THE INDIANA DUNES-LEGACY OF SAND

Special Report 8

State of Indiana
Department of Natural Resources
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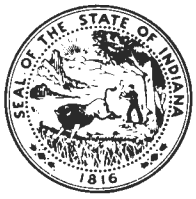
The Indiana Dunes-Legacy of Sand

By JOHN R. HILL

DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY SPECIAL REPORT 8



PRINTED BY AUTHORITY OF THE STATE OF INDIANA
BLOOMINGTON, INDIANA: 1974

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For sale by Geological Survey, Bloomington, Ind. 47401
Price 75 cents

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Introduction

The area including the Indiana Dunes State Park and Dunes National Lakeshore is unique in its diversity of geologic features and terrain. The forces of glaciers, wind, and water have combined over the eons to create picturesque morainal topography, a vast fresh water lake, great expanses of sand in the form of beaches and dunes, and bogs containing exotic plant species. Soon to be completely surrounded by an ever-expanding urban-industrial complex, the dunes area will remain as a lasting monument to the complexity and beauty of nature.

Glacial History

The park area, as well as all northern Indiana, was subjected to four major glaciations during the Pleistocene Epoch, that is, during the past million years. Listed below are the names of these major ice advances and the duration of each. The Dunes area is situated on deposits associated with the last glaciation, the Wisconsinan. Deposits left by the earlier glaciers are not found surficially in the Dunes area because they were either buried under the Wisconsinan *drift* (see glossary for definition of italicized terms) or stripped away by the Wisconsinan ice sheet.

Approximate age (in years)	Glaciation	Interglaciation
		Recent
5,000 - 70,000	Wisconsinan	
		Sangamonian
300,000	Illinoian	
		Yarmouthian
700,000	Kansan	
		Aftonian
1,000,000	Nebraskan	

Between glacial advances there were periods of relative climatic warming, during which the glaciers retreated northward. Forests, prairies, and swamps developed atop the glacial debris of the previous ice advance. Materials, such as soils, formed during the interglacial periods are not visible in the park area either because they were destroyed by the advancing Wisconsinan ice sheet or because they were buried by the deposition of glacial debris, lake clays, and beach sands. However, materials deposited either directly or indirectly by the Wisconsinan ice sheet are abundant throughout the state and federal parks.

The actively advancing Wisconsinan continental glacier moved vast amounts of debris by carrying boulders, gravel, silt, sand, and clay within, beneath, and on top of its frozen mass. As this glacier waxed and waned, the mixture of unsorted debris was deposited by the ice as *till* in the form of *ground* and *end moraines.* The Valparaiso Moraine, a massive, arcuate end moraine, which extends around the southern perimeter of Lake Michigan, is one of the most impressive glacial features in northwestern Indiana (area 5, pl. 1). At its highest point, near Valparaiso, the moraine is more than 800 feet above sea level, rising 200 feet above Lake Michigan to the north and more than 150 feet above the Kankakee flood plain to the south. The Valparaiso Moraine, which lies entirely beyond the boundaries of the two parks except at Pinhook Bog (area 6, pl. 1), serves as a major divide separating drainage northward to Lake Michigan from drainage southward to the Kankakee River. Till deposited before the formation of the Valparaiso Moraine is in the form of flat-lying ground moraine (area 4, pl. 1) and is associated with an earlier advance of the Wisconsinan glacier.

As the Wisconsinan ice sheet retreated northward, large volumes of meltwater that were produced carried off the ice-borne sand and gravel and deposited it as *outwash.* Outwash deposits reworked by wind and water are visible throughout the Dunes area in the form of sand dunes and beaches and, in the West Beach area (area 7, pl. 1), as gravel deposits partially covered by sand.

Silt and clay, absent from the outwash deposits, were laid down as lake sediments. Mud carried in suspension by glacial meltwaters was deposited in standing water where rapidly flowing glacial streams bearing these materials came to rest. Lake, pond, and swamp deposits of the type just described can be seen in the federal park (area 8, pl. 1), as well as south of the state park (pl. 1).

