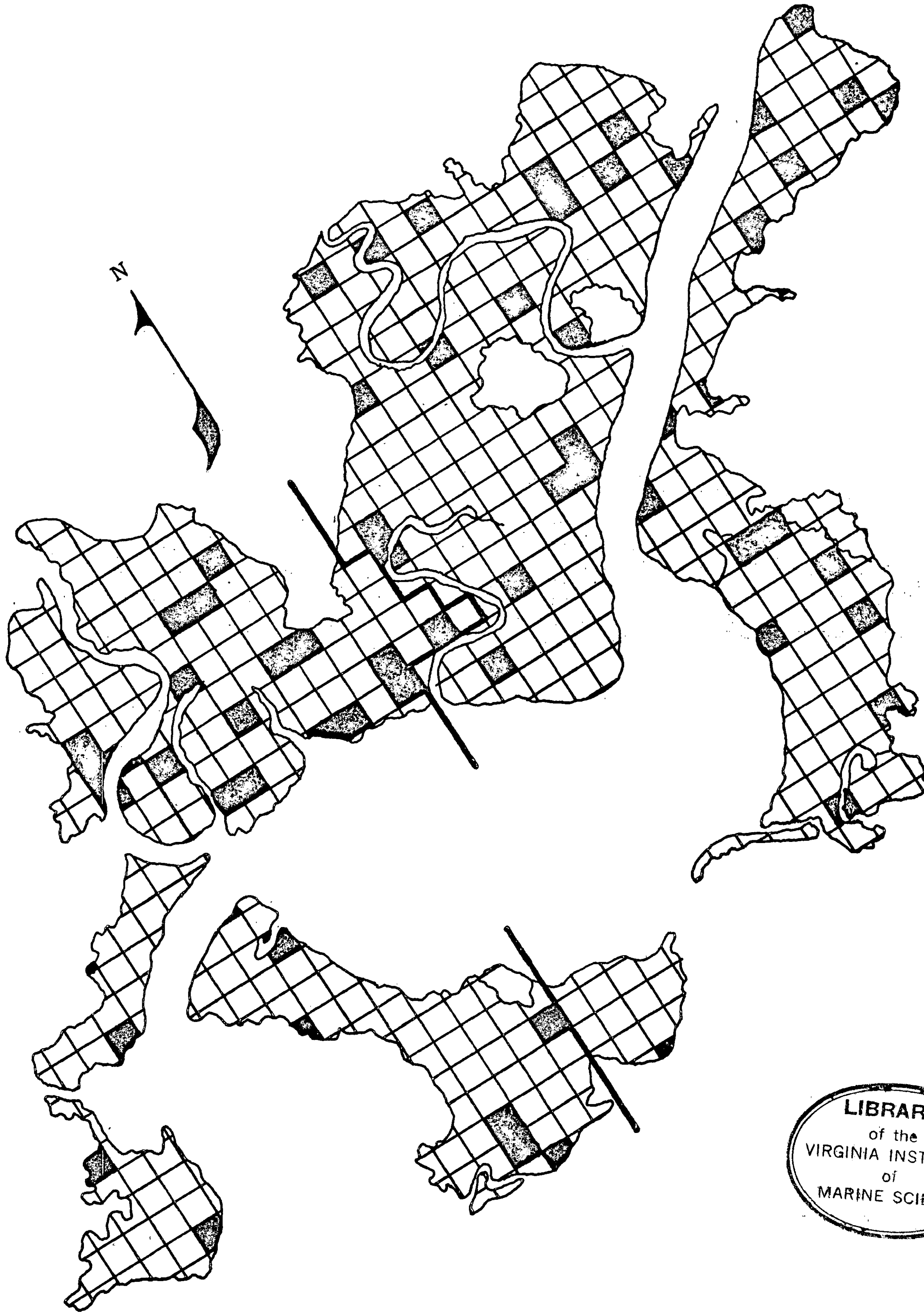

Fig. 5 . Grid system and sample sites (Strata V-VI).

vegetation from a square meter plot which was approximately centered in each grid. Within each plot, the per cent coverage by each species was estimated and the number of stems per species counted. Per cent coverage was estimated as that portion of the sample plot shaded by each species. Density values were obtained by enumeration of the individual stems, provided the estimated number of stems per plot was less than four hundred. If the stem number exceeded this value, as was often the case in the upper reaches of the salt marsh, either 0.25 or 0.50 square meter subsamples were examined and the data were expanded to yield an estimate of the total number of individuals per square meter. Furthermore, density was determined on the basis of the number of stems counted rather than on the number of "mother" plants. Most marsh plants reproduce by rhizomes; therefore, the density figures herein reported represent the number of upright plants without regard as to whether they originated from seed or rootstock, or whether they were still attached subterraneously to a "mother" plant.

Adequacy of sampling was determined by drawing species-area curves. Interpretation of these curves indicated that the effort expended in sampling each marsh area was in all instances at least four-fold in excess of that required to equal the "minimal-area" of Vestel (1938) and three-fold in excess of the "minimal-area" of Cain (1950).

An importance value for each species of plant in each of the marsh types and the total system was arrived at by employing the methods of Phillips (1959). The following formulae were used to obtain analytic data :

1. $$\text{Relative density} = \frac{\text{No. individuals of each species}}{\text{No. individuals of all species}} \times 100$$

2. $$\text{Relative dominance} = \frac{\text{No. of acres coverage of each species}}{\text{No. of acres coverage by all species}} \times 100$$

3. $$\text{Relative frequency} = \frac{\text{No. times the species occurred}}{\text{No. times all species occurred}} \times 100$$

4. $$\text{Importance value} = \text{Relative density} + \text{Relative dominance} + \text{Relative frequency}$$

Before commencement of the sampling program, a tide staff was installed at Tanyard Landing on 19 August 1964. Water levels were recorded on ten different dates from 19 August through 11 November 1964.

Surface and bottom water samples were collected during high tide on 19 August and 10 October 1964. On November 11, surface samples were obtained during high tide. Water depths at each river channel station were determined by sounding with a weighted line. Salinity determinations were made at the Virginia Institute of Marine Science with an induction salinometer (Model RS-7A, Industrial Instruments).

RESULTS

The distribution of plant species in all types of marshes is governed by several variables such as soil type, soil moisture, pH, alkalinity, biotic factors, and differences in elevation; but, in tidal marshes other factors such as changing water levels and salinity are also of paramount importance. It is of more than passing interest to determine the range of salinity and water levels in order to evaluate or assess the effect of these two variables on plant distribution.

During the study it was found that the average tidal range (i. e. from mean low to mean high water) was 3.8 feet. The minimum and maximum tidal variations recorded were 2.9 and 5.1 feet, the latter was recorded immediately following the passage at sea of Hurricane Dora on 13 September 1964.

The range in mean values of surface salinities recorded during the study period was 0.79-14.72$^{o}/_{oo}$. The minimum salinity obtained at the fresh water end of the river was 0.33$^{o}/_{oo}$ and the maximum obtained at the river's mouth was 16.37$^{o}/_{oo}$. Slight stratification of salinity was noted where maximum water depths were recorded and slight variation also occurred during the tidal cycles. However, local variation in salinity, brought about by stratification and the ebb and flood of the tides, was not considered to be significant with regards to the distribution of marsh plants. Location of the tide staff and water sampling stations, including average salinities and mean water depths, are illustrated in Fig. 6.

Water depths varied between 1.5-20.0 feet, while the average depth for the river channel was 9.1 feet.

Beginning in 1956, personnel of the Virginia Institute of Marine Science obtained monthly salinities and temperature of the waters adjacent to the mouth of the river. Data thus recorded are comparable to those I noted, and are presented in Table A of the Appendix.

A total of 77 species of plants was identified from collections and observations made in the Poropotank River marsh and marsh border during all phases of the field investigation. This list appears in Table B of the Appendix. In the course of sampling the square meter plots, 30 species of marsh plants were recorded and this checklist appears in Table 1. The nomenclature employed follows that of Gray's Manual of Botany (Fernald, 1950). Eleven families and 24 genera of marsh plants comprise the latter checklist. Frequently represented and important families were the Gramineae, Cyperaceae, and the Compositae. The Juncaceae and Polygonaceae, though of lesser importance, were also represented.

Average Salinity (o/oo)	Average Water Depth (Ft)
0.79	3.0
1.99	7.0
4.11	11.5
6.33	7.8
7.70	13.3
8.79	14.8
9.38	7.8
10.26	8.0
11.37	13.0
13.17	6.0
13.90	12.0
14.20	4.8
14.72	

* Location of tide staff.

Fig. 6 . Water sample stations, average salinities, and mean water depths.

