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The Evolution of a Barrier Island: 1930-1980

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INTRODUCTION

Old photos are among the most useful sources of information for reconstructing what coastal areas looked like as early as 100 years ago[11]; however, high-quality vertical aerial photographs are seldom available for dates earlier than 1938. A recent search through the archives of the U.S. Army Corps of Engineers Coastal Engineering Research Center (CERC) uncovered an excellent set of rare old vertical aerial photographs of a 32-km section of the Outer Banks of North Carolina. The photos, originally ordered as background data for a beach erosion study by the Beach Erosion Board[2] date 1932, 1933, 1934, and 1936 and have a scale of approximately 1:11,000.

The area of coverage of these photographs (Fig. 1) extends from Bodie Island to Rodanthe, on Hatteras Island; this section of the islands include both Oregon Inlet and New Inlet. The latter is an inlet that breached Hatteras Island during a northeaster in March of 1932.

Considering their age, the photos are of excellent quality, although not equivalent to present day mapping photos. To the best of our knowledge, they are the earliest aerial record of the Outer Banks before the period of development, and most importantly, before the initial stages of the Works Progress Administration (WPA) and Civilian Conservation Corps (CCC) dune stabilization program.

The contrast between these early views of the barrier islands and the present is dramatic, the result of a complex combination of natural and manmade effects. The general absence of major storms in the last 20 years plus the termination of widespread livestock grazing in the early 1900's allowed natural revegetation of the area. However, much of the change must be attributed to the success of the dunes in stabilizing the islands.

The stabilized dunes and their impact on the barrier islands have been the subject of much research and some controversy. As a result of this research, congressional legislation for the National Seashores, coupled with a desire to manage the land as described in policy reports, the National Park Service has decided to stop maintaining the dunes within the seashore boundaries. Instead, the barrier islands will be allowed to revert back to their "natural" state under the action of waves, tides, and winds wherever possible. The implications of this new policy affect not only the Outer Banks, but also other barriers with dune systems within the National Park system.

The purpose of this paper is to offer a view of the North Carolina barrier islands as one would have seen

