Cape Hatteras National Seashore: Geomorphic Map Unit Properties Table (East Carolina University Map; 1:10,000 scale)

Group	Subgroup	Map Unit (Symbol)	Geologic Description	Geologic and Environmental Features and Processes	Geologic Resource Management Issues	Geologic History and Habitat
BEACH FEATURES (BF)		Ocean Beach (BF_ocbeach) Inlet Spit and Flat (BF_spit_flt)	Beach: a sand body that extends from the wet/dry line to the base of a dune field, scarped dune, or island berm crest. Inlet Spit and Flat: subparallel sand ridges adjacent to modern or paleo-inlets. Characterized by curved ridge structures on gently ramped flats.	**Sediment Transport Processes**—Units are frequently inundated during storms and high tides. Ridges form in response to overflow conditions. Barrier islands are continuously reshaped by the constant movement of sand by wind, waves, and currents. Storm winds move sand into the island interior and estuary, and build dunes. Overwash builds island elevation, expands marsh platforms and estuarine shoals, and creates and maintains early-succession habitat. **Inlets**—Created when storms drive surges across and through the island from the ocean or estuarine side. It widens by erosion and collapse of the adjacent bank, and deepens as flow scours the channel. They provide sediment to the back-barrier system through the growth of spits and delta deposits, which become platform marshes when the inlet closes. **Barrier Island Evolution and Behavior**—Sediment availability and shoreline erosion patterns are influenced by the geologic framework of older stratigraphic units occurring beneath and seaward of the shoreface. **Barrier Island System Units**—Predominantly sand. **Paleontological Resources**—Fossils may wash ashore or be exposed.	**Shoreline Erosion**—Ocean shoreline change rates range from -2 m/yr to 2 m/yr. Erosion rates and breach potential are highest north of Rodanthe, southern Pea Island, the Buxton and Isabel inlet areas, and northeastern Ocracoke Island. **Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion, landward migration, and conversion of tidal wetlands to open water. **Hurricane Impacts and Human Responses**—Storms move sand across and off the island, create overwash and breaches, and drive landward migration. Overwash adds saline water to surficial aquifers and groundwater. **Inlet Modifications—**Inlet modifications disrupt the inlet's ability to provide sediment to downdrift shorelines. Newly opened inlets are often closed artificially to maintain the highway infrastructure. The Oregon Inlet terminal groin and revetment stopped erosion of northern Pea Island, but soundward accretion of the Bodie Island spit has narrowed and deepened the inlet. Oregon Inlet stabilization causes shoreline erosion of up to 4 m/yr on Pea Island. **Recreational and Watershed Land Use**—ORV use disturbs beach ecosystems, damages backshore vegetation, limits seaward dune development, and prevents post-storm dune recovery. **Coastal Engineering and Shoreline Armoring**—Seawalls, bulkheads, and other structures to inhibit wave action are expensive and accelerate erosion in front of the structures. Temporary soft stabilization (sandbags) have similar effects but are permitted in North Carolina. There have been 17 recorded beach nourishment projects in the park. Most nourishment sand is sourced from inlet deltas and channels; its removal destabilizes the inlets and impacts regional sediment budgets. Between 1962 and 2011, over 7.8 million m^3 of sediment were emplaced on park beaches. **Highway 12 Transportation Corridor**—Highway 12 is very vulnerable to shoreline erosion and storm overwash, and has been repeatedly damaged in numerous places in the last few decades. Debate over how to replace the route is ongoing. **Paleontological Resource Inventory, Monitoring, and Protection**— Beachcombers are allowed to collect unoccupied shells at Cape Hatteras National Seashore, but NPS policy states that fossils cannot be collected from NPS lands.	Beach unit is among the most indicative features of modern barrier island geomorphological processes. Spit and flat features are indicative of sand accretion during periodic overflow events and evolve in patterns. Cultural artifacts may wash ashore. Habitat: Shorebird foraging. Wrack consisting of offshore algae (*Sargassum* spp.), dune grasses, submerged aquatic vegetation, and estuarine marsh grasses. Inlet spits support *Spartina patens* grasses, mixed grasses, and scrub shrub.

