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Plant Diversity Along a Salinity Gradient of Four Marshes on the York and Pamunkey Rivers in Virginia

JAMES E. PERRY[1] and ROBERT B. ATKINSON[2]

[1] Department of Resource Management and Policy, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia 23062;
[2] Christopher Newport University, Department of Biology, Chemistry, and Environmental Science, Newport News, Virginia 23606-2998

ABSTRACT

Diversity of emergent wetland plant species was measured in four tidal marshes on the York and Pamunkey Rivers, Virginia. Each marsh represented a different salinity regime (polyhaline, mesohaline, oligohaline, or tidal freshwater). The tidal freshwater marsh had the highest species diversity index of the sites. However, the next highest diversity index was seen in the marsh with the highest salinity, possibly due to an obligate halophytic component absent from the other sample plots. Facultative halophytes dominated the polyhaline, mesohaline, and oligohaline marshes. No similarity existed between the dominant flora of the tidal freshwater marsh and that of the other three marshes.

INTRODUCTION

Floristic and vegetative studies on tidal marshes of the Patuxent River (Anderson et al. 1968), York River (Wass and Wright 1969), and James River (Atkinson et al. 1990) of the Chesapeake Bay, have shown that as salinity decreases, the number of species found in a marsh increases. Odum et al. (1984) described the change in dominant plant communities of the Atlantic east coast along salinity gradients. They noted a large increase in species diversity of tidal freshwater marshes over their polyhaline and mesohaline counterparts (Odum et al. 1984). Mitchell (1991) and Hershner et al. (1991) documented the transition of dominant plant composition along an oligohaline and freshwater salinity gradient on the Mattaponi River, Virginia. However, these studies did not measure or quantify plant species diversity parameters along the salinity gradient.

The establishment of the York River component of the Chesapeake Bay National Estuarine Research Reserve in Virginia (CBNERRVA) has provided the opportunity for such a study in the Chesapeake Bay. The York River sites represent complete ecological units (i.e., contiguous aquatic, wetland, and terrestrial zones) along the salinity gradient of the York River (U.S. Department of Commerce 1991). The purpose of this study was to quantify plant species diversity of tidal emergent wetlands of the CBNERRVA sites. Data collected from permanent transects provides a description of the marsh vegetation communities and baseline data for future quantifying and monitoring of temporal-spatial changes within the CBNERRVA sites.

SITE DESCRIPTION

Four sites comprise the York River component of the Chesapeake Bay National Estuarine Research Reserve in Virginia (CBNERRVA) (Figure 1). Each site is located within a different salinity regime but with the same semi-diurnal tides (range of approximately one meter) (Brooks 1983, U.S. Department of Commerce 1991).

High salinity conditions (polyhaline) are found at the Goodwin Islands site; mesohaline conditions at the Catlett Islands site; oligohaline conditions at Taskinas Creek site; and tidal freshwater conditions at Sweet Hall Marsh, located on the Pamunkey River, a major tributary

