

SOME PERCHED DUNES OF NORTHERN LAKE
MICHIGAN AND THEIR VEGETATION

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The sand dunes of the Lake Michigan shore may, for the purposes of our discussion be divided into groups according to their location. Those at the south end of the lake, situated principally in Indiana, differ in some respects from the sand areas scattered along the east shore upon the lower peninsula of Michigan. The formation of the Indiana dunes is in general more recent and is to be referred to that period during which the waters of the lake have stood at approximately their present level. A smaller portion of the area was developed during the later stages of the glacial Lake Chicago.

In contrast with this the dunes of the lower peninsula of Michigan are to be associated with a more remote origin connected with bodies of water or ice belonging to former ages.

It is the purpose of this paper to record a few of the phenomena connected with the occurrence of various dunes found upon the islands in the northern part of Lake Michigan and upon the adjacent mainland.

Nearly all the dunes of this and similar regions are of *lacustrine* origin, being formed from sand thrown upon the shore by the waves and then caught up by the wind, carried inland, and piled in characteristic mounds and ridges. Some of these lacustrine dunes have accumulated upon the existing beach and may therefore be called *beach dunes*, while others are developed upon substrata elevated some distance above the beach and may be termed *perched dunes*. They may have been formed either by a wind eddy at the top of a short cliff, or have travelled inland from the beach over higher land. The term is

also applied to dunes formed upon an old beach which from the subsidence of the lake level finds itself much above the level of existing waters.

The beach dunes are characteristic of depositing shores and to this class are to be referred those of the southern end of Lake Michigan, while perched dunes are more characteristic of eroding shores and are frequent along the east shore of Lake Michigan, ranging from 10 to 400 feet above the present level of its waters.

While it is evident that the greater part of the shore dunes of Michigan belong to one or other of the types just mentioned, it is conceived that dunes may also have been formed from sandy material deposited by the action of ice and water about the margin of the Pleistocene ice sheet and afterwards worked over by the wind. Dunes of such an origin may be termed *terrestrial* in contrast to those of lacustrine formation that derive their material directly from the lake. It seems probable that some of the interior dune areas of Michigan are of this type and recently evidence has been obtained that at least a few of the shore dunes are terrestrial rather than lacustrine in their origin.

THE NIPISSING BEACH DUNES

The beach developed by the water of the Nipissing Great Lakes has been carefully traced by Leverett and Taylor.¹ Upon portions of this beach sand dunes have been subsequently deposited, although on account of the comparatively recent date of its development, they are nowhere very extensive. At a point near the north end of the bar separating Portage Lake from Lake Michigan, a gravel ridge between 15 and 20 feet above the present lake is partially uncovered just back of a low fore-dune and again just north of Point Betsie lighthouse is a similar ridge. From their height and general character it seems probable that these beaches are Nipissing. On either side of the mouth of the Platte River the Nipissing beach does occur, extending for several miles, covered in many places by low grassy dunes, but none of these appear as interesting as some development upon the Fox and Beaver Islands.

¹Leverett, Frank, and Taylor, F. B. The Pleistocene of Indiana and Michigan and the history of the great lakes. U. S. Geol. Surv. Monograph 53: 447-463. 1915.

On South Fox Island the lighthouse stands upon an isolated mound of sand at the extreme south of the island. This mound is a dune some 70 feet high and 200 yards across, standing upon a gravel bar some 400 yards long and half as broad, and connecting it with the main portion of the island. From the ridges of the island to the lighthouse dune the ridge is swept bare for more than 200 yards and its surface is seen to be about 20 feet above the lake and this agrees so well with the elevation of the Nipissing beach that it seems probable that it was actually formed by those lakes.

