ESTUARINE COMMUNITIES

Contents

ESTUARINE COMMUNITIES THEME

Concept: The Estuarine Communities theme encompasses coastal zone communities whose character depends primarily on flooding by salt or brackish water. Most are tidal marshes influenced by full-strength or somewhat diluted brackish seawater. Also included, though they are somewhat different, are the communities of beaches and low sand spits, which are not regularly flooded but are frequently flooded or battered by seawater.

Distinguishing Features: Estuarine Communities are distinguished by tidal flooding by brackish or salt water or by occurrence on ocean beaches or low-lying spits. They have vegetation dominated by a limited number of plant species that are able to tolerate regular or at least frequent exposure to moderate or high salt concentrations. Beyond *Spartina alterniflora, Spartina patens, Juncus roemerianus, Salicornia virginica, Sarcocornia ambigua, Distichlis spicata, Borrichia frutescens, Iva frutescens, Cakile edentula, Cakile harperi*, and *Limonium carolinianum*, most plant species are limited to the few least extreme Estuarine Communities and occur in much greater abundance in Freshwater Tidal Wetlands or other themes. Freshwater Tidal Wetlands share some species, but all those communities also contain additional species less tolerant of salt.

Within this theme, communities can be divided into the small group of the Upper Beach and Sand Flat communities and the marsh communities. Marsh communities occur in and around estuaries, on both the mainland and the back of barrier islands. They usually occur in zoned complexes that contain multiple communities, though one often dominates the majority of the complex. Marsh communities are divided based on the level of salinity, with Salt Marshes being flooded by full-strength seawater. Brackish Marshes are somewhat less salty, either because they are flooded with diluted seawater or because they are less frequently flooded by full-strength seawater and salinity is reduced between flooding events. Salt Shrub communities are less salty still, enough to be able to support woody vegetation. Salt Flats, on the other hand, are hypersaline.

The Upper Beach and Sand Flat communities are not flooded by normal high tides but are the most frequently flooded by seawater during storms. They are distinguished by sparse vegetation, frequent reworking of the sand, and strong salt spray.

Synonyms:

Sites: Estuarine Communities occur on both barrier islands and the mainland, around large estuaries, narrow lagoons, or along tidal creeks, or on the ocean shoreline. All occur at or only slightly above mean sea level.

Soils: Soils range from organic deposits to clay or silt to wave-worked sand.

Hydrology: Most sites are permanently saturated, but those on beaches and on raised marsh edges may be well drained at times. Tidal flooding may be regular, occurring twice a day with the astronomical tides; it may be irregular but frequent, occurring with wind tides; or it may be irregular but infrequent, occurring only at the higher tides or during storms. Salinity varies with connection to the ocean. Areas on the ocean shoreline and within a few miles of inlets are subject

to full strength sea water. Estuarine areas more distant from inlets have brackish water, the seawater diluted by fresh water. Local areas where seawater is trapped and evaporated have higher salt concentrations.

Vegetation: Vegetation of Estuarine Communities may be sparse or very dense, but it is low in diversity. Most communities are strongly dominated by one or a few plant species that are specialized to tolerate salt. *Spartina alterniflora, Spartina patens, Juncus roemerianus, Salicornia virginica, Sarcocornia ambigua, Distichlis spicata, Borrichia frutescens, Iva frutescens, Cakile edentula,* or *Cakile harperi* may dominate in different communities. A few additional species, such as *Limonium carolinianum*, are present in multiple communities. More species may occur, especially in the least extreme communities such as Brackish Marsh (Transitional Subtype), but they remain a small set of the species most able to survive periodic saltwater flooding.

Dynamics: As with the maritime communities, Estuarine Communities are often extremely dynamic. Waves, storms, erosion, and deposition of sediments, along with unusual processes such as wrack deposition, may disturb communities. Even in these salt-tolerant and frequently flooded communities, increases in salt concentrations or prolonged flooding can be significant disturbances. Changes in the balance of salt and freshwater input caused by droughts, upstream dams, dredging of navigation channels, and rising sea level can shift community zones or can stress communities and kill vegetation temporarily or permanently (extensive literature reviewed in Gilbert et al. 2012). Most Estuarine Communities are able to develop quickly in newly suitable sites.

In addition, all communities in this theme are strongly affected by rising sea level. As with natural disturbances, they adapt well to the background level of rise, with most communities accreting material and raising their elevation to keep pace. However, they may be threatened or detrimentally altered by accelerated sea level rise or a combination of rise with increased disturbance. There is also a potential for drastic changes on a broad scale. Existing community patterns based on the current configuration of tidal inlets and barrier islands will change quickly if many new inlets form or if the barrier islands are eroded below sea level.

In many of the communities, tidal flushing drives ecosystem function. Tidal flows provide a steady supply of nutrients, leading to high productivity. They carry organic matter from the marsh to the estuarine waters, providing the basis for a productive food web there. They provide habitat for many animals, including commercially important fisheries. Additional organic matter accumulates in marsh sediments, providing important sinks for carbon.

Comments: This theme contains some of the best studied and least studied communities in North Carolina. The extensive communities in this theme lie near research stations, are contained in public lands, and are of great interest for their role in ecosystem services. A number of regional vegetation studies and a few focused specifically on marshes have provided a good understanding of community patterns. However, several unusual communities are newly recognized or have usually been overlooked, and these are not well understood.

The inclusion of Upper Beach and Sand Flat communities in this theme is marginal. They are different in many ways but appear to fit somewhat better here than in Maritime Grasslands.

References:

Gilbert, S., K. Lackstrom, and D. Tufford. 2012. The impact of drought on coastal ecosystems of the Carolinas. Research Report: CISA-2012-01. Columbia, SC: Carolinas Integrated Sciences and Assessments.

KEY TO ESTUARINE COMMUNITIES

1. Community on an ocean beach or low-lying sand spit; not subject to normal tidal flooding but readily flooded by seawater in moderate storms; vegetation sparse.
   2. Community on a low-lying, largely featureless, sand spit. ..... **Sand Flat**
   2. Community on the upper beach, seaward of the foredunes.
      3. Community in the northern part of the coast, north of Cape Hatteras; *Cakile edentula* abundant, though *Cakile harperi* may be present. ..... **Upper Beach (Northern Subtype)**
      3. Community in the southern part of the coast, south of Cape Hatteras; *Cakile harperi* predominant over *Cakile edentula*. ..... **Upper Beach (Southern Subtype)**

1. Community not on a beach; if on a sand spit then influenced by normal tidal flooding; vegetation dense or sparse; community on the landward side of a barrier island or around an inland estuary, generally in a complex of marsh communities or as a fringing wetland.
   4. Community occurring in salt pannes, where seawater is trapped and evaporates to produce hypersaline conditions; vegetation sparse to moderate, dominated by *Distichlis spicata, Sarcocornia*, or *Salicornia*; *Spartina alterniflora* and *Borrichia frutescens*, if present, with low cover. ..... **Salt Flat**
   4. Community not occurring in salt pannes; salinity equal to seawater or less.
      5. Community dominated by shrubs; on the upland edge of a marsh.
         6. Community dominated by *Borrichia frutescens*. ..... **Salt Shrub (Low Subtype)**
         6. Community dominated by *Iva frutescens, Baccharis halimifolia, Morella cerifera*, or other species.
            7. Community moderately to strongly dominated by combinations of *Iva frutescens* or *Baccharis halimifolia*, sometimes with *Morella cerifera* codominant. .... **Salt Shrub (High Subtype)**
            7. Community weakly dominated by shrubs, more typically herbaceous; shrubs may include *Baccharis, Iva, Morella*, or small *Juniperus* or *Pinus taeda*. **Brackish Marsh (Transitional Subtype)**
      5. Community dominated by herbs; shrubs sparse or absent.
         8. Community dominated by *Spartina alterniflora*.
            9. *Lilaeopsis chinensis* or other species less tolerant of salt abundant along with *Spartina alterniflora*. ..... **Brackish Marsh (Smooth Cordgrass Subtype)**
            9. Only highly salt-tolerant species such as *Limonium carolinianum*, *Distichlis spicata*, *Sarcocornia ambigua*, or *Salicornia virginica* present with *Spartina alterniflora*.
               10. Community north of Cape Hatteras..... **Salt Marsh (Virginian Subtype)**
               10. Community south of Cape Hatteras ..... **Salt Marsh (Carolinian Subtype)**
         8. Community not dominated by *Spartina alterniflora*; dominated by *Spartina patens, Juncus roemerianus*, or a mix of species.
            11. Community dominated by *Juncus roemerianus*; often few or no other species present. .. . . **Brackish Marsh (Needlerush Subtype)**
            11. Community not dominated by *Juncus roemerianus*; dominated by *Spartina patens* or a mix of species.
               12. Community dominated by *Spartina patens*, with few associated species other than *Juncus roemerianus, Spartina alterniflora, Borrichia frutescens*, *Limonium carolinianum*, or species of similar salt tolerance. ..... **Brackish Marsh (Salt Meadow Cordgrass Subtype)**
               12. Community a mix of species, *Spartina patens* is often present but does not strongly dominate; multiple species less tolerant of salt, such as *Fimbristylis castanea, Schoenoplectus pungens, Bolboschoenus robustus, Typha angustifolia, Panicum virgatum, Mikania scandens, Thelypteris palustris*, and *Osmunda spectabilis* present; some shrubs and small trees may also be present. ..... **Brackish Marsh (Transitional Subtype)**

SALT MARSH (VIRGINIAN SUBTYPE)

Concept: Salt Marshes are *Spartina alterniflora*-dominated marshes regularly flooded by salt water at or near full seawater salinity. The Virginian Subtype covers examples of the Virginian faunal zone, from Cape Hatteras northward, which differ in the composition of their fauna and algal flora.