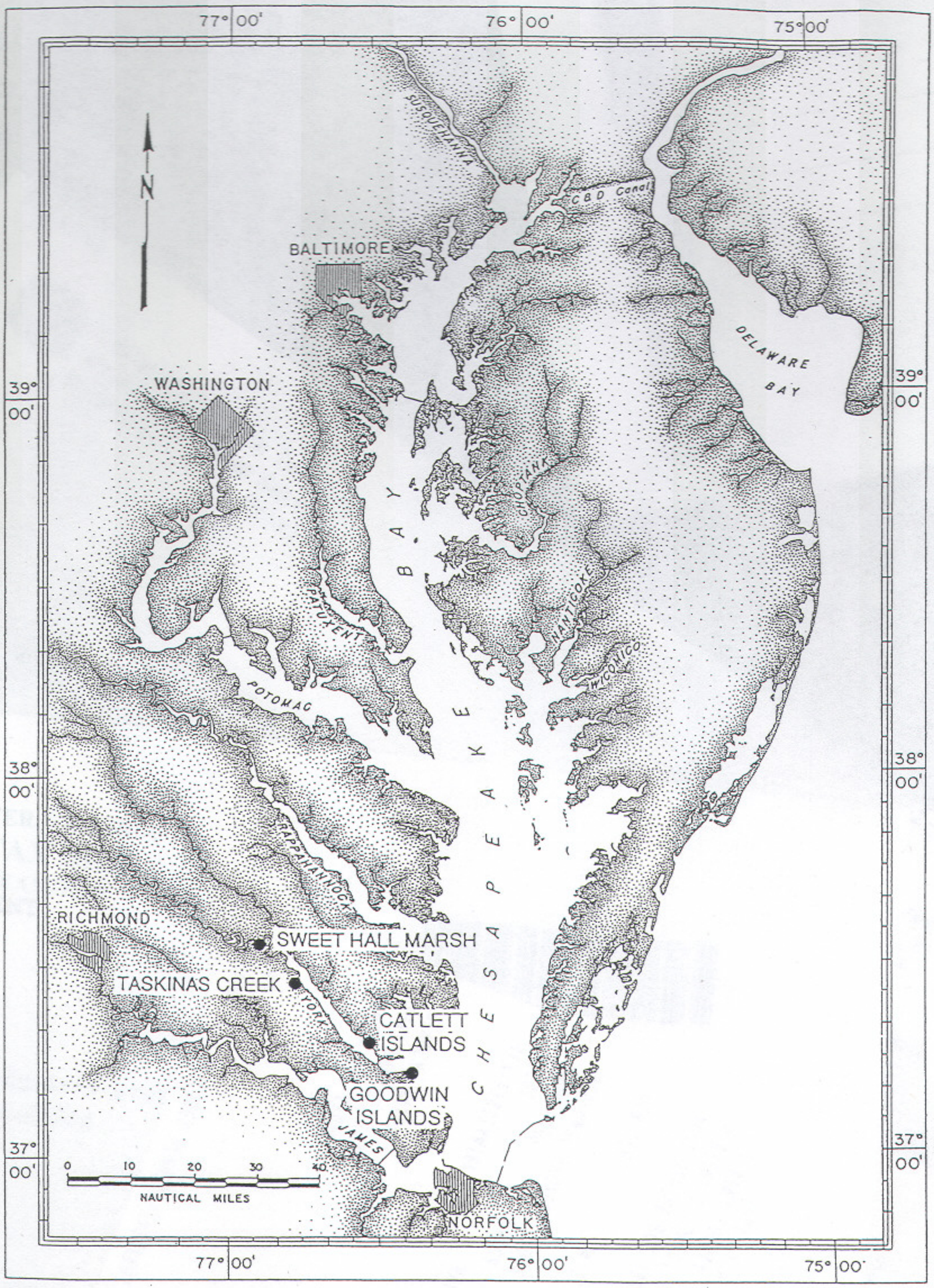

Figure 1. Location of CB-NERRSVA sites on the York and Pamunkey Rivers. Salinity is highest at Goodwin Islands site and decreases to near zero at Sweet Hall Marsh.

Table 1. Physical description of York River component CBNERRVA sites. Tide range was approximately the same at each site (1.0–1.1 m)

Site	Total Size (hectares)	Marsh Size (hectares)	Distance Upstream (km)	Salinity Range (ppt)
Goodwin Islands	154.5	111.7	0.0	18.0–22.0
Catlett Islands	168.4	84.2	35.2	8.0–18.0
Taskinas Creek	210.7	33.6	44.4	0.5–8.0
Sweet Hall Marsh	444.0	385.0	83.3	0.0–5.0

of the York River (Table 1). The marsh vegetation of Sweet Hall Marsh was dominated by mixed broad leaved herbaceous and graminoid wetland species and the vegetation of the other three sites by graminoid wetland species.

METHODS

Vegetation communities within each site were visually identified by signatures on recent aerial photographs and verified in the field by observation of marked changes in dominant species. Two distinct salt marsh communities, one high and one low marsh, occurred at Goodwin Island, Catlett Island, and Taskinas Creek. Four distinct fresh water communities, three low and one high marsh occurred at Sweet Hall Marsh (U.S. Department of Commerce 1991). A minimum of one transect per community was established perpendicular to the shoreline with quadrats located at 10 meter intervals along the transects. Transects terminated at the upland boundary of the site or where open water was encountered. In most cases the transects crossed both low and high marsh communities. For these transects a species area curve was constructed to provide an adequate number of plots for each community. If a physical barrier (e.g., upland edge or a large creek) or a different vegetation community was encountered prior to smoothing out of the curve, more transects were added. Total number of transects established at each site were: Goodwin Island (4); Catlett Islands (3); Taskinas Creek (3); and Sweet Hall Marsh (5).

