THE ORIGIN AND FATE OF THE MIGRATING DUNES, NAPEAGUE, N.Y.

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The migrating dune system at Napeague is located on the south fork of eastern Long Island and consists of three parabolic dunes ranging in height from 10 to 25 meters. The dunes are composed of sediments eroded from adjacent headlands. These sediments are carried into Napeague Harbor by coastal currents and, initially, are deposited as a series of offshore ridges. These sediments are then transported to the beach face by wave action. From the beach face they are moved landward by eolian processes and ultimately form a dune.

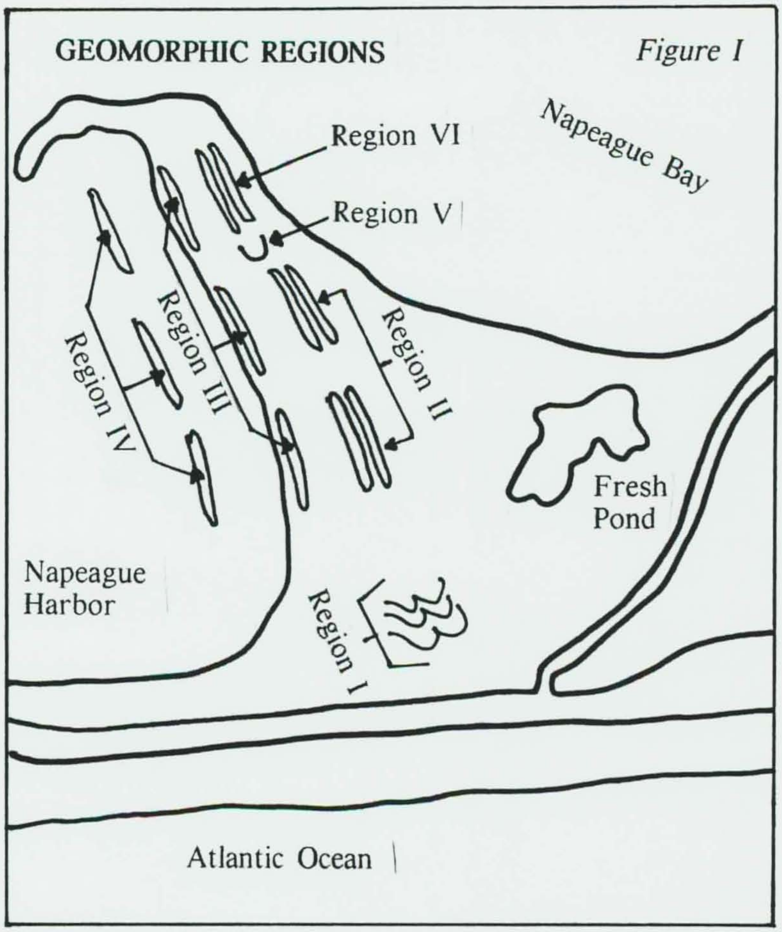
Once formed, the dune is shaped and set in motion by the prevailing winds from the northwest and, therefore, migrates in a southeasterly direction. Migration continues at a rather rapid rate until another dune is formed. The more recently formed dune alters the wind regime which, in turn, decreases the migration rate of the earlier dune. In addition, the countervailing prevailing winds off of the Atlantic Ocean further slow, and eventually halt the migration of the earlier dune. This process of dune formation, migration, etc., continues as long as sufficient sediment is supplied from the beach face.

LOCATION AND SITE DESCRIPTION

The migrating dune system is bounded by Napeague Harbor to the west, Gardiners Bay to the north and the Atlantic Ocean to the south. The study area is subdivided into six geomorphic regions (Figure 1). Region I is the actual migrating dune system consisting of Dune 1 which is well vegetated and no longer active, Dune 2 which is essentially stable and Dune 3, the most active dune. Dune 3 is bilobate and its western lobe is the most active with a migration rate of approximately 1.0 meters per year. The eastern lobe is considerably less active and is in the process of assuming a star shaped morphology due to the deflection of the winds by the western lobe.

Geomorphic Region II is immediately to the north of the migrating dune system. This region consists of a series of terrestrial ridges of low relief intersected by areas of even lower relief. The ridges are vegetated with the halophytic shrub groundsel tree (*Baccharis halimifolia*) and high tide bush (*Iva frutescens*).

The areas of lower relief contain stands of the common reed (*Phragmites communis*), cat tail (*Typha* sp.) and/or various sedges (*Scirpus* sp.).



