critical levels of suspended sediment above which the plant will not exist.

Ruppia maritima has also been shown to be sensitive to increased water temperatures, particularly at the time of new growth from rhizomes (11). This plant has been observed to decline significantly around the effluent of a steam electric generating station (12).

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RICHARD R. ANDERSON
Department of Biology
The American University
Washington, D.C. 20016

Emergent Vascular Plants of Chesapeake Bay Wetlands

Present Status of Taxonomical Knowledge

The taxonomic status of both wetland and upland vascular plants in the northeastern United States has been well defined and worked over. Contemporary nomenclature and organization of the species are presented in two comprehensive identification manuals (1, 2). Hitchcock (3) gives an excellent coverage of the grasses, including a list of their taxonomic synonyms. Herbaria which include wetland plants of the Chesapeake Bay are available at the Smithsonian Institution, the University of Maryland, and the College of William and Mary. An ongoing review of the flora of Virginia is now stimulating additional field collections from Virginia wetlands. Common names have been coined for most of the vascular plants in the northeastern U.S., but an attempt to standardize these names (4) is not yet universally accepted.

Present Status of Knowledge About the Distribution and Abundance of the Group

To my knowledge the wetland vegetation of the Chesapeake Bay has not yet been surveyed comprehensively enough for construction of distribution maps of individual species or plant community types. Ecological studies at scattered points around the Bay have provided some data on relative abundances at the study sites. Most of these studies are cited by Wass & Wright (5) and by Wass (6).

Two annotated checklists have recently been compiled for vascular plants of the Chesapeake Bay and areas potentially subject to flooding by it (6, 7). The Univ. Md. list of 421 species covers all land areas within the high tide limits of the Bay and its tributaries, both in Maryland and Virginia. The VIMS list of 435 species is restricted to Virginia (including the barrier islands of the Atlantic seashore) and the

Patuxent River estuary in Maryland. Both lists include the flora of salt and brackish marshes, beaches, and freshwater swamps. The VIMS list also covers ponds and floodplains on tidal creeks, and shores subject to storm wave inundation. Each list contains many species not found in the other, so together they probably comprise a fairly complete flora of Chesapeake Bay wetlands. However, more field work will be needed to assure a comprehensive flora. For example, an intensive floristic survey at Rhode River in Anne Arundel County, Maryland (8) turned up seven species not included in the Univ. Md. list and three not included in the VIMS list.

Both lists are annotated to show the collection sites of species. The annotations in the VIMS list are more detailed and for some species indicate relative abundances. However, these annotations are insufficient to show distribution patterns of the species. Wass & Wright (5) found a dearth of floristic data on Virginia wetlands and inadequate herbaria in counties bordering the Bay. Current revision of the Flora of Virginia should improve this situation.

Descriptions of the species composition and general distribution of the major types of wetlands (salt and brackish marshes, beaches, and freshwater swamps) are given by Shreve *et al.* (9) for Maryland by G. A. Marsh (11) for Virginia. Table 1 compares the principal types of salt and brackish marsh vegetation in the two states. As salinity decreases the flora becomes more diverse and finally includes more species than Table 1 can accommodate.

Both Shreve (9) and G. A. Marsh (11) discuss beach vegetation types along the Atlantic seacoast, but only Shreve describes it within the Bay. He notes three zones of increasing diversity of species as the beach becomes higher and less subject to inundation. Limited areas of beach vegetation at Rhode River in Maryland are described by Higman (8).

Freshwater swamps, which cover large areas along the floodplains of tidal rivers in Virginia and southern Maryland, are considered by G. A. Marsh (11) to be the least known of wetland types. Shreve (9) describes two principal types of swamp—cypress and mixed hardwood. In Maryland, cypress swamps occur along the Pocomoke River in Worcester County and at Battle Creek in Calvert County. Hardwood swamps follow tidal river floodplains on both sides of the Bay. Shreve describes the composition of hardwood swamp in different locations in considerable detail. Wass & Wright (5) briefly describe the vegetation of hardwood swamps in Virginia.

