Cape Hatteras National Seashore: Geomorphic Map Unit Properties Table (North Carolina Geological Survey Map; 1:24,000 scale)

Group	Subgroup	Map Unit (Symbol)	Geologic Description	Geologic and Environmental Features and Processes	Geologic Issues	Geologic History and Habitat
INTERTIDAL FEATURES		Beach (beach)	Area between the ocean shoreline (wet/dry line) and the toe of the Fore-island Dune Complex with a narrow, steep profile.	**Sediment Transport Processes**—Barrier islands are continuously reshaped by the constant movement of sand by wind, waves, and currents. Overwash builds island elevation and creates and maintains early-succession habitat. **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. **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. Periodic flooding during storms and high lunar tides, especially near inlets. **Paleontological Resources**—Fossils may wash ashore or be exposed.	**Shoreline Erosion**—Ocean shoreline change ranges 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. **Inlet Modifications**—Modifications disrupt sediment transport 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 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. 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: Active wave area habitat for shorebirds and other marine life.

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INTERTIDAL FEATURES	SPIT COMPLEX	Sand Flat (sand_flat) Ridge and Swale (ridge_swale)	Sand Flats: unvegetated, low (<1 m [4 ft]) elevation and relief; merge with the beach along the shoreline. Ridge and Swale: components situated lateral to sand flats, merging toward the interior and trending subparallel to the axis of the barrier island; curve toward the back of the island closer to the inlet.	**Sediment Transport Processes**—Sand flats are subject to regular tidal flooding and overwash. 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 and creates and maintains early-succession habitat. **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. **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. 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. Ridge and swale areas represent older and more stable portions of the spit complex.	**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. **Inlet Modifications**—Soundward accretion of the Bodie Island spit has narrowed and deepened the stabilized Oregon Inlet. **Recreational and Watershed Land Use**—ORV use disturbs beach ecosystems, damages backshore vegetation, limits seaward dune development, and prevents post-storm dune recovery. 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. **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.	Sand flats are generally associated with first development of Fore-island Dune Complex. Habitat: Algae crusts, episodic ponded water.
INTERTIDAL FEATURES	Marsh Platform (pf_marsh)		Unit is present along tidal creeks as low-lying areas (<1 m [2 to 3 ft] elevation) and developed in depressions between relict ridges or behind former sand flats. Approximately 1 m (several feet) of localized peat development during sea-level rise.	**Sediment Transport Processes**—Marsh areas are subject to regular tidal flooding and storm overwash. Barrier islands are continuously reshaped by the constant movement of sand by wind, waves, and currents. Storm winds move sand into the estuary. 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 System Units**—Predominantly peat and sand (from overwash). **Paleontological Resources**—May contain pollen.	**Shoreline Erosion**—Estuarine shoreline change rates range from -1.2 m/yr (marsh) to 0.2 m/yr (beach). 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. 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.	Marsh elevations correspond to sea level and are sensitive to sediment supply. May contain cultural resources. Habitat: Grasses such as *Juncus* and *Spartina patens*.
INTERTIDAL AND SUPRATIDAL FEATURE	BEACH AND FORE-ISLAND DUNE COMPLEX	Dune Saddle (dnesadl_bch)	Gaps or breaks along dune ridges in beach and fore-island dune systems with elevations <3 m (10 ft).	**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 build dunes. Overwash builds island elevation 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 System Units**—Predominantly sand.	**Coastal Vulnerability and Sea-Level Rise**—Erosion, overwash, and inlet formation will continue to change island morphology. **Hurricane Impacts and Human Responses**—Saddles represent potential high-water flow pathways that are vulnerable to coastal flooding during storms. Storms move sand across and off the island, create overwash and breaches. Overwash adds saline water to surficial aquifers and groundwater. Rainwater adds fresh water to surficial aquifers and groundwater.	Important features for predicting future overwash channels or inlets. Habitat: May provide local protection from prevailing winds.

