

Geologic Resources Inventory Scoping Summary

Fire Island National Seashore

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The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a geologic resources inventory report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

The National Park Service held a GRI scoping meeting for Fire Island National Seashore on June 24, 2010 at the park's River Room in Long Island, New York. A site visit at the seashore occurred the following day. Heather Stanton (Colorado State University [CSU]) facilitated the discussion of map coverage and Bruce Heise (NPS-GRD) led the discussion regarding geologic processes and features at the park. After an introduction by park Superintendent, Chris Soller, Norbert Psuty from Rutgers University presented a brief geologic overview of the park and surrounding area. Participants at the meeting included NPS staff from the park and Geologic Resources Division, geologists from Rutgers University (Dr. Psuty) and the U.S Geological Survey (USGS), and cooperators from Colorado State University (see table 2). This scoping summary highlights the GRI scoping meeting for Fire Island National Seashore including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Established on September 11, 1964, Fire Island National Seashore contains more than 7,923 ha (19,579 ac) of which 552 ha (1,363 ac) are wilderness (Otis Pike Fire Island High Dune Wilderness Area) and approximately 1,214 ha (3,000 ac) are offshore. The park receives more than two million visitors per year. The park includes units at the The William Floyd Estate, Main Headquarters and Maintenance Facilities in Patchogue, Fire Island Lighthouse, Sailors Haven, Talisma/Barette Beach, Watch Hill and the federally designated Otis Pike Fire island High Dune Wilderness.

Fire Island is a barrier island that trends approximately 55 km (32 mi) east to west off the southern coast of Long Island, New York. The island averages less than 1 km (0.6 mi) in width. Fire Island Inlet bounds the barrier island to the west and Moriches Inlet is at the eastern end of the island. Much of the park area is in the Great South Bay, Narrow Bay, and Moriches Bay to the north of the island, and the Atlantic Ocean to the south of the island. The park boundaries extend 1,220 m (4,000 ft) offshore into the bay to the north, and 305 m (1,000 ft) offshore into the ocean to the south.

Fire Island is located just south of the maximum extent of Pleistocene glacial advance in New York, and glacial outwash unconsolidated deposits mantle the underlying bedrock onshore. The bedrock throughout the area includes Cretaceous sedimentary units buried deep below the overlying unconsolidated sediments. First developed as a spit of sediment from an eroding headland, the

barrier island itself contains very young, Holocene sands derived from the glacial deposits at the cliffs and bluffs of Montauk, offshore shoals, and remnants of earlier inlet deltas. The processes of wind, waves, and currents generate local and regional sediment transport that is manifested in changing beach-dune morphologies, episodic inlet formation and associated tidal deltas, active and paleo- dune features in various stages of evolution, and overwash events that combine to create a dynamic barrier island system.

Geologic Mapping for Fire Island National Seashore

During the scoping meeting, Heather Stanton (CSU) showed some of the main features of the GRI's digital geologic maps, which reproduce all aspects of paper maps, including notes, legends, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, an Adobe Acrobat PDF help document that captures ancillary map data, and a map document that displays the map, and provides a tool to access the PDF help document directly from the map document. Final data products are posted at NEW LINK. The data model is available at <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm>.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 1). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps (table 1) and mapping needs in the vicinity of the park unit boundary. Scoping session participants then select appropriate source maps for the digital geologic data or develop a plan to obtain new mapping, if necessary.

Table 1. GRI Mapping Plan for Fire Island National Seashore

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Long Island	Intersects all FIIS and quadrangles of interest	Fuller, M.L., 1914, The geology of Long Island, New York, U.S. Geological Survey, Professional Paper 82, 1:125000 scale	Paper	No	Digitize map for identified quadrangles of interest



Figure 1. Area of interest for Fire Island National Seashore, New York. The 7.5-minute quadrangles are labeled in black. Green outlines indicate national seashore boundaries.