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OVERWASH-PLAIN FEATURES	UPPER OVERWASH RAMP (UO)	Sparse to Unvegetated (UO_unveg) Grass (UO_grass) Scrub Shrub (UO_scrb_shrb)	Upper overwash ramp begins at the island berm crest with a slightly undulating surface and slopes of varying degrees to the middle overwash ramp, lower overwash ramp, or adjacent estuary. Small isolated dunes are present locally. Sparse to unvegetated: dominated by salty groundwater with a surface of xeric vegetation. Vegetative cover increases successively away from the beach to grass- and shrub-dominated areas on the upper ramp. Shrub: communities expand oceanward on very wide ramps with dune fields or ridges.	**Sediment Transport Processes**—Barrier islands are continuously reshaped by the constant movement of sand by wind, waves, and currents. Overwash builds island elevation, expands marsh platforms and estuarine shoals, and creates and maintains early-succession habitat. **Inlets**—Created when storms drive surges across and through the island from the ocean or estuarine side. It widens by erosion and collapse of the adjacent bank, and deepens as flow scours the channel. They provide sediment to the back-barrier system through the growth of spits and delta deposits, which become platform marshes when the inlet closes. **Freshwater Aquifers**—Units have a relatively deep freshwater table or salty groundwater; farther from the beach, freshwater dominates and the water table rises. The dunes near Theoff Point at the southern end of Bodie Island are favorable for fresh groundwater development because they are unlikely to be inundated by salt water or overwash. **Barrier Island System Units**—Predominantly sand with shell gravel pavements that may contain paleontological resources.	**Shoreline Erosion**—Ocean shoreline change rates range from -2 m/yr to 2 m/yr. Erosion rates and breach potential are highest north of Rodanthe, southern Pea Island, the Buxton and Isabel inlet areas, and northeastern Ocracoke Island. **Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion and landward migration. **Hurricane Impacts and Human Responses**—Storms move sand across and off the island, create overwash and breaches, and drive landward migration. Overwash adds saline water to surficial aquifers and groundwater. **Highway 12 Transportation Corridor**—Highway 12 is very vulnerable to shoreline erosion and storm overwash, and has been repeatedly damaged in numerous places in the last few decades. Debate over how to replace the route is ongoing.	Units record landward changes in morphology and vegetation in overwash ramp areas. Successive landform development and vegetation give important relative age dates for island development. Cultural artifacts may wash ashore. Habitat: Xeric vegetation dominated by firewheel (*Gaillardia pulchella*), prickly pear cactus (*Opuntia* spp.), and scattered eastern red cedar (*Juniperus virginiana*), lichens, moss. Grass flat communities include sea oats (*Uniola paniculata*), salt meadow hay (*Spartina patens*), broomstraw rush (*Andropogon scoparius*), pennywort (*Hydrocotyle bonariensis*), sea rocket (*Cakile edentula*). Shrub habitat dominated by salt myrtle (*Baccharis halimifolia*), wax myrtle (*Myrica cerifera*), yaupon holly (*Ilex vomitoria*), marsh elder (*Iva frutescens*), bayberry (*Myrica pensylvanica*), eastern red cedar (*Juniper virginiana*), salt meadow hay (*Spartina patens*), cat brier (*Smilax* spp.), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*).
		Foredune (UO_fdune) Urban (UO_urbdune)	Foredune: natural features forming along the uppermost portion of the overwash plain with irregular geometry and variable size. Absent in areas where constructed dunes disrupt the natural sediment-supply process.	**Sediment Transport Processes**—Barrier islands are continuously reshaped by the constant movement of sand by wind, waves, and currents. Storm winds move sand into the island interior and estuary, and build dunes. Overwash builds island elevation. **Barrier Island System Units**—Predominantly sand.	**Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion and landward migration. **Hurricane Impacts and Human Responses**—Units are continuously evolving through blowouts, cut and fill structures, and scarping. Sand inundation associated with active dunes. **Recreational and Watershed Land Use**—ORV use disturbs beach ecosystems, damages backshore vegetation, limits seaward dune development, and prevents post-storm dune recovery. **Coastal Engineering and Shoreline Armoring**—Seawalls, bulkheads, and other structures to inhibit wave action are expensive and accelerate erosion in front of the structures. Temporary soft stabilization (sandbags) have similar effects but are permitted in North Carolina. There have been 17 recorded beach nourishment projects in the park. Most nourishment sand is sourced from inlet deltas and channels; its removal destabilizes the inlets and impacts regional sediment budgets. Between 1962 and 2011, over 7.8 million m^3 of sediment were emplaced on park beaches.	Natural dunes are rare in modern developed beach areas and serve as models for the evolution of barrier island systems. Habitat: Locally vegetated by sea oats (*Uniola paniculata*) and on the lee side by salt meadow hay (*Spartina patens*), sea rocket (*Cakile edentula*), goldenrod (*Solidago sempervirens*), wax myrtle (*Myrica cerifera*), eastern red cedar (*Juniper virginiana*), and pennywort (*Hydrocotyle bonariensis*).