TABLE 1 . CHECKLIST OF THE 30 MARSH PLANTS OBTAINED IN SAMPLING

Family	Species	Common Name
Typhaceae	Typha angustifolia L.	Narrow-leaf Cat-tail
Gramineae	Distichlis spicata (L.) Greene	Marsh Spike-grass
"	Cinna arundinacea L.	Wood Reedgrass
"	Spartina cynosuroides (L.) Roth	Salt Reed-grass
"	S. alterniflora Loisel	Salt-water Cord-grass
"	S. patens (Ait.) Muhl.	Salt-meadow Grass
"	Leersia oryzoides (L.) Sw.	Rice-Cutgrass
"	Zizania aquatica L.	Wild Rice
"	Echinochloa walteri (Pursh) Nash	*Wild Millet
"	Unidentified Gramineae	Grass
Cyperaceae	Cyperus strigosus Britt.	Sedge
"	Eleocharis quadrangulata (Michx) Vahl	*Squarestem Spikerush
"	E. parvula (R. & S.) Link	*Dwarf Spikerush
"	Fimbristylis castanea (Michx) Vahl	Fimbristylis
"	Scirpus olneyi Gray	*Olney's Three-square
"	S. robustus Pursh	Saltmarsh Bulrush
Araceae	Peltandra virginica (L.) S. & E.	Arrow-Arum
Juncaceae	Juncus roemerianus Scheele	*Needlerush
Polygonaceae	Polygonum punctatum Ell.	Water-Smartweed
Amaranthaceae	Acnida cannabina L.	Water-Hemp
Lythraceae	Lythrum lineare L.	Loosetrife
Umbelliferae	Sium suave Walt.	Water-parsnip
"	Lilaeopsis chinensis (L.) Ktze.	Lilaeopsis
Asclepiadaceae	Asclepias incarnata	Swamp Milkweed
Rubiaceae	Hedyotis boscii DC.	Madder
Compositae	Baccharis halimifolia L.	Groundsel-tree
"	Pluchea purpurascens (Sw.) DC.	Marsh-Fleabane
"	Iva frutescens L.	Marsh-Elder
"	Borrichia frutescens (L.) DC.	Sea-Ox-Eye
"	Helenium autumnale L.	Sneezeweed

* Neil Hotchkiss. 1950. Checklist of marsh and aquatic plants of the U. S.

It was estimated that 969 acres contained emergent plants, while 31 acres consisted of wooded islands situated within the brackish and salt water marshes. The fresh water marsh consisted of 44 acres or 4.5 per cent of the total marsh system. The slightly brackish water marsh, or fresh-brackish water transitional marsh, accounted for 58 acres or 6.0 per cent. The brackish water marsh amounted to 198 acres or 20.5 per cent, while the salt water marsh occupied 669 acres or 69.0 per cent of the total marsh area. Per cent coverage for the marsh types and point estimates of each are presented in Table 2 and the estimated acreage of each community, within the marsh types, are presented in Table 3. Total marsh coverage by each stratum and the acreage coverage by each species in the strata are shown in Tables C and D of the Appendix.

Frequency, per cent coverage, and density data are given in Tables 4-6 and the importance values for each species of plant in each of the four marsh types are presented in Tables 7-12.

TABLE 2. PER CENT COVERAGE (ACRES), WITH INTERVAL AND POINT ESTIMATES, FOR EACH MARSH

Marsh Type	% Coverage (With Estimates)	Total Acreage	Acres Plant Coverage
Fresh Water Marsh	68.5 ± 11.3	43.6	29.9
Slightly Brackish Water Marsh	63.0 ± 15.7	58.0	36.5
Brackish Water Marsh	73.6 ± 7.3	198.3	147.8
Salt Water Marsh	64.4 ± 5.5	668.8	430.3
Total Marsh Area	66.5	968.7	644.6
Wooded Islands		31.3	
Total Area		1000.0	

TABLE 3 . ESTIMATED ACREAGE OF EACH COMMUNITY IN THE MARSH TYPES

Community (or seral stage)	Fresh	Slightly Brackish	Brackish	Salt
P. virginica	8.7			
Z. aquatica - *E. quadrangulata*	17.4			
S. alterniflora - *H. autumnale*	13.1			
T. angustifolia - *S. olneyi*	4.4	5.8		
S. alterniflora - *P. virginica*		5.8		
S. alterniflora - *Z. aquatica*		5.8		
S. alterniflora - *E. walteri*		34.8		
S. cynosuroides		5.8	63.2	
S. alterniflora - S. robustus			76.5	
S. alterniflora - *P. purpurascens*			23.4	
T. angustifolia - *S. alterniflora*			7.3	
S. alterniflora (tall form)			27.9	152.9
S. alterniflora (short form)				248.5
D. spicata - *S. patens*				219.9
J. roemerianus				38.0
S. patens - *I. frutescens* - *B. halimifolia*				9.6
Total Acreage :	44	58	198	669
Per cent of total acreage :	4.5	6.0	20.5	69.0

TABLE 4. FREQUENCY (%) OF OCCURRENCE OF EACH PLANT IN THE MARSH TYPES

Species Obtained	Fresh	Slightly Brackish	Brackish	Salt
E. quadrangulata	30			
H. autumnale	40			
Unid. Gramineae	10			
S. suave	10			
A. incarnata	10			
C. strigosus	10			
C. arundinacea	10			
P. virginica	20	20		
Z. aquatica	70	30		
E. walteri	10	20		
P. punctatum	20	70	17	
S. olneyi	10	*	6	
T. angustifolia	*	10		
P. purpurascens		10	14	3
S. cynosuroides		20	51	7
L. oryzoides			3	
L. lineare			11	*
S. robustus			40	33
A. cannabina			9	3
L. chinensis			6	6
D. spicata			17	43
S. patens			17	30
B. frutescens			3	*
B. halimifolia			3	1
F. castanea			3	3
J. roemerianus			3	10
I. frutescens			3	3
H. boscii				1
E. parvula				1
S. alterniflora	60	100	89	81
Vascular Plants :	100	100	100	100

* Observed but not obtained in sampling.

TABLE 5 . ESTIMATED MEAN PER CENT COVERAGE FOR EACH PLANT PER SAMPLE PLOT IN THE MARSH TYPES

Species Obtained	Fresh	Slightly Brackish	Brackish	Salt
E. quadrangulata	3.0			
H. autumnale	3.5			
Unid. Gramineae	Tr.			
S. suave	Tr.			
A. incarnata	0.5			
C. strigosus	Tr.			
C. arundinacea	Tr.			
P. virginica	8.0	2.0		
Z. aquatica	35.5	2.0		
E. walteri	1.0	4.5		
P. punctatum	Tr.	0.5	0.3	
S. olneyi	6.5	*	0.1	
T. angustifolia	*	4.0	0.7	
P. purpurascens		Tr.	0.3	0.1
S. cynosuroides		7.0	20.3	0.8
L. oryzoides			Tr.	
L. lineare			0.7	*
S. robustus			3.4	2.9
A. cannabina			Tr.	0.1
L. chinensis			Tr.	Tr.
D. spicata			1.9	8.6
S. patens			5.0	16.5
B. frutescens			0.1	*
B. halimifolia			Tr.	0.1
F. castanea			Tr.	Tr.
J. roemerianus			0.4	5.4
I. frutescens			0.9	0.2
H. boscii				Tr.
E. parvula				Tr.
S. alterniflora	10.5	43.0	39.4	29.6
Grand Average :	68.5	63.0	73.6	64.4

* Observed but not obtained in sampling.

TABLE 6 . MEAN NUMBER OF INDIVIDUALS OF EACH SPECIES PER SAMPLE PLOT IN THE MARSH TYPES

Species Obtained	Fresh	Slightly Brackish	Brackish	Salt
E. quadrangulata	3.40			
H. autumnale	1.60			
Unid. Gramineae	0.10			
S. suave	0.10			
A. incarnata	0.20			
C. strigosus	0.30			
C. arundinacea	0.20			
P. virginica	0.80	0.30		
Z. aquatica	31.30	2.20		
E. walteri	0.70	2.60		
P. punctatum	0.30	1.40	0.60	
S. olneyi	7.80	*	0.31	
T. angustifolia	*	1.80	0.49	
P. purpurascens		0.10	0.57	0.16
S. cynosuroides		6.20	15.00	0.49
L. oryzoides			0.03	
L. lineare			1.77	*
S. robustus			5.66	8.36
A. cannabina			0.23	0.37
L. chinensis			0.17	0.14
D. spicata			7.69	124.01
S. patens			39.34	440.54
B. frutescens			0.09	*
B. halimifolia			0.03	0.23
F. castanea			0.03	0.21
J. roemerianus			0.31	86.76
I. frutescens			0.11	0.03
H. boscii				0.04
E. parvula				**
S. alterniflora	9.90	42.90	50.00	64.89
Grand Average :	56.70	57.50	122.43	726.23

* Observed but not obtained in sampling.
** Not counted.