Geomorphic Region III consists of a series of discontinuous linear coastal dunes fronting on Napeague Harbor. The dune along the midsection of the harbor is significantly lower than the linear dunes to the north and south. The vegetation on this lower section consists of dune grass (*Ammophila breviligulata*) which indicates a high energy environment. The more southerly dune is in the shrub stage with beach plum (*Prunus maritima*) dominating, while the dune to the north is densely vegetated with red cedar (*Juniperus virginiana*) and beach plum. The presence of the beach plum and cedar indicate a lower energy environment.

Geomorphic Region IV, located to the west of the linear dune, consists of two ridges, one in the intertidal and the other slightly further offshore. The ridges, like the linear dune, are discontinuous and intersected by areas of significantly lower relief. These low areas are drainage channels through which water flows on rising and falling tides. On a falling tide the water runs parallel to the ridge until it encounters a drainage channel and then moves offshore through the channel. The velocity of the water running parallel to the ridge is sufficient to remove sand-sized particles and expose cobbles and small boulders as pavements. The drainage channels that intersect the ridges are aligned with each other and also correspond with the areas of low relief that intersect the linear dunes of Region III and the ridges of Region II.

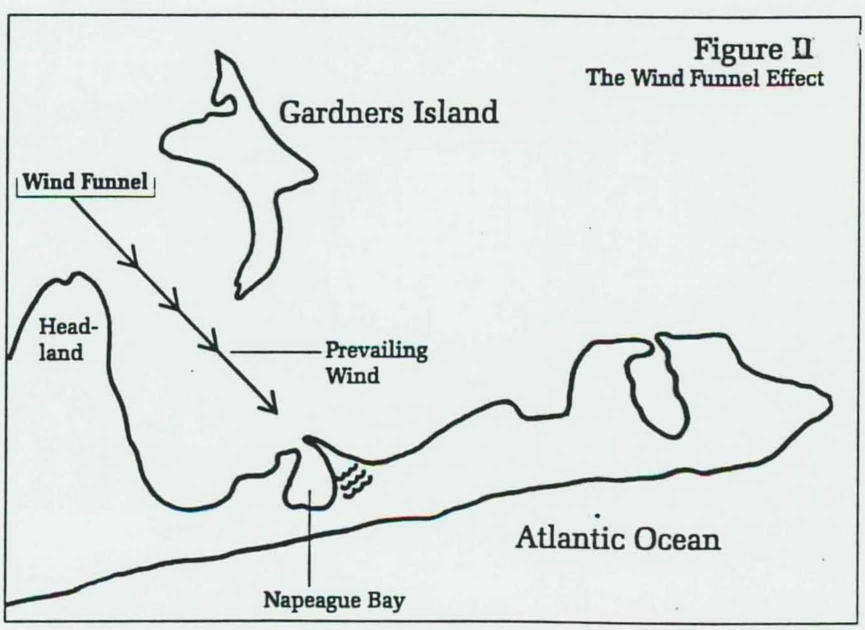
Pavements are also found behind the linear dunes of Region III and the ridges of Geomorphic Region II. All of these pavements are uniformly spaced at intervals of 45 meters on a heading of 328°. Thus, it is believed that the offshore ridges are present day analogs of the terrestrial ridges; the terrestrial ridges, therefore, mark earlier coastlines.

Geomorphic Region V is represented by a small dune located immediately landward of the northern gap in the linear coastal dune. This landform is intermediate in morphology exhibiting characteristics of both a parabolic and dome shaped dune and is termed a hybrid dune.

Geomorphic Region VI is immediately to the north of Region V and consists of a series of ridges that are thought to be a northern extension of the Region II ridge system. These ridges are of significantly higher relief and are well vegetated with bearberry (*Arctostaphylos uva-ursi*), common hair grass (*Deschampia flexuosa*) and dune grass (*A. breviligulata*). The presence of these species indicate that these ridges are drier and therefore, higher than those of Region II.

The final area of significance to the migrating dune is the wind funnel formed by Gardiners Island to the north of the study area and the headland to the west (Figure 2). As noted previously, prevailing northwesterly winds form and set the dunes in motion. These winds funnel between Gardiners Island and the western headland, focus on the midsection of the coastal linear dune and begin the process of dune formation and migration.

Figure II
The Wind Funnel Effect



ENERGY REGIMES

The differences noted in the heights and vegetational characteristics of Geomorphic Regions II, III and VI are directly related to the wind funnel formed by Gardiners Island and the western headland. The areas subject to the greatest wind energy are the low midsection of the linear coastal dune of Region III and Region II where the ridges are also low. The ridges of Geomorphic Region VI, on the other hand, are significantly higher than those of Region II. Region VI lies within the wind shadow of Gardiners Island and, thus, is subject to a lower energy regime.