Upon the Beaver Islands the beaches have been traced by Taylor and there is no doubt as to the identity of those occupied by the dunes under consideration. Upon the west shore

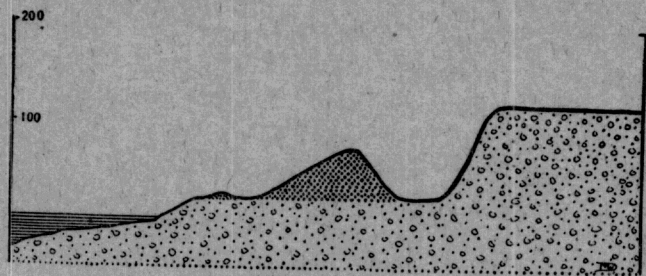


Fig. 1. Diagrammatic east-west cross section of a dune perched upon a wave-cut terrace of Nipissing age. Beaver Island, Mich. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

of High Island the dunes form a crescent about the inner side of a bay about two miles across. The shore is gravelly throughout and just back of the fore-dune a well developed beach is seen, partly covered with partially fixed low dunes. An exactly similar area about 100 yards broad is to be seen on the west shore of Beaver Island. At the northern end of the west shore dune area of Beaver Island this low complex of beach gravel and small superimposed dunes merges into a sand cliff of higher sand ridges, but farther south it passes to a strong wave-cut bench from 100 to 200 yards wide with a steep cliff 50 to 100 feet high (Fig. 1). Upon this bench, the most striking development of the Nipissing beach upon the island, a dune

ridge 20 to 50 feet high has been built up and in some parts strengthened by a grassy fore-dune. The ridge is completely fixed and was evidently formerly covered by a mesophytic forest of maple, beech, and hemlock, with a small amount of *Abies balsamea*, *Picea canadensis*, and *Populus balsamifera* at the outer edge. This has been cut off, and the dune cover now consists of a few remnants of trees and coppice from the former forest, together with such pioneers as *Betula alba papyrifera*, *Prunus pennsylvanica*, *Populus grandidentata*, *Ostrya virginiana* and *Acer spicatum*.

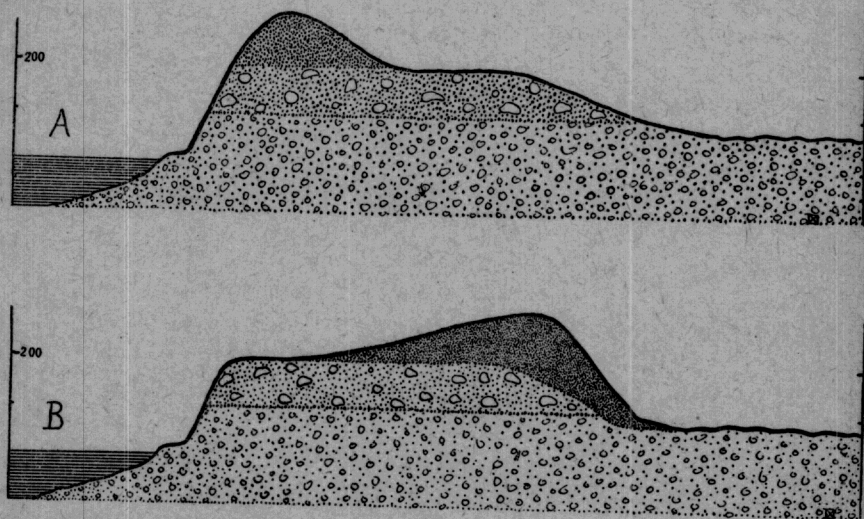
A most distinctive shrub association has developed upon the gravel of the Nipissing beach as well as upon the low dunes which are developed before or are perceived upon it. It occurs both upon High and Beaver Islands, and is characterized by low growth, small thick leaves, a large amount of vegetative propagation from buried stems and by a decided scarcity of grasses. On Beaver Island a scanty sprinkling of *Agropyron dasystachyum* is almost the only grass present, but on High Island there are in addition small amounts of *Ammophila arenaria*, and *Calamovilfa longifolia*. The effect of exposure to the strong winds of the west and south-west seems to be the cause of a decided dwarfing in all the larger shrubs. Species that upon other dune habitats attain a height of 3 to 6 feet or even more are here reduced to a foot or less. *Prunus pumila*, *Cornus stolonifera* and *Salix* spp. afford examples of such dwarfing except when they occur within the shelter of the succeeding border zone of forest. The same thing is true of *Populus balsamifera* which is seldom more than a yard high among the shrubs, although it occurs rather freely within that association.