During the scoping meeting the following quadrangles were determined to be of interest for park resource management needs: Patchogue, Bellport, Moriches, Eastport, Bayshore West (and southern extension), Bayshore East (and southern extension), Sayville, Howells Point and Pattersquash Island. Given that the park is a barrier island, it was determined that, in addition to the Fuller (1914) geologic map of Long Island, a coastal geomorphology map is needed. Shoreline changes have altered the island and its topographical components since 1914 and there are many more mappable units available than the single Cretaceous formation (Km) on the 1914 map, including marsh, sand, tills (glacial deposits), but that map does give a picture of pre-development on Fire Island. The GRI will digitize the existing Fuller (1914) publication for the park's quadrangles of interest, but will need to contract out the mapping of the coastal geomorphology with the NPS Coastal Mapping Protocol for guidance. An additional resource that could be consulted for data covering Fire Island National Seashore is the New York State GIS Clearinghouse (<http://www.nysgis.state.ny.us/>).

There has been no geomorphological study for the whole of Fire Island National Seashore. However, many spatial data exist for the area. The USGS and NPS are currently developing coastal vulnerability indices for Fire Island National Seashore. Previously, Hilary Stockton of the USGS

produced a coastal vulnerability index for the park that is available online. GRD helped fund a Roxanne Fire Island mapping project (contact: Charlie Roman); these data are not yet available. Much LiDAR data exist for Fire Island National Seashore. Rachel Harrah did a 3-D comparison dating back from the 1960s through the present; however, these data are still in need of interpretation. Mosquito ditches on the island and at the Floyd Estate (historic features) may be in a 2009 GIS. Stonybrook has much data available for Great South Bay. Norb Psuty and the Rutgers University group have more than 34 years of shoreline movement information, bayside data, and process-related data.

The park is interested in a water table map. This would require boreholes and wells over a broad area. The NPS Water Resources Division may be a source of information and support for such an endeavor. The park would also like to have map coverage showing years of beach replenishment perhaps as polygons with attributes showing dates and the amount of sand added. To act as the bases for studies of land change, the park needs the earliest good quality chart showing datums, the earliest aerial photographs, etc.

Geologic Resource Management Issues

The scoping session for Fire Island National Seashore provided the opportunity to develop a list of geomorphological features and processes, which will be further explained in the final GRI report. During the meeting, participants prioritized the most significant issues as follows:

- (1) Coastal stabilization and management, and
- (2) Impacts from climate change.

Other geologic resource management concerns discussed include fluvial and lacustrine features and processes, seismicity, visitor and resident use, and slope processes. The park is currently working on its general management plan. Knowledge of the geology of the area would add to this endeavor.

Coastal evolution and management

The coastline at Fire Island National Seashore is constantly changing. Two of the major factors influencing the shoreline geomorphological evolution in the park are sea level change and sediment supply/sediment budget. Sea level change plus other components such as wave energy (dimension and direction) control the transport of sediment in the system. Long Island has glacial sediments in the form of till, moraine, and outwash. Along Fire Island, wave action and longshore currents are transporting sediment from east to west. Beaches naturally widen in the summer and narrow during the winter. Coastal features include beaches, dunes, back barrier flats, tidal marshes, ephemeral offshore bars, offshore sand ridges, and ebb tide deltas (at Moriches). These features are created and modified by coastal processes of longshore drift and sediment transport by wind and water. With current levels of sea level rise, instability is causing shoreline erosion, wetland loss and continual displacement of shoreline features. These results in a morphology manifested as scarps, cliffs, and displacement of dunes and beaches. To understand the potential landform changes at Fire Island, knowledge of the sediment budget is critical.

The dynamic coastal system at Fire Island National Seashore has been the subject of extensive anthropogenic impacts for many generations. The “cultural” versus “natural” dichotomy of features throughout much of the park are gradations rather than absolutes because most of the area is not