	MIDDLE OVERWASH RAMP (MO)	Sparse to Unvegetated (MO_unveg) Grass (MO_grass) Scrub Shrub (MO_scrb_shrb) Forest (MO_forest)	Middle overwash ramp is relatively flat, with a dry to damp surface. This unit occurs only on relatively wide islands. Vegetation succession goes from unvegetated to grass to shrub to forest (if storm events are infrequent, ocean shoreline recession is slow, and/or a protective dune field is present).	**Sediment Transport Processes**—Overwash builds island elevation, expands marsh platforms and estuarine shoals, and creates and maintains early-succession habitat. **Freshwater Aquifer**—Supply is recharged through rainfall and depleted through residential use, evapotranspiration from the surface and vegetation, and surface drainage from wetlands. Groundwater systems and aquifers can be affected by impoundments, weather conditions, and water withdrawal; these influences alter hydrologic processes, wetland function, and the distribution, composition, diversity, and structure of vegetation communities. **Barrier Island System Units**—Predominantly sand. Erosion resistance is low to moderately low where forested.	**Hurricane Impacts and Human Responses**—Units are often slightly wet and inundated during storm events. Units are associated with infrequent, but pervasive, storm events that destroy or bury existing stabilizing vegetation. Overwash adds saline water to surficial aquifers and groundwater. Rainwater adds fresh water to surficial aquifers and groundwater.	Units form as a function of island size, sediment supply, overwash frequency, vegetation patterns, and island morphology. Unvegetated areas represent new overwash fans following major storm events. May contain cultural resources. Habitat: Grass species include salt meadow hay (*Spartina patens*) and broom straw (*Andropogon scoparius*). Scrub shrub species include salt myrtle (*Baccharis halimifolia*), wax myrtle (*Myrica cerifera*), yaupon holly (*Ilex vomitoria*), marsh elder (*Iva frutescens*), bayberry (*Myrica pensylvanica*), eastern red cedar (*Juniper virginiana*), salt meadow hay (*Spartina patens*), cat brier (*Smilax* spp.), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*). Forest species include pine (*Pinus* spp.), live oak (*Quercus virginiana*), eastern red cedar (*Juniper virginiana*), wax myrtle (*Myrica cerifera*), yaupon holly (*Ilex vomitoria*), cat brier (*Smilax* spp.), poison ivy (*Toxicodendron radicans*), and muscadine grape (*Vitus rotundifolia*).

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OVERWASH-PLAIN FEATURES	MIDDLE OVERWASH RAMP (MO)	Interior Marsh (MO_intmarsh)	Unit contains sandy, organic-rich soil with a high, fluctuating water table. Grades into platform marsh areas with a gentle decline in elevation, ranging from <1 m (39 in) to a few centimeters above mean sea level.	**Sediment Transport Processes**—Frequently flooded by wind and storm tides and estuarine water flowing through tidal channels. Overwash builds island elevation, expands marsh platforms and estuarine shoals, and creates and maintains early-succession habitat. **Freshwater Aquifer**—Supply is recharged through rainfall and depleted through residential use, evapotranspiration from the surface and vegetation, and surface drainage from wetlands. Groundwater systems and aquifers can be affected by impoundments, weather conditions, and water withdrawal; these influences alter hydrologic processes, wetland function, and the distribution, composition, diversity, and structure of vegetation communities. **Barrier Island System Units**—Predominantly sand and peat. Erosion resistance is low. **Paleontological Resources**—May contain pollen spores and other recent organic remains.	**Hurricane Impacts and Human Responses**—Overwash adds saline water to surficial aquifers and groundwater. Rainwater adds fresh water to surficial aquifers and groundwater.	Unit is interstitial between the middle overwash ramp and dry grass flat areas. Unit has a sandy substrate, in contrast to the peaty substrates of platform marsh areas. Habitat: Algal mats, marsh vegetation including smooth cordgrass (*Spartina alterniflora*), salt meadow hay (*Spartina patens*), black needlerush (*Juncus roemerianus*), saltgrass (*Distichlis spicata*), sea oxeye (*Borrichia frutescens*), soft-stemmed bulrush (*Scirpus robustus*), sawgrass (*Cladium jamaicense*), common reed (*Phragmites australis*), giant cordgrass (*Spartina cynosuroides*), cattail (*Typha angustiflora*), depending on groundwater salinity.