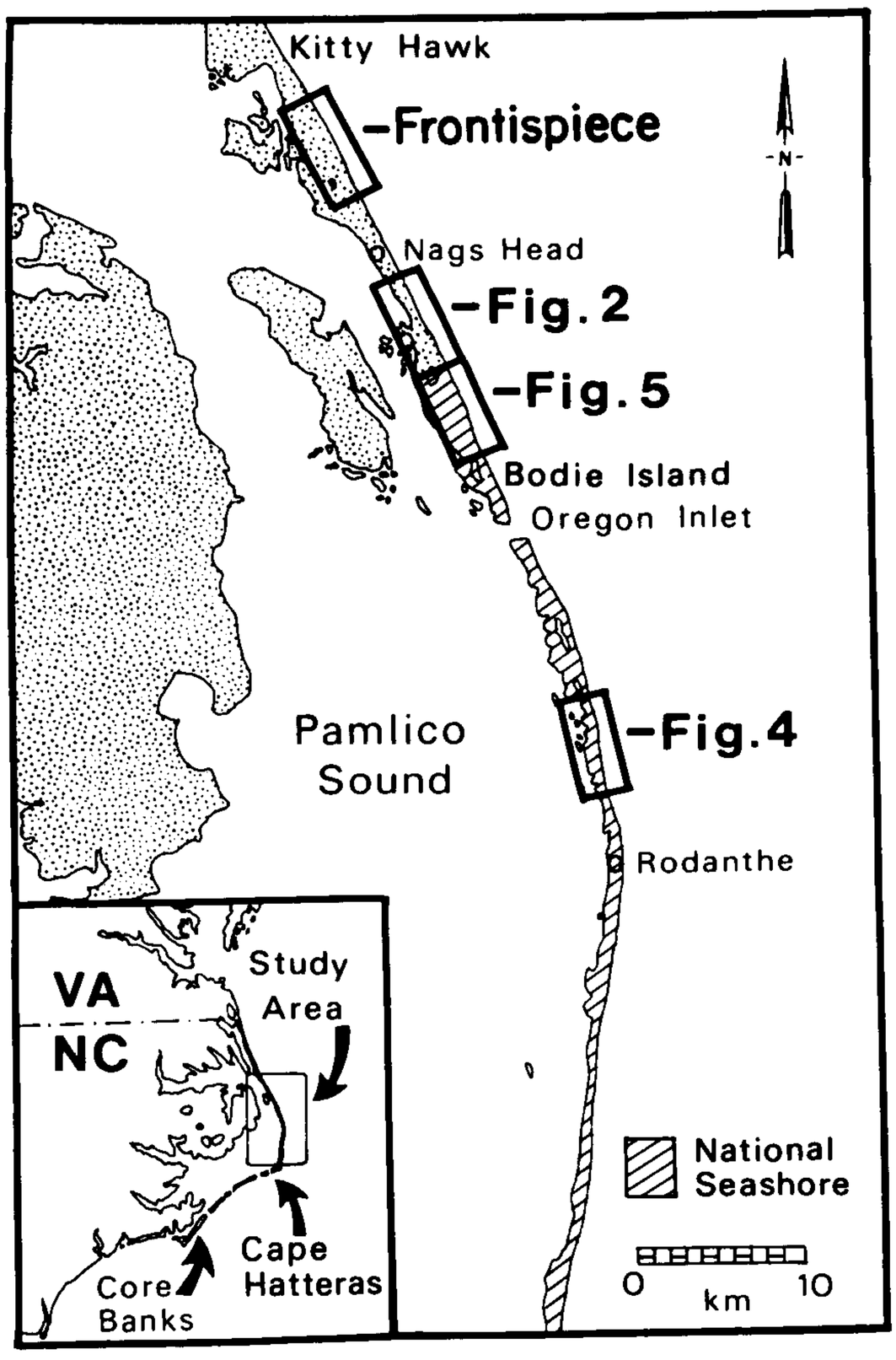

Fig. 1 Study area.