Distinguishing Features: Salt Marshes are distinguished by dominance by *Spartina alterniflora* in association with near-full strength seawater. *Distichlis spicata*, *Salicornia* spp., *Sarcocornia* spp., *Limonium carolinianum*, and other salt-tolerant species occur in limited amounts, but species less tolerant of salt, even estuarine species such as *Lilaeopsis chinensis*, are scarce or absent.

The Virginiana Subtype is believed to differ from the Carolinian Subtype in the composition of the animal communities and algae. It has been suggested that the alga *Ascophyllum nodosum* is characteristic of the Virginian Zone and not the Caroliniana Zone. At present, the two subtypes should be distinguished by geographic location.

Synonyms: *Spartina alterniflora* North Atlantic Salt Marsh Herbaceous Vegetation (CEGL004192). Ecological Systems: Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh (CES203.260).

Sites: Salt Marshes occur on intertidal flats near tidal inlets, where seawater is little diluted by fresh water. They may occur on or near barrier islands on relict or active flood tidal deltas, or on overwash deposits. Some are contiguous expanses, though fed by dendritic tidal channels, others are clusters of small to medium size islands. On the mainland, they may occur on low flats along estuaries or in bands along tidal creeks.

Soils: Salt Marshes occur on sandy or finer-textured mineral soils such as Carteret (Typic Psammaquent) or Bohicket (Typic Sulfaquent).

Hydrology: Salt Marshes are regularly flooded by saltwater, with flooding driven primarily by astronomical tides. The water is euhaline (30-40 parts/thousand).

Vegetation: Salt Marsh (Virginian Subtype) vegetation in North Carolina is not well described. This community is strongly dominated by *Spartina alterniflora*. Frequent associated species include *Limonium carolinianum, Salicornia virginica, Sarcocornia ambigua*, and *Distichlis spicata*. Additional species such as *Juncus roemerianus, Spartina patens*, *Symphyotrichum subulatum*, and *Borrichia frutescens* may occur in the transition to adjacent communities.

Range and Abundance: Ranked G5. The Virginian Subtype is scarce in North Carolina at present, due to the configuration of the barrier islands. Oregon Inlet is the only long-persistent tidal inlet north of Cape Hatteras, and intertidal flats capable of supporting Salt Marsh are limited there. A newly formed inlet farther south may be developing Salt Marsh. This subtype was more abundant in the 1800s, where several inlets were present in the northern Outer Banks. The Virginian Subtype, as defined, is the predominant salt marsh of the northern Atlantic coast, ranging northward to Nova Scotia.

Associations and Patterns: Salt Marshes in general are matrix communities, but the Virginian Subtype in North Carolina occurs as a large patch community. It is associated with other salt-tolerant estuarine communities. Salt Flat patches may be embedded in them. Brackish Marsh, Salt Shrub, or Salt Flat may occur immediately inland of them.

Variation: Salt Marshes have very low vascular plant diversity and show little variation in vegetation. Many descriptions of marshes emphasize zonation. Many make a distinction between low marsh and high marsh. Low marsh, flooded more regularly, is more productive and has taller *Spartina alterniflora*. High marsh, at the upper end of the tidal range, has shorter vegetation. However, additional species may be present in it. Many of the areas described as high marsh zones would be classified here as Brackish Marsh, Salt Shrub, or Salt Flat communities rather than Salt Marsh.

Dynamics: See the discussion of dynamics for the Carolinian Subtype. The Virginian Subtype likely has similar dynamics, but dynamics may be different in North Carolina because of the extremely low tidal amplitude where it occurs. This is not true throughout the range of this community to the north.

While North Carolina has little of this subtype at present, this is partly an accident of this point in history. When inlets were more frequent in the northern Outer Banks, as recently as the 1800s, they may have been extensive. When the Outer Banks were not continuous, as in the 1600s, they may have covered vast areas in northeastern North Carolina.

Comments: The concept of Salt Marsh has been narrowed from that in the 3rd Approximation, even as it has been split into two subtypes. Previously, it conceptually included all the upper zones, including potentially large areas of *Spartina patens*, *Juncus roemerianus*, or other species. Brackish Marsh (Transitional Subtype) now covers most of these upper zones.

Salt Marshes are notable in being regarded as having limited importance for biodiversity, because of their low richness in the taxa typically measured, while being extremely important for ecosystem services. They are an interesting counterexample to the frequent belief that diverse ecosystems are more productive than simple ones, or that the most productive ecosystems will support the most species.

The division of the Virginian and Carolinian subtypes follows that of the NVC associations. Salt Marshes have low diversity and have the same dominant grass from Florida to Nova Scotia. However, it is argued that this broad range of latitude must come with ecological variation and differences in associated algae and animal species worth recognizing. In early versions of the NVC association, the alga *Ascophyllum nodosum* was included in the name. The NVC notes that this species, along with *Fuscus versiculosus* and *Ulva* spp., are characteristic, forming extensive mats at the base of the grass culms, but notes that they may be scarce at the southern end of the range where North Carolina is located.

Rare species:
Vertebrate animals: *Nerodia sipedon williamengelsi.*

References:

SALT MARSH (CAROLINIAN SUBTYPE)

Concept: Salt Marshes are *Spartina alterniflora*-dominated marshes regularly flooded by salt water at or near full seawater salinity. The Carolinian Subtype covers examples of the Carolinian faunal zone, from Cape Hatteras southward, which differ in the composition of their fauna and algal flora from the more northern marshes.

Distinguishing Features: Salt Marshes are distinguished by dominance by *Spartina alterniflora* in association with near-full-strength seawater. *Distichlis spicata*, *Salicornia* spp., *Sarcocornia* spp., *Limonium carolinianum*, and other salt-tolerant species occur in limited amounts, but species less tolerant of salt, even estuarine species such as *Lilaeopsis chinensis*, are scarce or absent.

The Carolinian Subtype is believed to differ from the Virginian Subtype in composition of the associated algal and animal communities, but the differences are not well determined. It is suggested that the alga *Ascophyllum nodosum* may be characteristic of more northern marshes and absent in the Carolinian Zone. At present, the two subtypes should be distinguished by geographic location.

Synonyms: *Spartina alterniflora* South Atlantic Salt Marsh (CEGL004191). Ecological Systems: Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh (CES203.260).

Sites: Salt Marshes occur on intertidal flats near tidal inlets, where seawater is little diluted by fresh water. They may occur on or near barrier islands on relict or active flood tidal deltas, or on overwash deposits. Some are contiguous expanses, though fed by dendritic tidal channels, others are clusters of small to medium size islands. On the mainland, they may occur on low flats along estuaries or in bands along tidal creeks.

Soils: Salt Marshes occur on sandy or finer-textured mineral soils such as Carteret (Typic Psammaquent) or Bohicket (Typic Sulfaquent). Some Salt Marsh soils are cat clays (acidic sulphate soils), in which drying leads to a change from neutral pH to extreme acidity as sulfides oxidize to sulfuric acid.

Hydrology: Salt Marshes are regularly flooded by saltwater, with flooding driven primarily by astronomical tides. The water is euhaline (30-40 parts/thousand).

Vegetation: Salt Marsh (Carolinian Subtype) is strongly dominated by *Spartina alterniflora*. No other vascular plant species has high constancy in CVS plot data or site reports, but *Limonium carolinianum* and *Salicornia virginica* are fairly frequent. *Distichlis spicata* and *Sarcocornia ambigua* sometimes occur. *Juncus roemerianus, Spartina patens, Borrichia frutescens, Symphyotrichum tenuifolium*, and a few other species may occur in the transition to adjacent communities.

Range and Abundance: Ranked G5. The Carolinian Subtype is abundant on the coast of North Carolina, occurring over large expanses in the southern half of the state. This community ranges from North Carolina to Florida.

Associations and Patterns: The Carolinian Subtype is a matrix community, occurring as a regular part of the landscape mosaic of barrier islands and salt estuaries. It is associated with other salt-tolerant estuarine communities. Salt Flat patches may be embedded in them. Brackish Marsh, Salt Shrub, or Salt Flat may occur immediately inland of them.

Variation: Salt Marshes have very low vascular plant diversity and show little variation in vegetation. Many descriptions of marshes emphasize zonation (e.g., Adams 1963). Many make a distinction between low marsh and high marsh. Low marsh, flooded more regularly, is more productive and has taller *Spartina alterniflora*. High marsh appears to refer to several different kinds of vegetation. Some are covered by other communities in the 4th Approximation, such as Brackish Marsh subtypes, Salt Flat, or Salt Shrub. It may also be ecotonal Salt Marsh, where species of these communities mix with *Spartina alterniflora*. The *Spartina* often is noted as being shorter in the high marsh, because of reduced input of nutrients and because evaporation increases salt concentration. However, additional species may be present in it.

In additional to zonal variation, Salt Marshes may differ subtly with variation in tidal amplitude. North Carolina's examples range from less then one foot to over five feet, and examples in South Carolina and Georgia experience even greater amplitudes.