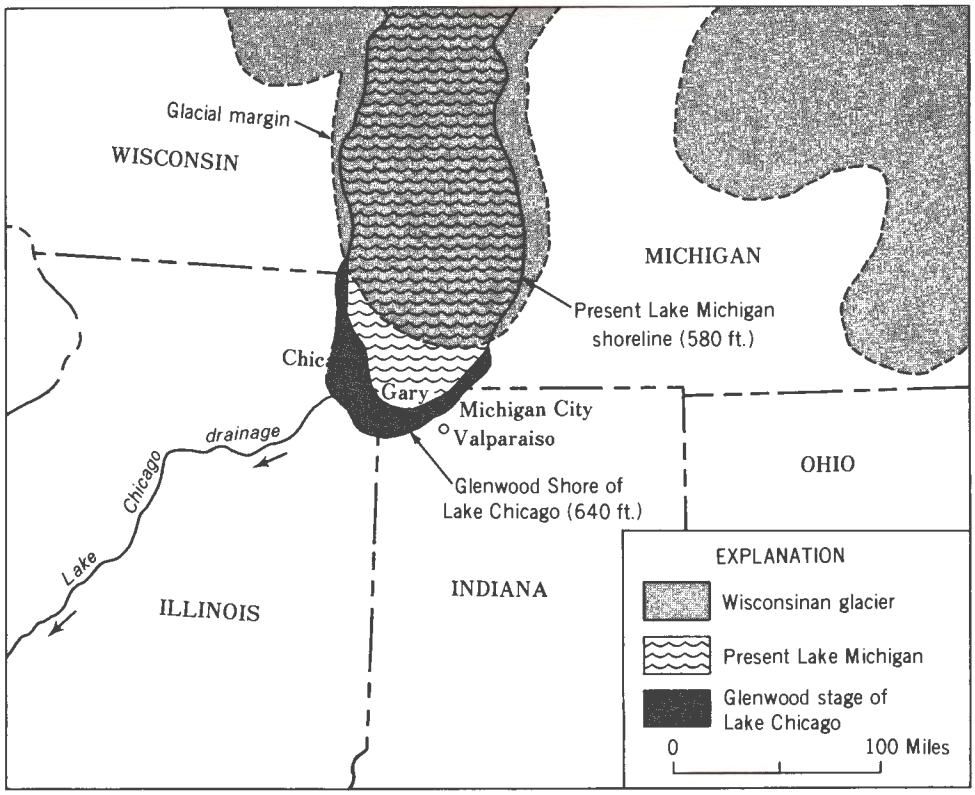


Figure 1. Map of glacial Lake Chicago during the Glenwood high water stage.

Glacial Lake Chicago

Lake Michigan, the third largest of the Great Lakes and the sixth largest lake in the world, came into existence about 2,000 years ago at the close of the last major glaciation, the Wisconsinan. Ancestral Lake Michigan (glacial Lake Chicago), from which Lake Michigan formed, had much the same shape as present-day Lake Michigan, but its shores, especially the arcuate south shore, extended inland as far as 10 miles from the present beach. The Chicago area was, from 12,000 to 2,000 years ago, under water as was all land now in the state and federal parks.

Lake Chicago (fig. 1) formed about 12,000 years ago from glacial meltwaters dammed on the south, east, and west by the belt of glacial till called the Valparaiso Moraine and on the north by the retreating ice mass. The original shoreline stood at 640 feet above sea level, but the shore of present-day Lake Michigan is only 580 feet above sea level. What happened to lower the lake to its present level? With the final retreat of the glaciers, Lake Chicago remained as an enormous fresh water body, brim full to overflowing. The Valparaiso Moraine, the U-shaped earthen dike deposited by a lobe of the Wisconsinan glacier, was breached in the area now known as Palos Park, Chicago, by waters spilling southward over and downcutting into the moraine. Gradually, the lake level fell. The lowering of the lake level was punctuated by several still stands, the lake level falling rapidly at a given period, only to stabilize for a time, and then fall again. In all, there were three stages of lake-level lowering, each level being marked by a beach and associated series of sand dunes (fig. 2). The oldest and first beach level represents the Glenwood stage

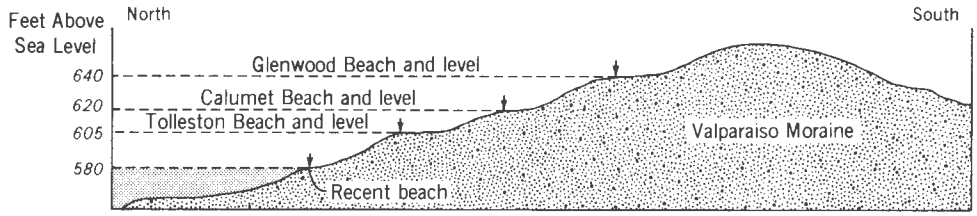


Figure 2. Cross section illustrating the three major beaches and corresponding levels of glacial Lake Chicago.

