Brackish Marsh Community

In the brackish marsh community (Figures 10 and 11) no single species typically covers more than 50% of the marsh and species diversity is much higher than the saltmarsh cordgrass community that occurs in areas of higher salinities (usually 15 to 20 ppt or higher). Typically, associated vegetation includes: saltmarsh cordgrass, saltmeadow hay, saltgrass, black needlerush, saltbushes, threesquare bulrush, big corgrasss and cattails. Small areas within the marsh may be dominated by one or more species as many are distrubted throughout the marsh according to their tolerance for both inundation and salinity. The wetland vegetation is distributed vertically from mean sea level, where saltmarsh corgrass dominates, to the upper limits of tidal inundation, where the saltbushes occur (Figure 10).

This marsh type is considered a microcosm of all the communities found in saline water and is ranked along with the Saltmarsh Cordgrass community as one of the highest valued marsh areas in Virginia because of its productivity, diversity and value as erosion, water quality control and flood buffering. Because of their location in low to moderate salinity areas many are know spawning and nursery grounds for finfish and crabs. They also are important as a valuable foraging area and habitat for a wide diversity of wildlife species.

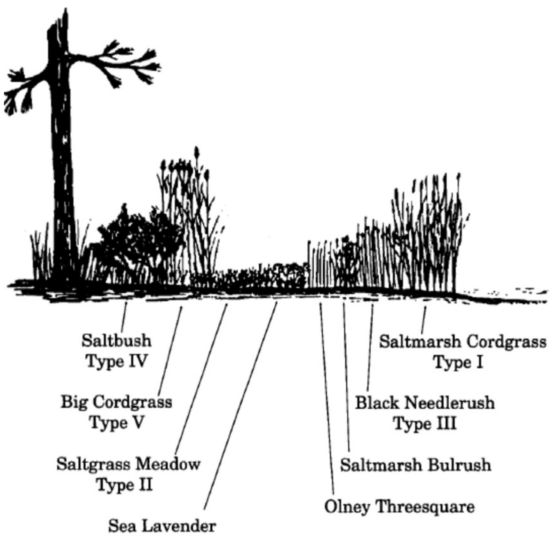

Figure 10. Brackish Water Mixed Community showing distribution of plant species from creek edge to upland. (Reproduced from VMRC 1993)

Figure 11. Brackish Water Mixed Community showing distribution of plant species from creek edge to upland. (Photo courtesy of VIMS CCRM)

Freshwater Mixed Marsh Community

In the freshwater Mixed Marsh Community (Figures 12 and 13) no single species covers more than 50% of the site and in the York River more that 50 species may be found within a single marsh. There may be both considerable temporal and spatial variability in the abundance of individual species in this marsh community type with principle factors affecting the dominance including: season,

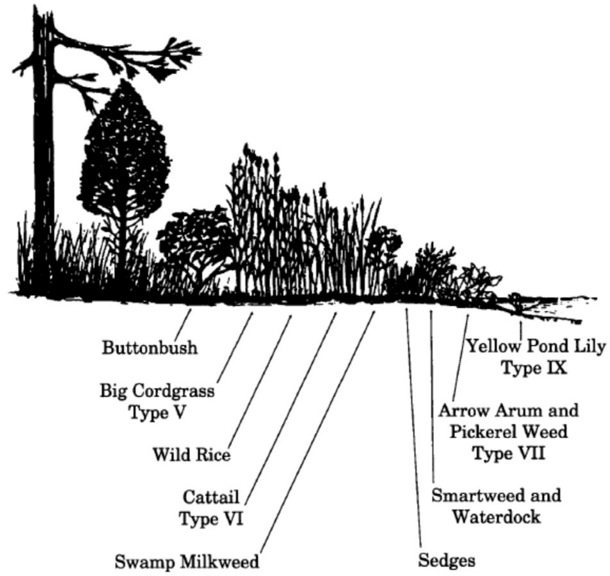

Figure 12. Freshwater Mixed Community showing distribution of plant species from creek edge to upland. (Reproduced from VMRC 1993)

Figure 13. Freshwater Mixed Community (Photo courtesy of VIMS CCRM)

elevation and salinity or conductivity of the tidal waters. Figure 10 shows a characteristic distribution of dominant species extending from the creek or river edge to the upland for freshwater marshes in this region. Here the emergent marsh extends from below low water to the upper limits of storm tidal inundation. Yellow pond lily (*Nuphar luteum*) may be found growing below low water, however its leaves and flowering shoots must extend above the usual high tide. Arrow arum (*Peltandra virginica*) and pickerel weed (*Pontederia cordata*) are dominant at low to mid tidal elevations and in the spring and early summer may dominate large areas of the marsh. During the mid to late summer an over story of wild rice (*Zizania aquatica*) and other species may develop as the early species die back. Highest elevation will support big cordgrass, cattails and various small trees and shrubs such as buttonbush.