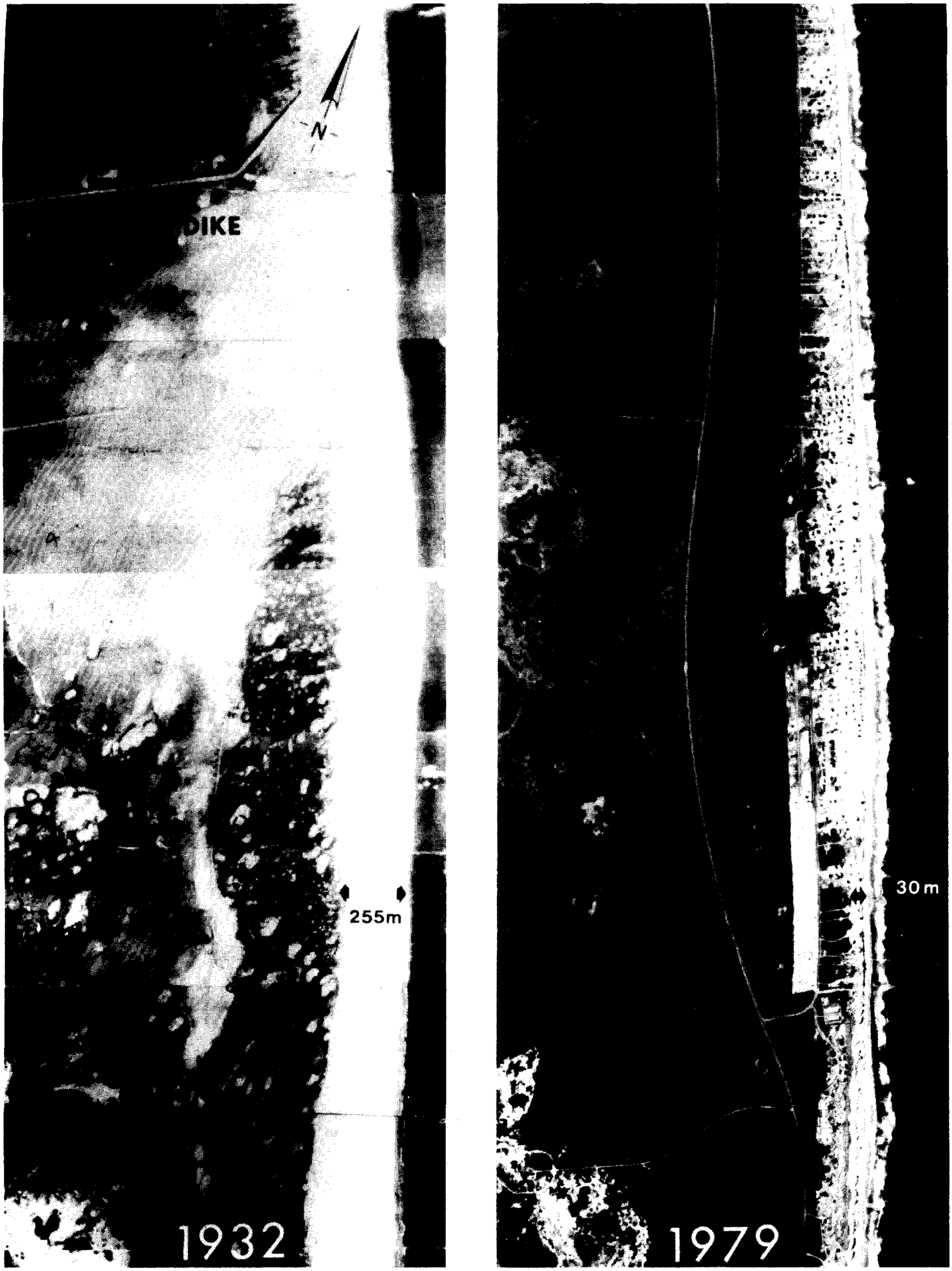

Fig. 2 Comparison between 1932 and 1979 aerial images. The road shown in 1932 is visible as the most seaward roadway in 1979 and gives some indication of the changes which have occurred.

them in the early 1930s and to contrast this view with a collection of photos dated in the late 1970s and early 1980s. In addition, the history and philosophy of the dune construction program will be reviewed.

THE OUTER BANKS IN TRANSITION: 1930-PRESENT

Stick[20] painted a bleak picture of the Outer Banks in the late 1920s and 1930s.

> On the eve of the Great Depression the fortunes of the Bankers had reached a new low. Because no effort had been made to improve the strain of beef cattle, stock raising was relegated to minor importance. Shipwrecks were becoming a rarity, and a decrease in the lifesaving operations was in prospect. More stringent hunting laws and a growing shortage of waterfowl were causing dissatisfaction among the non-resident owners of the large gunning clubs. Maritime traffic through the Banks inlets was confined largely to small fishing vessels, and the steamboat lines no longer operated on the sounds.
>
> There was no shipbuilding on the Banks, no commercial outlets for yaupon; no more shore whaling; no porpoise seining from the beach. Commercial gunning was outlawed, the diamondback terrapin was practically extinct, and a blight was destroying the eel grass. Even the commercial fishermen were beginning to have difficulties.
>
> Further, from Currituck to Beaufort Inlet, erosion had become such a problem that much of the Banks was swept clean by storm-driven waters whenever a hurricane passed over.

In response, some farsighted townfathers began preparing the area for the tourist invasion that followed World War II. In the early 1930s the first roads appeared, bridges were built connecting the islands to the mainland, a memorial to the Wright Brothers was erected, and the seed for the Cape Hatteras National Seashore was planted.

Early development can be seen in the April 15, 1932 aerial photo of Kill Devil Hills (frontispiece). Construction of the Wright Brothers Memorial is already visible as well as the present day "beach road" which parallels the shoreline. Other than these few landmarks the island is essentially undeveloped. This is in sharp contrast to the March 5, 1981 photo, (frontispiece) which clearly illustrates both the stabilization around the Wright Memorial and an enormous amount of development, from the few scattered houses in 1932 to high density housing right up to the dune line.

Probably the most important attribute of the 1932 photos is the width of the active sand zone. The width then was about 125 m which is similar to the width of the active sand zone on the unstabilized Core Banks, south of Cape Hatteras. Along the same areas on Bodie Island today, the active sand zone averages less than 75 m and is in places only 15 m wide (Fig. 2).

This wide active zone in the 1930s was maintained by wave uprush and overwash during storms and by wind transport. Though there was concern about the islands washing away, beach erosion, defined as the removal of sediment from the oceanfront, was not as important an issue as today because there were few oceanfront structures in the 1930s. In fact, except for Life Saving sta-

Fig. 3 View of the Wright Memorial in 1932 shortly after its construction. (Photo courtesy of the *National Geographic*). Approximate location of the photograph is indicated by a cross on the Frontispiece.

tions, the only oceanfront structures of any consequence were a series of pile-supported homes located in Nags Head which were built near the turn of the century. They have survived to the present by being routinely moved back from the beach face and repaired as storms and erosion occurred.