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SUPRATIDAL FEATURES	FORE-ISLAND DUNE COMPLEX	Dune Ridges (dunerdge)	Unit is present as prominent, linear, shore-parallel sand ridges separated by swales. As many as three distinct ridges crop out locally, with heights generally <7 m (20 ft). Toe elevations are 2 to 3 m (6 to 8 ft) toward the ocean and 1 to 3 m (4 to 8 ft) toward the island interior.	**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. **Hurricane Impacts and Human Responses**—Storms move sand across and off the island, create overwash and breaches. Overwash adds saline water to surficial aquifers and groundwater. Rainwater adds fresh water to surficial aquifers and groundwater. **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.	Form prominent and extensive portions of Fore-island Dune Complex, important sediment supply for the system. May contain cultural resources (artifacts). Habitat: None documented.
	FORE-ISLAND DUNE COMPLEX, DUNE RIDGE	Interdune Swale and Dune Ridge (intswale_dr) Dune Saddle and Dune Ridge (dnesadl_dr)	Swales: closed, relatively low-lying areas in dune complexes with bases <3 m (10 ft) in elevation. Saddles: gaps or breaks along dune ridge lines with an elevation threshold of <2 m (10 ft).	**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 builds 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 System Units**—Predominantly sand.	**Shoreline Erosion**—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**—Dune saddles represent potential high-water flow pathways or breach points that are vulnerable to coastal flooding during storms. Storms create overwash and breaches. 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.	Important features for predicting future overwash channels or inlets; if they remain stable, swales may become marshy areas. Habitat: May provide local protection from prevailing winds.
	OVERWASH COMPLEX	Overwash Flat (owflat) Overwash Flat and Overwash Channel (owflt_owchn)	Overwash Flats: long-term accumulations of sand overwash behind the Fore-island Dune Complex, often in lobate forms. Overwash Channels: linear features associated with cuts through the fore-island dune.	**Sediment Transport Processes**—Associated with overwash during seasonal high tides and storm events. 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. **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 and landward migration. **Hurricane Impacts and Human Responses**—Units are frequently reworked during storms.	Flats are deposited as lobes in discrete events, then reworked by wind, water, and humans into large flats. Habitat: Early-succession. Shorebird foraging. If stable for a sufficiently long period, can support vegetation.
		Overwash Fan (owfan)	Well defined locally as individual lobes from discrete storm events. Often with associated channels.	**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. **Barrier Island System Units**—Forms during storm events and is prone to flooding. Predominantly sand.	**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. **Recreational and Watershed Land Use**—Constructed dune ridges have minimized overwash and inlet formation.	Unit records discrete storm events (obvious on satellite imagery) and can be used to date overwash events during island development. Cultural resources (artifacts) may wash ashore during storms. Habitat: Early-succession. Shorebird foraging. If stable for a sufficiently long period, can support vegetation.
		Isolated Dunes (isodune)	Isolated dunes occur in the overwash flat area and/or farther inward as remnants of former fore-island dune ridges or as sand accumulations due to local traps.	**Barrier Island System Units**—Predominantly sand. Unit is localized and can be associated with anthropogenic features.	**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. Along the barrier segment between Avon and Buxton, this has resulted in substantial island narrowing and four relocations of Highway 12.	Isolated unit can be remnant of former dune ridge or form as a result of sand trapping by vegetation or fencing. Interior dune sand source is enigmatic; its identification requires more research. Habitat: Vegetation may trap sand, forming isolated dunes.