Species cover estimates were collected from 1 m × 1 m plots arranged at ten meter intervals along the transects. Cover data recorded in the field was converted to mid-class ranges (Mueller-Dombois and Ellenberg 1974) for data analysis. Frequency was calculated from the cover data. Density counts were made in 1/4m × 1/4m plots systematically arranged in one corner of the 1 m × 1 m cover plots. The adequacy of sample size was tested with a running mean analysis for each site (Mueller-Dombois and Ellenberg 1974). Relative frequency, relative density, and relative dominance were calculated for each species. Species importance values (IV), the sum of the above three parameters (Curtis and McIntosh 1950, Phillips 1959, Mueller-Dombois and Ellenberg 1974), were used to determine the dominant species at each site. Species diversity for each site was calculated using the Shannon index (Shannon and Weaver 1949). All site data were collected between August 10 and 14, 1990. Plant nomenclature follows Gleason and Cronquist (1991). Voucher specimens are deposited in the Virginia Institute of Marine Science Teaching Herbarium.

RESULTS

The Shannon's Diversity Index showed the site with the lowest salinity, Sweet Hall Marsh, had the highest diversity of the four sites. Goodwin Islands, with the highest salinity and a large number of obligate halophytes, was second, Taskinas Creek third, and finally, Catlett Islands (Table 2).

Goodwin Islands: *Distichlis spicata* had the highest IV, followed closely by *Spartina alterniflora*. *Aster tenuifolius, Borrichia frutescens, Limonium carolinianum, Salicornia virginica,* and *Suaeda linearis,* all obligate halophytes, were unique to the Goodwin Islands transects. The dominant species of the site are given in Table 2. A total of eleven vascular plant species

Table 2. Dominant species and Shannon's diversity index for each site. Dominance is defined as the sum of Relative Importance Values (RIV) of species, when ranked in descending order, that total greater than 50%. RIV is calculated by dividing the individual species IV by the sum of all IV's for that site

Site Dominant Species	% Total RIV
Goodwin Islands	
Distichlis spicata	33.5
Spartina alterniflora	32.0
Total % of dominant species: 65.5	
Shannon's Diversity Index: 0.668	
Catlett Islands	
Spartina alterniflora	48.0
Distichlis spicata	30.7
Total % of dominant species: 78.7	
Shannon's Diversity Index: 0.542	
Taskinas Creek	
Spartina patens	48.0
Distichlis spicata	30.7
Total % of dominant species: 70.5	
Shannon's Diversity Index: 0.647	
Sweet Hall Marsh	
Peltandra virginica	18.3
Carex stricta	9.8
Leersia oryzoides	8.8
Polygonum punctatum	6.9
Polygonum arifolium	6.7
Total % of dominant species: 50.4	
Shannon's Diversity Index: 1.351	

occurred in the vegetation transects of Goodwin Islands (Table 3). All are considered salt tolerant.

Catlett Islands: *Spartina alterniflora* had the highest IV followed by *Distichlis spicata, Spartina patens,* and *Juncus roemerianus*. Dominant species at this site were the same as those of Goodwin Islands (Table 2). Six species occurred in the vegetation transects of Catlett Islands (Table 3). All are considered salt tolerant.

Taskinas Creek: *Spartina patens* had the highest IV followed by *Distichlis spicata, Spartina alterniflora, Spartina cynosuroides,* and *Scirpus* spp.. *Spartina patens* and *D. spicata* were the dominant species of the site (Table 2). Ten species occurred on the Taskinas Creek transects (Table 3).

Sweet Hall Marsh: Fifty-six species occurred in the vegetation transects of Sweet Hall Marsh (Table 4). Salt tolerant species were poorly represented, fresh water species were common. Dominant species where *Peltandra virginica, Carex stricta, Leersia oryzoides, Polygonum punctatum,* and *P. arifolium* (Table 2).

DISCUSSION

It has been stated that plant species diversity increases upstream in an estuary as the salinity decreases (Anderson et al. 1968, Wass and Wright 1969, Odum et al. 1984). Results from this study support that hypothesis and noted that small variation in species diversity occurred between marshes with polyhaline to oligohaline salinity.