The 1930s photos confirm descriptions by "Outer Bankers" who are old enough to remember the predune stabilization era. For example, Oliver O'Neal, of Buxton, North Carolina, now 79, recalls in a 1982 newspaper article (Coastland Times, Manteo, North Carolina) that when General Billy Mitchell's landing strip was being constructed on Hatteras Island for his historical demonstrations of airpower in 1923,

> "... The beach was wider and there were no ocean-side dunes in those days, and the sea tide washed over with every blow. I remember after one storm there was water on the field — maybe five or six inches — and General Mitchell landed in it. Well, the airplane set up a stern wave just like a boat, and when the wave caught the tail of the plane, it flipped her up on her nose. He wasn't hurt and they put a new propeller on the plane and flew it off when the tide went down."

The site of General Mitchell's air strip is now protected by a high stabilized barrier dune and has not been overwashed in 30 years. But according to Mr. O'Neal, and others living along the Outer Banks, before stabilization washovers were the rule, rather than the exception.

Further evidence of the importance of overwash along the Outer Banks was presented by Boc and Langfelder[3]. They report, based on analysis of aerial photographs, that "approximately 85% of North Carolina's coast has been subjected at one time or another to some category of overwash since 1938" (p. 15). And, for Dare County (which encompasses the study area), "the entire county has shown the entire range of overwash classifications." (p. 6).

The artificial dune has succeeded in one of its primary purposes; it has prevented lowland flooding during major storms. At the same time revegetation with grasses of the dune areas contributed to the reduction of windblown sediment on the interior of the island. This situation can be seen around the Wright Brothers Memorial. In a 1932 photo, (Fig. 3), reprinted from *National Geographic*, the low areas surrounding the base of the monument were unvegetated and open to ocean flooding during major storms. Since construction of the dune, this flooding occurs only during major storms, such as the Ash Wednesday storm of March, 1962, when the dune is breached. As shown on the frontispiece these low areas now support a thick stand of pine trees. With the lee side of the dune now stabilized, as the shore retreats, the beach is narrowing and the dune faces are being scarped.

The frontispiece also shows a wide active beach zone of uniform width, but there is no evidence of recent overwash into the interior. This is in marked contrast to Figure 4 which shows New Inlet (Fig. 4A) on October 7, 1932, a few months after its opening in March. The dynamic nature of the New Inlet area is supported by a long history of inlet openings and closings. Stick[20] reported that prior to Oregon Inlet's opening in 1846, New Inlet existed from 1738 to 1922 but was not navigable until after the colonial period. An attempt was made to reopen it in 1925, but it quickly closed.

The unstable nature of the area is also evident in the large-scale overwash features south of the inlet. Ocean to sound overwash was obviously an important process in this low, narrow area. Figure 4B, taken on February 21, 1933, and Figure 4C, on November 13, 1936, show later configurations of New Inlet. The two wooden bridges shown in Figure 4C were abandoned soon after the inlet closed, but they are still visible in the 1979 photograph shown in Figure 4D. The transition from Figure 4A to Figure 4D clearly illustrates the role of the duneline to stabilize the interior of the island, allowing revegetation and changing its character and ecology.

Another interesting region, now known as South Nags Head, is shown in Figure 5A on April 15, 1932. Again, notice the wide active beach zone, here with a width of 255 m. Overwash and lowland flooding were common processes in this region. The same area today, (Fig. 5B) shows little indication of past flooding and overwash. The area is thickly vegetated, including the soundside marshes. Development has occurred only along the higher elevations near the oceanside. This area has a history of high erosion rates, up to 3 m/yr. The only recognizable features to relate Figure 5A to its present appearance are the parallel canal and dike at the top of the photo. These were originally constructed by a Bodie Island hunt club to improve wildfowl nesting habitats.

THE DUNE STABILIZATION PROJECT

In order to appreciate the new Park Service dune management strategy, particularly in light of the condition of the islands in the 1930s, it is necessary to understand the history of the dune stabilization project.

Authorization for establishment of the Cape Hatteras National Seashore in 1937 was closely related to the dune construction project. The prevailing viewpoint at that time (and even presently, in some cases) was that the mid-Atlantic barrier islands had at one time been heavily forested. Nash[13] stated that less than 100 years ago the "Outer Banks were covered with trees, shrubs, vines and grasses and other types of vegetation from the sound almost down to the edge of the ocean".