TABLE 7 . FREQUENCY, DENSITY, DOMINANCE, AND IMPORTANCE VALUES FOR PLANTS IN THE FRESH WATER MARSH

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value
Z. aquatica	70	55.2	50.7	175.9
S. alterniflora	60	17.5	15.5	93.0
H. autumnale	40	2.8	5.6	48.4
E. quadrangulata	30	6.0	4.2	40.2
S. olneyi	10	13.8	9.8	33.6
P. virginica	20	1.4	11.3	32.7
P. punctatum	20	0.5	Tr.	20.5
E. walteri	10	1.2	1.4	12.6
A. incarnata	10	0.4	1.4	11.8
C. strigosus	10	0.5	Tr.	10.5
C. arundinacea	10	0.4	Tr.	10.4
S. suave	10	0.2	Tr.	10.2
Unid. Gramineae	10	0.2	Tr.	10.2

TABLE 8 . FREQUENCY, DENSITY, DOMINANCE, AND IMPORTANCE VALUES FOR PLANTS IN THE SLIGHTLY BRACKISH WATER MARSH

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value
S. alterniflora	100	74.6	67.2	241.8
P. punctatum	70	2.4	1.6	74.0
S. cynosuroides	20	10.8	10.9	41.7
Z. aquatica	30	3.8	3.1	36.9
E. walteri	20	4.5	7.8	32.3
P. virginica	20	0.5	3.1	23.6
T. angustifolia	10	3.1	6.3	19.4
P. purpurascens	10	0.2	Tr.	10.2

TABLE 9 . FREQUENCY, DENSITY, DOMINANCE, AND IMPORTANCE VALUES FOR PLANTS IN THE BRACKISH WATER MARSH

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value
S. alterniflora	88.6	40.8	53.5	182.9
S. cynosuroides	51.4	12.3	67.7	131.4
S. patens	17.1	32.1	12.7	61.9
S. robustus	40.0	4.6	11.1	55.7
D. spicata	17.1	6.3	4.2	27.6
P. punctatum	17.1	0.5	1.7	19.3
L. lineare	11.4	1.4	3.4	16.2
P. purpurascens	14.3	0.5	Tr.	14.8
A. cannabina	8.6	0.2	Tr.	8.8
S. olneyi	5.7	0.3	Tr.	6.0
L. chinensis	5.7	0.1	Tr.	5.8
I. frutescens	2.9	0.1	2.8	5.8
J. roemerianus	2.9	0.3	1.4	4.6
T. angustifolia	-	0.4	3.4	3.8
B. frutescens	2.9	0.1	Tr.	3.0
L. oryzoides	2.9	Tr.	Tr.	2.9
F. castanea	2.9	Tr.	Tr.	2.9
B. halimifolia	2.9	Tr.	Tr.	2.9

TABLE 10 . FREQUENCY, DENSITY, DOMINANCE, AND IMPORTANCE VALUES FOR PLANTS IN THE SALT WATER MARSH

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value
S. alterniflora	81.4	8.9	46.6	136.9
S. patens	31.4	60.7	25.8	117.9
D. spicata	42.9	17.1	13.2	73.2
S. robustus	32.9	1.2	4.9	39.0
J. roemerianus	10.0	11.9	8.5	30.4
S. cynosuroides	7.1	0.1	0.9	8.1
L. chinensis	5.7	Tr.	Tr.	5.7
A. cannabina	2.9	0.1	Tr.	3.0
P. purpurascens	2.9	Tr.	Tr.	2.9
F. castanea	2.9	Tr.	Tr.	2.9
I. frutescens	2.9	Tr.	Tr.	2.9
B. halimifolia	1.4	Tr.	Tr.	1.4
E. parvula	1.4	-	Tr.	1.4
H. boscii	1.4	Tr.	Tr.	1.4

TABLE 11 . FREQUENCY, DENSITY, DOMINANCE, AND IMPORTANCE VALUES FOR PLANTS IN THE ENTIRE MARSH SYSTEM

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value
S. alterniflora	83.2	12.1	48.0	143.3
S. patens	22.4	57.3	18.3	98.0
D. spicata	28.8	15.9	9.2	53.9
S. robustus	29.6	1.4	4.4	35.4
S. cynosuroides	20.0	1.1	7.9	29.0
J. roemerianus	6.4	10.8	5.8	23.0
P. punctatum	12.0	0.1	0.3	12.4
Z. aquatica	8.0	0.6	2.6	11.2
P. purpurascens	6.4	0.1	Tr.	6.5
L. chinensis	4.8	Tr.	Tr.	4.8
A. cannabina	4.0	0.1	Tr.	4.1
P. virginica	3.2	Tr.	0.7	3.9
L. lineare	3.2	0.1	0.3	3.6
H. autumnale	3.2	Tr.	0.3	3.5
S. olneyi	2.4	0.2	0.5	3.1
E. walteri	2.4	0.1	0.5	3.0
E. quadrangulata	2.4	0.1	0.2	2.7
I. frutescens	2.4	Tr.	0.3	2.7
F. castanea	2.4	Tr.	Tr.	2.4
T. angustifolia	0.8	0.1	0.7	1.6
B. halimifolia	1.6	Tr.	Tr.	1.6
A. incarnata	0.8	Tr.	0.1	0.9
Unid. Gramineae	0.8	Tr.	Tr.	0.8
S. suave	0.8	Tr.	Tr.	0.8
C. strigosus	0.8	Tr.	Tr.	0.8
C. arundinacea	0.8	Tr.	Tr.	0.8
L. oryzoides	0.8	Tr.	Tr.	0.8
B. frutescens	0.8	Tr.	Tr.	0.8
E. parvula	0.8	-	Tr.	0.8
H. boscii	0.8	Tr.	Tr.	0.8

TABLE 12 . IMPORTANCE VALUES FOR EACH PLANT IN THE MARSH TYPES AND THE ENTIRE SYSTEM

Species	Fresh	Slightly Brackish	Brackish	Salt
E. quadrangulata	40.2			
H. autumnale	48.4			
Unid. Gramineae	10.2			
S. suave	10.2			
A. incarnata	11.8			
C. strigosus	10.5			
C. arundinacea	10.4			
P. virginica	32.7	23.6		
Z. aquatica	175.9	36.9		
E. walteri	12.6	32.3		
P. punctatum	20.5	74.0	19.3	
S. olneyi	33.6		6.0	
T. angustifolia		19.4	3.8	
P. purpurascens		10.2	14.8	2.9
S. cynosuroides		41.7	131.4	8.1
L. oryzoides			2.9	
L. lineare			16.2	
S. robustus			55.7	39.0
A. cannabina			8.8	3.0
L. chinensis			5.8	5.7
D. spicata			27.6	73.2
S. patens			61.9	117.9
B. frutescens			3.0	
B. halimifolia			2.9	1.4
F. castanea			2.9	2.9
J. roemerianus			4.6	30.4
I. frutescens			5.8	2.9
H. boscii				1.4
E. parvula				1.4
S. alterniflora	93.0	241.8	182.9	136.9

DISCUSSION

Although submerged aquatics growing in the Poropotank River were not sampled quantitatively, six species were observed. Wigeongrass, *Ruppia maritima* L., was distributed throughout the river system. I have also observed this plant in both fresh and brackish waters of Back Bay, Virginia and Currituck Sound, North Carolina (Unpublished data of the Back Bay - Currituck Sound Coop. Invest., 1958-1963). The most frequently encountered submerged "aquatic" in the northern fresh water end of the river was sago pondweed, *Potamogeton pectinatus* L.. Other species, confined to and occurring only infrequently in fresh water, were the waterweed, *Elodea canadensis* Michx.; southern naiad, *Najas guadalupensis* (Spr.) Mag.; wild-celery, *Vallisneria americana* Michx.; and the hornwort, *Ceratophyllum demersum* L..