The composition of this association varies somewhat, although generally its dominant members are *Arctostaphylos Uva-ursi*, *Prunus pumila*, *Salix longifolia*, *S. syrticola*, *Populus balsamifera*, and in some localities *Potentilla fruticosa* and *Cornus stolonifera*. With these broad leaved shrubs *Juniperus horizontalis* and *J. communis* mingle freely and in places become dominant with the gradual elimination of the willows, cherries, and poplars. Either the broad or needle leaved shrubs may be succeeded by the trees of a marginal shore forest

in which *Populus balsamifera*, *Betula alba papyrifera*, *Abies balsamea*, *Thuja occidentalis* and *Picea canadensis* are most abundant. On the more open portion of these low dunes there are mingled with the shrubs such herbaceous plants as *Artemisia canadensis*, *Cirsium Pitcheri*, *Zygadenus chloranthus* and *Lithospermum Gmelini*.

HIGH PERCHED DUNES

The rapid erosion along the east shore of Lake Michigan has developed many stretches of steep shore cliffs cut in the Fig. 2. Diagrammatic east-west cross sections through a shore



cliff near Frankfort, Mich., showing stratified clays and gravels upon which is perched a sand dune. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

morainic material. These cliffs very much in height and are frequently surmounted by dunes of considerable size. Only a few of the most notable of those recently examined are here described.

A half mile north of Frankfort the eroded shore shows distinct stratification of morainic clays and gravels while upon the moraine there is perched a dune, the top of which, according to the maps of the U. S. Lake Survey, reaches the height of

320 feet above the lake, about 100 feet being sand (Fig. 2A). This dune area is about half a mile long and about half that width, and has recently been mapped and described by Waterman². The upper stratum of morainic material is largely composed of boulder clay, giving when eroded a number of "razor-back" cliffs. The dunes have been fixed and forested but through them has cut a complex of wind-sweeps ending in a semicircular blow-out popularly known as "The Crater" (Fig. 2B). The wind-sweep throughout the greater part of its channel has cut quite through the sand and has exposed the surface of the morainic plateau. The sand of which this perched dune is composed may well have been derived from the waters of the former Lake Algonquin, although there is nothing to show that they are not of terrestrial origin. In this connection it may be recalled that the moraine upon which the dunes are perched are at least 150 feet above the supposed level of Lake Algonquin or of the Nipissing Great Lakes.

A second example of even more remarkable perching is found four miles north of Empire in the Sleeping Bear dunes. Here the morainic substratum is in the form of a kame-like ridge with its long axis parallel to the Lake Michigan shore and its flat top about 400 feet above the lake. At the north and east of this plateau the gravelly surface is much lower, while an east-west section through the ridge just north of "The Bear" shows that a peak (Fig. 3A) of gravel near the eastern side projects above the sand which has been swept from the plateau and is moving towards the east. That the greater part of this plateau was formerly well covered with perched dunes is evidenced by the great banks of sand on the west side where they present a great advancing lee front over a mile long with a maximum height of over 300 feet (Fig. 3A). Upon this wind swept plateau the most conspicuous dune remnant, perched on the edge of the shore cliff, is the isolated mound some 90 feet high and four times as broad, known as the "Sleeping Bear" (Fig. 3B). The north and east slopes are still well covered with the remnants of a mesophytic forest in which *Thuja occidentalis*, *Sorbus americana*, *Acer saccharum* and *Tsuga canadensis*

² Waterman, W. G. Ecology of Northern Michigan dunes: Crystal Lake Bar region. Rep. Mich. Acad. Sci. 19: 197-207. 1917.