Denudation, submergence during periods of high tides, and erosion of the islands was thought to result from extensive grazing and lumbering in the 1800s[7]. Without an elevated, well-vegetated dune, it was reasoned that the Outer Banks would eventually erode away. In the early 1930s, a massive public works project was initiated in order to create a continuous line of vegetated, protective foredunes from the Virginia State line to Ocracoke Inlet[7]. This program was originally administered by the North Carolina Transient Bureau. Authority was then transferred to the Virginia Transient Bureau, then again to the North Carolina WPA. Final authority ended up with the National Park Service on August 1, 1936[24].

The erosion control project was first suggested when a local newspaper ran an article in July, 1933 proposing the development of a rehabilitation program and creation of a new park for the Outer Banks[20]. The

article suggested that the shifting sands could be reclaimed and sand dunes built up. In addition, it was proposed that the project would provide much needed employment for the "Bankers". As a final step to the project, the reclaimed area would be designated as a national seashore complete with a new highway, thus making the Outer Banks easily accessible to tourists.

There was widespread public and political support for the proposed stabilization project. It was recognized that erosion of the islands could not be entirely halted, but prevailing opinions held that it could be controlled to a large extent[10]. Stick[20] quoted geologist H.J. Bryson as saying "There is no question but that reforestation along this beach would stop the erosion to a large degree". It was also thought that this portion of North Carolina could even be developed into a productive timber region[20]. However, support for the stabilization project was not unanimous. Some scientists and planners within the National Park Service ranks were skeptical of the desirability of the project[4].

The Federal project was backed by emergency funds from the State of North Carolina. According to Stratton and Hollowell[21], 1500 WPA and CCC workers were employed to create a continuous line of foredunes using sand and brush fencing (Fig. 6). These dunes were then stabilized with vegetation. In addition, a sand laboratory was set up, old and new methods of sand fixation were examined, and weather conditions affecting the stabilization process were recorded. The project did not rely on one method of sand fixation. Numerous field experiments were conducted in order to determine the best method of fixation for a given area. By 1940, protective sand dunes had been created from the Virginia state line to the middle of Ocracoke Island.

These dunes had been constructed through the use of more than 1000 km of sand fencing. Although five types of fencing were tried, only those of prefabricated brush and slat panels were found to be satisfactory. The placement of the fencing varied according to the conditions at a given site. "The best general rule to follow in starting the barrier dune is to estimate from the type of sand the width of the base of the dune that you want to build, then start the dune so that when eventually finished, the base on the ocean side will nearly meet with the crown of the beach, thereby attaining a desirable natural slope"[21]. In order to achieve the required height, it was often necessary to place additional lines of fencing above the first set. A dune base of sufficient width was obtained by using up to eight lines of fences. Dune height varied from 3-8 m and dune base widths were 25-100 m. Throughout the project, however, one of the primary objectives was to create dunes that simulated a natural dune system as closely as possible[24].

When the dunes had been built up to the desired height and width, establishment of a vegetative cover on the dunes was initiated. Four types of grasses were utilized with success. These were *Ammophila brevigulata* (Beach Grass), *Uniola paniculata* (Sea Oats), *Spartina patens* (Cord Grass), and *Cynodon dactylone* (Wire Grass). Grasses were obtained both from nurseries and transplanted from local areas where they were abundant. Planting in rows was avoided since this practice increased sand erosion around the base of the plants. In most cases, the survival rate of these transplanted grasses approached 100%[21].

In addition to the grasses, shrubs and tree seedlings were also planted. The planting of the shrubs and seedlings was the third phase of the program, but represented the initial stages of the ultimate goal of the Outer Banks reforestation. As of 1940, Stratton and Hollowell[21] reported that a total of almost 13.2 million m^2 of grasses and over 2.3 million shrubs and seedlings had been planted.

In conjunction with the dune stabilization project, a series of benchmarks were established along a baseline at 0.8 km intervals[13]. In 1937, beach profile surveys were taken at approximately 300 m intervals along this baseline[19]. These cross-sectional surveys were taken for two reasons. First, the profiles were used to determine where it was necessary to place the first sand fences. Secondly, it was anticipated that successive sets of surveys from the same location would be utilized to document the results of the stabilization project[24]. This has, in fact, been carried out by the National Park Service in 1961, 1963-1965 and again in 1976-1977.

