

SAND DUNES
at
STURGEON BAY and
SLEEPING BEAR

Hazel L. Bradley
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SAND DUNES AT STURGEON BAY AND SLEEPING BEAR

The sand dunes of two areas along the eastern shore of Lake Michigan were studied as class work in Plant Ecology at the University of Michigan Biological Station, Cheboygan County, Michigan, in July, 1947. The work was under the direction of Dr. F. C. Gates.

LOCATION AND HISTORY

Two dune areas were studied, the first along the shore at Sturgeon Bay, west of Levering and north of Cross Village in Emmet County, Michigan. There was once a thriving lumbering town located on this bay, with railroad lines and a wagon road connecting it with other parts of the state. There was also considerable boat traffic on Lake Michigan and docks at Sturgeon Bay. Now there is nothing left of the town, railroads or docks. A Coast Guard installation once occupied a hill near there, which is now an active dune referred to in this paper as the Coast Guard Dune.

The second area studied is farther south on the lake shore, west and a little north of Traverse City, near the village of Glen Haven in Leelanau County. On Sleeping Bear Point, near an abandoned Coast Guard Station, the formation, movements and vegetation of the dunes were studied. The class also visited a large dune, two or three miles south of the Point, called the Sleeping Bear.

The origin of this dune is doubtful. It lies on top of a plateau that was formed by glacial deposit and rises over 350 feet above the level of Lake Michigan. There are two different theories of the origin of the Sleeping Bear Dune. One is that this dune was formed there by the blowing sand, then became vegetated and remained fairly stable for some time. The other theory is that this dune was once part of a long, large fringing dune and that some of the other parts have been blown or washed away, leaving the Sleeping Bear isolated.

CLIMATE

The climate is favorable for plant growth in both of these areas. The temperature range, growing season and rainfall are all sufficient for the growth of a great variety of plants. However, the inability of the sand to hold moisture to some degree limits the water supply for dune vegetation.

The prevailing winds here are from the west and they are of the utmost importance in producing, shaping and changing the dunes, which in turn influence the vegetation upon them.

SPECIAL FACTORS

The soil in the dune areas is sand or gravel and supports a variety of vegetation quite different from that in other neighboring areas. The shifting of this soil by the wind action makes it very difficult for most plants to become established in it. However, areas that are undisturbed for a period of years become covered with forests of various types.

METHODS AND FIELD WORK

Sturgeon Bay

In studying this area, the class wandered over some of the dunes, observing the kinds of plants and their relationship to the movements and the accumulation of the sand. A transect was taken of the fringing dune from the lake's edge up to the border of the tree-covered area, the vertical rise being measured for every two meters of forward movement, and the vegetation of each step recorded. A similar transect was taken on both windward and leeward slopes of the Coast Guard Dune. This data was used in preparing the profiles of these dunes. (Figures 1 and 2.)

The Line-Interception Method, described in previous papers on the aspen and bog associations, was used for two five-meter lines, one half way up the lake side of the fringing dune and one a third of the way up the Coast Guard Dune.

The root systems of Ammophila breviligulata growing on two square meters of surface were dug up by hand, counted and measured. Table 1 gives all the data obtained in these studies.

Sleeping Bear Point and Dune

Count quadrats (30+) were taken in the Ammophila Association on a dune at Sleeping Bear Point.

At the Sleeping Bear Dune, profile measurements were taken (Plate 1) from the crest of the plateau at the lakeside to the top of the dune. Here again the changes in elevation were measured in two-meter steps.

Aneroid readings were taken by the instructor to determine the height of the crest of Sleeping Bear above the Coast and Geodetic marker, which is on a large rock of the plateau, not far from its edge and north of the dune.

General observations were made by walking over large areas of the dunes. Some digging was done in order to study a parasite on the roots of a common dune plant.