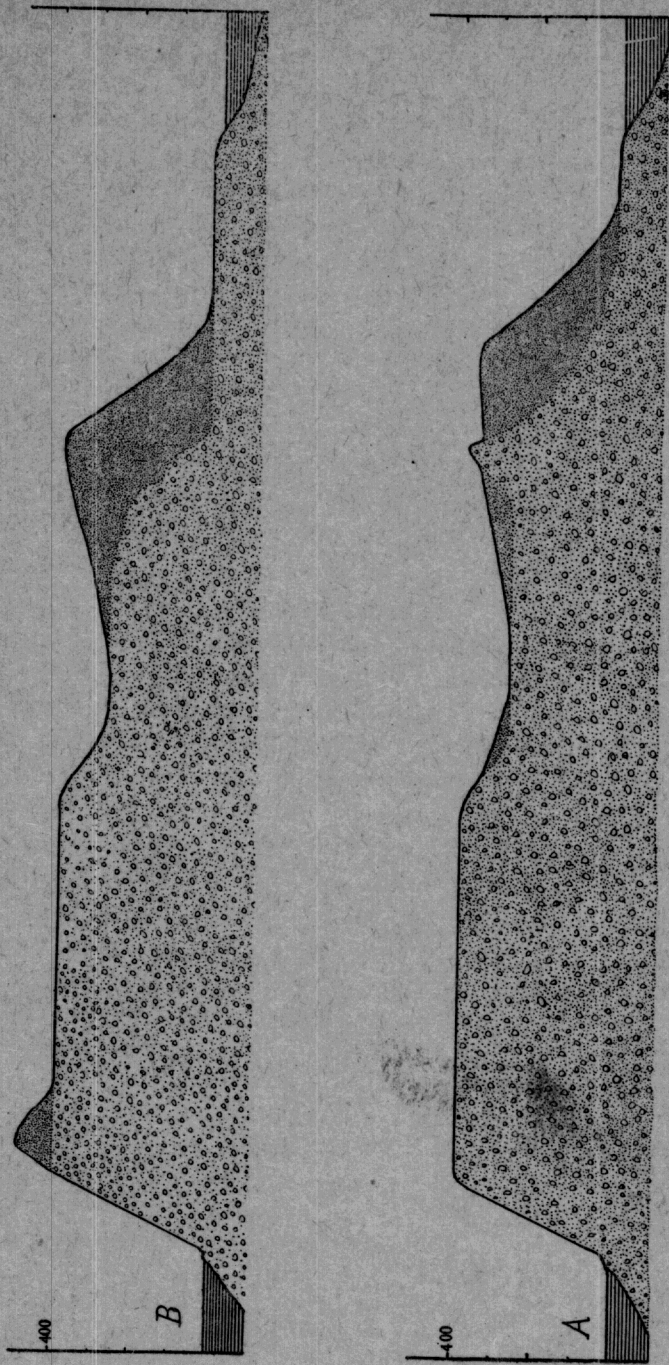


Fig. 3. Diagrammatic east-west cross sections through the kame-like gravel ridge and the perched dunes at Sleeping Bear Point, Mich. The section extends from Lake Michigan on the left to Glen Lake on the right, section A being just north of the Sleeping Bear Dune and section B directly through the Sleeping Bear Dune. Vertical height in feet at the left of diagram. Horizontal scale one-half the vertical.

are conspicuous. The other sides are being eroded but show signs of having been covered with forest.

It seems quite probable that dunes of the size of Sleeping Bear or even larger could have been formed at the top of a high shore cliff, but it is difficult to imagine that the great mass of sand that has been swept from the morainic plateau and forms the great moving dune advancing towards the east could have been so brought up from the lake at least 300 feet below. The hypothesis of a terrestrial origin for the sand would on the contrary seem more suited to explain the situation if it could be supported by adequate data. Such data have not been obtained in the Sleeping Bear area but appear upon one of the islands to the north.