and is preserved as a series of ridges and foredunes about 640 feet above sea level (area 3, pl. 1). The second major stage, the Calumet, is represented by the beach terrace at the 620-foot elevation (area 2, pl. 1). The third stage of Lake Chicago, called the Tolleston, is marked by the beach ridge and associated dunes found at the 605-foot elevation (area 1, pl. 1). The Tolleston stage began about 8,000 years ago and persisted until about 2,000 years ago, when the water of Lake Chicago was lowered to 580 feet above sea level, that is, to the level of present-day Lake Michigan. At about the same time the lake drainage changed from a southerly route through Illinois to the northerly route through the St. Lawrence River.

Much of the expansive sand dune area seen from U.S. Highway 20 north to the lake is associated with two or more of the Lake Chicago beach levels. Throughout most of the Dunes National Lakeshore, it is difficult to isolate the Tolleston beaches from the recent, as they merge one into the other, the result of thousands of years of wind and water erosion and deposition. In the West Beach area (area 7, pl. 1), however, a sand ridge or scarp rises some 3 to 10 feet above the present beach level. This sand scarp is a remnant of the Tolleston beach of 8,000 years ago. In most places along the West Beach shore, wind erosion has removed more than half of the old Tolleston ridge. Sand being blown from the recent beaches inland is gradually masking the break between the old and the new dunes and will one day completely bury or alter the old beaches beyond recognition.

The headquarters building of the Dunes National Lakeshore is on the Calumet beach terrace. Just south of the building, between Indiana Highway 12 and U.S. Highway 20 in the Furnessville area, the Glenwood beach, or oldest beach level, can be seen.

Shoreline Processes

The Dunes National Lakeshore and Indiana Dunes State Park together include some 14 miles of Lake Michigan shoreline that is subjected to alteration by wave and current action every moment of each day. Thus, the beach is an ever-changing feature of the lake.

Waves in Lake Michigan, as those in the oceans, are generated by two forces: wind and, to a much lesser degree, the tidal effects of the moon and the sun. Once in motion, the waves can strike the shore in one of two ways: head on or obliquely. It is only under unusual storm or wind conditions, however, when wave fronts are parallel to the shore, that the waves strike the beach head on.

If wave motion were limited to head-on approaches, the beaches in the park area, as along the entire Lake Michigan shoreline, would be very uniform. Because waves most often strike obliquely, however, beaches of the Dunes area are not uniform. In fact, it is apparent to the park visitor that the beach is *cuspate* in form and that the expanse of open sand beach is quite variable in detail.

Figure 3. Oblique waves producing longshore currents at shoreline near Ogden Dunes.

Figure 4. Sediments borne by longshore currents trapped on the up-current side of the groyne at Michigan City harbor.

Figure 5. Lake currents undercutting old Lakeshore Drive at Central Avenue near Beverly Shores.

Figure 6. Beach and over-steepened foredune in the Dunes National Lakeshore near Beverly Shores reduced by strong wave action.

Much of the shoreline irregularity is due to a current which acts parallel to the shoreline and is thus called a *longshore current.* In general, longshore currents are generated by obliquely striking waves that have a component of force acting parallel to the shore in the general direction toward which the oblique waves are moving (fig. 3). Wave-generated longshore currents have a prevailing east-to-west flow direction in the Dunes area. Therefore, a general tendency exists for materials to be transported southwestward along the shoreline. Evidence of the east-to-west sediment movement can be seen about 10 miles east of the federal park boundary on Indiana Highway 12 at the Michigan City harbor *groyne* (fig. 4) where marked sediment accumulation is occurring on the east side of the projection. The groyne interrupts the normal east-to-west movement of sediments, which causes accumulation on the up-current side.

The effects of longshore currents are not always constructive, however. Much of the Dunes area is now being stripped away, in many areas of the state and federal parks at the rate of more than 15 feet per year. Portions of the old Lakeshore Drive have been undercut and washed away by longshore current and wave action, as near Beverly Shores, for example (fig. 5). The destruction of one section of beach and the construction of an adjacent area is all part of natural beach processes. Man, however, can easily alter this natural erosion-construction balance—and often does.