If the entire Poropotank River marsh system were classified on the basis of importance values (Table 11), the marsh could be considered to be an association of *S. alterniflora*. Subdominant plants would respectively be *S. patens*, *D. spicata*, *S. robustus*, *S. cynosuroides*, and *J. roemerianus*. All of these except *S. cynosuroides* are typically characterized as salt water marsh forms; thus, it is evident that the unqualified use of the ranking system is inappropiate to adequately describe the major marsh types (i. e. fresh, brackish, and salt water). It is readily apparent that coverage (acreage) places undue emphasis in the ranking system and that a refinement is necessary if we are to adequately describe the individual marsh types within the whole system. This then brings us to describing each major marsh type separately, recognizing that each is not a thoroughly discrete unit, but rather a continuum of types. I have therefore proposed a classification of four distinct but partially overlapping marsh types.' They are respectively the fresh water marsh, the slightly brackish water marsh, the brackish water marsh, and the salt water marsh. Each classification was arrived at through field observation, analysis of relative importance values, community associations, combination of strata, and species composition.

My classifications are presented in the sections that follow.

The Fresh Water Marsh

Eight families of flowering plants, which included 13 genera and species, were represented in sampling the fresh water marsh. The most important plants obtained were respectively Z. aquatica, S. alterniflora, H. autumnale, and E. quadrangulata. Four communities were recognized within this marsh type and are illustrated in Fig. 7. The dominant community was Z. aquatica - E. quadrangulata, the deep reed-

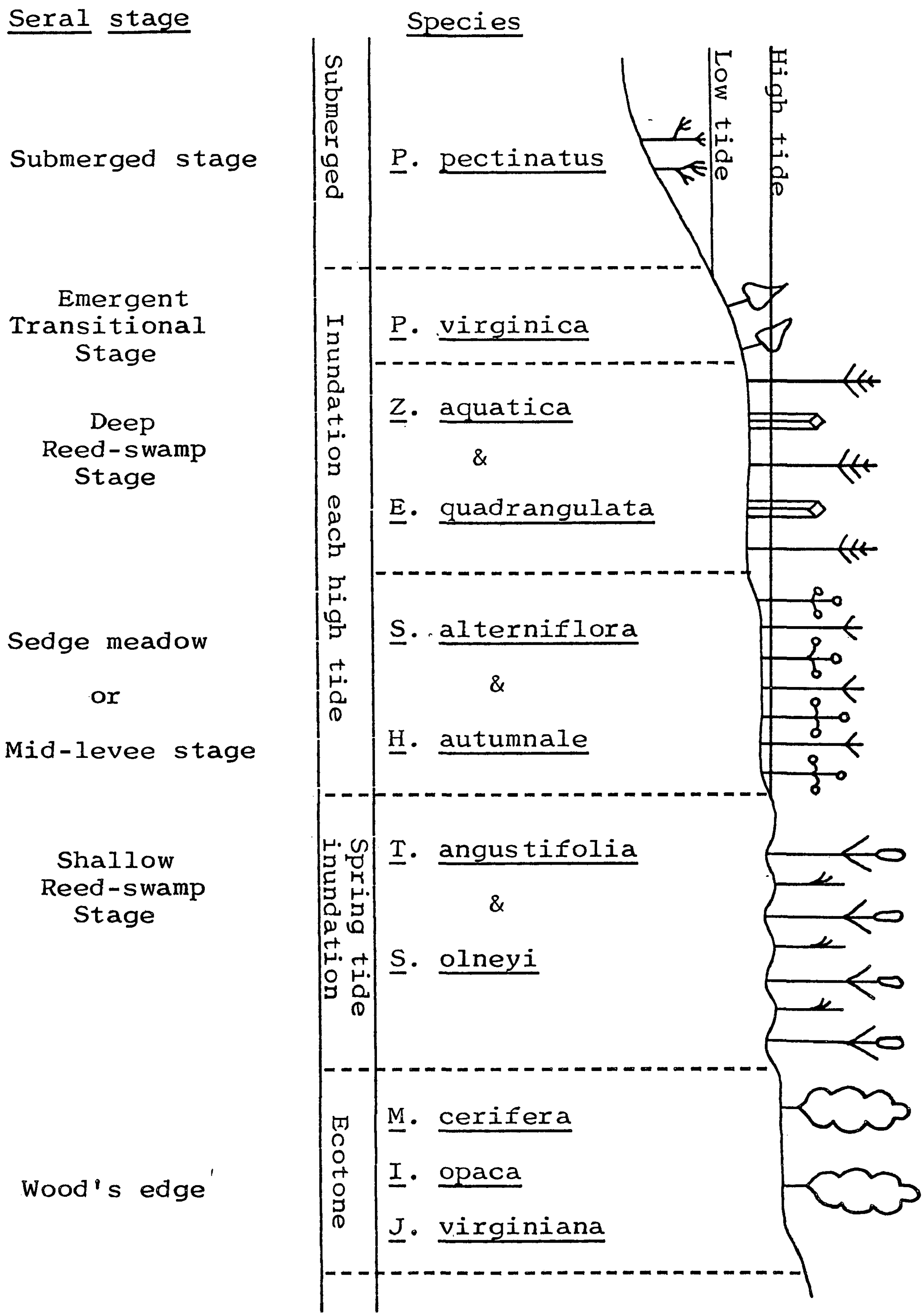

Fig. 7. Community zonation in the fresh water marsh.

swamp stage. This community consisted of 17 acres or 40.0 per cent of the marsh type (Table 3).

The most important single species in the fresh water marsh was Z. aquatica, which accounted for 52 per cent of the plant coverage in the 44 acres.

The maximum salinity recorded in the river waters adjacent to the marsh was $0.79^{o}/_{oo}$. This measurement was obtained after the passage of Hurricane Dora on 13 September 1964 and was collected immediately after the storm surge.

The occurrence of S. alterniflora as a dominant plant in a fresh water marsh has not previously been recorded in the literature and will be discussed below.

The Slightly Brackish Water Marsh

The slightly brackish water marsh is a transitional, but distinct type, which occurred between the fresh and the brackish water marshes. It is similar to the adjacent types in that it shares species in common; however, most community associations recorded were different (Fig. 8). Five community types were recognized within this marsh and the dominant classification was the S. alterniflora - E. walteri seral stage, or the cordgrass - wild millet community. This stage accounted for 35 acres or 60.0 per cent of the marsh type (Table 3).

Five families of plants representing 7 genera and 8

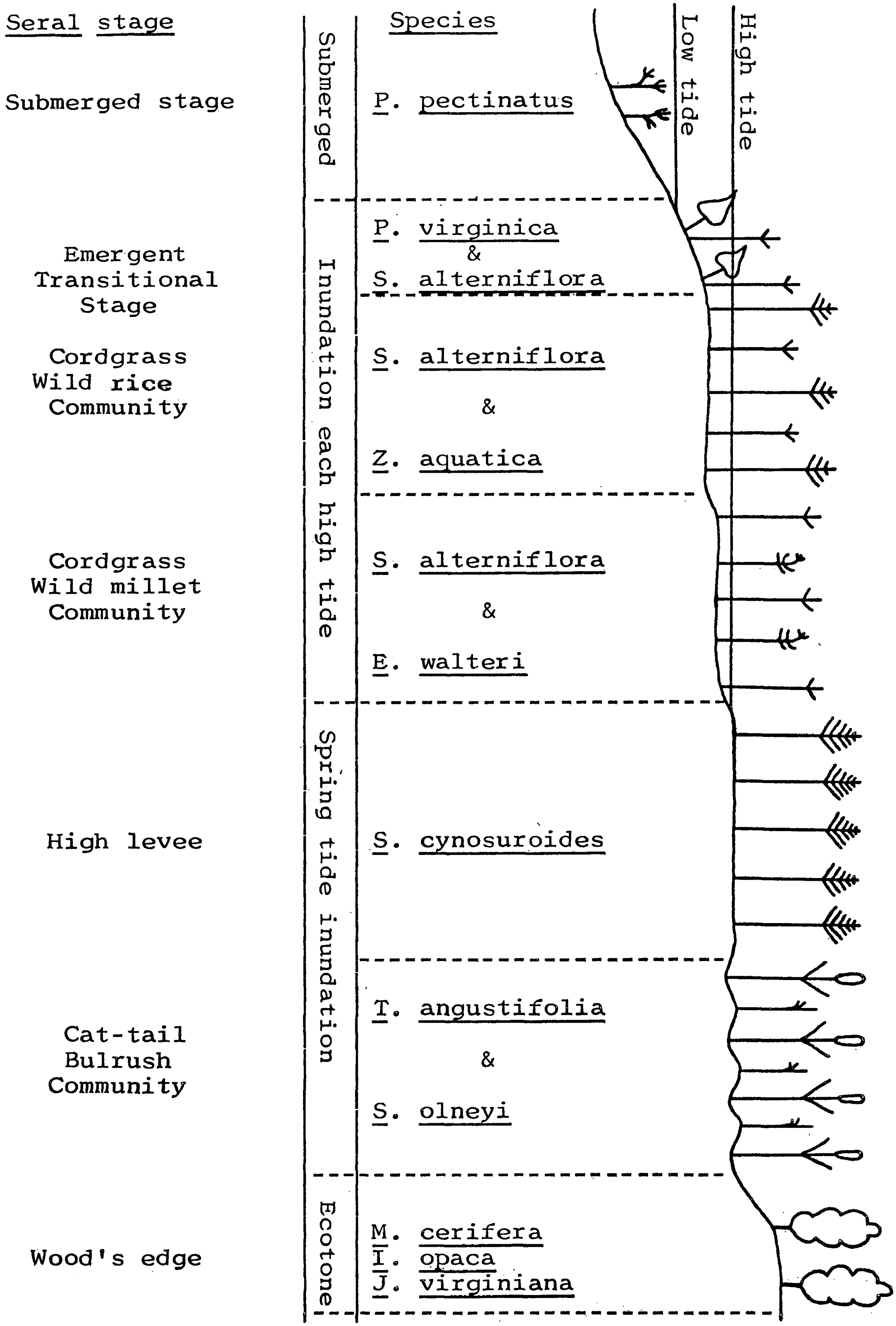

Fig. 8. Community zonation in the slightly brackish water marsh.