DESCRIPTION OF AREAS

Sturgeon Bay

Fringing Dune

A fringing dune is formed along lakes where sand is brought in by wave action and then dried out and blown by the wind. A beach usually shows about three zones, (1) the forebeach, along which there is wave action but no plants, (2) a mid-beach, where the driftwood collects and some plants may grow, and (3) the upper beach, where plants become established.

Sand that accumulates along the fore- and mid-beaches will become dry and start blowing. If there is no plant life in the

the upper beach, the sand will blow on across this part, but any vegetation there will tend to stop the movement of the sand and start a dune. Embryonic dunes are thus formed along the shore by single plants or small groups of them. If, however, there is a well-developed belt of vegetation along the upper beach, a long fringing dune may result. There is such a dune formed along the shore of Sturgeon Bay south of the Coast Guard Dune.

Using the data obtained by the class and that obtained by the class of 1941, Profiles A and B, Figure 1, were made. These show the formation of the fringing dune and the vegetation upon it. Profile A is based upon the data of 1947, Profile B upon that of 1941. These do not necessarily represent the same part of the dune.

It will be noted that near the lake there is sand and driftwood. About 10 meters from the water's edge is the beginning of the *Ammophila* Association, which follows on over the crest of the dune and into the depression back of it. There it is replaced by low-growing vines such as *Arctostaphylos uvaursi* and *Juniperus communis depressa* and forbs such as *Smilacina stellata* and *Lathyrus maritimus*. Shrubs and trees begin to appear here. Among them are *Cornus stolonifera*, *Populus deltoides*, *Prunus pumila*, and *Prunus virginiana*. *Rosa* sp. and *Rhus toxicodendron* are quite common just below the line of larger trees.

The *Ammophila* Association is so common and so important in the vegetation of dune areas that it will be discussed in detail elsewhere in this paper. Let it suffice here to say that this association is responsible for the formation of this fringing dune and it covers all the main part.

Coast Guard Dune

This is a large dune which was once covered with vegetation and thus stabilized. Thuja forest still covers part of the leeward slope, but in the early thirties a road was made up the windward side of the dune, causing it to become active again. Use of the road destroyed the vegetation in that strip, allowing the wind to catch the sand and start it moving. Plants and trees were undermined and destroyed and large cavities, called blowouts, were made in the sand.

One large blowout that formed at the bottom of the dune near the lake, later filled with water in which plants could get a start. Now it is revegetated. Above that area there is now another large blowout.

The trees that formerly covered the crest and leeward side of the dune are now either wholly or partly buried by the sand that has been swept off the windward side. At the top of the dune there are tree tops and extensions of vines such as *Vitis vulpina* and *Celastrus scandens* that once grew in the trees. Thuja forest still covers the lee side of the dune or is being covered by it.

Profiles C and D, Figure 2, show the present form of the dune as compared with its form in 1941. It will be noted that the crest of the dune has been lowered and the sand has moved farther into the woods on the lee side. The sand

also extends in noticeable quantity for 55 meters into the forest from the inland base of the dune.

Part of the windward side is now becoming vegetated with the *Ammophila* Association, which tends to reduce the blowing of the sand. Perhaps in a few years it will again become a stabilized dune.

Area Behind Old Town Site

Back of the former location of the town of Sturgeon Bay is an area which was once forested. After it was cleared some of it was used for farming and some was allowed to re-vegetate as it would.

From the north end of the town a road led east to Mackinac City in earlier days. This road together with the removal of the buildings of the town left exposed areas where the wind could start moving the sandy soil. Thus dunes have been formed to the east of the old town site.

Several types of plants have served to stop the movement of sand to form dunes and dunelets. Some small ones examined were formed by *Juniperus*, *Arctostaphylos* and pines. Some of the grasses such as *Calamovilfa longifolia* and *Andropogon scoparius* have aided in holding the soil, though they are not as effective as *Ammophila*.

Some of these plants will withstand the effects of being partially buried and then exposed again by the shifting of the sand. A few small pines in this area show a good deal of tolerance to these unfavorable conditions as shown in Plate 2. Others have died.