South Fox Island, lying in Lake Michigan about 35 miles north of Sleeping Bear Point is about 5 miles long and a fourth as wide, the long axis of the island running some 30° west of north. The chief topographical features are a continuous ridge of morainic material capped with dunes, varying from 200 to 325 feet in height, and from 200 to 400 yards in width, running along the western side and a gravelly plain of low elevation which occupies the eastern side of the island (Fig. 4A).

The western shore is being rapidly eroded and the cliffs rise abruptly from a very narrow beach strewn with pebbles and glacial boulders. The cliffs are composed of mixed morainic clays and gravels while a distinct horizontal line separates the lower more stony mass from the upper more sandy material. This line has an elevation running from about 125 feet at the south of the island to somewhat more than 200 feet at the north. This upper stratum of sandy material has been somewhat worked over by the wind and at least one large wind sweep has developed, the trough being floored with glacial gravel and the whole terminating in a bald dune, about 325 feet high, forming the highest elevation upon the island (Fig. 4B). Much of the sandy stratum, however, presents evidence of having been deposited by agencies other than wind. The evidence consists in an admixture of pebbles, bits of rock, and particles of soil both larger and smaller than the grains of wind-blown

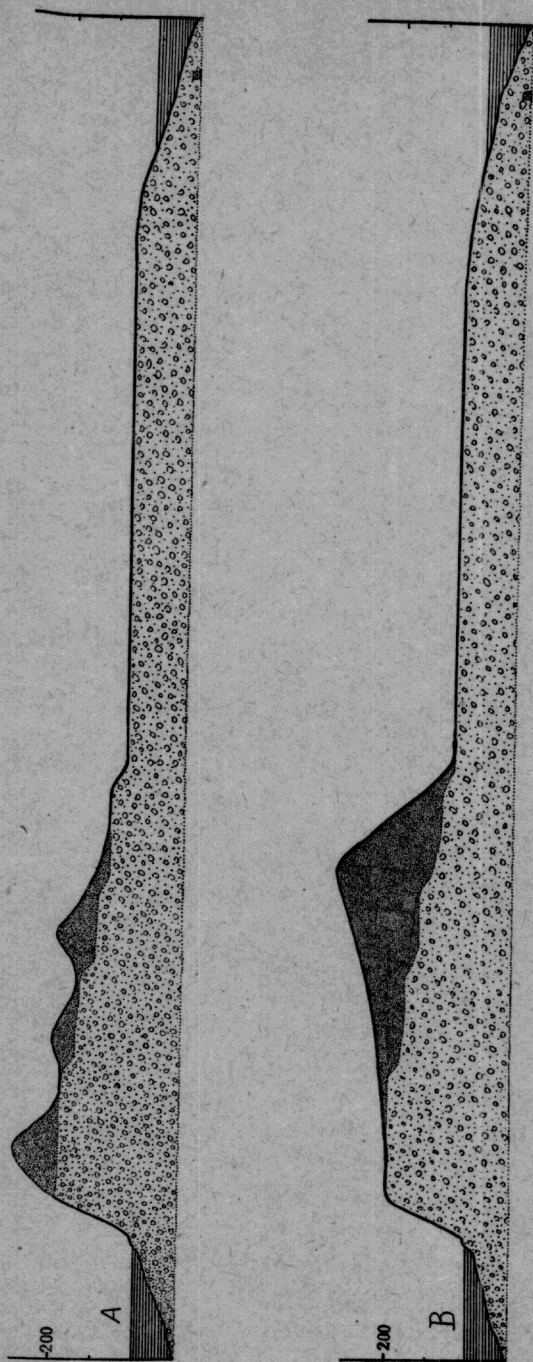


Fig. 4. Diagrammatic east-west sections through South Fox Island showing gravel ridge and perched dunes. Vertical height in feet at the left of the diagram. Horizontal scale one-half the vertical.