The freshwater mixed community has one of the highest annual productions of tidal wetlands in this region with annual production exceeding 1800 kg ha-1. These marshes are also highly valuable for wildlife and waterfowl as the plants produce a diversity of abundant seeds, roots and tubers that are readily consumed. Typically, tidal waters are important spawning and nursery grounds for many resident and anadromous fish such as the striped bass, shad and river herring. The marshes are also important as flood and erosion buffers and sediment filters, however much of the aboveground vegetation dies back in the winter creating broad mudflats. Sediments are readily trapped during the growing season however enabling most of these areas to maintain themselves under conditions of rising sea level. Salinity intrusions during years of drought may significantly change the community structure within one year's time (Davies, 2004) as more salt resistant species dominate. A broad diversity of species helps to maintain this flexibility.

CBNERRVA TIDAL WETLANDS

Goodwin Island

The wetland types within the Goodwin Island complex (see Hobbs, this Issue, Figure 3) include smooth cordgrass, black needlerush, salt-meadow hay, and tall reed marshes. The smooth cordgrass marshes make up a predominant portion of the Goodwin Island marshes. They are dominated by smooth cordgrass (*Spartina alterniflora*) with few other species present. Several small salt pannes, less than 200 m^2 and dominated by scattered patches of saltgrass (*Distichlis spicata*) and glasswort (*Salicornia virginica* and *S. bigelovii*), exist scattered within the northern smooth cordgrass marsh communities. A 1-2 m wide berm, approximately 0.5 m height, is found on the north, south, and west border of the islands. The berms are dominated by salt bushes (*Iva frutescens*) and salt meadow hay (*S. patens*) (Laird, 2001). No berm is found on the east side, having been eroded by wave activity (Perry, personal observation). Here, smooth cordgrass dominates to the edge of the marsh.

A large salt-meadow hay community exists on the west side of the islands, inland of the smooth cordgrass community. The community is dominated by a mix of salt meadow hay and saltgrass. Other species present include: marsh aster (*Aster tenuifolius*), *Fimbrisstylis autumnalis* (no common name), smooth cordgrass, and water parsnip (*Sium suave*) (Laird, 2001). Fires are a common disturbance in this community, as well as the tall reed community (see below) and maritime forest found on the largest island.

A large (approx. 13 ha) tall reed type community is located on the south-east side of the largest island, landward of the smooth cordgrass marsh. Dominated by tall reed (*Phragmites australis* ssp. *australis*), few other species were present (Laird, 2001). Small patches of tall reed also exist on the east side of the largest island; however, they are constantly eroding away (Perry, personal observations). Reserve managers are actively working to eradicate this invasive form of the tall reed (Reay, personal communications).

Several saline needlerush communities are found scattered throughout the salt marsh community on the southeast side of the largest island. These were usually monotypic and consisted solely of the black needlerush (*Juncus roemerianus*).

Overall, the dominant plant of Goodwin Island marshes is the saltgrass, followed closely by smooth cordgrass. Marsh aster, sea ox-eye (*Borrichia frutescens*), sea lavender (*Limonium carolinianum*), glasswort (*Salicornia virginica*) and (*Suaeda linearis*), all obligate halophytes, are common (Perry and Atkinson, 1997, Laird, 2001). Perry and Atkinson (1997) and Laird (2001) identified a total of eleven vascular plant species in the Goodwin Island marshes. Vascular plant diversity is low due to the stress of salt and inundation.