Dynamics: Salt Marshes are well known for their high productivity, considered among the highest in the world for broad ecosystem types. Though their vascular plant diversity is limited by salinity, the environment is very favorable for adapted plants. Regular tidal flushing provides a steady supply of plant nutrients and exports organic matter to the adjacent estuary. Because of this, they are particularly important for estuarine food webs and for commercial fisheries. Salt Marshes are also important for nutrient cycling. Uptake of nutrients by plants enhances water quality in the adjacent waters. Denitrification recycles excess fixed nitrogen back to the atmosphere.

Salt Marshes are usually stable, with patches persisting for long periods, but some portions may be very dynamic. Those adjacent to open water may be affected by shoreline erosion, while some on the back sides of barrier islands may be buried by overwashed sand. Patches may be lost if sand deposition raises the surface above tide levels. New Salt Marsh environments may form behind barrier islands as inlets migrate or open, creating new flood tidal deltas. Storm surges and storm waves may affect salt marshes. These marshes are often important in protecting upland shorelines from storm erosion. The complex structure of the grass diffuses wave energy better than bare shorelines and better than most kinds of vegetation. Some other processes documented to disturb marshes in other states may potentially affect North Carolina's marshes. For example, Silliman et al. (2005) described die-off of marsh patches from South Carolina to Louisiana driven by drought-related increases in salinity but exacerbated by excess grazing by periwinkles (*Littorina*).

A crucial dynamic for Salt Marshes at present is the effect of rising sea level. Marshes may keep pace with rising sea level if production of organic matter and deposition of sediment is fast enough.

This has clearly been happening in many places in North Carolina, but it is not clear whether it will continue to keep up if sea level rise accelerates.

Comments: Salt Marshes are well studied. They are recognized in most vegetation studies, such as Au (1974), Godfrey and Godfrey (1976), and Rosenfeld (2004). Numerous other studies, not cited here, focus on their ecosystem ecology and ecosystem services.

The concept of Salt Marsh has been narrowed from that in the 3rd Approximation, even as it has been split into two subtypes. Previously, it conceptually included all the upper zones, including potentially large areas of *Spartina patens*, *Juncus roemerianus*, or other species. Brackish Marsh (Transitional Subtype) now covers most of these upper zones. Because of the inclusion of higher and more mixed zones, it is unclear which rare species previously listed as occurring in Salt Marsh are likely to truly be in this community.

Salt Marshes are notable in being regarded as having limited importance for biodiversity, because of their low richness in the taxa typically measured, while being extremely important for ecosystem services. They are an interesting counterexample to the frequent belief that diverse ecosystems are more productive than simple ones, or that the most productive ecosystems will support the most species.

The division of the Virginian and Carolinian subtypes follows that of the NVC associations. Salt Marshes have low diversity and have the same dominant grass from Florida to Nova Scotia. However, it is argued that this broad range of latitude must come with ecological variation and differences in associated algae and animal species worth recognizing. In early versions of the NVC association, the alga *Ascophyllum nodosum* was included in the name. The NVC notes that this species, along with *Fuscus versiculosus* and *Ulva* spp., are characteristic, forming extensive mats at the base of the grass culms, but notes that they may be scarce at the southern end of the range where North Carolina is located.

Rare species:
Vertebrate animals: *Malaclemys terrapin centrata* and *Nerodia sipedon williamengelsi.*

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Silliman, B.R. J. van de Koppel, M.D. Bertness, L.E. Stanton, and I. A. Mendelssohn. 2005. Drought, snails, and large-scale die-off of southern U.S salt marshes. Science 310:1803-1806.

BRACKISH MARSH (SMOOTH CORDGRASS SUBTYPE)

Concept: Brackish Marshes are marshes that are salt influenced but to a lesser degree than Salt Marshes, due to regular or irregular flooding by brackish water or by infrequent flooding by salt water mitigated by freshwater input. The Smooth Cordgrass Subtype covers examples of regularly flooded brackish to oligohaline tidal rivers or sound shores, dominated or codominated by *Spartina alterniflora*, and having plants intolerant of sea water salinity.

Distinguishing Features: The little-known Smooth Cordgrass Subtype is distinguished from other Brackish Marsh subtypes by the presence of *Spartina alterniflora* and by occurrence in regularly flooded brackish areas. The presence of *Lilaeopsis chinensis* and other plant species intolerant of full sea water salinity distinguishes this subtype from Salt Marsh.

Synonyms: *Spartina alterniflora* - *Lilaeopsis chinensis* Herbaceous Vegetation (CEGL004193). Ecological Systems: Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh (CES203.260).

Sites: The Smooth Cordgrass Subtype occurs on the shorelines of tidal rivers or estuaries where the water is brackish to oligohaline.

Soils: Details of soil are not known. This subtype potentially occurs on either organic or mineral soil.

Hydrology: The Smooth Cordgrass Subtype is within the normal tidal range and may be flooded regularly by astronomical tides or irregularly by wind tides.

Vegetation: This community is not well known in North Carolina. It is dominated by *Spartina alterniflora* and includes various other plant species tolerant of brackish to oligohaline conditions but not tolerant of seawater. These may include *Lilaeopsis chinensis* or potentially *Schoenoplectus pungens, Bolboschoenus robustus, Samolus parviflorus, Eleocharis* spp., or other species.

Range and Abundance: Ranked G3G4. The range and abundance of this subtype in North Carolina are very poorly known. The related NVC association is widespread farther north, extending to Massachusetts, but the relationship of North Carolina's communities to it is somewhat uncertain.

Associations and Patterns: The Smooth Cordgrass Subtype appears to be a small patch community. Where it occurs, it is usually a narrow band several meters wide along lengths of shoreline.

Variation: Examples presumably vary with degree of salinity. It may be appropriate to divide this into brackish and fresh/oligohaline versions.

Dynamics: Dynamics are very little known. Since this subtype occurs on the shoreline of marsh complexes, it presumably is particularly susceptible to wave erosion. These communities may play

a role in protecting the marshes behind them. Many estuarine shorelines are scarped or collapsing, and it is possible examples have been lost to wave erosion in places.

The environmental factors that produce this community are unclear. Given the presence of less salt-tolerant plants, the salt tolerance of *Spartina alterniflora* does not appear to be the most important factor. Given that salinity levels are increasing as sea level rises, they do not appear to be relict stands from a saltier past.

Comments: This community is little known, and it is not entirely clear that it occurs in large enough patches to treat as a distinct community. Its recognition in North Carolina is based on observation by Alan Weakley on the Cape Fear River near Wilmington, where patches of several acres with abundant *Lilaeopsis*, as well as narrow fringes, were seen along oligohaline waters. The author has seen fringes several meters wide along the Brunswick River near the transition of Tidal Freshwater Marsh to Brackish Marsh. Bands dominated by *Spartina alterniflora* have also been reported on the shoreline of Brackish Marsh complexes at Cedar Island and Piney Island. These are tentatively recognized as the same community, but this needs further investigation. The relationship of this vegetation to communities farther north is uncertain. The NVC description of the association suggests it is most often in fresher water on large tidal rivers, and notes dynamics caused by dilution of salinity during spring snowmelt.

Rare species: No rare species are known to be associated with this community.

References:

BRACKISH MARSH (NEEDLERUSH SUBTYPE)

Concept: Brackish Marshes are marshes that are salt influenced but to a lesser degree than Salt Marshes, due to regular or irregular flooding by brackish water or by infrequent flooding by salt water mitigated by freshwater input. They include marshes of estuarine areas at some distance from oceanic inlets, where the water is brackish, and higher zones of Salt Marshes in areas with salt water. The Needlerush Subtype covers examples dominated by *Juncus roemerianus*, often with few or no other vascular plant species present. This common subtype may occur either as an upper zone of Salt Marshes, in the headwaters of tidal creeks upstream from Salt Marshes, or in vast expanses in the brackish sounds. In the sounds, it may be influenced by wind tides or lunar tides.

Distinguishing Features: Brackish Marshes are distinguished from Salt Marshes by having vegetation dominated by *Spartina patens*, *Juncus roemerianus*, or by having *Spartina alterniflora* in combination with less salt-tolerant species such as *Lilaeopsis chinensis*. They are distinguished from Tidal Freshwater Marsh subtypes by lacking salt-intolerant species. The Needlerush Subtype is distinguished from other subtypes by the dominance of *Juncus roemerianus*. It is distinguished from the Needlerush Subtype of Tidal Freshwater Marsh by the absence of less salt-tolerant plant species such as *Thelypteris palustris*, *Osmunda regalis*, *Sagittaria lancifolia*, and *Pontederia cordata*.

Synonyms: *Juncus roemerianus* Herbaceous Vegetation (CEGL004186).
Ecological Systems: Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh (CES203.260).

Sites: Brackish Marshes occur along estuaries, lagoons, and tidal creeks, on barrier islands, on islands within the sounds, and on the mainland. Sites are only slightly above mean sea level, allowing them to be flooded by ordinary tides, at least the higher spring tides or wind tides. Mainland sites are usually small to large expanses of flat organic deposits, but they may occur as bands lining tidal creeks. Examples on and near barrier islands tend to be on relict flood tidal deltas, often occurring as complexes of small islands separated by tidal channels.

Soils: The Needlerush Subtype can occur on either organic or mineral soils. Most of North Carolina's examples are organic, and are mapped as Lafitte (Typic Haplosaprist), Hobonny (Typic Haplosaprist), or Currituck (Terric Haplosaprist). A minority are Bohicket (Typic Sulfaquent). Clontz (1994) noted gradients in soil chemistry in a large Needlerush Subtype marsh, with nitrate increasing landward and pH and conductivity lower as freshwater input diluted salt.