One dune back of the town site has covered a large *Tilia* tree, or nearly so. A few of the top branches are protruding from the top and lee side of the dune, well-leaved and apparently healthy. On the windward side are some of these upper branches which are leafless and dead. These were formerly covered with sand, but now are exposed again as it has been blown away from them. The picture, Plate 3, shows an Ecology class among the branches of this tree-in-the-dune.

Sleeping Bear

Sleeping Bear Point

The foundation material underlying Sleeping Bear Point is a glacial moraine, the same as that under the dune. On the Point the sand has blown up and over the moraine in many places, so that there are several dunes, most of them active at the present time.

Only a few years ago there were groves of aspens and other trees on these dunes. In one of the valleys there was typical prairie vegetation. Now the groves of trees are disappearing because the sand has been blown out from around the roots (Plate 4) or they have been buried by it. The valley with the prairie plants is nearly filled up. At one point sand covers the top of a *Betula* tree, which was exposed for its 65 feet of height less than fifteen years ago. Sand has filled in to a depth of nearly 80 feet at another place. (See Plate 9.)

A grove of cottonwood trees, numbering more than 100 in 1928, was undercut by the wind until most of the trees fell over and died. Some of the remaining ones had roots exposed for 18 feet of length but now these roots are being covered again by the filling that is taking place.

Besides the trees already mentioned, the vegetation here belongs for the most part to the *Ammophila* Association. Much Melilotus alba was found with *Ammophila* in one area, which is rather unusual.

Sleeping Bear Dune

The general formation of the Sleeping Bear Dune has already been described. Before 1932 this dune was higher than its present crest and was completely covered with coniferous forest. The west side formed a regular slope all the way up from Lake Michigan. In 1932 a road was made up the west side for hauling ~~up~~ materials to build a look-out station for the Coast Guard.

Since that time the sand has been blowing out from the west side and piling up on the leeward side of the dune. Changes in the contour of the dune are shown in profiles, lettered E, F, and G on Figure 3, for the years 1937, 1941, and 1947. In 1936 the crest was 153 feet above the Coast and Geodetic marker. This year it is 115 feet above this marker. Plates 5 and 6 show the doom to which the trees and other vegetation on Sleeping Bear are rapidly going.

ASSOCIATIONS

Ammophila Association

The most important plant society from the standpoint of building and holding sand dunes is the *Ammophila* Association. (Plate 7) To become established in this type of area, where water supplies are apt to be low and where the roots may be exposed by having the wind blow away the soil, a plant must have a root system capable of extending itself both vertically and horizontally. No plant

No plant is better fitted for this than *Ammophila breviligulata*, whose roots were dug up by the class at Sturgeon Bay, counted and measured. From two square meters of surface were obtained 171 green culms and 120.85 meters of rhizomes. From one square meter 20.06 meters of large-sized roots were measured and a great mass of fine rootlets obtained, a remarkable root system.

With *Ammophila*, which is dominant, are commonly associated the *Artemisia caudata*, *Lathyrus maritimus*, *Smilacina stellata* and *Cirsium pitcheri*. *Tanacetum huronense* is common in some places. Grasses characteristic of this association are *Andropogon scoparius*, a typical prairie grass, *Agropyron dasystachyum* and *Calamovilfa longifolia*, which has somewhat more difficulty in establishing itself than *Ammophila* because of a weak root system.

Other typical plants in the sand dunes, usually in the *Ammophila* Association, are *Asclepias syriaca*, *Solidago racemosa gillmani*, *Erigeron annuus*, *Anemone multifida*, and *Zygadenus chloranthus*.

On the dunes near Sleeping Bear, *Artemisia* was found with the root parasite, *Anoplanthus fasciculata*, attached. Plate 8 shows some members of the class digging up these plants to show their attachment. It is believed that the seeds of *Anoplanthus* will not germinate unless they are in contact with a living *Artemisia* root.