strictly natural, but modified by humans in some way. Further, many of these modifications are in turn changed by natural processes and the sequence continues. Coastal modifications include jetties, groins, bulkheads, riprap, sea walls, hardened shorelines, and dikes (fig. 2). The interaction of longshore transport and inadequate sediment supply with widespread construction of bulkheads is causing localized erosion on the developed north shore of the island (fig. 3). On the extreme eastern end of Fire Island, the barrier island was breached and an inlet (Moriches) formed in 1931. The ebb tidal delta and flood tidal delta that were created with this new inlet sequestered sand that would have been transported westward to the present Fire Island National Seashore. The inlet is now armored and stabilized and sediments may be bypassing the interruption in the alongshore transport system. However, waves refracting around the ebb tidal delta create localized erosional and depositional zones at the shoreline. Farther to the west, beyond the effects of the inlet, there is a return to the ambient negative sediment budget and slow erosion. At the western margin of the island, Fire Island Inlet is jettied, but the updrift jetty is full and the navigation channel must be dredged periodically. The downdrift island (Jones Beach [Gilgo] Island) receives the dredge material and supports the continuation of littoral transport to the west, mostly onto Gilgo Beach and points a little further west. There are actively dredged channels leading to marinas on the north shore of the island. Formerly, all material dredged from these local channels was put on the beach. Now, in areas such as Sailors Haven, dredge material is put in the upland areas, above mean high tide. Further, many of the small islands on the bay side are composed of dredge spoil. The NPS has oversight over the dredging of the entrance to the Sailors Haven Marina, but has not dredged the Watch Hill Channel or Marina since its construction in the mid 1970's(?). The park needs to understand the dredging history to determine the effect dredging is having on the availability of sediment in the alongshore transport system, the creation of sediment sinks, and the distribution of wave energy reaching the shore. However, this is a very complex matter and the NPS can probably only track permits at this point because good records of the timing and amount of dredging may not exist. The Department of Environmental Conservation (DEC) for NY State issues regulations and permits for dredging.

Offshore sand ridges are mined for beach nourishment and there is a submerged Cretaceous outcrop offshore that linked to sediment transported to Fire Island (USGS and Army Corps of Engineers [ACOE]). Other culturally-placed sand used for beach nourishment and other inland purposes on Fire Island was imported from Long Island. This sand appears as yellow/orange and oxidized in the topography. It was put in place to create dunes and protect property, create walkways, and manipulate the dune crestline. Theoretically, there should be no cultural development seaward of the mapped dune line. This established line, seaward of which dune sand renourishment is not allowed, is not shifting as the dunes are migrating. Thus, because of long-term erosion since the establishment of the line, the dune line is now in the open ocean in places. Dune erosion is widespread and many areas have houses seaward of the active/natural foredune position, making them more susceptible to storm damage (fig. 4). The Coastal Erosional Hazard Area, defined by the DEC was updated between 8 and 15 years ago. This may be out of date considering the dynamic nature of the coastal environment at Fire Island.

Impacts from climate change

The park is very interested in management under the scenarios of a changing climate. Even a small change in sea level will have dramatic effects on the coastal landforms within the park, and will impact Fire Island National Seashore in numerous ways. As sea level rises, increased storm activity

(frequency and intensity) will cause more breaches from the ocean side to the bay side, and consequently more sediment will be washed into the bay. Critical habitats, cultural resources, and infrastructure will be damaged or lost. There will be more demand for beach nourishment. In the natural setting, features will be displaced, but not necessarily lost. Habitats will migrate if there is space available; however, if anthropogenic features get in the way, the natural migration will be immediately affected and thus impact environments downdrift. Geomorphology and topography dictate what type of habitat forms at Fire Island. These will all hinge on sea level change, the rate of change, management decisions, and the sediment budget. There is net sea level rise as seas are elevating eustatically, islands are sinking through sediment compaction and tectonic adjustment, and there is net sediment loss in the Fire Island barrier system. Demands and conditions are exceeding the capacity of the system to sustain itself in place. Sea level rise increases the dynamic nature of the barrier island system. The park does not necessarily want to accelerate impacts, but is partial to letting the system evolve. Another potential impact of climate change to the park is saltwater intrusion into the shallow water aquifer that underlies the island.

Other geologic resource management issues

Fluvial and lacustrine features and processes

At the Floyd Estate, there are two streams which start as groundwater seeps and are tidal-influenced to some extent downstream. These streams form the boundary between the NPS and adjacent landowners. Home Creek is on the east, and O'Dells Creek (Lawrence Creek per USGS maps) is to the west. There are tidal wetlands and anthropogenic mosquito ditches there as well.

There are two diked ponds at the Floyd Estate. These were created to entice waterfowl for hunting purposes. Unsupported historical information suggests that in the 1930s-1940s, excess DDT, which was used for mosquito control, was dumped into these ponds. Information also suggests that the product was dumped to post larger consumption numbers. This is somewhat supported by the amount of DDE (the half-life of DDT) that the NPS has found in the sediments (ponds are silting up), but does not want to disturb the contaminated sediments. Any breach of the diked ponds could release DDE into the surrounding wetland areas.