Hydrology: Brackish Marshes may be regularly or irregularly flooded by astronomical tides or by wind tides. The largest examples occur in the sounds where the water is brackish, where tidal flooding may be semidiurnal or irregular. Examples also occur where the water is close to the salinity of sea water, in upper zones that are flooded only by the highest tides or upstream along tidal creeks where the salinity is reduced.

Vegetation: The Needlerush Subtype is generally strongly dominated by *Juncus roemerianus*. In the transition to other communities, it may be codominated by *Spartina alterniflora, Distichlis spicata, Spartina patens*, or *Borrichia frutescens*. Along the estuary shoreline of patches, *Spartina cynosuroides* may codominate or may dominate a narrow band. Other salt-tolerant species found in CVS plots with limited frequency include *Hydrocotyle bonariensis, Solidago mexicana, Limonium carolinianum, Fimbristylis castanea*, *Baccharis halimifolia*, and the exotic *Phragmites australis*. A number of other species may occur in the upland ecotone, including *Panicum virgatum, Lythrum lineare, Ptilimnium capillaceum*, and *Kosteletzkya pentacarpos*.

Range and Abundance: Ranked G5. The Needlerush Subtype is very extensive — widespread in all but the northernmost part of North Carolina's coast. It is extensive around Pamlico Sound, Roanoke Sound, and the Neuse River estuary, and occurs along numerous tidal creeks from there southward to the state line. The NVC association is very widespread, extending from Delaware and Maryland to Texas.

Associations and Patterns: The Needlerush Subtype is a matrix community, dominating large areas and occurring as a regular part of the landscape mosaic in estuarine and barrier island marsh complexes. It often occurs as the most extensive community in areas such as Cedar Island, Piney Island, mainland Hyde and Dare counties, Pamlico County, and Roanoke Island. There, it may be associated with the Salt Meadow Cordgrass Subtype, with Estuarine Fringe Pine Forest, Marsh Hammock, Estuarine Beach, and less often Salt Shrub. Closer to the coast, it occurs as a smaller zone in marsh complexes, where it is associated with Salt Marsh, Brackish Marsh (Salt Meadow Cordgrass), Salt Flat, Salt Shrub, and maritime communities.

Variation: The Needlerush Subtype often shows little variation in vegetation, but it may vary in the abundance of associated species with the transition to other communities. As in the Salt Meadow Cordgrass Subtype, two variants are recognized that may have different dynamics and associated species.

Salt Variant occurs in areas with salinity near full strength seawater, occurring in higher portions that get only irregular tidal flooding. It occurs as an upper zone of Salt Marsh and was treated as part of Salt Marsh in the 3rd Approximation. It is one of several kinds of vegetation known as high marsh.

Brackish Variant occurs in brackish water estuaries, where salinity is lower. It usually occurs as the predominant community in marsh complexes. Sometimes it is the only community, sometimes the Salt Meadow Cordgrass Subtype, Estuarine Beach, Estuarine Fringe Pine Forest, or Marsh Hammock may be present. This variant may be regularly flooded by astronomical tides or may be irregularly flooded by wind tides, but generally is flooded more frequently.

Dynamics: Needlerush Subtype dynamics probably are intermediate between those of the Salt Meadow Cordgrass Subtype and of Salt Marsh. Where they are frequently flushed by tidal waters, their productivity may contribute substantially to the food webs of the estuary and to removing nutrients from the water. It may also store substantial organic matter on the site, accumulating organic soils. The Salt Variant, flooded less often, probably contributes less.

As with other marshes, Needlerush Subtype patches often are stable for long periods. Because it often occurs as a fringing marsh, it can be important for protecting upland shorelines from wave erosion. However, the Needlerush Subtype may be subject to shoreline erosion, to disturbance by storm surges and waves, and, on the back of barrier islands, by deposition of sand by overwash. Wrack — thick piles of litter and debris deposited by storm tides — may bury local patches of marsh, killing the vegetation and preventing its reestablishment for several years. While this occurs in all tidal marshes, the dense standing dead material in the Needlerush Subtype makes it particularly susceptible, and wrack deposits may form broad bands of considerable length.

Marsh salinity levels may shift gradually or abruptly, as inlets open, close, or migrate. Hackney and Yelverton (1990) noted the changes in tidal amplitude and salinity around Wilmington related to dredging of the Cape Fear River as well as to rising sea level. This may cause marsh communities to give way to different communities.

As with other tidal marshes, many Brackish Marsh patches have been keeping pace with rising sea level by accumulating organic matter and sediment for decades or centuries. Because tidal flushing is generally less than in Salt Marshes, and because sediment supply is often low where they occur, this accumulation has been driven more by primary productivity and accumulation of organic matter than by mineral sediment. It is thus even more uncertain if they will be able to keep up as sea level rise accelerates.

Needlerush marshes are often remarkable in the uniformity of their vegetation, often with only a single plant species present over large areas. Cooper and Waits (1973), analyzing associations among many marsh species, found most to have predictable associations with other species but found *Juncus roemerianus* to have almost no associates. This presumably is because of its dense growth habit and the tendency of its dead culms to stand and form dense shade.

Variation was noted by Clontz (1994). Vegetation height was predicted by salinity, with taller vegetation where salt was diluted by freshwater input from the landward side. Biomass and density appeared to correlate with combinations of phosphorus and nitrogen.

While some Brackish Marsh complexes occur as complexes of small to medium size islands, many occur as large expanses connected to the mainland. These can carry fire and would have been subject to natural ignition whenever the adjacent inland communities burned. Burning has been practiced in some larger Brackish Marshes for wildlife management. Fire removes the dense standing crop of deal culms and increases the production of new vegetation. It appears to increase plant diversity by reducing the heavy dominance of *Juncus roemerianus*.

Comments: The Needlerush Subtype is well studied. As a regular part of the landscape, it has been recognized in most coastal vegetation studies, such as Rosenfeld (2004), Au (1974), Adams (1963), and Godfrey and Godfrey (1976). It has also had extensive study focused on ecosystem ecology and ecosystem services.

Rare species:
Vascular plants: *Eleocharis cellulosa, Eleocharis rostellata,* and *Ludwigia alata*.

Vertebrate animals: *Alligator mississippiensis, Circus hudsonius, Himpantopus mexicanus, Laterallus jamaicensis, Malaclemys terrapin centrata, Nerodia sipedon williamengelsii,* and *Seminatrix pygaea paludis*.

References:

Adams, D.S. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology 44: 445-456.

Au, S.F. 1974. Vegetation and ecological processes on Shackleford Banks, North Carolina. National Park Service Scientific Monograph Series No. 6.

Clontz, R.B. 1994. An ecological assessment of a *Juncus roemerianus*-dominated tidal marsh within the Sealevel Tract, Sealevel, North Carolina. M.S. Thesis, Duke University.

Cooper, A.W., and E.D. Waits. 1973. Vegetation types in an irregularly flooded salt marsh on the North Carolina Outer Banks. Journal of the Elisha Mitchell Society 89: 78-91.

Godfrey, P.J., and M.M. Godfrey. 1976. Barrier island ecology of Cape Lookout National Seashore and Vicinity. National Park Service Scientific Monograph Series No. 9.

Hackney, C.T., and G.F. Yelerton. 1990. Effects of human activities and sea level rise on wetland ecosystems in the Cape Fear River estuary, North Carolina, USA. In: Whigham, D.F., R. Good, and J. Kvet. 1990. Wetland Ecology and Management: Case Studies. Tasks for Vegetation Science. Springer.

Rosenfeld, K.M. 2004. Ecology of Bird Island, North Carolina, an uninhabited undeveloped barrier island. M.S, Thesis, North Carolina State University, Raleigh.

BRACKISH MARSH (SMOOTH CORDGRASS SUBTYPE)

Concept: Brackish Marshes are marshes that are salt influenced but to a lesser degree than Salt Marshes, due to regular or irregular flooding by brackish water or by infrequent flooding by salt water mitigated by freshwater input. The Smooth Cordgrass Subtype covers examples of regularly flooded brackish to oligohaline tidal rivers or sound shores, dominated or codominated by *Spartina alterniflora*, and having plants intolerant of sea water salinity.

Distinguishing Features: The little-known Smooth Cordgrass Subtype is distinguished from other Brackish Marsh subtypes by the presence of *Spartina alterniflora* and by occurrence in regularly flooded brackish areas. The presence of *Lilaeopsis chinensis* and other plant species intolerant of full sea water salinity distinguishes this subtype from Salt Marsh.

Synonyms: *Spartina alterniflora* - *Lilaeopsis chinensis* Herbaceous Vegetation (CEGL004193). Ecological Systems: Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh (CES203.260).

Sites: The Smooth Cordgrass Subtype occurs on the shorelines of tidal rivers or estuaries where the water is brackish to oligohaline.

Soils: Details of soil are not known. This subtype potentially occurs on either organic or mineral soil.

Hydrology: The Smooth Cordgrass Subtype is within the normal tidal range and may be flooded regularly by astronomical tides or irregularly by wind tides.

Vegetation: This community is not well known in North Carolina. It is dominated by *Spartina alterniflora* and includes various other plant species tolerant of brackish to oligohaline conditions but not tolerant of seawater. These may include *Lilaeopsis chinensis* or potentially *Schoenoplectus pungens, Bolboschoenus robustus, Samolus parviflorus, Eleocharis* spp., or other species.