Present Status of Knowledge Concerning the Biology of the Group

Little direct research into the morphology and/or physiology of wetland plants in the Chesapeake has come to the writer's attention. Esau (10) described the anatomical adaptations of several species, some of which occur in the Bay, to a halophytic environment. Shreve (9) noted the adaptations present in *Spartina alterniflora.*

Several ecological studies have been made to explain the distribution of salt marsh species and vegetation types in relation to salinity, frequency of tidal inundation, substrate preference, and other factors. The relative importance of these factors is still disputed.

Adams (12) concluded that tide-elevation factors predominate in determining the distribution of salt marsh species, and developed a formula for determining the mean elevation of occurrence for a species at any location from the range of tide. Adams also measured salinities and ion concentrations in the coastal marshes of North Carolina, where he found no major differences in salinity among the plant communities. However, his salinity data are probably inapplicable to marshes in the Chesapeake Bay, where the water is much less representative of the open sea and is strongly influenced by outflow from the Susquehanna River (Blair Kinsman, pers. comm.).

Only two recent ecological studies have been made of salt marshes in the Chesapeake Bay. Anderson *et al.* (13) correlated the distribution of 97 species with decreasing salinity along a 25-mile stretch of the Patuxent River in Maryland. In the more saline marshes, he also noted a zonation of species with increasing elevation. The second study, by Philipp & Brown (14) correlated 52 species with frequency of submergence and character of substrate at two sites which differed in salinity at South River, also in Maryland. The results of these two studies are difficult to compare directly, since Anderson worked up the gradation of species occurrence over a large area while Philipp &

TABLE 1. Salt marsh plant communities described in Maryland and Virginia

Habitat	Maryland Communities (from Shreve, 9)	Virginia Communities (from Marsh, 11)
HIGH SALINITY		
Intertidal zone (lower)	*Spartina alterniflora* dominant, often pure	Same
Intertidal zone (higher)	*Spartina alterniflora* still dominant, associated on the Eastern Shore with *Salicornia herbacea, Spergularia marina, Atriplex patula,* & *Aster tenuifolius*; on the Western Shore with *Acnida cannabina, Limonium carolinianum, Pluchea camphorata,* & *Solidago sempervirens*	*Spartina alternifloria* dominant, decreases in height as elevation rises and substrate becomes sandier. Associated species not listed.
Above mean high tide (flooded by spring tide)	*Spartina patens* & *Distichlis spicata* dominate; common associates are *Aster tenuifolius, Aster subulatus, Juncus gerardi, Gerardia maritima, Pluchea camphorata,* & *Pluchea foetida*	*Spartina patens* & *Distichlis spicata* dominate lower elevations; *Juncus roemerianus* may form nearly pure stands at higher elevations. Common associates are *Salicornia* sp., *Borrichia frutescens, Sabatia stellaris,* & *Limonium nashii*
Flooded only by storm tide	Not distinguished	*Spartina patens,* scattered *Iva frutescens* & *Baccharis halimifolia*
BRACKISH		
Intertidal zone	*Iva frutescens, Typha angustifolia, Spartina cynosuroides,* or *Scirpus olneyi* dominant; associates include *Scirpus robustus, Scirpus americanus, Zizania aquatica*	*Spartina alterniflora* dominant (moderate salinity) or *Typha angustifolia* & *Peltandra virginica* (low salinity); various assoc.
Above mean high tide	Vegetation similar to high salinity marsh, plus varied associates: *Hibiscus palustris, Eryngium virginianum, Phragmites communis,* etc. (*Juncus gerardi* & *Pluchea foetida* are absent)	Vegetation similar to high salinity marsh, plus new species: *Fimbristylis* sp., *Pluchea purpurascens, Atriplex patula, Aster tenuifolius* (*Phragmites* rare)
Flooded only by storm tide	*Baccharis halimifolia, Panicum virgatum, Cuscuta* sp., *Strophostyles umbellata,* most species of high salinity marsh	Vegetation similar to high salinity marsh, plus *Eupatorium serotinum, Cassia fasciculata, Lespedeza capitata*

Brown concentrated on the specific environments of species in only two areas. More research will be needed to determine the most important correlations between physical environment and species distribution.