Fire Island National Seashore has many ephemeral pools and many acres of wetlands. Duck ponds on Fire Island (used to breed ducks) occur at Smith Point County Park on the eastern end of Fire Island. This county park has a huge parking lot, campground, and bathhouse and is within NPS boundaries.

On the western end of the park, Kismet Pond has freshwater features including native cattails and the invasive/exotic phragmites. An area called Clam Pond is a small embayment connected to Great South Bay. Fire Island Pines has some freshwater areas as does Point O'Woods and Watch Hill. Ponds and freshwater areas are related to the topography and to the presence of freshwater aquifers underlying the barrier island. There are locations where water percolates upward from the aquifer into the bay and ocean as well as into adjacent sites of freshwater/brackish water wetlands.

Seismicity and tsunamis

The passive eastern continental margin of the United States is not a hotspot for seismicity. Nevertheless, seismic events occur all along the coast as buried ancient structures accommodate stresses within Earth's crust. Historically, there were two magnitude ≈ 5 earthquakes in the New

York City area. One was on Coney Island in 1884 and another occurred locally in the 1730s. There are low-magnitude events occurring on a constant basis. It is possible that evidence of seismic deformation could be discovered in the sediments at Fire Island National Seashore such as blowouts and liquefaction features.

Tsunamis may occur in coastal areas. There are historic references to tsunami deposits; however, these would be hard to differentiate from large waves events (storms, hurricanes).

Visitor and resident use

There are 17 permanent communities on Fire Island and the park receives heavy visitation as well. Visitors and residents impact park resources at Fire Island National Seashore. Each community has its own rules and land use practices. Typical uses include ORVs, marinas, hardened structures on the bay side, inlet management and stabilization, dune cuts, structures on dunes and beaches, and sand mined or manipulated for beach nourishment (this impacts potential sources of wave energy) (fig. 5). There are two exposed and possibly two other groins at Ocean Beach. Water Island has small groins on the bayside. However, groins are exposed on the oceanside of the wide beaches of Fire Island during periods of high visitor use. An Eastern Carolina University inventory also noted the presence of many bayside groins.

Mass wasting and erosion

Mass wasting issues at Fire Island National Seashore include pervasive erosion. Following severe storms, such as that in March 2010, the beach is often scoured up to the base of the foredune (fig. 6). Slowly, naturally occurring processes will return to beach profile, but typically there is a net long-term loss of sediment and a slow inland displacement of the beach and dune system. There are times after severe storms, that the communities determine a need to implement beach nourishment projects to protect the homes and infrastructure located directly on the fragile dunes,

There are some bluffs on the bay side that could experience slumping, particularly at Sailors Haven, and Water Island east of Talisman. Bluffs can reach 10 m (33 ft) in height and are sloughing locally. There are many dune crossings in the park (some are actual sidewalks) that may correlate to potential hazards and breaches. Interruptions of older dune features may help predict where future washovers and dune breaches are likely to occur.

At Fire Island, the distinction between the natural process of erosion and anthropogenic-induced erosion is difficult, but must be clearly differentiated. There is a difference between natural shoreline change and anthropogenic manipulation. This is a data/interpretation sensitivity issue as it is hard to tell within the confidence limits from the data available.



Figure 2. Groins at Ocean Beach. These tetrapods were originally put in place to protect a water tower from inundation and/or coastal erosion. The tower has since been moved inland. View is to the west. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).



Figure 3. Erosion on the bay side near the Sunken Forest at a NPS bulkhead protecting a small marina. View is to the northeast. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).



Figure 4. A newly constructed house (2005) located on the seaward side of the natural foredune at Fire Island. Note sand fences in place to trap windblown sand. Purplish sand in the foreground is enriched in dense garnet/magnetite grains. View is to the west. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).



Figure 5. Houses at Point O'Woods with sandbags on the beach in an attempt to harden the seaward face of the foredune and reduce further erosion. Impact is associated with the March 2010 storm. View is to the northeast. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).