Range and Abundance: Ranked G3G4. The range and abundance of this subtype in North Carolina are very poorly known. The related NVC association is widespread farther north, extending to Massachusetts, but the relationship of North Carolina's communities to it is somewhat uncertain.

Associations and Patterns: The Smooth Cordgrass Subtype appears to be a small patch community. Where it occurs, it is usually a narrow band several meters wide along lengths of shoreline.

Variation: Examples presumably vary with degree of salinity. It may be appropriate to divide this into brackish and fresh/oligohaline versions.

Dynamics: Dynamics are very little known. Since this subtype occurs on the shoreline of marsh complexes, it presumably is particularly susceptible to wave erosion. These communities may play

a role in protecting the marshes behind them. Many estuarine shorelines are scarped or collapsing, and it is possible examples have been lost to wave erosion in places.

The environmental factors that produce this community are unclear. Given the presence of less salt-tolerant plants, the salt tolerance of *Spartina alterniflora* does not appear to be the most important factor. Given that salinity levels are increasing as sea level rises, they do not appear to be relict stands from a saltier past.

Comments: This community is little known, and it is not entirely clear that it occurs in large enough patches to treat as a distinct community. Its recognition in North Carolina is based on observation by Alan Weakley on the Cape Fear River near Wilmington, where patches of several acres with abundant *Lilaeopsis*, as well as narrow fringes, were seen along oligohaline waters. The author has seen fringes several meters wide along the Brunswick River near the transition of Tidal Freshwater Marsh to Brackish Marsh. Bands dominated by *Spartina alterniflora* have also been reported on the shoreline of Brackish Marsh complexes at Cedar Island and Piney Island. These are tentatively recognized as the same community, but this needs further investigation. The relationship of this vegetation to communities farther north is uncertain. The NVC description of the association suggests it is most often in fresher water on large tidal rivers, and notes dynamics caused by dilution of salinity during spring snowmelt.

Rare species: No rare species are known to be associated with this community.

References:

BRACKISH MARSH (TRANSITIONAL SUBTYPE)

Concept: Brackish Marshes are marshes that are salt influenced but to a lesser degree than Salt Marshes, due to regular or irregular flooding by brackish water or by infrequent flooding by salt water mitigated by freshwater input. The Transitional Subtype is currently broadly defined to cover the more diverse but highly varied vegetation of the irregularly flooded inland transition zones of Brackish Marsh and Salt Marsh communities. It is an area of increasing freshwater or inland influence but where other communities are not able to develop because of periodic saltwater flooding.

Distinguishing Features: The Transitional Subtype is distinguished by herbaceous or mixed vegetation on the fringe of a marsh complex, influenced by irregular salt or brackish tidal flooding, not fitting any of the other Brackish Marsh, Salt Marsh, or Salt Shrub communities, and generally with more diverse and mixed composition. It should be recognized only where it covers a substantial area, broader than a narrow ecotone. This subtype may be closely related to Salt Shrub but is distinguished by having relatively small numbers of *Borrichia, Iva*, *Baccharis, Morella*, or other shrubs. A few other shrubs or trees may be present. Where salt shrub is absent, the transition to scrub or forest vegetation is generally clear. The transition to Maritime Wet Grassland on barrier islands may be ambiguous, as these communities share some species. However, presence of species not tolerant of frequent saltwater flooding, such as *Rhynchospora colorata*, *Centella erecta*, and *Muhlenbergia sericea*, should distinguish Maritime Wet Grassland.

Synonyms: *Panicum virgatum - Spartina patens* Herbaceous Vegetation (CEGL006150).
Ecological Systems: North Atlantic Coastal Plain Brackish Tidal Marsh (CES203.894).

Sites: The Transitional Subtype occurs on the higher edge of other marsh communities, in the transition to uplands or to nontidal wetlands.

Soils: Soils are not well known for the Transitional Subtype. They may have characteristics intermediate between marsh soils such as Bohicket (Typic Sulfaquent) and sandy soils such as Corolla (Aquic Quartzipsamment) or Duckston (Typic Psammaquent). In mainland sites they may transition to organic soils.

Hydrology: The Transitional Subtype is at the upper edge of the normal tidal range. It is flooded by the highest tides, which may be astronomical or wind tides. Between tidal flooding, salinity presumably is diluted by rainwater or seeping freshwater.

Vegetation: The Transitional Subtype is extremely variable in its flora and dominant plants. *Spartina patens* is usually present and often abundant, even where not dominant in the adjacent marshes. *Schoenoplectus pungens, Bolboschoenus robustus*, *Fimbristylis castanea, Distichlis spicata*, and *Borrichia frutescens* are frequent in the few CVS plots, site descriptions, and published literature (e.g., Adams 1963, Clontz 1994, Cooper and Waits 1973) recognizable as this community. Other species that may occur include *Osmunda spectabilis, Mikania scandens, Thelypteris palustris, Solidago mexicana, Hydrocotyle bonariensis, Hydrocotyle verticillata/umbellata, Eleocharis* spp. (*parvula*, *tuberculosa*, and others), *Spartina cynosuroides, Cladium jamaicense, Typha angustifolia, Juncus roemerianus, Panicum amaraum, Panicum*

virgatum, Cyperus odoratus, Sabatia stellaris, Sabatia dodecandra, Ludwigia decurrens, Ludwigia alata, Ptilimnium capillaceum, Agalinis maritima, Symphyotrichum subulatum, Symphyotrichum tenuifolium, Pluchea purpurascens, Echinochloa walteri, Lythrum lineare, Amaranthus cannabinus, Rumex verticillatus, Persicaria spp., *Kosteltzkya pentacarpos, Iva frutescens, Morella cerifera, Juniperus silicicola*, and *Pinus taeda*.

Range and Abundance: Ranked GNR (likely G4). The abundance in North Carolina is very poorly known, but the Transitional Subtype potentially occurs throughout the barrier islands and other salty or brackish estuaries. The NVC association ranges far to the north, as far as New Hampshire, but it is unclear how much the northern examples resemble North Carolina's. It seems likely that an equivalent community exists in states to the south.

Associations and Patterns: Brackish Marsh (Transitional Subtype) appears to be a small patch community, usually occurring in narrow bands that amount to only a few acres. A few patches may be larger. Further investigation is needed to determine how regularly it is part of marsh landscapes. The Transitional Subtype is always associated with some other subtype of Brackish Marsh or with Salt Marsh. On the upper site, it may be bordered by any barrier island community or by any nonriverine wetland or upland community on the mainland.

Variation: The Transitional Subtype, as defined, is an extremely variable community, but patterns of variation have not been sorted out. Cooper and Waits (1973) recognized what they called mixed type and marginal type of marsh vegetation that appears to correspond to this subtype. This may be a basis for distinction, with the marginal subtype containing more freshwater species. It may also be appropriate to divide the community into northern and southern subtypes, as has been done with Salt Marsh.

Dynamics: Little is known specifically about the dynamics of the Transitional Subtype. Tidal flooding is infrequent but is an ongoing environmental stress that controls what plants are present. Flooding by unusually salty water or for longer periods because of major storms may be an important natural disturbance that kills some plants. This community may be particularly susceptible to deposition of wrack by storm surges, burying patches of the community and creating bare patches.

Examples on the mainland likely burn naturally. Cecil Frost believed that with regular fire, savanna-like upland vegetation transitioned directly to marsh along mainland estuaries, but that *Juniperus* and shrubs came to dominate in the absence of fire.

Comments: This subtype is seldom described or sampled; it is very poorly known in North Carolina. Further revision may well be needed as data accumulate. This community resembles a Tidal Freshwater Marsh in having a more diverse flora, but its flora is a subset of Tidal Freshwater Marsh species most tolerant of the more frequent salt exposure.

Panicum virgatum - (Cladium mariscus ssp. jamaicense, Juncus roemerianus) Herbaceous Vegetation (CEGL004962*)* is a Gulf Coast equivalent community. *Schoenoplectus americanus - Spartina patens* Herbaceous Vegetation (CEGL006612) is another transitional association, questionably attributed to North Carolina. It is reported to occur between low marsh and high

marsh, rather than at the edge of high marsh. It is unclear if it occurs in North Carolina and if it would be distinguishable from this subtype if it did.

Rare species:
Vascular plants: *Eleocharis parvula* and *Ludwigia alata.*

References:
Adams, D.S. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology 44:445-456.

Clontz, R.B. 1994. An ecological assessment of a *Juncus roemerianus*-dominated tidal marsh within the Sealevel Tract, Sealevel, North Carolina. M.S. Thesis, Duke University.

Cooper, A.W., and E.D. Waits. 1973. Vegetation types in an irregularly flooded salt marsh on the North Carolina Outer Banks. Journal of the Elisha Mitchell Society 89:78-91.

SALT FLAT

Concept: Salt Flats are communities of salt panne areas in the upper parts of salt marsh complexes, where salt water is concentrated by evaporation between tides. Sparse to moderately dense vegetation is dominated by plants tolerant of hypersaline conditions, such as *Salicornia virginica*, *Sarcocornia ambigua*, and *Distichlis spicata*.

Distinguishing Features: Salt Flats are distinguished from Salt Marshes and all other communities by the predominance of the above species, with few other species present. Often a white salt crust is visible on the soil.

Synonyms: *Salicornia* (*virginica, bigelovii, maritima*) - *Spartina alterniflora* Herbaceous Vegetation (CEGL004308).
Ecological Systems: Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh (CES203.260).