The erosion and destruction of beaches in the Dunes area are not solely the product of longshore currents, however. Simple wave action breaks up and washes away hundreds of tons of sandy shore every day. Much of the irregularity and beauty of the shoreline in the Dunes area is due to the direct action of waves. The combined effects of wave and current activity concentrate sands offshore as *bars* and *shoals* as well as onshore as beaches. Undulating crests and troughs of sand along with treacherous *rip currents,* producing undertow, are especially apparent to the unwary swimmer. Large waves produced by strong shoreward winds are erosional rather than constructional and account for much of the loss of beach sands and *foredunes* (fig. 6). The same waves that

Figure 7. Foredune with plant cover in the Indiana Dunes State Park.

Figure 8. Typical blowout in the Dunes area adjacent to the parking lot at the Indiana Dunes State Park.

strip away vast areas of beach carry the eroded sand offshore, there reworking and reshaping the aqueous sand concentrate into intricate *bars, spits,* and *shoals.* Conversely, low, slow-moving waves carry the accumulated offshore sands onto the beach, thus causing beach accretion. Along any given beach the balance between the constructive and destructive forces serves to maintain the beaches, though of varying widths, indefinitely. As the beaches are stripped away, the sand from the beaches is carried just offshore, where it awaits either transport along the shore or redeposition as fresh beach at a new or the same locality. Thus, it should be remembered that the beach is an ever-changing and, at best, transient feature subject to the cycles of nature.

The Sand Dunes

Perhaps the most impressive features of the Dunes area are the extensive and beautiful dunes themselves. Dunes from the three levels of Lake Chicago, as well as those forming along the shore of present-day Lake Michigan, grace the state and federal parks, each series of dunes with its own characteristic flora, sizes, and shapes. Nature trails crossing the nearly 6,000 acres of scenic Indiana Dunes State Park and Dunes National Lakeshore provide the park visitor with the opportunity to walk through dense oak, pine, and maple forests, or to behold breathtaking vistas from high atop such dunes as Mount Tom.

To enhance appreciation for the dunes it is advantageous to discuss the way in which these magnificent features come into existence. The first dunes to form are the foredunes, those nearest the beach. The beach serves as the sand source for the foredune, and landward winds from off the lake move the sand inland. Some of the sand grains are rolled along by the wind, but if wind velocities are sufficiently high, the individual sand grains actually bounce along by a process known as *saltation.* In time a sinuous ridge is produced parallel to the shore—a ridge continuously growing in height and breadth. Its windward slope makes an angle of about 10° with the horizontal, and its lee slope, an angle of 30° to 35°. Trees, shrubs, and grass contribute to the form and stability of many of the dunes (fig. 7). Foredunes are found along the entire shoreline of the Dunes area and range from only a few feet to 100 feet or more in height, such as Mount Holden and Mount Tom in the state park.

Blowouts, known by early settlers as "slides," form on foredune ridges. A blowout begins as a small channel or gap excavated by wind in a preexisting foredune. The gap enlarges until it looks like an amphitheater. During the early stages of formation, a blowout is nearly stripped of vegetation because of rapid removal of sand from the dunal slope. Blowouts (fig. 8) are scattered along the entire length of beach in the Dunes area; perhaps the best-developed and largest blowout is on the lake side of Mount Tom, at the extreme west edge of the state park. Blowouts are primarily found in the foredune area, although they may develop on a smaller scale in the *interdunal* or *backdune* areas farther inland.

Landward, just behind the foredunal complex, is the interdunal area with its ponds, marshy areas, and unique forms of sand dunes. In the interdunal and backdunal areas, dunes form primarily under the control of vegetation (fig. 9). These vegetationally controlled dunes include *parabolic dunes, longitudinal dunes,* and *transverse dunes* named on the basis of their shapes and positions relative to the prevailing wind direction. The foredune, discussed earlier, is a type of transverse dune. All these dune types can be seen just behind the foredunes in both the state and federal parks.

Figure 9. Sand knob in West Beach interdunal area protected from wind erosion by its plant cover.