Figure 6. Erosional scarp from the March 2010 storm at Robert Moses State Park. Note the high beach surface (beach nourishment area) just beyond the umbrella. View is to the northwest. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Features and Processes

Coastal features and processes

Fire Island is one of a series of barrier systems along the eastern United States. These barrier islands are a relatively recent occurrence, forming after the end of the last ice age. At the glacial peak approximately 20,000 years ago, sea level was 120 m (390 ft) lower than at present and the continental shelf was exposed more than 100 km (60 mi) offshore. Upon glacial melt and retreat, sea level rose fairly rapidly. The rate of sea level rise has fluctuated ever since and it is the change in this rate that is responsible for the landforms present at the park today. Approximately 5,000 years ago, sea level was 7 m (23 ft) lower than at present. About 3,000-2,500 years ago, the rate of sea level rise slowed to about 0.3 mm/yr (0.01 in./yr) and sea level was still several meters below its present level. This created a type of system equilibrium where sands and sediments being churned by wave action during sea level rise were allowed to organize and accumulate. They gained elevation and barrier island components (islands, wetlands, backbay environments) developed. There was horizontal expansion and development as well as height increase. Some 300 to 400 years ago, sea level rise rate changed again, becoming faster, and caused a negative sediment budget. This was possibly the result of the agricultural revolution followed by the industrial revolution (i.e. human impacts). The barrier islands began to narrow. Sea level is continuing to rise with local rates between 2 and 4 mm/yr (0.08 and 0.2 in./yr). Areas underlain by unconsolidated deposits experience global sea level rise in addition to local subsidence, making the net sea level change even greater.

Wind and water constantly shape and reshape the coastal features at Fire Island National Seashore, which hosts myriad coastal features including beaches, dune ridges, barrier spits, foredunes, stranded foredunes, secondary dunes, ancestral barrier cores, washover fans, inlets, tidal deltas, berms, marshes, and backbay lagoons. Beaches are a land feature, a transitory strip of sand often mapped as “beach”. This ever shifting coastal system is controlled by many factors including the rate of sea level change, the amount of relative sea level rise, sediment supply, longshore drift, storms (these tap sediments that are usually immune to coastal processes), wave direction, and anthropogenic impacts. Offshore wind and waves, mostly from the southeast cause largely westerly flow of currents and sediment transport towards the west. Inlets, bays, and marsh islands tend to increase in number in a downwind/current direction of a barrier island system. Coarser sands, from the flood tide delta and ocean, are sourced from glacial debris. Glacial till and outwash contribute nearly all of the sediment to Fire Island. Finer sand is from the mainland.

Older barrier island components exist on Fire Island National Seashore. In Great South Bay there is evidence of old inlets and shoals (old deltaic deposits). On the bay side, submarine margins of the barrier include older dune ridges that move westward through time. These form an ancestral barrier core. Fire Island also has a well-developed coastal foredune with occasional pieces of older remnant (secondary) dunes behind the foredune. The older, inland dunes represent an ancestral shoreline location. These old dunes may date to an early time of island development approximately 1,200 years ago at Sailors Haven. There are accretionary ridges at the western end of Robert Moses State Park. These ridges indicate that the island builds westward through time. The new island is slowly transgressing. At Old Inlet, remnant dune ridges exist around an old, filled inlet and represent progressive barrier island processes. Another old inlet exists 1 km (0.6 mi) to the east where part of the filled inlet geomorphology repeats. Old flood tidal delta deposits on the bay side of the island

indicate the presence of old inlets. In November, 2009, a washover occurred in Robert Moses State Park. These types of features supply sediments into Great South Bay. Abundant subaqueous shoals in the eastern portion of the bay indicate old inlet sites. Farther west, sediments have been restricted from the bay, and recurved spits and accretionary ridges indicate migrating multiple inlets instead of just one inlet creating a delta and then healing.

The park contains many acres of salt marsh within its boundaries. Vegetation types within salt marsh have extensive root systems, enabling them to withstand brief storm surges and buffer storm impacts. The salt marsh system acts as a sediment trap and filter, absorbing nutrients and pollutants that would otherwise flush into the aquatic environment. By trapping passing sediment, they also can create more land area in a specific location. Salt marshes are vital habitat for fish, wading birds, and waterfowl. Park resource managers consider salt marsh communities as biological indicators of the overall condition of the ecosystem. Salt marshes within the park are under threat of degradation from sea level rise, storms, shoreline changes, ditching, watershed development, nutrient loading, and introduction of exotic species.

Geomorphological features are divisible as formed via accumulation or erosion. Features formed by accumulation include beaches, dunes, sand-inundated marshes, barrier spits, and accreted headlands. Features formed by erosion include bluffs, cliffs, channels, scours, and scarps. However formed, the topography, habitat, and ecosystem at Fire Island National Seashore are worthy of careful management, but reactions to changes are hard to predict due to pervasive anthropogenic development.