species were obtained in sampling the slightly brackish water marsh. The most important species recorded was *S. alterniflora*, which accounted for 68 per cent of the plant coverage. Dominant species were respectively *S. alterniflora*, *P. punctatum*, *S. cynosuroides*, *Z. aquatica*, and *E. walteri* (Table 8).

Indicator species used in the classification of this marsh were *P. punctatum* and *E. walteri*.

The range of average salinities recorded in the river adjoining the marsh was 0.79-4.11$^{o}/oo$.

The Brackish Water Marsh

The brackish water marsh is a transitional, but distinct, type like the slightly brackish water marsh. It is similar to adjacent marsh types in that it shares many species in common; however, community associations differ and show a greater similarity with the salt water marsh than with the slightly brackish water marsh. Six communities were recognized within the type and these are illustrated in Fig. 9. The dominant classification in the brackish water marsh was the *S. alterniflora* - *S. robustus* stage or the cordgrass - bulrush community. This seral stage accounted for 76 acres or 38.6 per cent of the marsh (Table 3).

Nine families representing 15 genera and 18 species of phanerogams were obtained in sampling the brackish water

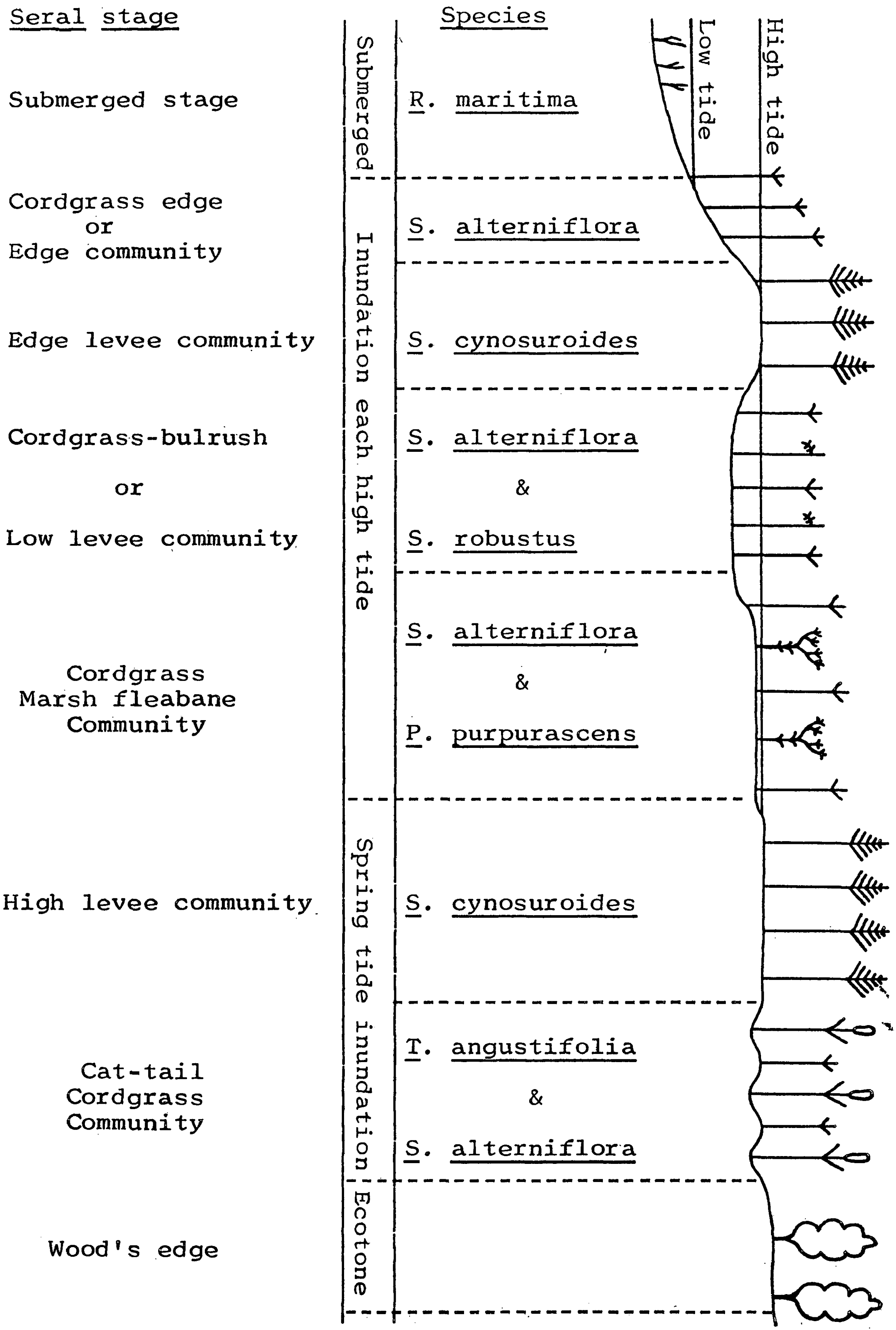

Fig. 9. Community zonation in the brackish water marsh.

marsh. Typical indicator species used in the classification of this marsh were S. cynosuroides, S. robustus, S. olneyi, P. purpurascens, A. cannabina, and L. chinensis. Dominant species obtained were respectively S. alterniflora, S. cynosuroides, S. patens, and S. robustus.

The most important single plant was S. alterniflora and it accounted for 54 per cent of the total plant coverage. The relative dominance of S. cynosuroides in the marsh was greater than S. alterniflora; however, the latter species had a higher relative frequency and density (Table 9). Therefore, the salt reed-grass, S. cynosuroides, is considered a co-dominant in this marsh.

The range in mean salinities recorded from the waters adjacent to this marsh was $4.11\text{-}9.38^{o}/_{oo}$.

The Salt Water Marsh

The salt water marsh flora is a distinct type comprised of 8 families that represented 11 genera and 13 species of emergent plants. Six communities were recognized and are illustrated in Fig. 10. The dominant community in the salt water marsh was the low meadow or nearly pure stand of the short form of S. alterniflora. This seral stage consisted of 249 acres or 37.2 per cent of the marsh type (Table 3).

Typical indicator species used in the classification of this marsh were S. alterniflora, S. patens, D. spicata, J. roemerianus, F. castanea, and I. frutescens. Dominant plants