Catlett Islands

Catlett Islands (see Hobbs, this Issue, Figure 5) are comprised of a series of Holocene sand ridges and valleys. The ridges are covered with maritime forest dominated by *Juniperous virginiana* (eastern red cedar) and *Pinus taeda* (loblolly pine). The valleys are dominated by salt marsh communities; however several large saltmeadow communities existed in the high marsh zone. Numerous small monotypic stands of saline black needlerush are dispersed in the upper end of the salt marsh community. *Iva frutescens* (salt bushes) forms a thin ecozone (approx. 2 m, Laird 2001) between the tidal marshes and maritime forest. Erosion is common on the south and southeast side of the islands and, therefore, the saltmeadow communities may dominate to the waters edge.

Spartina alterniflora (salt marsh cordgrass) is the most common species in the tidal marshes with co-dominants *Distichlis spicata* (saltgrass), *Spartina patens* (saltmeadow hay), and *Juncus roemerianus* (black needlerush) (Perry and Atkinson, 1997). The Catlett Island marsh communities are very similar in distribution and composition to those of Goodwin Islands. Perry and Atkinson (1997) found only six species along a series of five wetland vegetation transects. Missing were the halophytes found in the more saline tidal marshes (e.g. *Borrichia frutescens*) (Perry and Atkinson, 1997, Laird 2001).

Taskinas Creek

Taskinas Creek (see Hobbs, this Issue, Figure 6) is comprised of a large watershed with embayment marshes. It receives a large freshwater input from runoff in its headwaters creating a sub-estuary system. Because of its topography, it contains both high and low marshes. It has a 1 m tidal range and a salinity range of 15-20 ppt at the mouth (reference CB-NERR-VA data) to <0.05 ppt at the headwater. The beaver (*Castor canadensis*) plays an important role in the headwater of this ecosystem. They have built long dams across the headwaters that are several decimeters high. New growth of swamp forest is found upstream of the dams (see Reay, this issue). Downstream of the dams are found a large array of wetland types from tidal freshwater to brackish to smooth cordgrass type communities. Berms and high organic content of soil characteristic of salt marsh communities are located near the mouth and decreases as one moves upstream and nears the tidal freshwater marshes (freshwater mixed community).

Spartina alterniflora dominate the marshes at the junction of the York River and Taskinas Creek. Originally, a large high marsh zone of *Iva frutescens* (saltbush) inhabited the north end of the marsh at the junction where it was presumed that the *S. alterniflora* had eroded away earlier (Perry and Atkinson, 1997). On a current data-gathering trip (Perry, unpublished data 2006), we noted that most of the *I. frutescens* has now eroded away and that that remains has died back, apparently from an increase in inundation. The remaining highmarsh, which appears to be rebuilding by sand washing onto the marsh during storms, has become dominated with *S. cynosuroides* (tall cordgrass). Freshwater species such as *Juncus geradii* (military rush) and *Schoenoplectus pungens* were first found in the high end of this marsh.

Moving upstream approximately 1 km, *S. cynosuroides* becomes more dominant on the edges and the points (tips) of the marshes while the saltmeadow communities became more common in the interior, indicating a possible increase in marsh elevation (Laird, 2001). The saltmeadow community was dominated by *S. patens* and *D. spicata* (Perry and Atkinson, 1997, Laird, 2001). *Schoenoplectus robustus* (saltmarsh rush) dominated some small areas (less than 100 m^{-2}), scattered throughout the mid-marsh and marsh edges. *Schoenoplectus pungens*, and *Typha angustifolia* are commonly scattered to along the landward margin of the marshes. Perry and Atkinson (1997) note that ten species occurred in the mesohaline marshes, however, they noted that there were fewer obligate halophytes.

Taskinas Creek has moderate diversity overall due to the diversity of habitats. Diversity is low in marshes located near mouth (characteristic salt marsh communities) and jumps in the freshwater mixed community located approximately 2 km upstream.