Present Status of Knowledge Concerning the Role of the Group in the Bay Ecosystem

The importance of wetland vegetation, particularly that of salt marshes, to the Chesapeake Bay ecosystem is well recognized. Wass & Wright (5) discussed the productivity of Virginia salt marshes and their ecological relationships to the Bay. These relationships include the transfer of nutrients from estuarine water to plants, the trapping of sediment in the marsh, the role of plant detritus as a base material for estuarine food chains, the role of living marsh vegetation as a source of food and shelter for wildlife, and the stabilization of erosion and deposition by marshes. Wass & Wright also discussed the details of estuarine food webs which begin in the marshes.

A multi-disciplinary research program on estuarine and salt marsh ecology is now in progress at Rhode River, in Maryland. This program is conducted by the Smithsonian Institution and others, and includes studies on marsh productivity, detritus food chains, marsh vegetation types, sediment movements, and movements of phosphorus and other nutrients in marshes.

The importance of salt marsh plants to wildlife, particularly birds and muskrats, is discussed in detail by Martin *et al.*(15). Wass & Wright (5) note examples of wildlife utilization of marsh plants on the Eastern Shore of Virginia. Meanley & Webb (16) have studied the nesting ecology of the red-winged blackbird in salt marshes of the upper Chesapeake. Table 2 summarizes the examples of salt marsh utilization described in these studies.

Present Status of Knowledge Concerning the Sensitivity of the Group to Man-Induced Environmental Changes

Apart from deliberate destructive activities such as dredging and filling, wetlands are sensitive to several forms of pollution and other human disturbances. Since the distribution of many salt marsh species evidently depends to some degree upon salinity, engineering projects which alter the salinity of portions of the Bay should likewise alter the floristic composition of salt marshes in the affected areas. An increased sediment load in tidal creeks from upstream erosion, and thus a heavier deposition of sediment in marshes, should gradually induce an expansion of the marshes and a change in their micro-topography. This appears to be occurring at the mouth of a tributary of Rhode River, but no quantitative data have been taken and the biological significance is still speculative.

Teal (17) describes the vulnerability of salt marshes to pollution by heavy metal ions and

TABLE 2. Utilization of salt marsh plants by wildlife

Plant Species	Utilization: Food	Utilization: Shelter
Spartina alterniflora *Spartina cynosuroides* *Scirpus* spp. *Cyperus* spp.	Seeds eaten by ducks & shore birds (*Spartina* seeds important only to black duck). Rootstocks eaten by geese & muskrat.	Dense stands shelter many birds; stems are used for muskrat houses.
Typha angustifolia	Tubers important to geese & muskrats. Not used by ducks.	Nest cover for blackbirds & marsh wrens.
Distichlis spicata *Elocharis* spp.	Seeds & rootstocks eaten by ducks.	Nest cover for ducks, esp. shoveller & cinnamon teal.
Salicornia europaea	Branches eaten by geese, seeds by ducks.	
Acnida cannabina *Hibiscus palustris* *Juncus* spp.	Seeds eaten by ducks. Roots of *Juncus* eaten sparingly by muskrats.	*Hibiscus* used moderately by red-winged blackbirds as nest site.
Iva frutescens *Baccharis halimifolia*		Favorite nest cover of red-winged blackbird, also boat-tailed grackles.
Panicum virgatum		Moderate use by red-winged blackbird.

DDT residues, which accumulate in marshes with sediments and are ingested by marsh invertebrates. He mentions a study of the effects of DDT in Long Island salt marshes, but gives no citation. Wass & Wright (5) cite a study of the role of *Spartina alterniflora* in carrying iron, zinc, and manganese into estuarine food chains.

Pollution by sewage, whether primarily or secondarily treated, raises the level of nutrients in salt marshes. Wass & Wright (5) noted that *Spartina* spp. grows taller and has a darker green color than normal when sewage is present. During the growing season, salt marshes are able to absorb some of the excess nutrients which otherwise would create algal blooms in the estuaries. The role of the marshes as a sediment trap is being studied in the Patuxent.

Anderson (18) noted the effects of thermal pollution on two salt marsh grasses, *Spartina alterniflora* and *Phragmites communis.* Both species could tolerate temperatures up to 35°C. *Spartina* grew about twice as tall in the heated water. The balance of Anderson's study was devoted to submersed aquatic plants.

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DANIEL HIGMAN

Chesapeake Bay Center for Environmental Studies
Smithsonian Institution
Edgewater, Maryland 21037