One of the major problems in the study of migrating dune systems is the deliniation of long term energy regimes. In this case, however, the energy regime is clearly delineated by the vegetation and geomorphology of Regions II, III and VI.

FORMATION OF THE MIGRATING DUNE

Essentially there are four possible mechanisms that may account for the formation of the migrating dunes. These mechanisims involve 1) a blowout of the linear coastal dune, 2) a "snow fence" effect whereby sediment from the coastal dune accumulates on the ridges of Geomorphic Region II, 3) the formation of a minor wind funnel formed as wind passes through the northern gap in the linear dune and 4) a combination of mechanisms two and three.

As noted, the midsection of the linear coastal dune is aligned with the major wind funnel formed by Gardiners Island and the western headland. As sediment from the beach face accumulates on the linear dune a critical height is reached and the dune becomes subject to the full force of the wind focused by the wind funnel. Such winds, from a single direction, discourage the development of stabilizing vegetation which could lead to a blowout of the linear dune. Supporting evidence for this scenario are the vegetational sequences of the linear dune. The section of the dune aligned with the wind funnel is vegetated with dune grass which is indicative of high energy environments. The north and south sections, on the other hand, are not influenced by the wind funnel, are of a higher elevation and are populated by red cedar/shrub and shrub communities respectively which indicate a lower energy environment.

Geomorphic Regions II and III are pertinent to the "snow fence" hypothesis. Region III is the low midsection of the coastal dune which is directly in the path of the prevailing winds focused on this area by the wind funnel. Region II, landward of the coastal dune, is also subject to this high energy regime. This region consists of four north-south ridges of low relief. The dominant vegetation on these ridges are groundsel tree and high tide bush, both of which indicate a high, brackish water table.

The "snow fence" hypothesis involves the movement of sediment from the midsection of the coastal dune to the landward ridge adjacent to this dune. This ridge is moist and the sediment would tend to accumulate since it would be resistent to eolian transport. Once sufficient sediment accumulates on the ridge, capillary action would become ineffective and the newly deposited sand would remain dry. The sediment would then become subject to eolian transport to the low ridge further landward. This lower, landward ridge would then trap and accumulate sediment, become higher and drier and the process would be repeated. Thus, each ridge would serve as a sediment source for another, more landward ridge. Sediment would continue to accumulate on the most landward ridge until it attained a certain critical height. Once this occured, the prevailing wind, focused by the wind funnel, would form these sediments into a migrating parabolic dune. Sufficient sediment must accumulate on the ridge before a newer dune would form.

The third hypothesis involves the hybrid dune of Geomorphic Region V. This dune is landward of the gap in the coastal dune that separates the higher, well vegetated northern section of the coastal dune from the lower midsection. The gap is aligned with the major wind funnel formed by Gardiners Island and the western headland. The gap would form a minor wind funnel that would further focus the wind. Thus, the wind, traveling through this minor wind funnel, would increase in velocity with a concomitant increase in its ability to transport sediment from the beach face. Once to the lee of the coastal dune and beyond the influence of the minor wind funnel, the wind current would disperse, its carrying capacity would decrease and the wind blown sediment would be deposited. This material would tend to accumulate as a circular, dome shaped deposit and would eventually reach a critical height, at which time it would be subject to the full force of the prevailing wind. Once this occurs the dune will convert to a parabolic form and begin to migrate.

Of the three mechanisms, none accounts fully for the height and quantities of sediment in the migrating dunes. A combination of mechanisms two and three, however, more fully explain the process. Thus, a fourth mechanism involves the formation of an "embryonic" dune landward of the minor wind funnel. Once this dune reaches a sufficient height, it would begin to convert to a parabolic dune and migrate in a southeasterly direction under the influence of the prevailing wind. Its pathway would traverse Geomorphic Region II where the dune's volume would be augmented by the sediment that had accumulated on the ridges. This sediment would be supplemented by additional wind-blown sand from the coastal dune.

As the newly formed dune moves southeastward, sediment would again accumulate landward of the minor wind funnel and on the low ridges of Region II. Thus, the process would be repetitive and serve to explain the rather uniform spacing between the migrating dunes.

SUMMARY

The migrating dune system at Napeague involves a complex series of interactions between the offshore ridges, the coastal dunes and the terrestrial ridges. The mechanism involving the formation of the hybrid dune of Region V and its subsequent migration through Region II appears to most adequately explain the landforms in the study area as well as the quantities of sediment contained in the migrating dune system.

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