The tidal marsh communities of the York and Pamunkey Rivers can be separated into

Table 3. Importance Values (IV) of macrophytes for Goodwin Islands, Catlett Islands, and Taskinas Creek, 1990, listed in alphabetical order (* denotes dominant species, – marks species that were not present in transects on that site)

Species	Goodwin Islands	Catlett Islands	Taskinas Creek
Aster tenuifolius	3.99	–	–
Atriplex patula	–	5.79	–
Borrichia frutescens	0.78	–	–
Distichlis spicata	100.52*	92.18*	76.84*
Fimbristylis caroliniana	1.62	1.91	–
Hibiscus moscheutos	–	–	1.45
Iva frutescens	2.34	–	1.47
Juncus roemerianus	–	15.56	–
Kosteletzkya virginica	–	–	1.08
Limonium carolinianum	11.72	–	–
Scirpus pungens	–	–	10.09
Scirpus robustus	1.95	–	11.58
Spartina alterniflora	95.98*	144.01*	37.25
Spartina cynosauroides	–	–	25.63
Spartina patens	59.82	40.55	134.60*
Suaeda linearis	0.02	–	–

Table 4. Importance Values (IV) of macrophytes for Sweet Hall Marsh, 1990, listed in descending order

Species	IV	Species	IV
1. *Peltandra virginica*	54.58	29. *Galium obtusum*	1.80
2. *Carex stricta*	29.49	30. *Scirpus pungens*	1.73
3. *Leersia oryzoides*	26.49	31. *Saururus cernuus*	1.67
4. *Polygonum punctatum*	20.64	32. *Kosteletzkya virginica*	1.62
5. *Polygonum arifolium*	20.17	33. *Bidens coronata*	1.30
6. *Murdannia keisak*	17.92	34. *Mikania scandens*	1.13
7. *Osmunda regalis*	20.64	35. *Hypericum virginicum*	1.11
8. *Thelypteris palustris*	20.17	36. *Panicum virgatum*	0.84
9. *Spartina cynosuroides*	8.23	37. *Calystegia sepium*	0.87
10. *Pontederia cordata*	8.08	38. *Aster vimineus*	0.69
11. *Hibiscus moscheutos*	8.03	39. *Decodon verticillatus*	0.65
12. *Eleocharis fallax*	7.09	40. *Viburnum dentatum*	0.59
13. *Bidens laevis*	6.15	41. *Teucrium canadense*	0.58
14. *Woodwardia areolata*	5.98	42. *Amaranthus cannabinus*	0.54
15. *Impatiens capensis*	5.22	43. *Cyperus erythrorhizos*	0.54
16. *Carex hyalinolepis*	5.07	44. *Lobelia cardinalis*	0.54
17. *Polygonum sagittatum*	4.87	45. *Lonicera japonica*	0.39
18. *Zizania aquatica*	3.85	46. *Sium suave*	0.36
19. *Pluchea odorata*	3.62	47. *Eleocharis obtusa*	0.36
20. *Boehmeria cylindrica*	3.41	48. *Vernonia noveboracensis*	0.33
21. *Ludwigia palustris*	3.04	49. *Scirpus validus*	0.22
22. *Typha angustifolia*	2.72	50. *Cyperus esculentus*	0.21
23. *Sagittaria latifolia*	2.00	51. *Rosa palustris*	0.19
24. *Phragmites australis*	2.00	52. *Asclepias incarnata*	0.18
25. *Apios americana*	1.96	53. *Hypericum* spp.	0.18
26. *Iris virginica*	1.95	54. *Dicanthelium scoparium*	0.18
27. *Nuphar luteum*	1.88	55. *Rumex verticillatus*	0.18
28. *Echinochloa walteri*	1.85	56. *Thalictrum pubescens*	0.18

three divisions: halophytic (consisting of obligate and facultative halophytes), brackish (consisting of facultative halophytes), and freshwater (consisting of glycophytes) (Wass and Wright 1969, Hershner et al. 1991, Mitchell 1991). The most saline of the sites sampled in this study, Goodwin Islands, has the second highest plant species diversity index. This may be due in part to the presence of both obligate halophytes such as *Borrichia frutescens, Limonium carolinianum, Salicornia virginica,* and *Suaeda linearis,* and facultative species such as *Spartina alterniflora, Distichlis spicata,* and *Spartina patens*. Obligate halophytes were absent or occurred in only very small numbers on the other sites. The salinity of Catlett Islands and Taskinas Creek could exclude freshwater species that were found in Sweet Hall Marsh. Since Catlett Islands and Taskinas Creek were dominated by facultative halophytes, with few obligate halophytes, species diversities here were slightly lower than the more saline Goodwin Island site.

Baseline vegetation data established by this work, with the addition of repeated data from the same transects over the following years, can be used to quantify any temporal-spatial vegetation dynamics occurring in the CBNERRVA marshes. These studies could examine changes in diversity during a single growing season and from year to year. Similar studies in other estuarine systems and research to determine salinity and tidal inundation tolerances of individual species, as well as the effects of inter-specific competition on diversity in these salinity regimes are badly needed.

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