History and geology connections

Poised off the southern shore of Long Island, Fire Island National Seashore has long been a settlement site and important recreation area. Archaeological remains attest to early American Indian inhabitants. Offsite, outside park boundaries, there are ancient borrow pits and offshore sand mines as evidence of early American Indian activity. Other historic features that have a connection to geology include the William Floyd estate, perched on the glacial outwash uplands along the southern shore of Long Island. This 260 ha (640 ac) estate is a cultural and agricultural landscape on a glacial outwash plain. It became an early settlement, then estate, then summer retreat before being set aside as natural area (fig. 7). The estate reflects more than 200 years of anthropogenic land use and change.

The history at Fire Island National Seashore includes a long and ongoing progression of land-use changes and human attempts to manipulate the natural system. Early residents began the futile struggle to keep the dynamic coastal features in place including attempts to armor inlets, nourish beaches, and build on foredunes.

Paleontological resources

According to the paleontological resource inventory and monitoring report prepared by the Geologic Resources Division for Fire Island National Seashore, there is potential to find fossils in glacial deposits on Long Island. There are Cretaceous rocks at depth. Reworked fossils often wash up on beaches.

Glacial features

During the Pleistocene, episodic cooler climates led to global glaciation events. Of these, the Illinoian and later Wisconsinan events strongly influenced the development of the landscape in the Fire Island area. The park sits just south of the glacial terminus of the Wisconsinan event and the surrounding area exhibits a glaciated landscape to the north and an unglaciated landscape to the south. The glacial terminus was across Staten Island and the Narrows into Long Island. After the glacial event peaked, some 20,000 years ago, the terminal moraine formed approximately 14,000-16,000 years ago with a seaward apron of glacial outwash spreading southward.

Fire Island is mostly very recent, Holocene sands derived in part from reworked glacial outwash deposits. Offshore bars and shoals may still be providing some sediment to the system. Bluffs to the east cut into outwash and terminal moraine. These are not in the park, but likely provide some sediment that affects the dynamic barrier system at Fire Island. The Floyd Estate unit is located on glacial outwash seaward of the terminal moraine.

Aeolian features

There are several areas of active dune formation and migration on Fire Island. The primary dunes east of Watch Hill are as high as 12 m (40 ft) (fig. 8). Secondary dunes, behind many primary dunes are crescent shaped with low interdunal swales in between. There are dune blowout features on Fire Island. Aeolian processes tend to transport the finer, lighter grains of sand from the beach into the dune zone. Suites of heavy minerals have been brought to the area by glacial processes to be re-worked in the beaches and dunes. Magnetite/garnet sand layers often remain on the upper beach surface after the winter season and are an important component of the beach sand profile. Most of the major categories of dunes are represented here and mappable. These include foredunes, blowouts, dissected dunes, parabolic dunes, and artificial dunes/dikes (“artificial sand feature”). Some human-induced dunal sand ridges form as blowing wind and saltation encounter sand fences. At Davis Park, local residents persist in trying to accumulate sand through the erection of fence lines and by earth-moving equipment. Human activities are creating artificial features that must be reconciled on any geomorphic map. There is no loess on Fire Island, but wind-blown silt deposits are possible at the Floyd Estate.

Unique features

All existing habitats within the park are considered threatened. Unique resources at the park include the Sunken Forest, the Otis Pike Fire Island High Dune Wilderness Area, and eel grass beds throughout the boundaries of the park. The Sunken Forest, is a 16 ha (40 ac) maritime oak-holly forest occurring behind the secondary dune in the ancestral barrier core (fig. 9). This is one of the few mature (some trees are over 300 years old) maritime forests in New York and the northernmost holly-dominated maritime forest on the Atlantic barrier island chain. Other interesting geologic features at Fire Island include old relict inlets that serve as an example of a combination inlet and washover breach of a barrier island. This appears as an interrupted foredune line with recurved dunal features along the margins of the former inlet location. Fire Island also contains several units of ancestral barrier core, the oldest parts of the island.



Figure 7. The estate house at the William Floyd estate unit. The building and surrounding landscape reflect over 200 years of historical land use at the site. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University)



Figure 8. A high forested dune near the Sunken Forest. View is to the north. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).