sand. It seems most probable that this sandy soil was deposited simultaneously with or immediately following upon the formation of the kame-like ridge upon which it rests, and that it is due to similar combined action of ice and water. The exact method of its deposition may be more definitely explained upon further investigation, the main point of interest at the present time, however, is that the sandy mounds which cap the ridge are not composed of lacustrine sand piled up by the wind, but have an origin connected more immediately with the former ice sheet. It is evident that this material being largely sand and lying in an exposed situation has been subject to disturbance and working over by the wind. Dunes have been and are being formed from it and these dunes may be termed terrestrial in origin.

If it be granted, as the evidence seems to demand, that these perched dunes of Fox Island are terrestrial, it seems highly probable that many of those of the Sleeping Bear area had a similar origin, for the topography of the two regions is so extremely similar. The large mass of material in the advancing dune swept from the plateau upon which the Sleeping Bear dune rests would present no difficulty when explained by the hypothesis of terrestrial origin.

Without extensive investigation it is impossible to say just how many of the sand hills upon South Fox Island are dunes and how many are made up of glacial sands. It is certain that the high bald dune in the center of the island is composed of wind-blown material and is still slowly moving across the island, but it seems highly probable that many of the peaks which immediately surmount the shore cliff were, in their deposition, intimately related to some phase of glacial activity. The hills at the east of the shore ridge probably are in part dunes, and in part glacial sand hills, the two showing no difference in plant covering.

The variations in the plant associations of the various dune regions mentioned will be discussed elsewhere but it seems worth while to call attention to the climax mesophytic forest as developed upon the sand hills of South Fox Island. Although less than 25 miles from the mainland, where these species

abundant, the island is entirely without any *Pinus* or *Tsuga* nor was any *Acer pennsylvanicum* seen. *Salix* spp. were also represented by very few individuals, as were also *Picea canadensis* and *Quercus rubra*.

The mesophytic forest has covered all but a very few of the highest peaks and doubtless formerly extended over all the plain which forms the eastern half of the island. Less than 100 acres of the island have been completely cleared and cultivated, but more than three-fourths of its surface has been more or less cut over although there is little evidence of damage by fires. The higher hills being less easy of access, have had less of their timber removed and are covered with a rich growth of *Acer saccharum*, *Thuja occidentalis*, *Fagus grandifolia*, *Abies balsamea*, and *Tilia americana*, the three first being most abundant, the *Acer* dominating the gentler slopes and the *Thuja* the narrow valleys and steeper hillsides. Occasional trees of *Betula lula* and *Fraxinus americana* are found and where cutting has occurred *Betula alba papyrifera*, *Populus grandidendata* and *Prunus pennsylvanica* have come in. Among the shrubs are *Sorbus americana*, *Sambucus racemosa*, and *Taxus canadensis*, the latter being particularly abundant, while among the herbaceous vegetation were found such decidedly mesophytic forms as *Trillium declinatum*, *T. grandiflorum*, *Hepatica triloba*, *Actaea alba*, *Mitella nuda*, and *Mitchella repens*. Perhaps the most conspicuous fern was *Cystopteris bulbifera*, but *Botrychium virginianum*, *Aspidium marginale* and *A. spinulosum* were also fairly abundant.

In concluding, it may be mentioned that a similar mesophytic forest with *Thuja* as a conspicuous member is to be seen along the marginal shore dunes at Frankfort, while "forest graveyards" of *Thuja* upon the dunes of the Sleeping Bear complex as well as the remnant of forest upon Sleeping Bear dune itself would serve to indicate their former development in that region.

The writer wishes to acknowledge the courteous criticisms of Messrs. Frank Leverett and F. B. Taylor who were good enough to read his manuscript. He also wishes to state that

he assumes full responsibility for certain portions of the paper that are not entirely in accord with the views of these distinguished critics.