Vegetative Sequence from Shore Inland

Each major sequence of dunes, foredune, interdunal area, and backdunes, has its own unique type of vegetation and fauna which characterizes the dune and distinguishes it from another sequence. For

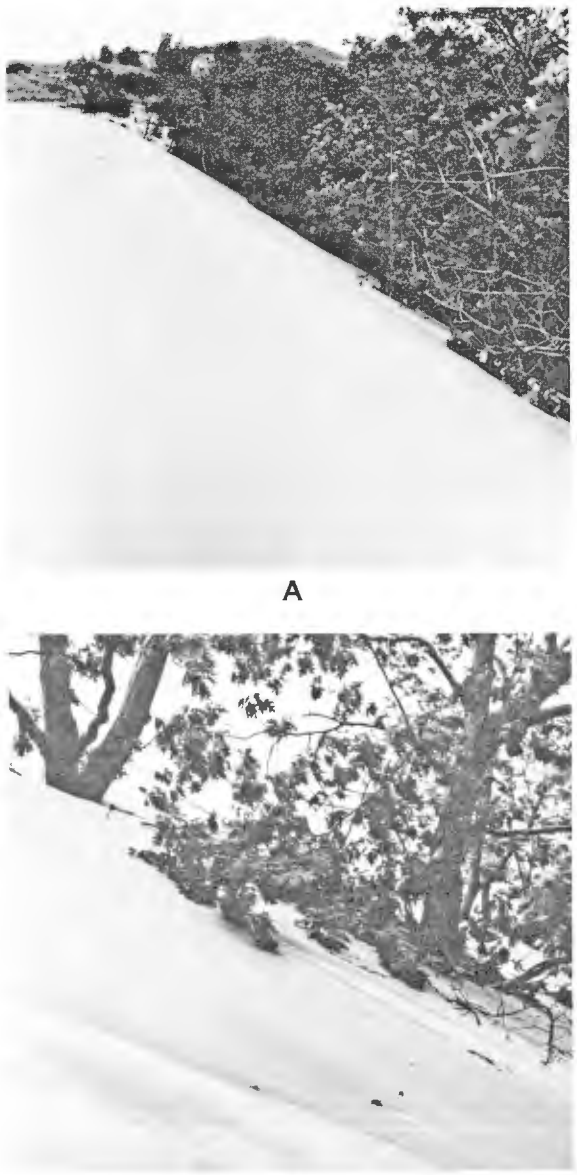


Figure 10. Migrating sand burying a living forest at West Beach. *A*, View of encroaching dune from crest. *B*, View of lee slope of the same dune midway between its base and crest.

instance, the foredune, the most recent dune to form, has cottonwood, marram grass, and sand cherry growing on its flanks.

Farther inland, the second line of dunes is covered with white and jack pines, juniper, poison ivy, and bluebells. This sequence, known as the pine dunes, was once a foredune. The old Tolleston beach foredunes are now covered with pine instead of the cottonwood association; the cottonwood flora has been displaced by dunes nearer the shore. Behind the pine dunes are the oak dunes. The oak dunes support black oak, white oak, basswood, and elm. Like the pine dune, the oak dune was also once a foredune but now is much older than either the recent or pine dunes. The Interpretive Center at the federal park, Indiana Highway 12 and Kemil Road, is on an oak dune, once a foredune of the Calumet stage of Lake Chicago.

The line of dunes farthest inland is called the beech-maple dunes and is covered with beech and maple trees, ferns, and tulips. Being on the oldest of the dunes, the beech-maple sequence has the best-developed soil. The beech-maple dunes were once the foredunal sequence of the Glenwood stage of Lake Chicago. Now the beech and maple forest grows so densely that the shade prohibits the growth of oak and pine. The beech-maple dunes can be seen between Indiana Highway 12 and U.S. Highway 20 in the Furnessville area.

If the present-day pine, oak, and beech-maple dunes were each once foredunes, plant remains should be buried somewhere in these dunes to substantiate the statement. When pine, oak, or beech-maple dunes are excavated, fragments of cottonwood should be recovered. Cottonwood, as discussed above, is associated with foredunes.

Just as the dunes of old were buried under drifting sand so are the recent dunes. In the West Beach area of the federal park, a contemporary forest is being buried by sand from a foredunal blowout (fig. 10). Within a few years the entire forest may be covered, only to be exhumed by the winds at some future time.