Throughout the 1940s, little attention was paid to either the stabilized dunes along the Outer Banks or the proposed national seashore. However, with the final acquisition of the land needed for the establishment of Cape Hatteras National Seashore in 1952, interest in the Outer Banks was again revived. Along with this renewed interest and the establishment of the national seashore, came an intensified effort to fortify the artificial dune system[15]. This work was thought necessary not only to protect the barrier island in general, but also to provide protection for the several villages incorporated within the National Seashore boundaries. The occurrence of hurricanes in both 1954 and 1955 reemphasized the need for protection.

With funds for emergency dune revitalization measures provided by the Federal Civil Defense Administration, the dune stabilization program resumed in 1953[22]. The 1930s dune system was rebuilt and the dune line was extended to the southern boundary of the National Seashore on Ocracoke Island[6].

The final objective of this renewed National Park Service stabilization project was to create a continuous dune line (using sand and brush fencing) along the coast with a height averaging 1.3 m and a base width of 8-15 m[22]. In fact, the plan at one time called for the barrier dune to extend all the way to Cape Lookout. In critically eroding areas, sand from the beach was bulldozed into an 2.5-3 m dune. Often a fence line was placed on top of the bulldozed dune to further increase the height of the dune and to stabilize it. The U.S. Army District Engineer's Interim Survey Report on Hurricane Protection[22] indicates that repairs to the bulldozed dunes were relatively rapid. The total cost of the stabilization project from its inception to 1965 was close to 5 million dollars[1].

A series of experimental dune building studies were conducted in conjunction with renewed dune stabilization efforts[18, 23, 25, 26, 27]. These investigations examined the most efficient methods of dune building and stabilization. Different fencing arrangements and types were examined as well as the ramifications of utilizing various species of grasses. Many of these studies suggested

Fig. 4 Four views of New Inlet showing the dynamic nature of the area in the 1930's, in marked contrast to the present more stable condition.