		Isolated Dunes (MO_isodune) Ringed Dunes and Beach Ridges (MO_rdune_br) Urban Dune (MO_urbandune) Paleo-inlet Spit (MO_p_inl_spt)	Isolated Dunes: common in unvegetated areas of the middle ramp, often on algal flats. Ringed Dunes: complicated geometries that form when isolated dunes are stabilized by vegetation through a process of dry-season sand trapping followed by wet-season reworking. Paleo-inlet Spits: subparallel ridges adjacent to inlets with curved ridge structures at oblique angles to the shoreline.	**Barrier Island System Units**—Predominantly sand.	**Hurricane Impacts and Human Responses**—Units associated with sand inundation and can be prone to major storm flooding.	Units are typically fleeting and constantly evolving naturally and under human influence. Paleounits record past overflow and blowout events. Ringed dunes form around stabilized structures, such as Ocracoke Village. Habitat: Isolated dunes may be stabilized by salt meadow hay (*Spartina patens*) or scrub shrub. Isolated ringed dunes may contain salt meadow hay (*Spartina patens*) and sea oxeye (*Borrichia frutescens*).
	LOWER OVERWASH RAMP (LO)	Platform Marsh (LO_pf_marsh)	The lower overwash ramp is a wet, flat, intertidal surface extending toward the back-barrier estuary, with strong vegetation zonation determined by salinity gradients. Marsh contains a <1-m- (3-ft-) thick peat or sandy peat substrate that is permanently water saturated. This unit often has tidal creek networks and occasional small ponds. Grades gently to a scarp abutting the estuary and a low fringing berm.	**Inlets**—Created when storms drive surges across and through the island from the ocean or estuarine side. It widens by erosion and collapse of the adjacent bank, and deepens as flow scours the channel. They provide sediment to the back-barrier system through the growth of spits and delta deposits, which become platform marshes when the inlet closes. **Estuaries**—Some sediment contributions is derived from erosion of the marsh shoreline. **Freshwater Aquifer**—Supply is recharged through rainfall and depleted through residential use, evapotranspiration from the surface and vegetation, and surface drainage from wetlands. Groundwater systems and aquifers can be affected by impoundments, weather conditions, and water withdrawal; these influences alter hydrologic processes, wetland function, and the distribution, composition, diversity, and structure of vegetation communities. **Barrier Island System Units**—Predominantly sand and peat. Frequently inundated and may locally contain quicksand or thick muck. **Paleontological Resources**—May preserve pollen.	**Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion, landward migration, and conversion of tidal wetlands to open water. **Hurricane Impacts and Human Responses**—Unit is constantly water saturated and should be avoided for infrastructure. Overwash adds saline water to surficial aquifers and groundwater. Rainwater adds fresh water to surficial aquifers and groundwater. High rainfall and flooding increases nutrients and sediments to the estuary, reduces estuarine salinity, and causes phytoplankton blooms. **Recreational and Watershed Land Use**—Toxic and nuisance algal blooms may occur in tidal creeks, marshes, and ponds on Ocracoke Island due to runoff or septic system leachate.	Wrack causes depressions, where it kills underlying marsh vegetation and may eventually form ponds that vary from hypo- to hypersaline in wet/dry seasons. May preserve cultural artifacts. Habitat: Decaying wrack deposits kill marsh platform vegetation, but are locally recolonized by sea oxeye (*Borrichia frutescens*), annual marsh glasswort (*Salicornia bigelovii*), perennial marsh glasswort (*Salicornia virginica*), saltgrass (*Distichlis spicata*), wax myrtle (*Myrica cerifera*), marsh elder (*Iva frutescens*), salt myrtle (*Baccharis halimifolia*).