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SUPRATIDAL FEATURES		Interior Dunes (intdune) Interior Marsh (inmarsh) Back-Barrier Berm (bk_br_brm)	Interior Dunes: large-scale dunes that are the highest points of some islands (3 to 30 m [10 to 90 ft] elevation). Can occur as single ridges or be more laterally extensive. Interior marshes: develop adjacent to water bodies, often in swales of relict beach ridge complexes or interior lowlands. Berms: subtle linear features adjacent to and slightly higher than marsh platforms. Up to 3 m (10 ft) high with complex internal morphology.	**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**—Interior Dunes and Back-Barrier Berm are sand. Interior Marsh is organic-rich sandy soil. **Paleontological Resources**—May contain pollen.	**Hurricane Impacts and Human Responses**—Dune unit can inundate local areas with sand deposits. Units should be avoided for recreation due to active dune formation or delicate marsh habitat. Rainwater adds fresh water to surficial aquifers and groundwater. **Recreational and Watershed Land Use**—Toxic and nuisance algal blooms may occur in swales on Hatteras Island, and in tidal creeks, marshes, and ponds on Ocracoke Island, that are impacted by runoff or septic system leachate. Groundwater withdrawals can disrupt habitat by limiting plant species richness and diversity in nearby swales.	Interior dune sand source is enigmatic; its identification requires more research. Marshes may be freshwater, berms tend to form in broad arcs of apparent relict flood tidal deltas, possibly due to the reworking of delta sand bodies by wave action. Habitat: Vegetation stabilizes interior dunes, providing habitat for plants preferring well-drained conditions. Marsh vegetation is prominent. Berms support leafy vegetation.
RELICT FEATURES		Relict Beach Ridge Complex (rel_bch_rdge) Relict Spit Complex (rel_splt) Water Body (water)	Relict Beach Ridges: crop out as sets of parallel ridges and swales in interior portions of islands. Elevation reaches 0 m (30 ft). Relict Spits: subtle arcuate-shaped ridges and swales in back-island areas with no active inlet connection. Water Bodies: ponds, streams, and other perennial water features; does not include ephemeral features.	**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. **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. The high and wide island mass at Buxton Woods are favorable for fresh groundwater development because they are unlikely to be inundated by salt water or overwash. **Barrier Island System Units**—Predominantly sand, and peat in local marshes. Erosion resistance is very low to low if vegetated.	**Hurricane Impacts and Human Responses**—Rainwater adds fresh water to surficial aquifers and groundwater. **Recreational and Watershed Land Use**—Toxic and nuisance algal blooms may occur in drainage ditches on Bodie Island, in swales on Hatteras Island, and in tidal creeks, marshes, and ponds on Ocracoke Island, that are impacted by runoff or septic system leachate. Groundwater withdrawals can disrupt habitat by limiting plant species richness and diversity in nearby swales.	At least 13 sequences of relict beach ridges are mappable locally. Habitat: Marsh vegetation in interior areas, leafy vegetation on dunes.
ANTHROPOGENIC FEATURES		Airport/Landing Strip (airport_land) Commercial/Industrial Facility (comm_indust)	Airport: includes buildings and pavement near Buxton, Ocracoke, and Wright Brothers memorial areas. Commercial Facilities: includes marinas, ferry terminals, parking lots, and buildings.	**Barrier Island System Units**—Predominantly sand, gravel, and building materials. Historical structures such as lighthouses and guard houses are associated with these units.	**Recreational and Watershed Land Use**—Impervious surface increases pollutant and nutrient runoff, degrading estuarine habitat. **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.	Units record the history of human presence on the barrier islands. Habitat: Plants and animals adaptable to human presence.
ANTHROPOGENIC FEATURES		Dredge/Spoil (drdge) Filled (filled)	Dredge/Spoil: includes features of positive relief with obvious source areas within waterways. There have been five recorded dredging projects within or immediately adjacent to the park. Fill Areas: often include wetlands and exhibit linear boundaries and atypically high elevations.	**Estuaries**—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 clay. Erosion resistance is moderate to low.	**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. **Coastal Engineering and Shoreline Armoring**—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.	Dredge spoil subject to wave modification and vegetation as natural processes overprint anthropogenic changes. Habitat: Fill areas often abut and/or overprint former marsh areas. The sounds provide habitat for birds, seagrass, oysters, and mid-Atlantic fish.

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ANTHROPOGENIC FEATURES		Erosion Control Structure (ersn_ctrl_st) Excavation (excavate) Dike (dike) Waterfowl Impoundment (wtrfwl_impnd)	Erosion Control Structures: may include hardening, riprap, and other artificial sediment traps. There are 48 coastal engineering structures in or immediately adjacent to the park. Excavation Areas: known from imagery and witness accounts, typically serving as spoil sources. There are 5 dredging projects in or immediately adjacent to the park. Dikes: built for several waterfowl impoundment areas in Pea Island National Wildlife Refuge.	**Estuaries**—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. **Freshwater Aquifer**—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 fill.	**Hurricane Impacts and Human Responses**—Structures may fail under extreme storm conditions. **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. **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. 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. **Recreational and Watershed Land Use**—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.	Units document human attempts to stop, slow, or reverse natural barrier island processes. Habitat: Plants and animals adaptable to human presence, waterfowl use impoundment areas.