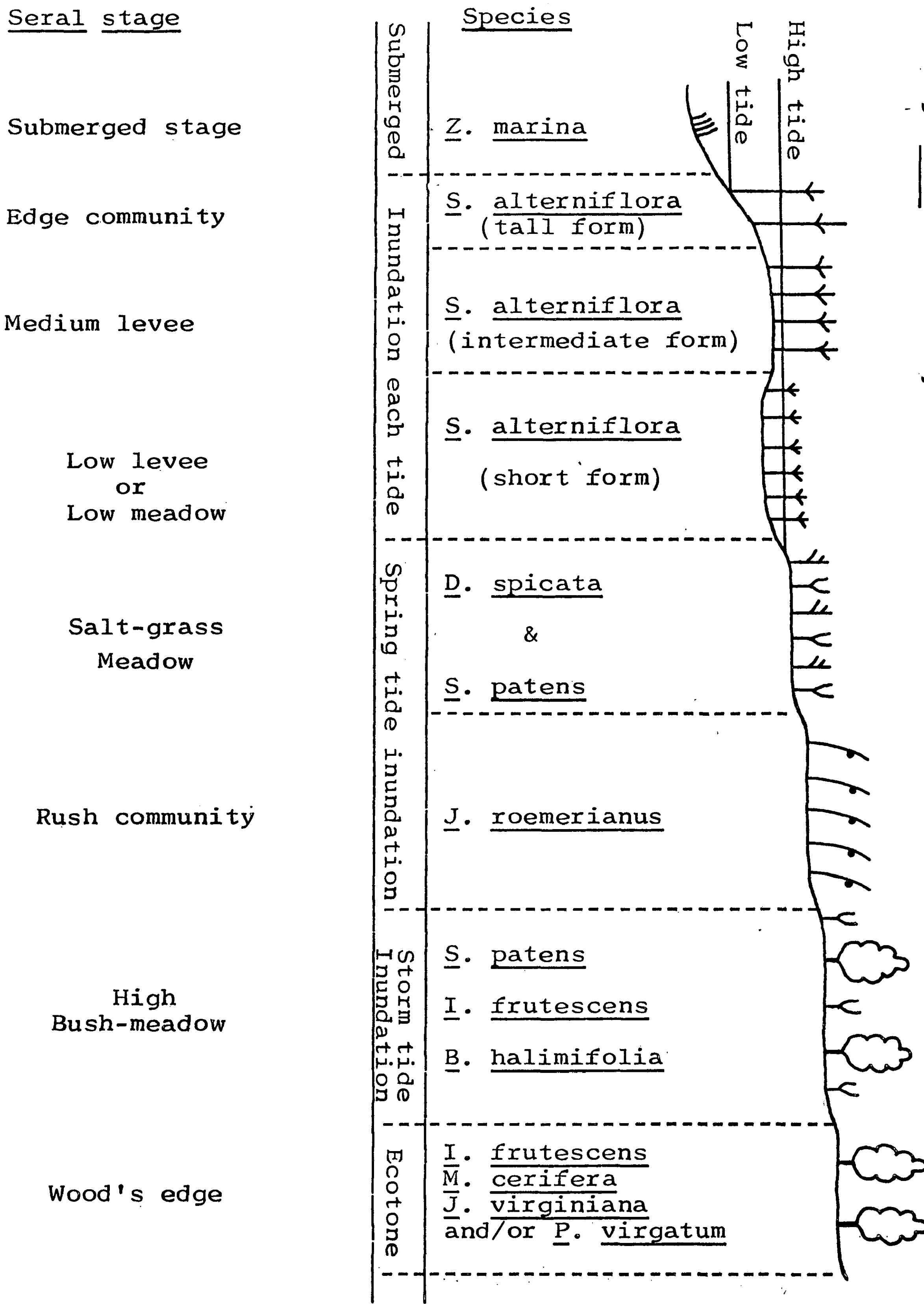

Fig. 10. Community zonation in the salt water marsh.

were respectively S. alterniflora, S. patens, D. spicata, S. robustus, and J. roemerianus.

The range of mean salinities recorded in the river waters adjacent to the marsh was 9.38-14.72°/oo.

Of particular interest in the foregoing classification was the occurrence of the saltmarsh cordgrass, S. alterniflora, as the only dominant plant associate in at least one community of each major marsh type. If one were to follow the classical scheme of classification, as outlined by Weaver and Clements (1938), the entire Poropotank River marsh system might well be classified as an S. alterniflora associe. This species was obtained as a dominant in one community of the fresh water marsh, three communities of the slightly brackish water marsh, four communities in the brackish water marsh, and one community (exhibiting three zones) in the salt water marsh. Observations made during the study revealed that this plant exhibited the best growth in the slightly brackish water marsh where the salinity of the inundating waters was less than 4.11°/oo. Stunted or chlorotic individuals were the dominants in the low meadow community of the salt water marsh (Fig. 10, Table 3). It appears that this species is better adapted to compete in the slightly brackish water transitional marsh than those plants typical of either the fresh or slightly brackish water conditions. The occurrence of a high population density, an extensive areal coverage, and a relatively high frequency of this species in a fresh water marsh is unusual under natural conditions. The plant is generally considered to be an indicator species of salt and brackish water tidal marshes.

Barren areas larger than one square meter in size were not observed during the present study. In contrast, Kurz and Wagner (1957) noted that salt barrens of several square meters were frequently encountered in the salt marshes of South Carolina and northern Florida. Sample plots examined in all marsh communities of the Poropotank River system contained at least one species of phanerogam. The same results were obtained in a previous tidal marsh study conducted on the western shore of Chesapeake Bay (Kerwin and Pedigo, 1965).

Twenty species of common marsh border and woodland plants were recorded from areas adjacent to the marsh types. Frequently encountered forest trees were the loblolly pine, P. taeda; scrub or poverty pine, P. virginiana; the beech, Fagus grandifolia Ehrh.; and mixed oaks, Quercus spp.. Frequently observed understory plants in the wooded areas were blackberries, Rubus spp.; poison ivy, Rhus radicans L.; mountain laurel, Kalmia latifolia L.; the flowering dogwood, Cornus florida L.; and the greenbriar, Smilax spp.. Frequently observed ecotone, or marsh border, plants were the switchgrass, Panicum virgatum L.; red cedar, Juniperus virginiana L.; myrtles, Myrica spp.; the American Holly, Ilex opaca Ait.; and the buttonbush, Cephalanthus occidentalis L.. The occurrence of P. virgatum, J. virginiana, and

Myrica spp. adjacent to the salt marsh was also noted in a prior study of a salt marsh (Kerwin and Pedigo, 1965).

CONCLUSIONS

Although the Poropotank River system quantitatively appeared to be a salt marsh, description of the whole area as a salt marsh was found to be inadequate because four different marsh types are clearly apparent. These are the fresh water marsh, the slightly brackish water marsh, the brackish water marsh, and the salt water marsh; as determined by field observation, analysis of importance values, community associations, and species composition. Moreover, the proposed groupings overlap as would be expected in a continuum.

The dominant plants found in the fresh water marsh and and slightly brackish water marsh did not appear to be important to the total system because of the relatively small acreage occupied by these plant types. Functionally, however, these species were of paramount importance at the community level of organization. Seven species of phanerogams obtained in sampling were confined to the fresh water marsh, while other plants were distributed in two or more marsh types. Furthermore, it was not uncommon to find the same species as a dominant in more than one community or marsh type, or in more than one community within the same marsh type.

Comparing my fresh water marsh classification with those proposed by other authors, the present grouping compares closely with the classical work of Weaver and Clements

(1938). The fresh water marsh community structure is also similar to that of the (shallow and deep fresh) coastal marshes as described by Martin, et al. (1953). The main differences between my classification and those of others was the inclusion of S. alterniflora in the fresh water marsh and the designation of the P. virginica community as the emergent transitional stage. An analogous community in the slightly brackish water marshes (i. e. at Back Bay, Virginia or Currituck Sound, North Carolina) would be the Pontederia cordata L. seral stage. Weaver and Clements (1938) did not distinguish an intermediate community between the floating aquatic stage (i. e. Potamogeton natans L.) and the reed-swamp stage (i. e. Z. aquatica or Scirpus validus Vahl.). Martin, et al. (1953) consider P. virginica as a member of the shallow fresh water marsh; however, it appears, from the results of my study, that this species is more typical of the deep fresh marshes of the same authors. The present classification is also similar to the Type I marsh (cattail-aquatic type) of Nicholson and VanDeusen (1953).

Comparing the slightly brackish water marsh with the marsh classification proposed by other authors, my grouping compares favorably with the Type II (slightly brackish water) marsh of Nicholson and VanDeusen (1953) in that several of the plant species shared are similar. However, my classification differs in that the saltmeadow cordgrass is not included in the present marsh type. Nicholson and VanDeusen (1953) state that the Type II marsh is similar to their Type I marsh, but includes species characteristic of more brackish water areas, such as _D. spicata_ and _S. patens_. They also state that _S. alterniflora_ occurs frequently along oreek banks and is often found scattered in the low areas of the marsh. In my own classification, _S. alterniflora_ was characteristic of the creek banks and was, not scattered but was rather evenly dispersed, and the most widely distributed plant in the marsh type. The slightly brackish water marsh has not previously been described by other wetland ecologists and appears to be exclusive to the estuarine systems of the Middle Atlantic Bight. Dr. Arthur W. Cooper (personal communic.) states that this marsh type does not exist along the Outer Banks of North Carolina, nor has it been described in the literature from studies conducted in other states.

Comparison of the brackish water marsh classification with that proposed by others showed a similarity with the Type II marsh of Nicholson and VanDeusen (1953); however, the present grouping contains not only typical brackish water species but also contains plants typical of the salt water marsh. Furthermore, although salt marsh plants were frequently obtained in the brackish water marsh, their importance values were low (Table 9). In addition, these species are also characteristic of the higher usually less saline reaches of the salt marshes along the western shore of the Chesapeake Bay.