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OVERWASH-PLAIN FEATURES	LOWER OVERWASH RAMP (LO)	Fringing Berm (LO_fring_brm) Strandplain Beach (LO_spln_bch) Back-Barrier Berm (LO_bk_br_bm)	Fringing Berms: up to 1 m (3 ft) in height and 1 to 3 m (3 to 9 ft) wide. These storm deposits are shore parallel <10 m (30 ft) from the edge of the platform marsh. Berm consists of mixed sand and peat. Strandplain Beaches: occur in eroded scarps and are often temporary or seasonal due to storm patterns. Back-Barrier Berms: form at the interface between estuarine and ocean storm–dominated systems and occur as ridges subparallel to the overwash plain. Berms are <2 m (6 ft) high and 25 m (77 ft) wide, and may have arcuate morphologies.	**Sediment Transport Processes**—Low-lying areas are prone to inundation and some units are associated with storm surge events. Storm winds move sand into the island interior and estuary. Overwash builds island elevation, and expands marsh platforms and estuarine shoals. **Inlets**—Created when storms drive surges across and through the island from the ocean or estuarine side. It widens by erosion and collapse of the adjacent bank, and deepens as flow scours the channel. They provide sediment to the back-barrier system through the growth of spits and delta deposits, which become platform marshes when the inlet closes. **Barrier Island System Units**—Predominantly peat and sand.	**Shoreline Erosion**—Estuarine shoreline change rates range from -1.2 m/yr (marsh) to 0.2 m/yr (beach). Estuarine erosion at Fort Raleigh NHS threatens infrastructure and cultural resources. The northern side of Ocracoke Village is eroding at 1.2 m/yr due to storm wind and waves from Pamlico Sound. **Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion, landward migration, and conversion of tidal wetlands to open water. **Hurricane Impacts and Human Responses**—Storms move sand across and off the island, create overwash and breaches, and drive landward migration. **Recreational and Watershed Land Use—**Constructed dune ridges have altered the park's ecosystem and geologic structure, minimized overwash and inlet formation, modified habitat and back-barrier estuarine processes. They have resulted in narrower beaches, steeper shoreface, increased wave energy hitting the shoreface, marsh scarps, and decreased sound productivity.	Fringing berm buffers the lower overwash ramp from the sound and records timing of storm surge events. Units are strongly associated with storm events and may be present only temporarily. They record the evolution of the low-lying back-barrier area. Habitat: Barren peat surfaces become colonized by *Salicornia bigelovii*, berms dominated by salt meadow hay (*Spartina patens*), giant cordgrass (*Spartina cynosuroides*), wax myrtle (*Myrica cerifera*), salt myrtle (*Iva frutescens*), black needlerush (*Juncus roemerianus*). Algal mats on strandplain beaches. Back-barrier berms provide habitat for eastern red cedar (*Juniper virginiana*), salt meadow hay (*Spartina patens*), salt myrtle (*Iva frutescens*), marsh elder (*Iva frutescens*), wax myrtle (*Myrica cerifera*), and yaupon holly (*Ilex vomitoria*). Higher forested areas have pine (*Pinus* spp.), live oak (*Quercus virginiana*), eastern red cedar (*Juniper virginiana*), salt myrtle (*Baccharis halimifolia*), marsh elder (*Iva frutescens*), wax myrtle (*Myrica cerifera*), and yaupon holly (*Ilex vomitoria*).
POLYDEMIC FEATURES (PF)		Tidal Creeks and Tidal Channels (PF_tidal) Pond (PF_pond)	Tidal Creeks and Channels: form in platform marshes, may be fed by tides or fresh groundwater from higher island elevations. Overwash plain deposits may bury headwaters of creeks. Where tidal creeks erode between platform marsh segments, the classic molar-tooth geomorphology forms. Tidal channels are 3 to 4 m (9 to 12 ft) deep, with steeply scarped peat shorelines. Ponds: formation, water composition, and duration in the general overwash plain vary. Many ponds are present as a function of the patterns, frequency, and abundance of storms and precipitation.	**Freshwater Aquifer**—Supply is recharged through rainfall and depleted through residential use, evapotranspiration from the surface and vegetation, and surface drainage from wetlands. Groundwater systems and aquifers can be affected by impoundments, weather conditions, and water withdrawal; these influences alter hydrologic processes, wetland function, and the distribution, composition, diversity, and structure of vegetation communities. **Barrier Island System Units**—Predominantly peat and sand. Erosion resistance is nonexistent. **Paleontological Resources**—May contain pollen.	**Shoreline Erosion**—Estuarine shoreline change rates range from -1.2 m/yr (marsh) to 0.2 m/yr (beach). **Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion, landward migration, and conversion of tidal wetlands to open water. **Hurricane Impacts and Human Responses** Overwash adds saline water to surficial aquifers and groundwater. Rainwater adds fresh water to surficial aquifers and groundwater. High rainfall and flooding increases nutrients and sediments to the estuary, reduces estuarine salinity, and causes phytoplankton blooms. **Recreation and Watershed Land Use**—Toxic and nuisance algal blooms may occur in tidal creeks, marshes, and ponds on Ocracoke Island due to runoff or septic system leachate.	Tidal creeks and channels are major forces of landscape change, eroding the upper platform areas. Ponds are constantly changing based on abundance of water and vary from open water to marshes and dried algal flats. May contain cultural resources. Habitat: Perimeter areas may contain soft-stemmed bulrush (*Scirpus robustus*), sawgrass (*Cladium jamaicense*), giant cordgrass (*Spartina cynosuroides*), cat tail (*Typha angustiflora*), common reed (*Phragmites australis*), and black needle rush (*Juncus roemerianus*). Ponds may contain algal mats and other marsh vegetation.