Sites: Salt Flat communities occur in the upper parts of tidal marshes in areas with near full-strength seawater. They are sometimes visible as slight depressions but often appear flat if water is not standing. Most occur on barrier islands, but occurrences in mainland marshes are possible.

Soils: Soils of Salt Flats are usually sandy and are hypersaline, often visibly crusted with salt. They are generally not distinguished in soil mapping.

Hydrology: Seawater enters these communities during regular or frequent irregular high tides and evaporates rather than draining away, producing hypersaline conditions.

Vegetation: Vegetation of Salt Flats is generally sparse to moderate and consists of the few species tolerant of high salt concentrations. *Distichlis spicata*, *Sarcocornia ambigua*, or *Salicornia virginica* usually dominate. *Spartina alterniflora* occurs with high frequency but is stunted and at low density. *Borrichia frutescens* and *Limonium carolinianum* are frequent, especially on the edges. Small numbers of other species from adjacent marsh communities may be present in the less extreme patches.

Range and Abundance: Ranked G5. Salt Flats are fairly frequent in the southern and middle parts of North Carolina's barrier islands, wherever the sounds are salty. The NVC association, as defined, ranges from Nova Scotia southward to at least North Carolina and potentially to Georgia.

Associations and Patterns: Salt Flats appear to be small patch communities in North Carolina, though some occurrences exceed the 50 acre rule-of-thumb size. They are a fairly regular feature of the marsh mosaic, which may lead to them being regarded as matrix communities with further study. Salt Flats usually occur with Salt Marsh, sometimes in association with Brackish Marsh or Salt Shrub in high marsh zones.

Variation: Salt Flats vary in degree of development and salt levels, among examples and at a fine scale within examples. The deepest portions may have no vegetation, while shallower examples are transitional to Salt Marsh.

Dynamics: Salt Flat communities are driven by increased concentrations of salt, created by evaporation of seawater that enters at high tide and cannot drain away. They may vary from year to year, as high rainfall or more frequent tidal flushing due to storms may dilute the salt. Little is known of the details of the creation or lifespan of patches. The shallow basins and blocked drainage that create them may form due to sand deposition by storm waves, overwash, or dune movement, potentially even by the accretion of the adjacent marsh. Patches may be destroyed by the same processes or by storm erosion.

Comments: Salt Flats are very distinctive and have been recognized by most authors describing barrier island vegetation, such as Au (1974), Godfrey and Godfrey (1976), Adams (1963), Cooper and Waits (1993), and Rosenfeld (2004). Numerous CVS and NatureServe plots represent it.

Rare species: No rare species are known to be specifically associated with this community.

References:

Adams, D.S. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology 44: 445-456.

Au, S.F. 1974. Vegetation and ecological processes on Shackleford Banks, North Carolina. National Park Service Scientific Monograph Series No. 6.

Cooper, A.W., and E.D. Waits. 1973. Vegetation types in an irregularly flooded salt marsh on the North Carolina Outer Banks. Journal of the Elisha Mitchell Society 89: 78-91.

Godfrey, P.J., and M.M. Godfrey. 1976. Barrier island ecology of Cape Lookout National Seashore and Vicinity. National Park Service Scientific Monograph Series No. 9.

Rosenfeld, K.M. 2004. Ecology of Bird Island, North Carolina, an uninhabited undeveloped barrier island. M.S, Thesis, North Carolina State University, Raleigh.

SALT SHRUB (HIGH SUBTYPE)

Concept: Salt Shrub communities are shrubby zones on the high edges of salt marshes, infrequently flooded with salt water and dominated by the most salt-tolerant shrubs. The High Subtype covers higher, less frequently flooded examples dominated by *Baccharis halimifolia*, *Iva frutescens*, and *Morella cerifera. Spartina patens* is sometimes an important component.

Distinguishing Features: Salt Shrub is distinguished from all other community types by having vegetation dominated or codominated by *Baccharis halimifolia*, *Iva frutescens*, or *Borrichia frutescens*. It may also have a substantial amount of *Morella cerifera* but is distinguishable from Maritime Shrub by the codominance of one of the other species. The High Subtype is distinguished from the Low Subtype by the predominance of *Baccharis halimifolia* or *Iva frutescens* rather than *Borrichia frutescens*.

Synonyms: *Baccharis halimifolia* - *Iva frutescens* - *Morella cerifera* - (*Ilex vomitoria*) Shrubland (CEGL003920).
Ecological Systems: Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh (CES203.260).

Sites: Salt Shrub occurs primarily on barriers islands, but it may potentially occur on the mainland. This community is usually located on the upper side of salt marsh complexes, at the transition to Maritime Grassland or Maritime Wetlands communities, at the upper limit of normal tidal flooding.

Soils: Soils are not distinguished in mapping, but they appear to be sandy soils more similar to Corolla (Aquic Quartzipsamment), Duckston (Typic Psammaquent), or Carteret (Typic Psammaquent), than to marsh soils such as Bohicket (Typic Sulfaquent).

Hydrology: The High Subtype is flooded only by the highest tides and by storm surges.

Vegetation: The High Subtype is a dense-to-open shrubland, dominated by combinations of *Baccharis halimifolia, Morella cerifera*, and sometimes *Iva frutescens*. *Borrichia frutescens* may be present in more open portions and in the lower transition. More open examples may have substantial *Spartina patens*, less often *Juncus roemerianus*. Some *Juniperus silicicola, Ilex vomitoria*, or *Persea palustris* may occur. Vines are usually present, most frequently *Toxicodendron radicans* and *Nekemias (Ampelopsis) arborea*, sometimes *Smilax bona-nox, Smilax auriculata*, or *Parthenocissus quinquefolia*. There is often a well-developed herb layer, dominated by *Spartina patens* or *Juncus roemerianus*. This community often is more diverse than either the marshes or maritime grasslands that border it, and often includes plants not found elsewhere on the island. Additional species that are highly constant or at least frequent in the limited plot data and site reports include *Solidago mexicana, Ipomoea sagittata, Hydrocotyle bonariensis, Cladium jamaicense, Andropogon glomeratus, Setaria magna, Setaria parviflora, Mikania scandens,* and *Typha latifolia*. Less frequent species that may occur include *Centella erecta, Persicaria* spp., *Pattalias palustre (Seutera angustifolia, Cynanchum angustifolium*), *Panicum virgatum, Fimbristylis castanea, Elymus virginicus* var. *Halophila*, *Pluchea* spp., and

Hydrocotyle verticillata/umbellata. The exotic *Phragmites australis* may be present and locally dominate.

Range and Abundance: Ranked G5. This community is believed to be widespread throughout the North Carolina coast, but it is often not documented. The association ranges southward to Florida and westward to Louisiana.

Associations and Patterns: The High Subtype is probably best treated as a matrix community. Individual patches are sometimes as narrow as 10 meters and sometimes are wide and extensive, but they are thought to be a regularly repeating part of the barrier island landscape. The High Subtype may be bordered by Salt Marsh, Brackish Marsh, or the Low Subtype of Salt Shrub on the lower side. On the upland side, it may be bordered by Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, or potentially Maritime Evergreen Forest.

Variation: Little is known about patterns of variation in this community.

Dynamics: Salt Shrub communities appear to be highly dynamic and subject to frequent natural disturbance. The dominant plants are tolerant of salt spray and limited saltwater flooding, but they can be stressed or killed by longer or more intense exposure. Other plants in the community are more sensitive; they probably are killed and must recolonize to be present after storm events.

Comments: Salt Shrub (High Subtype) appears to be closely related to Brackish Marsh (Transitional Subtype) in its habitat at the upper edge of salt marsh complexes and in much of its nonwoody flora. The ecological factors that lead to the presence or absence of the shrub layer that distinguishes them are not well known and need further study. It is unclear if the two communities readily turn into each other or if there are stable site-related differences.

The link to NVC associations is somewhat uncertain, and it has changed since the 4th Approximation Guide was published. This community was initially linked to *Baccharis halimifolia - Iva frutescens / Panicum virgatum* Shrubland (CEGL003921), a northern association reported to range southward to North Carolina. The new primary link, *Baccharis halimifolia - Iva frutescens - Morella cerifera* - (*Ilex vomitoria*) Shrubland (CEGL003920), is a southern association ranging northward to North Carolina. The two are similar enough that if both really occurred in North Carolina they would be difficult to distinguish. The distinction may correspond to the subtle distinction between the Carolinian and Virginian subtypes of Salt Marsh. This needs further investigation.

Iva frutescens / *Spartina patens* Shrubland (CEGL006848) is another northern association attributed to North and South Carolina. It appears so similar in composition that another association does not appear warranted in North Carolina.

Rare species:
Vascular plants: *Elymus virginicus* var. *halophila*.

References:

SALT SHRUB (LOW SUBTYPE)

Concept: Salt Shrub communities are shrubby zones on the high edges of salt marshes, infrequently flooded with salt water and dominated by the most salt-tolerant shrubs. The Low Subtype covers lower-lying, more frequently flooded examples dominated by *Borrichia frutescens*, often with a substantial component of *Juncus roemerianus*, *Spartina patens*, or *Distichlis spicata*.

Distinguishing Features: The Low Subtype is distinguished from all other communities by having *Borrichia frutescens* as the dominant shrub, with *Baccharis halimifolia, Iva frutescens*, and all species that are less salt-tolerant scarce and/or confined to higher microsites.