"Squeaking Sand"

Many visitors to the Lake Michigan shores are fascinated by the squeaking sound produced by walking on certain portions of the sand beach. The squeaking phenomenon is restricted to a band 25 to 100 feet wide which extends parallel to the water edge and inland from the wave-wash zone. The cause of the squeaking is an abrasion-induced vibration set up between the tiny sand particles as they are rubbed against one another by a person's walking or dragging an object on the sand surface. Why, then, doesn't all the sand squeak, including that in the dunes? The reason is that a thin film of water which coats the sand grains is essential in producing the sound. Only in the zone affected by wave spray is the proper quantity of water supplied to produce the effect. Too much water, as in the wave-wash zone, or too little,

as in the dry sands farther inland, and the sound cannot be generated.

Pinhook Bog

Pinhook Bog (area 6, pl. 1), in the Dunes National Lakeshore about 5 miles north of Pinhook, is a nature lover's paradise, resplendent with abundant varieties of exotic flora. The bog has long been a locality of extreme interest to professional botanists and to students.

Pinhook Bog originated as a *kettle lake* in late glacial to early postglacial time. This kettle lake was formed by the melting of a huge block of glacial ice, which on complete thawing left a depression in the surrounding materials. The depression was filled with water from springs and precipitation, and thus a lake was formed. Aquatic vegetation gradually choked the shores of the lake, finally spreading out across the entire surface of the water. Sphagnum moss began to grow over the surface of the lake until a spongy, floating carpet of vegetation stretched from shore to shore. The sphagnum mat, enriched with minerals from the bog water below, served as a soil in which the flora of Pinhook Bog grew and flourished. Today that flora still thrives in its unique setting on the northern flank of the Valparaiso Moraine.

Summary

The Indiana Dunes State Park and Dunes National Lakeshore encompass more than 6,000 acres of relatively unspoiled natural scenery. Lake Michigan, which evolved from glacial Lake Chicago, and its accompanying sand dunes are the result of 12,000 years of the combined energies of glaciers, wind, and water. Wave and longshore current activity continually build and destroy portions of the expansive sand beaches. While wave and current activity build shoals, beach ridges, and sand bars offshore, the wind onshore molds foredunes, blowouts, and sand ripples.

The Valparaiso Moraine, which once dammed glacial meltwaters to form glacial Lake Chicago, now serves as a major drainage divide separating waters which flow north into the lake from those which flow south to the Kankakee River.

The bogs, swamps, lakes, and undulating topography of the Indiana Dunes State Park and Dunes National Lakeshore are of unique beauty and are products, either directly or indirectly, of the great Ice Age.

Glossary

Backdune area: A series of dunes which form landward from the foredunes and are separated from the foredunes by the interdunal area.

Bar: A ridge of sand formed underwater by wave and current action; a bar may be parallel, perpendicular, or oblique to the shore.

Blowout: A saucer, cup, or trough-shaped hollow formed by wind erosion on a preexisting dune or other sand deposit.

Cuspate: Irregular, crescent-shaped mounds of beach material.

Drift: All materials deposited by a glacier, including outwash and till.

End moraine: A ridgelike accumulation of drift built along the margin of a glacial lobe, generally associated with glacial recession.

Foredune: A coastal dune or ridge parallel to the shoreline, produced by offshore winds.

Ground moraine: An areally extensive body of till having flat-lying to gently undulating topographic expression, generally deposited under advancing glaciers.

Groyne: A manmade structure extending into a body of water perpendicularly to the shoreline, primarily designed to retard longshore currents.

Interdunal area: A sandy valley between the foredunal and backdunal complexes.

Kettle lake: A depression in drift made by the wasting away of a detached mass of glacier ice that had been either wholly or partly buried in the drift, the hole subsequently being filled with water to form a lake.

Longitudinal dune: An elongate sand ridge which forms parallel to the prevailing wind direction.

Longshore current: A nearshore current moving essentially parallel to the shore, generated by waves approaching the shoreline obliquely.

Outwash: Stratified drift deposited by meltwater streams beyond active glacier ice, consisting primarily of sand and gravel.

Parabolic dune: A dune having the appearance of a parabola with the concave side toward the wind.

Rip current: Seaward-moving flow of water which returns the water carried landward by waves, generally concentrated in definite subsurface channels on the offshore lake bottom.