Cottonwood Association

Oftentimes after *Ammophila* and other plants have become established in the sand, cottonwood trees, *Populus deltoides*, spring up. They grow quite rapidly but are short-lived so that at the end of about 12 years of growth they begin to die off. The dune then becomes active and the whole cycle starts over again. The cottonwoods are apt to be found in patches on the dunes rather than widespread over large areas. Associated with them may be any combination of the typical dune plants already mentioned.

CONCLUSIONS

Study of these two dune areas brings out the fact that plant associations and plant successions on sand dunes do not follow any set pattern or logical sequence. The nature of the dunes themselves is one of instability and constant change. Therefore the vegetation upon them is also in a constant state of flux.

The *Ammophila* Association of plants is best adapted to the ever-changing dunes, the *Ammophila* usually establishing itself first along the edge of a beach pool and spreading out in all directions, both horizontally and vertically. *Lathyrus*, *Artemisia* and *Arctostaphylos* may come in with the *Ammophila* and these may be followed by low shrubs such as *Prunus pumila*, *Shepherdia canadensis*, or *Juniperus*. In time trees such as *Populus deltoides*, or the pine or *Thuja* associations may completely cover the dune.

On the other hand, any anthropic or other factor which at any time tends to expose the soil to wind action will change a stable dune to an active dune so that forests are undermined and destroyed or alternately buried (Plate 9) and reexposed by the movements of the sand.

While sand is being removed from the windward side, the dune is being built up and moved out on the opposite side, sometimes covering fields and orchards as well as forests. They often advance several meters per year at the base.

Only the presence of some obstruction such as is provided by vegetation will tend to stop the shifting of the sands. Relatively few plants are fitted for this purpose.

SUMMARY

Two sand dune areas along the shore of Lake Michigan were studied as class work in Plant Ecology at the University of Michigan Biological Station in the summer of 1947.

Wind action is the all-important factor in the formation and changing of sand dunes.

Dunes are of different types such as embryonic or fringing, depending upon their size or formation. They may be stable or active.

The Ammophila Association is the plant society best fitted for building and holding dunes. The root system of the dominant plant, Ammophila breviligulata, is very complex with many rootlets and rhizomes which allow it to survive and spread in the changing dune situation.

Other plant species characteristic of the dune areas are Artemisia caudata, Arctostaphylos uvaursi, Lathyrus maritimus, Cirsium pitcheri and the grass, Calamovilfa longifolia.

Plant succession may take place on the dunes. A possible succession might include Ammophila or Cottonwoods, or both, followed by pine or Thuja forests.

As the future of the dunes themselves is unpredictable, it is impossible to foresee just what changes may take place in the vegetation. It is certain that so long as sandy areas are exposed to wind action there will be destruction of vegetation and constant changes in topography, many of which are damaging to farm and forest.

A-

ANNOTATED SPECIES LIST

- Agropyron dasystachyum-- typical grass of sandy shores.
Ammophila breviligulata-- most common grass of sand dunes.
Andropogon scoparius-- typical grass of prairies.
Anoploanthus fasciculata-- parasite on Artemisia roots.
Arctostaphylos uvaursi-- characteristic ground vine in sand.
Artemisia caudata-- frequent on sandy shores and dunes.
Asclepias syriaca-- common in sandy pastures and open dunes.
Cakile edentula-- coast and shore plant, typical.
Calamovilfa longifolia-- typical of sandy shores.
Celastrus scandens-- Frequent on some dunes, hardwood thickets.
Cirsium pitcheri-- Common beach thistle.
Equisetum variegatum-- Infrequent on fringing dune.
Erigeron annuus-- Common in fields and waste places.
Juniperus communis depressa-- Frequent on sandy beaches.
Koeleria cristata-- Typical on dry soil.
Lathyrus maritimus-- Common legume on sandy beaches.
Lithospermum gmelini-- Frequent on Lake Michigan dunes.
Melilotus alba-- Occasional on dunes, frequent on sandy roadsides.
Populus deltoides-- Common on borders of streams and in sand.
Potentilla fruticosa-- Frequent along shores of upper Lake Mich.
Shepherdia canadensis-- Occasional in waste places.
Smilacina stellata-- Common on beaches and dunes.
Solidago racemosa gilmani-- The common goldenrod of the beach.
Tanacetum huronense-- Shores of Great Lakes, upper part.
Vitis vulpina-- Hardwoods, at edge; stream banks; conifers.
Zygadenus chloranthus-- Frequent on gravelly wasteland.