		Transverse Ridges (PF_trnv_dune) Dune Flat (PF_dune_flat)	Transverse Ridges: long, low, straight ridges forming transverse to the long trend of a barrier island. Unit forms when temporarily ponded waves of storm surge rework dune sands or by truncation of a large dune system. Dune Flats: form in areas of abundant sand supply as broad, rolling flat areas (elevation 2 to 3 m [6 to 9 ft] higher than the island berm) downwind of the island berm. Maximum relief of sand flat areas is <2 m (6 ft).	**Sediment Transport Processes**—Units are associated with active overwash and aeolian processes and are prone to sand and water inundation. **Barrier Island System Units**—Predominantly sand.	**Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion, landward migration, and conversion of tidal wetlands to open water. **Hurricane Impacts and Human Responses**—Storms move sand across and off the island, create overwash and breaches, and drive landward migration. Overwash adds saline water to surficial aquifers and groundwater. Rainwater adds fresh water to surficial aquifers and groundwater.	Transverse dune ridges suggest former inlet locations. Dune flats record the anthropogenic impacts of urbanization on the barrier islands, as they become vegetated and stabilized when the sand supply is truncated by roads, structures, and other changes. Long-standing, stable dune flats support cultural resources at Kitty Hawk and Whalebone Junction. Habitat: Vegetation ranges from nonexistent to some areas stabilized by sea oat (*Uniola paniculata*), salt meadow hay (*Spartina patens*), scrub shrubs such as salt myrtle (*Baccharis halimifolia*), marsh elder (*Iva frutescens*), wax myrtle (*Myrica cerifera*), yaupon holly (*Ilex vomitoria*), and eastern red cedar (*Juniper virginiana*). The oldest, forested areas contain pine (*Pinus* spp.), live oak (*Quercus virginiana*), eastern red cedar (*Juniper virginiana*), cat brier (*Smilax* spp.), poison ivy (*Toxicodendron radicans*), and muscadine grape (*Vitus rotundifolia*). Unit supports broad damp areas dominated by algae and freshwater marsh plants. Other species include salt meadow hay (*Spartina patens*), forests of pine (*Pinus* spp.), yaupon holly (*Ilex vomitoria*), and live oak (*Quercus virginiana*).

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POLYDEMIC FEATURES (PF)		Dune Field (PF_dunef) Sparse to Unvegetated Dune Field (PF_dune_unvg) Grassy Dune Field (PF_dune_grss) Forested Dune Field (PF_dune_fors) Urbanized Dune Field (PF_dune_urb)	Dune Fields: form atop dune flats when sand supply is sufficient. Dune heights range from 3 to 25 m (9 to 77 ft) or more. Dune morphology varies with formation process and wind direction. Dune vegetation varies from nonexistent to forested and urbanized, depending on sand supply. Infrastructure has stabilized dune areas at Kill Devil Hills, Nags Head Cove, the northern end of Jockey's Ridge, Kitty Hawk, and the southern half of the Seven Sisters dune field.	**Barrier Island System Units**—Predominantly sand. **Paleontological Resources**—May contain paleontological resources (paleosol horizons).	**Recreational and Watershed Land Use**—Constructed dune ridges have altered the park's ecosystem and geologic structure, minimized overwash and inlet formation, modified habitat and back-barrier estuarine processes. They have resulted in narrower beaches, steeper shoreface, increased wave energy hitting the shoreface, marsh scarps, and decreased sound productivity. Along the barrier segment between Avon and Buxton, this has resulted in substantial island narrowing and four relocations of Highway 12.	Large sand supplies (from paleo–Roanoke River delta deposits) record previous climatic conditions and sea-level stands that built sediment-rich or complex barrier island segments. Unit features prominently in photographs by the Wright brothers. Kill Devil Hill was used by the Wright brothers and is now stabilized. Contains cultural resources (buried soil profiles that may record early settlement) Habitat: Prior to 1930s stabilization efforts, dunes were virtually void of vegetation except some minor salt meadow hay (*Spartina patens*). Heavy forests on the Nags Head Woods dune field, unit supports mixed hardwood and pine forest with a scrub shrub perimeter.