The salt water marsh classification proposed here is similar to the classifications proposed by several authors. I found that the present grouping compares favorably with the Type VI marsh (saltmarsh type - S. alterniflora dominant) of Nicholson and VanDeusen (1953). Similarity exists particularly in the lower reaches of the marsh, while the higher reaches of the marsh (Fig. 10) are more similar to the Type V marsh (needlerush - saltmeadow type) of the same authors. This category is also similar to that proposed by Brown (1959) in North Carolina, the dominant plants being the same; but, differences occurring in community structure.

The classification of marsh types used indicates greater affinity with the classifications of marshes to the north of the Chesapeake Bay than to the south. This is well evidenced by comparing the results of the present study with the results of Miller and Egler (1950), Nicholson and VanDeusen (1953) and Martin (1959) on the north Atlantic coastal plain, and Wells (1928), Penfound (1952), Kurz and Wagner (1957), Brown (1959), and Adams (1963) on the south Atlantic coastal plain. Dominant plants within the salt marshes along the entire Atlantic Coast and Gulf of Mexico are the same or closely related species, but significant differences exist in community structure (i. e. species associations) in salt marshes bordering estuaries at different latitudinal sites. The northern affinity, exhibited by the flora of the salt marshes of the western shore of Chesapeake Bay, has previously been suggested by Kerwin and Pedigo (1965).

It is apparent that the distribution of *S. alterniflora* in the tidal river systems of the western Chesapeake Bay region is not governed by the presence or absence of brackish water, but rather the distribution is a manifestation of the inherent ability of the species to become established and to compete successfully with marsh plants growing in fresh water. Beal, *et al*. (1962) have been able to grow *S. alterniflora* in the laboratory under fresh water conditions, thus lending some evidence to support the above hypothesis.

SUMMARY

1. The results obtained by employing a random quadrat sampling plan revealed that the Poropotank River tidal marsh system could be classified into four marsh types. These are designated as the fresh water marsh, the slightly brackish water marsh, the brackish water marsh, and the salt water marsh.

2. Dominant species recorded from within the fresh water marsh were respectively Z. aquatica, S. alterniflora, H. autumnale, and E. quadrangulata. The dominant community within this marsh type was Z. aquatica - E. quadrangulata, or the deep reed-swamp stage. Indicator species used in the classification were Z. aquatica, P. virginica, H. autumnale, and E. quadrangulata. The mean range in salinity of the waters adjacent to the marsh was 0.33-0.79°/oo.

3. Dominant plants obtained from within the slightly brackish water marsh were respectively S. alterniflora, and P. punctatum. The dominant community within this marsh type was the S. alterniflora - E. walteri stage, or the cordgrass-wild millet community. Indicator species used in the classification were P. punctatum and E. walteri. The mean range in salinity of the river waters adjoining the marsh was 0.79-4.11°/oo.

4. Dominant plants recorded from within the brackish water marsh were respectively S. alterniflora, S. cynosuroides, S. patens, and S. robustus. The dominant community in this marsh type was the S. alterniflora - S. robustus stage, or the cordgrass-bulrush community. Indicator species used in the classification of this marsh were S. cynosuroides, S. robustus, S. olneyi, P. purpurascens, A. cannabina, and L. chinensis. The mean range in salinity of the waters adjacent to the marsh was 4.11-9.38$^{o}/_{oo}$.

5. Dominant plant species obtained from sampling within the salt water marsh were respectively S. alterniflora, S. patens, D. spicata, S. robustus, and J. roemerianus. The dominant community recorded in the marsh type was the S. alterniflora low meadow. Indicator species used were S. alterniflora, S. patens, D. spicata, J. roemerianus, F. castanea, and I. frutescens. The mean range in salinity of the waters adjacent to the marsh was 9.38-14.72$^{o}/_{oo}$.

6. Although several marsh types existed within the river system, it may be stated that the marshes of the Poropotank River are functionally a salt water marsh or an S. alterniflora multi-species association. Dominant plants for the entire system were respectively S. alterniflora, S. patens, D. spicata, S. robustus, S. cynosuroides, and J. roemerianus.

7. The saltmarsh cordgrass, S. alterniflora, occurred as a dominant plant in at least one community of each of the

four marsh types. It appears that the distribution of this species is not governed by the degree of salinity; rather its distribution is a manifestation of an ability to become established and compete successfully with other plants growing in fresh water.

8. Community associations within each of the four marsh types revealed the presence of 4 communities in the fresh water marsh, 5 communities in the slightly brackish water marsh, 5 communities in the brackish water marsh, and 4 communities in the salt water marsh.

9. The results of the present study show that the marshes of the Poropotank River exhibit greater affinity with marshes found to the north of the Chesapeake Bay than to those marshes situated to the south. Conspicuous differences appear in specific associations of the dominant plants at the community level of organization.

APPENDIX

TABLE A . SALINITY-TEMPERATURE DATA - VIRGINIA INSTITUTE OF MARINE SCIENCE BAY-RIVER CRUISES - STATION Y-20 (N. LAT 37°26' BY W. LONG 76°42') - MEANS FOR AUGUST THROUGH OCTOBER, 1956-1963

Year	Temperature °C Surface	Temperature °C Bottom	Salinity ‰ Surface	Salinity ‰ Bottom
1956	22.2	22.1	16.0	17.5
1957	21.7	22.1	16.9	18.6
1958	23.9	22.9	15.1	17.3
1959	26.1	26.1	15.9	17.8
1960	-			
1961	23.4	22.7	15.4	16.4
*1962	23.1	23.1	15.7	16.6
1963	-	-	**18.4	***20.2
Mean Value :	23.4	23.2	16.2	17.8

* September - October

** August - September

*** September

TABLE B . FLORAL CHECKLIST, POROPOTANK RIVER SYSTEM - FALL, 1964.

Family	Genus - Species	Common Name
	Submerged Aquatics	
Zosteraceae	*Potamogeton pectinatus* L.	Sago Pondweed
"	*Ruppia maritima* L.	*Wigeongrass
Najadaceae	*Najas guadalupensis* (Spreng.) Magnus	*Southern Naiad
Hydrocharitaceae	*Elodea canadensis* Michx.	Waterweed
"	*Vallisneria americana* Michx.	Wild-celery
Ceratophyllaceae	*Ceratophyllum demersum* L.	Hornwort
	Emergent Plants	
Typhaceae	*Typha latifolia* L.	Common Cat-tail
"	*T. angustifolia* L.	Narrow-leaf Cat-tail
Alismataceae	*Sagittaria latifolia* Willd.	Duck-potato
Gramineae	*Distichlis spicata* (L.) Greene	Marsh Spike-grass
"	*Phragmites communis* Trin.	Reed Grass
"	*Cinna arundinacea* L.	Wood Reed-grass
"	*Spartina cynosuroides* (L.) Roth	Salt Reed-grass
"	*S. alterniflora* Loisel.	Salt-water Cord-grass
"	*S. patens* (Ait.) Muhl.	Salt-meadow Grass
"	*Leersia oryzoides* (L.) Sw.	Rice-Cutgrass
"	*Zizania aquatica* L.	Wild Rice
"	*Panicum* sp.	Panic-Grass
"	*Echinochloa walteri* (Pursh) Nash	*Wild Millet
"	*Setaria* sp.	Bristly Foxtail
"	Unidentified Gramineae	Grass
Cyperaceae	*Cyperus strigosus* Britt.	Cyperus (Sedge)
"	*Eleocharis quadrangulata* (Michx) R.&S.	*Squarestem Spikerush

(Continued)

TABLE B . (CONTINUED)