Sweet Hall Marsh

Sweet Hall marsh (see Hobbs, this Issue, Figure 8) is a 440 ha. point marsh with a moderate forested watershed located on its north boundary. The wetland is dominated by low tidal marshes with a 1 m tide range. Salinity varies from <0.05 ppt to >15 ppt and is responsive to freshwater flows (CBNERR-VA data). Moderate freshwater input from runoff enters through the north forested area and from upstream. Upstream channel causes diversion of freshwater ebb-flows to use a southwest rout around the marsh. Flood-flows, on the other hand, travel through the major cross-marsh channel (see Hobbs, this issue, Figure 8). Wrack lines form berms on the rive edge up to 5 m wide. The berms are dominated by either a mix or low diversity stand of *S. cynosuroides*, *P. australis* ssp. *americanus* (tall reed grass), *Peltandra virginica* (arrow arum) and *Carex hyalinolepis*. More salt tolerant species are found on the downstream edge (east edge) than the upstream edge (west). Muskrat activity is common and appears to play a role in hydrology and composition of vegetation community (Doumlele, 1981, Perry and Hershner, 1999).

Wetland types include large areas of freshwater mixed communities, with a thin band of *Peltandra virginica* (arrow arum) along the lower elevations of the waterward fringe. A small Spatterdock community (dominated by *Nuphar luteum* (spatter dock)) is found midway down the upstream (west) side of the marsh. Fifty-six species were encountered by Perry and Hershner (1999) along a series of seven transects dissecting the marsh. Salt tolerant species (facultative halophytes) were poorly represented, but fresh water species were common. *Peltandra virginica* (arrow arum) is the dominant species in the mixed marsh areas, particularly in the first half of the growing season (Doumlele, 1981,Perry and Atkinson, 1997, Perry and Hershner, 1999, Davies, 2004). Co-dominants include: *Carex stricta*, *Leersia oryzoides* (rice cut-grass), *Polygonum punctatum* (spotted knotweed), and *P. arifolium* (tear-thumb). Late in the growing season, grasses such as *Echinochloa walteri* (Walter's millet), *Leersia oryzoides*, and *Zizania aquatica* (northern wild rice), and composites such as *Bidens laevis, B. cernua* (marsh beggar ticks), and *Pluchea odorata* (marsh fleabane) will become prominent, each dominating large, but highly diverse regions of the marsh (Doumlele, 1981, Perry and Hershner, 1999, Davies, 2004). Plant diversity is higher than that of the salt marshes and brackish marshes of the York River (Doumlele, 1981, Perry and Atkinson, 1997). While few obligate or facultative halophytes are present, their numbers have been increasing over past several decades (Perry and Hershner, 1999, Davies, 2004).

TIDAL MARSH FAUNA

The dominant fish species from Goodwin Island, based on biomass and total number of fish caught, was *Fundulus heteroclitus* (mummichogs) (Ayers, 1995, Cicchetti, 1998). Ayers (1995) reported that biomass peaked in Goodwin Islands in June, with a second peak in late September. Cicchetti (1998) found that *F. heteroclitus* used seagrass beds, unvegetated areas, and portions of the marsh as a low tide refuge. In all, there were 32 species of nekton captured between June and October 1995, with a mean overall abundance of 28.6 individuals per m^2 and a mean biomass of 3.89 g/m^2 (dry weight). Based only on biomass, the most dominant species was the blue crab, *Callinectes sapidus* (Cicchetti, 1998). Certain fish from the sciaenid family (e.g. white croaker, spot croaker, and weakfish) use marsh habitats in a transient or opportunistic manner, as do silversides (*Menidia menidia*). As well, the marsh surface is apparently used as a nighttime refuge by silversides. Cicchetti and Diaz (2000) found that predation on invertebrates was highest in marsh edge areas and a large portion was consumed by transient species. The major path for export of material from the marsh interior habitats into shallow water habitats was by blue crab predation on resident mud fiddler *Uca* and *Sesarma* crabs (Cicchetti, 1998, Cicchetti and Diaz, 2000).