POLYDEMIC FEATURES (PF)		Algal Flat (PF-algal_flt) Ridge and Swale (PF_rdg_swl) Swale Marsh (PF_swl_marsh) Paleo-inlet Spit (PF_p_inl_spt)	Algal Flats: dominate the lower supratidal portion of the overwash area and form in ephemeral ponds or depressions. Unit persists in highly fluctuating salinity. Ridges and Swales: subparallel couplets of low, regular sand ridges (<3 m [9ft] high) and adjacent shallow swales.	**Sediment Transport Processes**—Storm winds move sand into the island interior and estuary, and build dunes. Overwash builds island elevation. **Capes and Cape-Associated Shoals**—Alongshore sediment transport is toward the tip of Cape Hatteras, so that the sediment loads from the south and from the north meet and are deposited at Diamond Shoals. **Inlets**—Created when storms drive surges across and through the island from the ocean or estuarine side. It widens by erosion and collapse of the adjacent bank, and deepens as flow scours the channel. They provide sediment to the back-barrier system through the growth of spits and delta deposits, which become platform marshes when the inlet closes. **Estuaries**—The sounds provide habitat for birds, seagrass, oysters, and mid-Atlantic fish. Most sand in Core Sound and central and eastern Pamlico Sound is derived from barrier islands and offshore sediments carried through inlets and overwash fans. Additional major contributions are from rivers, shoreline erosion and biogenic production. **Barrier Island System Units**—Predominantly sand and peat. Algal flats are frequently flooded by waters of varying salinity.	**Shoreline Erosion**—Estuarine shoreline change rates range from -1.2 m/yr (marsh) to 0.2 m/yr (beach). **Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion, landward migration, and conversion of tidal wetlands to open water. **Hurricane Impacts and Human Responses**—Overwash adds saline water to surficial aquifers and groundwater. Rainwater adds fresh water to surficial aquifers and groundwater. **Recreational and Watershed Land Use**—Toxic and nuisance algal blooms may occur in Hatteras Island swales that are impacted by runoff or septic system leachate. Groundwater withdrawals can disrupt habitat by limiting plant species richness and diversity in nearby swales.	Algal mats can persist in conditions ranging from freshwater to hypersaline. No ridge and swale structure is forming today on the northern Outer Banks, but unit provides important age dates for sea-level highstand events. Units are among the oldest landforms present on the barrier islands. Many swales are dredged as navigational channels. May contain evidence of early settlements (<500 years old). Habitat: Perimeter of algal flats contains annual marsh glasswort (*Salicornia bigelovii*), perennial marsh glasswort (*Salicornia virginica*), saltgrass (*Distichlis spicata*), and sea oxeye (*Borrichia frutescens*). Sand ridges are heavily vegetated with mixes of pine and hardwood. Swales are dominated by wetland vegetation.