Figure 9. Wetland area within the Sunken Forest. Note the mature trees. Photograph is by Trista L. Thornberry-Ehrlich (Colorado State University).

Field Trip Notes

Stop 1: Lighthouse. There are parabolic dunes here that are heading towards the ocean due to local prevailing northwest-directed winds.

Stop 2: Beach near Robert Moses State Park. The well-developed foredune is characteristic of Fire Island National Seashore. There is a local scarp along the foredune from the March 2010 storm. Beach fill and nourishment efforts after the storm are obvious on the neighboring beach. Sand stockpiles exist on Democrat Point, which are used to fill breaches if they do not appear to be filling naturally. Nourishment material was taken from the ACOE inlet stockpile and brought in by dump trucks. It has raised the beach some 2-3 m (7-10 ft) above the storm flat. There is a sand dike here that is protection for the road and a parabolic dune some 5-6 m (16-20 ft) above the beach.

Stop 3: Kismet. The seaward part of this community was built on an artificial dune. The natural dune line runs through many beach homes. There are about 400 year-round residents, and about 4,200 homes within the park. There was beach scraping done here (see NPS website). In New York, beach scraping is only permitted on dry beaches with elevations 7-9 ft above NGVD29 (bulldozers transport sand beach into the dune face). At times, Kismet benefits from the natural drift system, then they can scrape the beach and put up fencing and sand grass. There is local orange sand that was trucked in from inland sources after the 1992 storm. Scraping has been permitted since the early 1990s. Those seeking a permit must reapply annually. Beach scraping lowers the elevation of the beach itself, the ocean comes closer to the foredune and there is no real net sediment change. The process probably moves a few cubic meters per meter. Tire tracks on the beach create miniscule sand traps. All homes out here have septic systems; many do not necessarily comply with land requirements. The systems can wash away during storms, but may be replaced during beach nourishment. The primitive system has a concrete septic tank with no bottom. This is considered acceptable because they are merely “seasonal”. There are obvious accumulations of garnet-magnetite sand that winnow out after quartz is blown away.

Stop 4: Dunewood. There is a newer house extending well onto the beach. It was rebuilt seaward in 2005 after a 1992 storm washed away the former structure. Since Norb Psuty’s original work here, over 100 houses have been lost to coastal processes at Fire Island National Seashore. The dune crest line is behind the houses. This line is created by connecting the dots between natural dunes and small remnants of the dune between structures. The dune is augmented for septic reasons, but no building should have been constructed here. From the defined dune line, there are regulations not to add sand to the dune south of that line, extending to the base of the dune itself. There is no “moving” crestline. Houses started being built here in the early 1900s and development is still continuing sporadically.

Stop 5: Groins at Ocean Beach. These groins were in place by 1969. Older groins are buried in the beach. They are bags of concrete. The present groins are individual tetrapods with some other rock boulders inland. Much of the beach and dune is a product of accumulation related to the groins on the updrift side and erosion on the downdrift side. The groins were placed to protect the old water tower, which is now moved further inland. There are deep wells here as well. This is the only community on the island to have a sewer system.

Stop 6: Point O'Woods. This community has its own light-gauge railroad. The beach here was severely eroded during and after the 2010 March storm when water was lapping against the dunes. They are defending the base of the foredune with white bags of sand. The beach is naturally re-accreting. There are scarps in the upper beach and dunes showing heavy mineral sands and garnet layers. Two dune crests merge near here, with Sunken Forest inland of the dune crests.

Stop 7: Sunken Forest. This area is a portion of an ancestral barrier core (an older foredune complex) that is now forested. The remnant holly forests here at Fire Island National Seashore are older than those at Sandy Hook in Gateway National Recreation Area. There are wetlands within Sunken Forest. There is bay side erosion at the NPS bulkhead protecting a marina. Local dredging and the structure created localized erosion. Trees are falling into the bay. Channel dredging here may aid shoreline stabilization by supplying the dredged material to positions of erosion, but the New York Department of Environmental Conservation does not allow wetland filling.

Stop 8: Boundary between Fire Island Pines and Talisman. Here a power/phone line that goes underwater to the mainland was exposed due to the erosion associated with a bulkhead. It is currently being redrilled horizontally inland of the shore. In the fall of 2009, the beach was not passable due to severe erosion. There is an offshore bar visible in the Talisman beach area at present. The bar builds in the storm season while the beach size decreases. In fair weather, the sand bar decreases in size, and the sand is transported back to the beach.