Synonyms: *Borrichia frutescens* / (*Spartina patens*, *Juncus roemerianus)* Shrubland (CEGL003924). Ecological Systems: Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh (CES203.270). Atlantic Coastal Plain Embayed Region Tidal Salt and Brackish Marsh (CES203.260).

Sites: Salt Shrub occurs primarily on barrier islands, but it may potentially occur on the mainland. It occurs on the upper side of salt marsh complexes, at the transition to Maritime Grassland or Maritime Wetlands communities, at the upper limit of normal tidal flooding. The Low Subtype occurs at slightly lower elevations, often by a few inches, where tidal flooding is somewhat more frequent. It may also occur in higher areas where salt is concentrated by evaporation, but that are not salty enough to support Salt Flat communities.

Soils: Soils are not distinguished in mapping, but they appear to be sandy soils more similar to Corolla (Aquic Quartzipsamment), Duckston (Typic Psammaquent), or Carteret (Typic Psammaquent), than to marsh soils such as Bohicket (Typic Sulfaquent).

Hydrology: The Low Subtype is flooded by the highest tides but not daily.

Vegetation: The Low Subtype has an open to dense, often patchy, shrub layer dominated by *Borrichia frutescens*. Plot data from CVS and Rosenfeld (2004) show *Spartina patens*, *Distichlis spicata*, and *Juncus roemerianus* as highly constant and *Salicornia virginica* as frequent. All of these species may sometimes codominate. This may partly represent areas of other communities that got included in the edges of plots, but these species also can dominate the areas between dense shrub patches. Other species that occur with high to moderate frequency include *Limonium carolinianum, Fimbristylis castanea, Solidago mexicana, Pattalias palustre (Seutera angustifolia, Cynanchum angustifolium*)*, Sarcocornia ambigua,* and *Symphyotrichum tenuifolium*. *Spartina alterniflora* may be present, and a few species shared with the High Subtype, such as *Iva frutescens, Baccharis angustifolia, Morella cerifera, Hydrocotyle bonariensis,* and *Convolvulus americanus (Calystegia sepium),* may be present.

Range and Abundance: Ranked G4. Salt Shrub apparently is widely distributed in North Carolina, wherever salt marshes occur. However, it is often overlooked in reports and is not fully represented in the database. The NVC association ranges from North Carolina south to Florida and westward potentially to Texas.

Associations and Patterns: The Low Subtype is probably best treated as a matrix community. Individual patches are sometimes as narrow as 10 meters and sometimes are wide and extensive, but they are thought to be a regularly repeating part of the barrier island landscape. It may occur with or without the High Subtype. It may be bordered by Salt Marsh or Brackish Marsh, on the lower side. On the upland side, it may be bordered by Maritime Dry Grassland, Maritime Wet Grassland, Maritime Shrub, or potentially Maritime Evergreen Forest. It sometimes grades into Salt Flat with a very gradual transition.

Variation: Little is known about patterns of variation in this community. Examples vary in the extent of shrub cover on a very fine scale, but the species composition appears to vary little across the range in the state.

Dynamics: Salt Shrub communities appear to be highly dynamic and subject to frequent natural disturbance. The Low Subtype contains few of the less salt-tolerant species found in the High Subtype, reflecting the more frequent saltwater flooding. It therefore is less disturbed by saltwater intrusion in storms. *Borrichia* is the most salt-tolerant of native shrubs. Wrack deposition also is a local natural disturbance.

Comments:

Rare species: No rare species are known in this community.

References:

Rosenfeld, K.M. 2004. Ecology of Bird Island, North Carolina, an uninhabited undeveloped barrier island. M.S, Thesis, North Carolina State University, Raleigh.

UPPER BEACH (NORTHERN SUBTYPE)

Concept: Upper Beaches are sparsely vegetated areas between the unvegetated intertidal beach and the foredunes, where regular tidal flooding does not occur but where salt spray is intense and heavy disturbance by waves occurs frequently during storms. The Northern Subtype covers examples from Cape Hatteras northward, where *Cakile edentula* (*Cakile edentula* ssp. *edentula*) dominates.

Distinguishing Features: Upper Beaches are distinguished from Sand Flats by occurrence in higher energy environments, on the ocean beach, generally between the shoreline and a line of dunes that focuses wave energy. They are distinguished from adjacent Dune Grass by the absence of significant cover of *Uniola paniculata* or *Ammophila breviligulata*. The seaward edge is the portion of the beach where all vascular plants are absent because of more regular tidal flooding and wave disturbance. The Northern Subtype is distinguished by being dominated by *Cakile edentula* ssp. *edentula* rather than *Cakile harperi (edentula* ssp. *harperi*).

Synonyms: *Cakile edentula* ssp. *edentula* - *Chamaesyce polygonifolia* Sparse Vegetation (CEGL004400).
Ecological Systems: Central Atlantic Coastal Plain Sandy Beach (CES203.064).

Sites: Upper Beach communities occur on barrier islands in the sparsely vegetated zone below the foredunes. They may also occur on a few back-barrier islands that are exposed to high wave energy and salt water.

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Upper beaches are above normal tide levels but are reached by saltwater and waves during storms and possibly at the highest tides. They are subject to heavy salt spray. The sand is excessively drained and presumably xeric when not flooded.

Vegetation: Upper Beach communities are sparsely vegetated, and short-lived plants are characteristic. *Cakile edentula* is the most frequent species of the Northern Subtype. Other species that may occur include *Euphorbia (Chamaecyse) polygonifolia, Amaranthus pumilus, Polygonum glaucum, Salsola kali, Atriplex arenaria, Sesuvium maritimum*, *Sesuvium portulacastrum*, *Chenopodium album*, and *Ipomoea imperati*. Small numbers of species of Dune Grass may be present, including *Uniola paniculata, Ammophila breviligulata, Panicum amarum, Triplasis purpurea*, and *Hydrocotyle bonariensis*.

Range and Abundance: Ranked G4G5. In North Carolina, this community potentially occurs along the coast from Cape Hatteras northward, though it may be degraded in portions by vehicle and foot traffic. The equivalent NVC association ranges northward to Maine.

Associations and Patterns: Upper Beach is probably best treated as a matrix community. Individual patches are sometimes as narrow as 10 meters and sometimes are wide and extensive, but they are thought to be a regularly repeating part of the barrier island landscape. They usually occur adjacent to Dune Grass communities. Seaward is an unvegetated intertidal beach.

Variation: Little is known about natural variation. Because plants are short-lived, composition and population sizes and can vary substantially from year to year in response to natural disturbance.

Dynamics: Upper Beach communities are probably the community most subject to heavy natural disturbance in all of North Carolina. The frequent saltwater flooding comes with surf focused on this zone rather than dissipated by overwash. Moslow and Heron (1994) noted that waves are the most important coastal process on the Outer Banks, from a geological perspective, and that this area has the highest wave height of anywhere on the east coast. However, overall wave energy varies with location. Coast lines with northeastern exposure, such as northern Hatteras Island, have the highest energy. The effect of this variation on Upper Beach communities should be investigated.

Besides wave disturbance, Upper Beaches occur at the wrack line, where there is regular deposition of floating material. While not generally heavy mats such as the wrack in marshes, it may cause local disturbance.

Beach renourishment projects and enhancement of dunes to make them more continuous are human processes that may alter the dynamics of this community, though the effect of this alteration is somewhat unclear. Many beaches have vehicle traffic that further disturbs part of the Upper Beach.

Comments: This community is often not mentioned in site descriptions and is represented by almost no plots. The two subtypes are recognized provisionally. As with Salt Marsh, they represent a low-diversity community with an enormous range of geographic regions and climate, which calls for some division even if there is not a strong floristic break. The subtypes follow a distinction recognized in NVC, one that is believed to correlate well with biogeography. However, the ranges of the two species of *Cakile* that mark it appear to overlap substantially in North Carolina. It is not clear how the two subtypes interact in the range of overlap. This needs further investigation.

The communities covered by the Sand Flat type were included in this type in earlier drafts of the 4th approximation, as well as in the 3rd approximation, but are now recognized as separate.

Rare species:
Vascular plants: *Amaranthus pumilus, Ipomoea imperati, Polygonum glaucum, Sesuvium maritimum,* and *Sesuvium portulacastrum*.
Vertebrate animals: *Caretta caretta, Chelonia mydas, Dermochelys coriacea,* and *Lepidochelys kempii.*

References:
Moslow, T.F., and S.D. Heron. 1994. The Outer Banks of North Carolina. Chapter 2 in: Davis, R.A., Jr. (Ed.) Geology of Holocene barrier island systems. Springer-Verlag Berlin Heidelberg. 464 pp.

UPPER BEACH (SOUTHERN SUBTYPE)

Concept: Upper Beaches are sparsely vegetated areas between the unvegetated intertidal beach and the foredunes, where regular tidal flooding does not occur but where salt spray is intense but saltwater flooding and disturbance by waves occurs frequently during storms. The Southern Subtype covers more southerly examples, from Cape Hatteras southward, where *Cakile harperi* (*Cakile edentula* ssp. *harperi*) is characteristic.

Distinguishing Features: Upper Beaches are distinguished from Sand Flats by occurrence in higher energy environments, on the ocean beach, generally between the shoreline and a line of dunes that focuses wave energy. They are distinguished from adjacent Dune Grass by the absence of significant cover of *Uniola paniculata* or *Ammophila breviligulata*. The seaward edge is the portion of the beach where all vascular plants are absent because of more regular tidal flooding and wave disturbance. The Southern Subtype is distinguished by the dominance by *Cakile harperi* rather than *Cakile edentula* in its narrower sense.