ANTHROPOGENIC FEATURES (AF)		Constructed Dune Ridges (AF_cn_dune_r) Constructed Interior Dune Ridges (AF_cn_idune)	Constructed Dune Ridges and Interior Dune Ridges: linear, ocean-parallel sand ridges built by bulldozers, then artificially vegetated with grass. Generally about 15 m (45 ft) wide at the base and up to 5 m (15 ft) high.	**Barrier Island System Units**—Predominantly sand.	**Shoreline Erosion**—Ocean shoreline change rates range from -2 m/yr to 2 m/yr. Erosion rates and breach potential are highest north of Rodanthe, southern Pea Island, the Buxton and Isabel inlet areas, and northeastern Ocracoke Island. **Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. Sea-level rise may accelerate shoreline erosion. **Hurricane Impacts and Human Responses**—Storms erode protective dunes. **Recreational and Watershed Land Use**—Constructed dune ridges have altered the park's ecosystem and geologic structure, minimized overwash and inlet formation, modified habitat and back-barrier estuarine processes. They have resulted in narrower beaches, steeper shoreface, increased wave energy hitting the shoreface, marsh scarps, and decreased sound productivity. Along the barrier segment between Avon and Buxton, this has resulted in substantial island narrowing and four relocations of Highway 12.	Units are out of equilibrium and are rapidly scarped on the ocean side and breached by storm surges. Units protect buildings and roads by preventing storm overwash and inlet migration. Units began in the 1930s with Works Progress Administration and Civilian Conservation Corps work camps. Habitat: Vegetation planted on these units includes sea oats (*Uniola paniculata*), American beachgrass (*Ammophila breviligulata*), salt meadow hay (*Spartina patens*). Older ridges become vegetated with salt myrtle (*Baccharis halimifolia*), marsh elder (*Iva frutescens*), wax myrtle (*Myrica cerifera*), yaupon holly (*Ilex vomitoria*), and eastern red cedar (*Juniper virginiana*).

Group	Subgroup	Map Unit (Symbol)	Geologic Description	Geologic and Environmental Features and Processes	Geologic Resource Management Issues	Geologic History and Habitat
ANTHROPOGENIC FEATURES (AF)		Road/Parking Areas (AF_rd_prk) Dredge Channels/Spoils (AF_drdge) Excavations (AF_excavate) Anthropic Overprint (AF_an_overpr)	Paved Areas: include roads, highways, and parking lots. Dredge Channels and Pits: sediment removal areas with most dredged material pumped offsite or deposited adjacent to the dredged area. Dredge often appears as linear ridges or rounded mounds. Excavations: artificially round or rectangular water features (including marinas and harbors) where sand was mined for constructed dune features. Anthropogenic Overprint: includes major urban areas with dense patterns of structures, parking lots, and roads.	**Barrier Island System Units**—Predominantly soil, sand, and gravel.	**Inlet Modifications**—The US Army Corps of Engineers sealed the 2003 Hurricane Isabel Inlet breach using sand dredged from the federally maintained ferry channel between Hatteras and Ocracoke islands. Sand dredged from Oregon Inlet was deposited offshore from 1960 to 1983, and was artificially bypassed to Pea Island beaches between 1983 and 2009. **Recreational and Watershed Land Use**—Impervious surface increases pollutant and nutrient runoff, degrading estuarine habitat. Constructed drainage ditches affect water distribution and quality on Bodie and Hatteras islands. Toxic and nuisance algal blooms may occur in nutrient-enriched drainage ditches on Bodie Island. **Coastal Engineering and Shoreline Armoring**—Seawalls, bulkheads, and other structures to inhibit wave action are expensive and accelerate erosion in front of the structures. Temporary soft stabilization (sandbags) have similar effects but are permitted in North Carolina. There have been 17 recorded beach nourishment projects in the park. Most nourishment sand is sourced from inlet deltas and channels; its removal destabilizes the inlets and impacts regional sediment budgets. Between 1962 and 2011, over 7.8 million m^3 of sediment were emplaced on park beaches. **Highway 12 Transportation Corridor**—Highway 12 is very vulnerable to shoreline erosion and storm overwash, and has been repeatedly damaged in numerous places in the last few decades. Debate over how to replace the route is ongoing.	Units record the human presence on the barrier islands. Units associated with urban development and access to natural areas. Anthropogenic unit includes cemeteries, monuments, Coast Guard stations, and camp grounds. Habitat: Inundated dredged areas contain salt myrtle (*Baccharis halimifolia*), marsh elder (*Iva frutescens*), salt meadow hay (*Spartina patens*), giant cordgrass (*Spartina cynosuroides*), and scrub shrub. Above the supratidal zone, dredged areas contain wax myrtle (*Myrica cerifera*), yaupon holly (*Ilex vomitoria*), northern bayberry (*Myrica pensylvanica*), pine (*Pinus* spp.), eastern red cedar (*Juniper virginiana*), salt meadow hay (*Spartina patens*), cat brier (*Smilax* spp.), and poison ivy (*Toxicodendron radicans*).