Family	Genus - Species	Common Name
	Emergent Plants	
Cyperaceae	Eleocharis parvula (R. & S.) Link	*Dwarf Spikerush
"	Fimbristylis castanea (Michx) Vahl	Fimbristylis
"	Scirpus americanus Pers.	Three-square
"	S. olneyi Gray	*Olney's Three-square
"	S. validus Vahl	Soft-stem Bulrush
"	S. robustus Pursh	Saltmarsh Bulrush
"	Rhynchospora sp.	Beak-rush
"	Carex sp.	Sedge
Araceae	Peltandra virginica (L.) S. & E.	Arrow-Arum
Pontederiaceae	Pontederia cordata L.	Pickerelweed
Juncaceae	Juncus roemerianus Scheele	*Needlerush
Polygonaceae	Rumex verticillatus L.	Swamp-Dock
"	Polygonum punctatum Ell.	Water-Smartweed
Amaranthaceae	Acnida cannabina L.	Water-Hemp
Phytolaccaceae	Phytolacca americana L.	Pokeweed
Malvaceae	Kosteletzkya virginica (L.) Presl	Seashore-Mallow
"	Hibiscus sp.	Rose-Mallow
Lythraceae	Lythrum lineare L.	Loosestrife
Umbelliferae	Hydrocotyle sp.	Water-Pennywort
"	Sium suave Walt.	Water-parsnip
"	Lilaeopsis chinensis (L.) Ktze.	Lilaeopsis
Asclepiadaceae	Asclepias incarnata DC.	Swamp Milkweed
Scrophulariaceae	Unidentified Scrophulariaceae	Figwort
Rubiaceae	Hedyotis boscii DC.	Madder
Campanulaceae	Lobelia cardinalis L.	Cardinal-flower
Compositae	Erigeron canadensis L.	Butter-weed
"	Baccharis halimifolia L.	Groundsel-tree

(Continued)

TABLE B . (CONTINUED)

Family	Genus - Species	Common Name
	Emergent Plants	
Compositae	Pluchea purpurascens (Sw.) DC.	Marsh-Fleabane
"	Iva frutescens L.	Marsh-Elder
"	Borrichia frutescens (L.) DC.	Sea-Ox-eye
"	Helenium autumnale L.	Sneezeweed
"	Unidentified Compositae	Composite
	Common Marsh Border and Woodland Plants	
Pinaceae	Pinus taeda L.	Loblolly Pine
"	P. virginiana Mill.	Poverty-Pine
"	Juniperus virginiana L.	Red Cedar
Gramineae	Panicum virgatum L.	Switchgrass
"	Andropogon virginicus L.	Broom-sedge
"	Unidentified Gramineae	Grass
Liliaceae	Smilax sp.	Greenbrier
Myricaceae	Myrica pensylvanica Loisel.	Bayberry
"	M. cerifera L.	Wax-Myrtle
Fagaceae	Fagus grandifolia Ehrh.	Beech
"	Quercus alba L.	White Oak
"	Q. rubra L.	Red Oak
Rosaceae	Rubus sp.	Bramble
"	Rosa palustris Marsh.	*Swamp Rose
Anacardiaceae	Rhus radicans L.	Poison Ivy
Aquifoliaceae	Ilex opaca Ait.	American Holly
Aceraceae	Acer rubrum L.	Swamp-Maple

(Continued)

TABLE B . (CONTINUED)

Family	Genus - Species	Common Name
	Common Marsh Border and Woodland Plants	
Cactaceae	*Opuntia humifusa* Raf.	Prickly Pear
Cornaceae	*Cornus amomum* Mill.	Red Willow
"	*C. florida* L.	Flowering Dogwood
Ericaceae	*Kalmia latifolia* L.	Mountain-Laurel
Rubiaceae	*Cephalanthus occidentalis* L.	Buttonbush

*Common names from : Hotchkiss, N. 1950.

TABLE C . TOTAL MARSH COVERAGE BY STRATA INCLUDING EACH HABITAT LEVEL, ACREAGE, AND BARREN GROUND

Habitat Level (Community)	Per Cent Stratum	Total Acreage	Mean Per Cent Coverage	Acreage Coverage	Mean Per Cent Barren	Acreage Barren
Semi-floating Marsh Stage	20.0	8.72	52.5	4.58	47.5	4.14
Low Reed-swamp Stage	40.0	17.44	83.8	14.61	16.2	2.83
Mid-levee Marsh	30.0	13.08	60.0	7.85	40.0	5.23
High Reed-swamp Stage	10.0	4.36	65.0	2.83	35.0	1.53
Total Stratum I :	100.0	43.6	68.5	29.87	31.5	13.73
Edge Marsh	10.0	5.80	45.0	2.61	55.0	3.19
Edge-levee Marsh	10.0	5.80	70.0	4.06	30.0	1.74
Low-levee Marsh	10.0	5.80	95.0	5.51	5.0	0.32
Mid-levee Marsh	60.0	34.80	62.5	21.75	37.5	13.05
*High Reed-swamp Stage	10.0	5.80	45.0	2.61	55.0	3.19
Total Stratum II :	100.0	58.0	63.0	36.54	37.0	21.49
Edge Marsh	13.3	14.56	82.5	12.01	17.5	2.53
Edge-levee Marsh	26.7	29.12	93.8	27.31	6.2	1.81
Low-levee Marsh	33.3	36.40	69.0	25.12	31.0	11.28
Mid-levee Marsh	13.3	14.56	77.5	11.28	22.5	3.28
High-levee Marsh	6.7	7.28	50.0	3.64	50.0	3.64
*High Reed-swamp Stage	6.7	7.28	80.0	5.82	20.0	1.46
Total Stratum III :	100.0	109.2	78.0	85.18	22.0	24.02

(Continued)

TABLE C . (CONTINUED)

Habitat Level (Community)	Per Cent Stratum	Total Acreage	Mean Per Cent Coverage	Acreage Coverage	Mean Per Cent Barren	Acreage Barren
Edge Marsh	15.0	13.37	65.0	8.69	35.0	4.68
Edge-levee Marsh	25.0	22.28	67.0	14.93	33.0	7.35
Low-levee Marsh	45.0	40.10	65.6	26.31	34.4	13.79
Salt-grass Meadow	10.0	8.91	95.0	8.46	5.0	0.45
High Meadow Marsh	5.0	4.46	95.0	4.24	5.0	0.22
Total Stratum IV :	100.0	89.1	70.3	62.64	29.7	26.49
Wooded Islands :		14.1				
Edge Marsh	20.0	76.40	50.6	38.66	49.4	37.74
Edge-levee Marsh	5.0	19.10	55.0	10.51	45.0	8.60
Low Meadow Marsh	37.5	143.25	57.7	82.66	42.3	60.60
Salt-grass Meadow	30.0	114.60	78.3	89.73	21.7	24.87
High Meadow Marsh	5.0	19.10	77.5	14.80	22.5	4.30
*High Reed-swamp Stage	2.5	9.55	30.0	2.87	70.0	6.69
Total Stratum V :	100.0	382.0	63.1	239.23	36.9	142.80
**Edge Marsh	20.0	57.36	37.5	21.51	62.5	35.85
Low Meadow Marsh	36.7	105.17	56.4	59.32	43.6	45.85
Salt-grass Meadow	36.7	105.17	85.9	90.34	14.1	14.83
High Meadow Marsh	6.7	19.13	95.0	18.17	5.0	0.96
Total Stratum VI :	100.0	286.8	66.0	189.34	34.0	97.49
Wooded Islands :		17.2				
Grand Totals : (Marsh)		968.7	66.5	644.56	33.5	324.14
(Wooded Islands)		31.3				

* Adjacent woods edge.
** Includes Edge-levee Marsh Community.

TABLE D . ACRES COVERAGE BY EACH SPECIES PER STRATUM - FALL, 1964

Species	I	II	III	IV	V	VI	Total
E. quadrangulata	1.31						1.31
H. autumnale	1.74						1.74
Unid. Gramineae	Tr.						Tr.
S. suave	Tr.						Tr.
A. incarnata	0.44						0.44
C. strigosus	Tr.						Tr.
C. arundinacea	Tr.						Tr.
P. virginica	3.49	1.16					4.65
Z. aquatica	15.70	1.16					16.86
E. walteri	0.44	2.90					3.34
P. punctatum	Tr.	0.58	1.09				1.67
S. olneyi	3.05	*	Tr.				3.05
T. angustifolia	*	2.32	2.18				4.50
P. purpurascens		Tr.	Tr.	Tr.	Tr.		Tr.
S. cynosuroides		4.06	29.48	13.37	3.82		50.73
L. oryzoides			Tr.				Tr.
L. lineare			2.18				2.18
S. robustus			4.37	2.67	15.28	5.74	28.06
A. cannabina			Tr.	Tr.	Tr.	Tr.	Tr.
L. chinensis			Tr.	*	Tr.	Tr.	Tr.
D. spicata			Tr.	2.67	30.56	25.81	59.04
S. patens			Tr.	8.02	49.66	60.23	117.91
B. frutescens				Tr.			Tr.
B. halimifolia				Tr.	Tr.		Tr.
F. castanea				Tr.	Tr.	Tr.	Tr.
J. roemerianus				0.89	19.10	17.21	37.20
I. frutescens				1.78	Tr.	Tr.	1.78
H. boscii					Tr.		Tr.
E. parvula					*Tr.		*Tr.
S. alterniflora	4.80	24.94	45.86	33.86	118.42	80.30	308.18

* Artifact of sampling.

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