Few studies have addressed fauna of marshes and adjacent tidal streams in freshwater habitats (see Brown and Erdle, this Issue). Tidal freshwater marshes have been reported to be more diverse than salt marshes for certain fish taxa and for earlier life stages, as well as for other vertebrate groups (Odum *et al.*, 1984, Odum, 1988). Only non-insect invertebrates were reported to be less diverse in tidal freshwater marshes than in salt marshes (Odum, 1988). In a review of the literature, Brinson *et al.*, (1981) found insect abundance and diversity was high for salt and freshwater systems, which was taken as evidence that low diversity vegetation (i.e. salt marshes) can still support diverse consumer assemblages. Muskrat (*Ondatra zibethicus*) are a commonly occurring mammal in many tidal fresh and brackish marshes (sensu Brinson *et al.*, 1981, Odum, 1984). Connors *et al.*, (2000) detected significant nitrogen cycle effects due to muskrat activities in tidal freshwater marshes, but concluded that their effect on vegetation structure was limited. *Aeschynomene virginica*, a vascular plant with the federally status of threatened and Commonwealth of Virginia status of endangered, has been identified in several muskrat eatout areas in the tidal freshwater marshes of the Mattaponi, Pamunkey, and Rappahannock rivers. Black rat snakes (*Elaphe obsoleta*), brown water snakes (*Nerodia taxispilota*), and diamondback terrapins (*Malaclemys terrapin*) have all been observed in all four CBNERRVA tidal marshes. Virginia rail have been seen and heard in Sweet Hall and Goodwin Island marshes (several nest were encountered at both sites) (Perry, personal observations).

RESEARCH AND MONITORING NEEDS

Changes in vegetation communities have been documented in Goodwin Island (Cicchetti, 1998, Cicchetti and Diaz, 2000, Laird, 2001) and Catlett Islands (Perry and Atkinson, 1997, Laird, 2001). On Goodwin Island these changes include loss due to eroding marsh faces (Cicchetti, 1998, Cicchetti and Diaz, 2000, Laird, 2001) and the progression of an aggressive wetland invasive plant; *Phragmites australis*). Understanding the rate of erosion, and rate of spread of the *P. australis*, will help understand how these changes may alter the functions served by these marshes. The role of sea level rise and the ability of accretion in the salt marshes to keep up with the rise is poorly understood on all the York River marshes. More information on accretion rates, sediment composition, changes in above and below ground biomass, is needed.

The population decline of the diamondback (*Malaclemys terrapin*) terrapin, such as found in the marshes of the Goodwin Islands, Catlett Islands, Taskinas Creek and Sweet Hall Marsh reserve sites (Chambers, personal communications), is of national concern. Diamondback terrapin populations are threatened by juvenile and adult mortality in crabpots, loss of nesting habitat, and nest destruction by mammalian predators (Ruzicka, 2006). Raccoons (*Procyon lotor*) on Goodwin Island are known to play a major role in the decline (Ruzicka, 2006, Chambers, personal communications). It is not known, however, if the interaction is through natural trophic interactions (predator/prey relationship), or if there is an anthropogenic increase in raccoon populations (aka subsidization, sensu Klemens, 2000), that, therefore, may lead to an increase in predation on the terrapin. The brown water -snake (*Nerodia taxispilota*), has been seen on all four CBNEERVA sites (Perry, personal observations). Little is known of its habitat needs, population status, or the role it plays in the tidal marsh ecosystem.

As sea level rates increase, salinity and inundation period are also expected to increase. Data are needed to better understand the impact that these changes may bring to the tidal marshes in the York River. Several studies have documented changes in the vegetation communities of Sweet Hall Marsh (Perry and Hershner, 1999, Davies, 2004). These changes have been attributed to relative sea level rise since salt-tolerant perennial species, e.g. *Spartina alternifolia* and *S. cynosuroides*, have become more prominent (Perry and Hershner, 1999, Davies, 2004). Perry and Hershner (1999) predicted that salt – tolerant perennials will play a more important role in the future. Davis (2004) found that yearly changes in vegetation composition was more complex than believed and that both fresh and salt water perennial species had the ability to lay dormant through adverse environmental conditions. Research is needed to better understand the role of both annual and perennial plant species in vegetation succession brought on by sea level rise, and what any change in vegetation composition may mean to loss of, or changes in, habitat values of the marsh. Data on the potential changes in tidal marsh nutrient processes due to increased salinity in the water column and soil pore spaces (as a function of increased rates of sea level rise) is poorly understood. Both above and below ground carbon storage may be affected (Blum and Christian, 2004), altering nitrogen and carbon storage. However, these data are lacking.

Little is known about how an increase in nutrient input from agriculture, industry, and non-point sources may alter the turbidity of the water column and change the sediment content available to the York River marshes. The former effect may decrease the amount of photoactive light available to aquatic and marsh plants, as well as deliver toxic pollutants into the marsh. The latter may alter the available sediments needed by the marsh to keep up with increases in sea level rise rates.

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