Synonyms: *Cakile edentula* ssp. *harperi* Sparse Vegetation (CEGL004401).
Ecological Systems: Southern Atlantic Coastal Plain Southern Beach (CES203.535).

Sites: Upper Beach communities occur on barrier islands in the sparsely vegetated zone below the foredunes. They may also occur on a few back-barrier islands that are exposed to high wave energy and salt water.

Soils: Soils are coarse sands classified as the Newhan series (Typic Quartzipsamment).

Hydrology: Upper beaches are above normal tide levels but are reached by saltwater and waves during storms and possibly at the highest tides. They are subject to heavy salt spray. The sand is excessively drained and presumably xeric when not flooded.

Vegetation: Upper Beach communities are sparsely vegetated, and short-lived plants are characteristic. *Cakile harperi* is the most frequent species of the Southern Subtype. Other species that may occur include *Cakile edentula, Euphorbia (Chamaecyse) polygonifolia, Amaranthus pumilus, Polygonum glaucum, Salsola kali, Atriplex arenaria, Sesuvium maritimum*, *Sesuvium portulacastrum*, *Chenopodium album*, and *Ipomoea imperati*. Small numbers of species of Dune Grass may be present, including *Uniola paniculata, Ammophila breviligulata, Panicum amarum, Triplasis purpurea*, and *Hydrocotyle bonariensis*.

Range and Abundance: Ranked G3. In North Carolina, this community potentially occurs along the coast from Cape Hatteras southward, though it may be degraded in portions by vehicle and foot traffic. The equivalent NVC association ranges southward through Georgia, with a disjunct area of occurrence in Florida.

Associations and Patterns: Upper Beach is probably best treated as a matrix community. Individual patches are sometimes as narrow as 10 meters and sometimes are wide and extensive, but they are thought to be a regularly repeating part of the barrier island landscape. They usually occur adjacent to Dune Grass communities. Seaward is an unvegetated intertidal beach.

Variation: Little is known about natural variation. Because plants are short-lived, composition and population sizes can vary substantially from year to year in response to natural disturbance.

Dynamics: Upper Beach communities are probably the community most subject to heavy natural disturbance in all of North Carolina. The frequent saltwater flooding comes with surf focused on this zone rather than dissipated by overwash. Moslow and Heron (1994) noted that waves are the most important coastal process on the Outer Banks, from a geological perspective, and that this area has the highest wave height of anywhere on the east coast. However, overall wave energy varies with location. Coastlines with northeastern exposure, such as Core Banks, have the highest energy, while those with more southern exposure, such as Ocracoke, Shackleford Banks, and Bogue Banks, have less. The effect of this variation on Upper Beach communities should be investigated. The NVC's description of this community emphasizes its occurrence in the microtidal region of North Carolina to Georgia, and of barrier island geomorphology being dominated more by overwash rather than tidal energy. However, tidal energy is less important than wave energy in Upper Beach communities. Storm flooding is believed to be more important in both subtypes.

Besides wave disturbance, Upper Beaches occur at the wrack line, where there is regular deposition of floating material. While not generally heavy mats like the wrack in marshes, it may cause local disturbance.

Beach renourishment projects and enhancement of dunes to make them more continuous are human processes that may alter the dynamics of this community, though the effect of this alteration is somewhat unclear. Many beaches have vehicle traffic that further disturbs part of the Upper Beach.

Comments: This community is often not mentioned in site descriptions and is represented by almost no plots. The two subtypes are recognized provisionally. As with Salt Marsh, they represent a low-diversity community with an enormous range of geographic regions and climate, which calls for some division even if there is not a strong floristic break. The subtypes follow a distinction recognized in NVC, one that is believed to correlate well with biogeography. However, the ranges of the two species of *Cakile* that mark it appear to overlap substantially in North Carolina. It is not clear how the two subtypes interact in the range of overlap. This needs further investigation.

The communities covered by the Sand Flat type were included in this type in earlier drafts of the 4th approximation, as well as in the 3rd approximation, but are now recognized as separate.

Rare species:
Vascular plants: *Amaranthus pumilus, Euphorbia bombensis, Ipomoea imperati, Polygonum glaucum, Sesuvium maritimum,* and *Sesuvium portulacastrum*.
Vertebrate animals: *Caretta caretta, Chelonia mydas, Dermochelys coriacea,* and *Lepidochelys kempii.*

References:

Moslow, T.F. and S.D. Heron. 1994. The Outer Banks of North Carolina. Chapter 2 in: Davis, R.A., Jr. (Ed.) Geology of Holocene barrier island systems. Springer-Verlag Berlin Heidelberg. 464 pp.

SAND FLAT

Concept: Sand Flats are sparsely vegetated areas on extensive low-lying sand flats, generally on the accreting ends of barrier islands.

Distinguishing Features: Sand Flat communities are distinguished by occurrence on accreting sand flats and by sparse vegetation containing *Sesuvium*, *Atriplex*, and *Suaeda*. Incipient dunes dominated by *Uniola paniculata* or *Ammophila* breviligulata may be present, but substantial areas of this plant should be regarded as inclusions of Dune Grass. Upper Beach communities may share some of the few plant species, but are more subject to wave action and salt spray and are characterized by *Cakile* spp.

Synonyms: *Sesuvium portulacastrum* - *Atriplex* spp. - *Suaeda* spp. Sparse Vegetation (CEGL004406).
Ecological Systems: Central Atlantic Coastal Plain Sandy Beach (CES203.064).

Sites: Sand Flats are barrier island areas with little or no topography, subject to overwash during storms but not exposed to high wave energy as beaches are. They generally are newly deposited sand spits on ends of barrier islands, formed as inlets migrate. Tidal deltas or large overwash deposits could potentially also form them. The surfaces are generally too young to have developed dunes.

Soils: Sand Flats consist of newly deposited sand, potentially with a high shell content, with little or no soil development.

Hydrology: Sand Flats likely are dry most of the time due to excess drainage. Conditions are salty but salt is not concentrated by evaporation, and salt presumably is leached by rainfall between overwash events. They are not flooded by the highest regular tides but are frequently overwashed by seawater during storms.

Vegetation: Sand Flats are sparsely vegetated overall. Plant cover consists of mats which may be locally dense but are often widely scattered. Mats are typically dominated by *Sesuvium portulacastrum, Sesuvium maritimum*, or *Suaeda linearis*. Other species may include *Spartina patens, Panicum amarum, Vigna luteola, Ipomoea imperati, Ipomoea sagittata, Sporobolus virginicus*, *Amaranthus pumilus*, and *Cyperus* sp. *Uniola paniculata* may be present in small amounts.

Range and Abundance: Ranked G3. Only a handful of well-developed examples in good condition occur in North Carolina. The association ranges from Delaware and Maryland southward to Florida.

Associations and Patterns: Sand Flats are large patch communities. They may cover areas of many acres but are not a regularly repeating part of most barrier island landscapes. They may contain patches of Dune Grass on developing dunes and may border Salt Marsh, Salt Shrub, or other Estuarine Communities.

Variation: Sand Flats probably vary mostly with age and stability or time since disturbance.

Dynamics: Sand Flats are young communities that are subject to frequent natural disturbance in the form of overwash. They often are short lived at any given place, because of the dynamic nature of inlets, and may appear or disappear in a few years. A dramatic example occurs at Hatteras Inlet, where 1.5 miles of predominantly Sand Flat has disappeared at the end of Hatteras Island since 1998. A relatively new inlet through Core Banks has migrated 1.2 miles in the same period, producing new Sand Flat habitat as dunes and overwash flats were destroyed on the other side of the inlet. Where sand spits last longer, dunes begin to form, and different barrier island communities develop. This may happen over decades or just a few years.

The dynamics of spit formation and migration may vary both with weather cycles over periods of years and with the configuration of the coast in different places. Their dynamics depend on the energy of tidal currents and the amount of sand moving in the longshore drift. Moslow and Heron (1994) note that tidal currents depend on the size of the tidal wedge as well as the tidal amplitude, and currents can be substantial even with the very limited tidal range on the Outer Banks. The authors also note that there have been 30 inlets in the Outer Banks over the last 400 years even though there are only around ten at present, indicating substantial turnover.

Comments: Besides the sparse vegetation, Sand Flats are often crucial places for animals. A number of birds nest on them, including a remarkable number of rare species. On accessible barrier islands, Sand Flats are often popular places for driving and often are disturbed by vehicle traffic. Both vehicle and foot traffic are a threat to rare birds nesting in this habitat, who readily abandon their nests if disturbed.

The inclusion of Sand Flat in the Estuarine Communities theme is marginal. They could potentially fit within Maritime Grasslands because they are not usually wet. However, the more frequent flooding with salt water, while not as frequent as in the tidal marshes, is similar to that in Salt Shrub.

Rare species:
Vascular plants: *Amaranthus pumilus, Ipomoea imperati, Polygonum glaucum,* and *Sesuvium maritimum*.
Vertebrate animals: *Charadrius melodus, Charardrius wilsonia, Haematopus palliatus, Hypoprogne caspia, Rynchops niger, Sterna hirundo,* and *Sternula antillarum*.

References:
Moslow, T.F., and S.D. Heron. 1994. The Outer Banks of North Carolina. Chapter 2 in: Davis, R.A., Jr. (Ed.) Geology of Holocene barrier island systems. Springer-Verlag Berlin Heidelberg. 464 pp.