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NEW
INLET
1936


DUNE
CARP
9

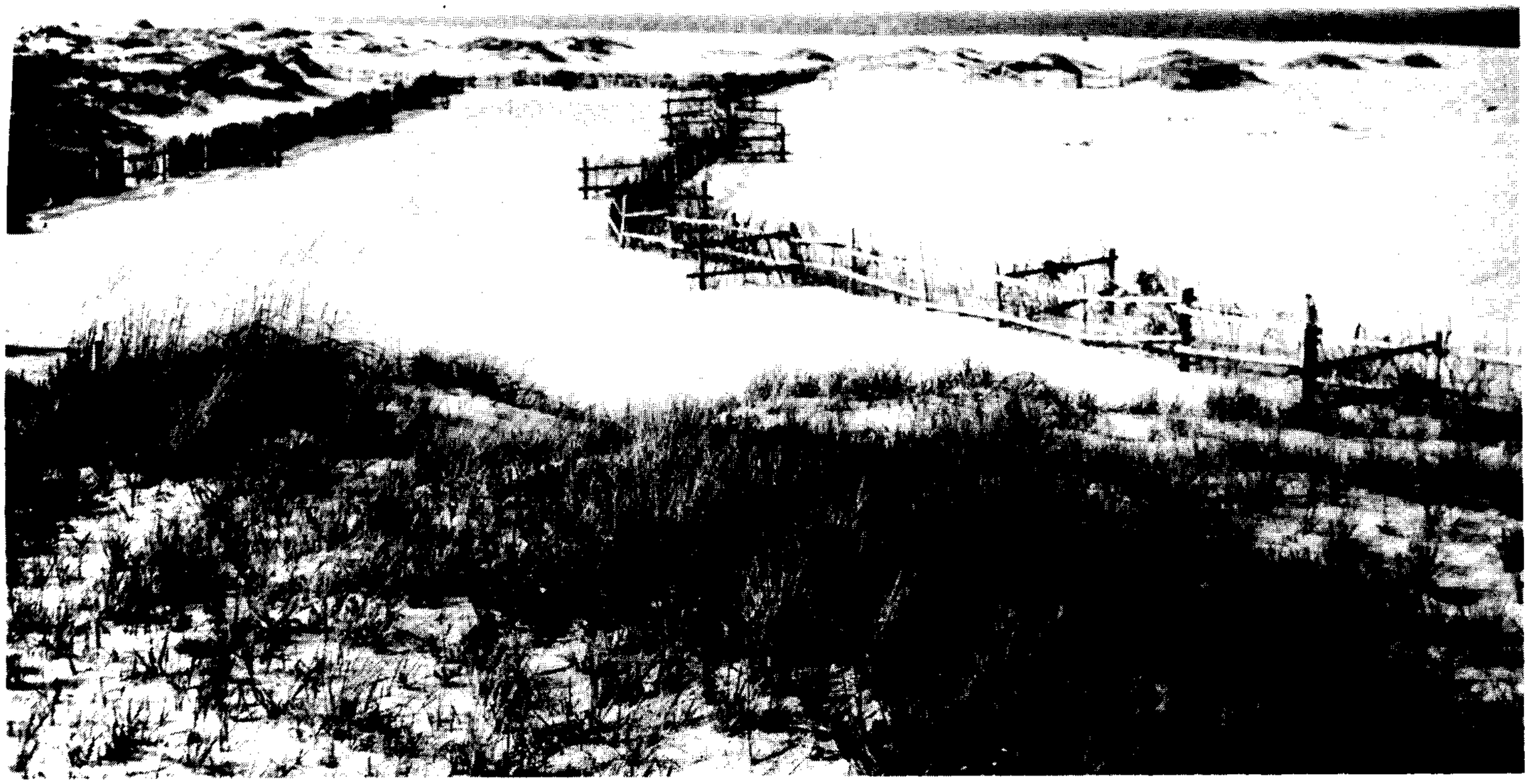

Fig. 6 Sand and brush fencing used to construct the dunes in the 1930's.

that the placement of the dunes, relative to the shoreline, was one of the critical factors in the success of a stabilization project.

In the early 1960s, a Dune Study Group was formed in order to document the relationship between winds, waves and the coastline[12]. The initial phase of this project was re-establishment of the 1937 CCC baseline. Surveys were then conducted at each of the original transect locations along the baseline[14]. Comparisons of these early 1960s cross-sections with those taken in 1937 indicated that severe erosion of the shoreline had taken place despite the presence of the artificial dune system.

Following the devastating effects of the March 1962 storm, the National Park Service continued constructing additional stabilized barrier dunes along the Outer Banks[22]. However, in 1972, Godfrey[8] proposed the concept of "preserving the processes" as opposed to preserving "things". At about the same time Dolan[5] published a paper in *Science* calling attention to the potential negative aspects of the barrier dunes from the geological standpoint. These studies evolved into the realization that the original "natural ecology" and condition of the Outer Banks was not actually known[9,15]. Prior reports had always assumed that past forests, evident from maps and the literature, and existing today in Kitty Hawk, Kill Devil Hills and elsewhere, were remnants of a previously extensive forest covering the entire Banks[15]. Godfrey[8] and Dolan's[5] studies helped to force recognition of the possibility that a major portion of the Banks did not naturally support a forest ecosystem.

Continuing problems with erosion despite dune stabilization attempts over a period of 40 years, and the economic implications, caused a change in Park Service policy by the early 1970s[16]. Accordingly, at the Cape Hatteras National Seashore, further attempts to arrest the dynamics of the islands through dune stabilization have been halted with the exception of the Cape Hatteras Lighthouse[17]. "The existing artificial dune line will gradually be eroded away by wave action: also, sand and water overwash will flow beyond the present line. A natural network of scattered dunes will form and be continuously altered by wind-carried sand and storm waves"[16].

CONCLUSIONS

These old aerial photographs graphically show that dunes can significantly alter the makeup of barrier islands. Though in their 40 years of existence they have caused a constriction of the active sand zones, they have permitted the stabilization and re-vegetation of the island. They do this by acting as a barrier to coastal flooding and overwash. Once flooding stops, vegetation begins to grow which limits and further traps wind-blown material. During storms, the dunes also act as sediment reservoirs, adding sand to the littoral zone.

Barrier dunes may survive an infrequent storm, but they cannot survive the steady long-term erosion that is occurring at South Nags Head and along much of the North Carolina Outer Banks. Since some minimum beach width will always be preserved, to maintain the dune it must migrate or build inland at a rate commensurate with the erosion rate. As the National Park Service has discovered, the maintenance of the dune line is a time-consuming and costly process with complicated land-use problems. Relocating the roads inland as the

old dunes erode away and new ones are established is not a simple matter, nor are the problems of dune and road encroachment into villages, park developments, and wetlands. If the National Park Service management strategy results in a return to the condition of the 1930's, some interesting changes are in store for the Outer Banks of North Carolina, and man's activities in the area will require re-evaluation.

ACKNOWLEDGMENT

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