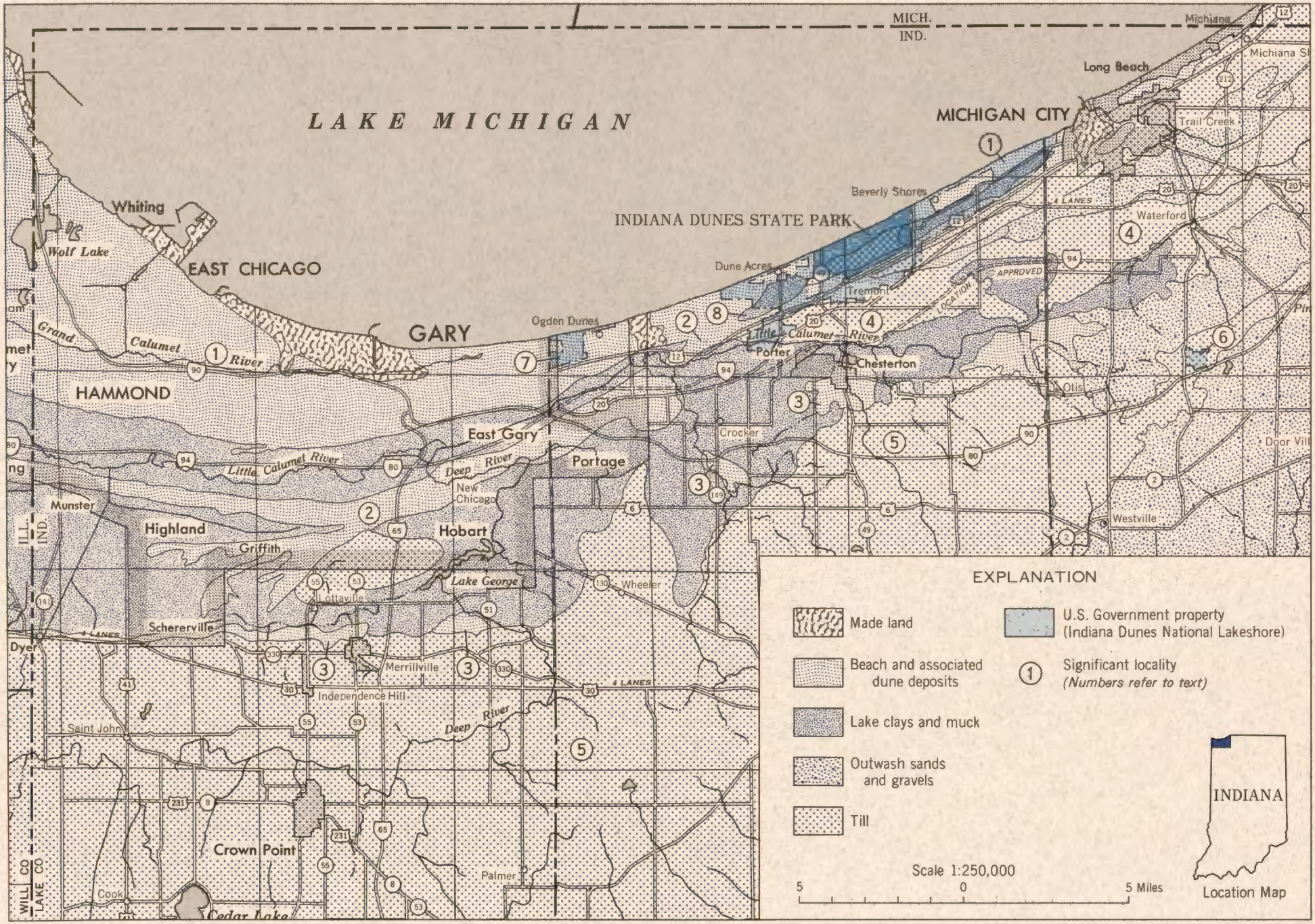
Saltation: The jumping or skipping of a sand grain in response to collison with other sand grains, the process being initiated by wind.

Shoal: A nearshore sand ridge produced by wave action; also, to become shallow gradually.

Spit: A bar which projects from the shore into an open body of water.

Till: An unsorted, glacially deposited material consisting of a clayey matrix in which are included particles ranging from sand to boulders in size.

Transverse dune: A sand ridge extending perpendicularly to the prevailing wind direction.



MAP OF DUNES AREA SHOWING GENERALIZED SURFICIAL GEOLOGY AND NUMBERED LOCALITIES

Modified from Indiana Geological Survey Regional Geologic Map 4, 1970.