Stop 9: Davis Park. This is the easternmost community before the designated wilderness. The wilderness boundary is at the base of the dunes allowing vehicle traffic on the beach. Relict dunes between the houses often show exposed septic systems. New water lines are in place behind the older ones. This community is perpetually eroding with much sand lost from the dune since 2009. One used to not be able to see the connecting pilings under the houses, but now some 3 m (10 ft) of sediment are gone. Many houses need their pilings extended. Beach nourishment happened here in 2007-2009. However, the trucked-in sand does not match the color of the native sand. Jim Allen (?) has a relevant publication. Water has been pooling on the beach because of scraping here. A shipwreck from the 1940s is visible near the shoreline.

Stop 10: Beach fronting the Fire Island Otis Pike Wilderness. Here are natural dunes, which are well-vegetated. Garnet-rich sand collects at the base of the dunes throughout the island as a function of greater density versus quartz grains. The group turned around at the wilderness boundary, taking the boat across Great South Bay.

Stop 11: Floyd Estate ca. 1724. Some 244 ha (604 ac) were donated by the family to the NPS in 1970. The place includes a house, cemetery, woods, marsh, pasture, 61 ha (150 ac) of salt marsh, and fields that are mowed annually. The family lived here from 1718-1976. Many ticks live here. O'Dells Creek (Lawrence Creek) runs along the western boundary. Home Creek runs around the eastern boundary. Both are groundwater fed. The park unit sits on an outwash plain. There is a ditch dug around the marsh to contain cattle and keep saltwater away from the fields and crops. Ponds were created at natural seeps. The larger Floyd Pond (southeastern portion of the park) is near a windmill. There is no beach here except at Indian Point, where there is a sandy spot. This place was at one time a hunting reserve. Other ponds were dug in the 1940s with islands for hunting water fowl. Teal Hole holds the most freshwater in a small pond. Native American shards, points, and

middens are in the southeastern area of the park, and there is a lot of erosion in the creeks as well as saltwater into the marsh (per Mary Laura Lamont). Near the headwaters for O'Dells Creek, American Indians had sweat lodges in the mucky areas near headwater. Remains appear on old maps (mounds?). "PC Pump" (?) just off property. Is there a cultural landscape report? Slaves made bricks with clay from a local source, possibly off the property. No clay is seen here, only sand. There is a small earthen dam on Home Creek (old, creek is tidal there). The area provides excellent turtle nesting habitat. The "Pikel" is the view from the house to the bay. It was used to alert the residents of incoming ships and the park preserves the cleared tract. Area has a great abundance of ticks!

Stop 12: Smith Point County Park. There is artificial fill here, a sheet metal bulkhead and general circus atmosphere around the bathhouse. TWA flight 800 crashed nearby. There is a memorial here, used in part to justify putting in the bulkhead and artificial structures. The armored inlet to the east is causing localized erosion of this shore into a crescent shape and accretion farther west. The inlet is far to the east, visible as a hook out into the ocean about 10 km (6 mi) from the concrete blocks at the bathhouse. Beach nourishment is ongoing here, but obviously is not working as the sheet metal and riprap are exposed again. There is an artificial dune here with very yellow sand.

Recommendations

1. Consult with Rebecca Beavers, who has a report on groins at Fire Island with Western Carolina University.
2. Consult the New York City administrations GIS clearinghouse for additional map data.
3. Consult the coastal resilience website by the Nature Conservancy, which includes scenarios with sea level rise and storms to predict potential impacts.

Action Items

1. GRI report author will consult the parks website on geology <http://www.nature.nps.gov/geology/parks/fiis/index.cfm>.
2. GRI author will track down a publication by Jim Allen on beach replenishment at Davis Park.
3. GRI will find a technical report on the NPS approach to beach scraping.

References

Kenworthy, J. P. and V. L. Santucci. 2003. Paleontological resource inventory and monitoring—Northeast Coastal and Barrier Network. Natural Resource Technical Report TIC # D-340. National Park Service, Fort Collins, Colorado.

National Park Service. 2010. Fire Island National Seashore. www.nps.gov/fiis (accessed July 25, 2010).

Table 2. Scoping Meeting Participants

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