Note-- This list does not include plants already listed in the aspen and bog associations.

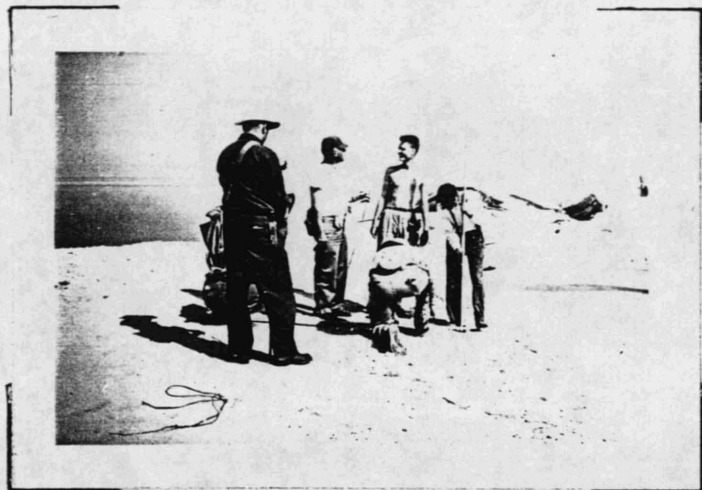


Plate 1 - Ecology Class Taking Data
for Profile of Sleeping Bear.

Photograph by H. L. Bradley, 1947



Plate 2 - Dunelet Forming around Pine at
Sturgeon Bay.

Photograph by C. H. Blair



Plate 3 - Ecology Class on Top of Tilia
at Sturgeon Bay.

Photograph by C. H. Blair



Plate 4 - Populus with Roots Exposed
by Wind.

Photograph by C. H. Blair.



Plate 5- Destruction of Forest on
Sleeping Bear Dune

Photograph by C. H. Blair



Plate 6- Windward Slope of Sleeping
Bear Dune.

Photograph by H. L. Bradley, 1947.

Plate 7- *Ammophila*
Association on Dune
near Sleeping Bear.

Photograph by H. L.
Bradley, 1947.



Plate 8- Digging *Ano-*
planthus and *Artemisia*.
near Sleeping Bear Dune.

Photograph by H. L.
Bradley, 1947.

Plate 9- Trees and Shrubs
Partly Buried by Shift-
ing Sands. Dune near
Sleeping Bear.
Photograph by H. L.
Bradley, 1947.

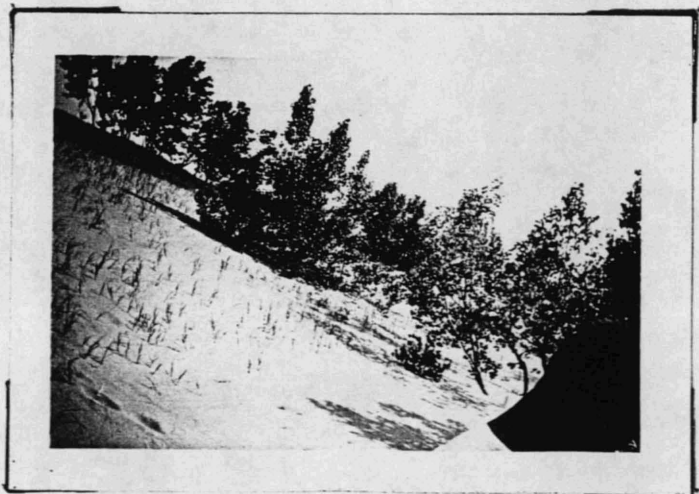
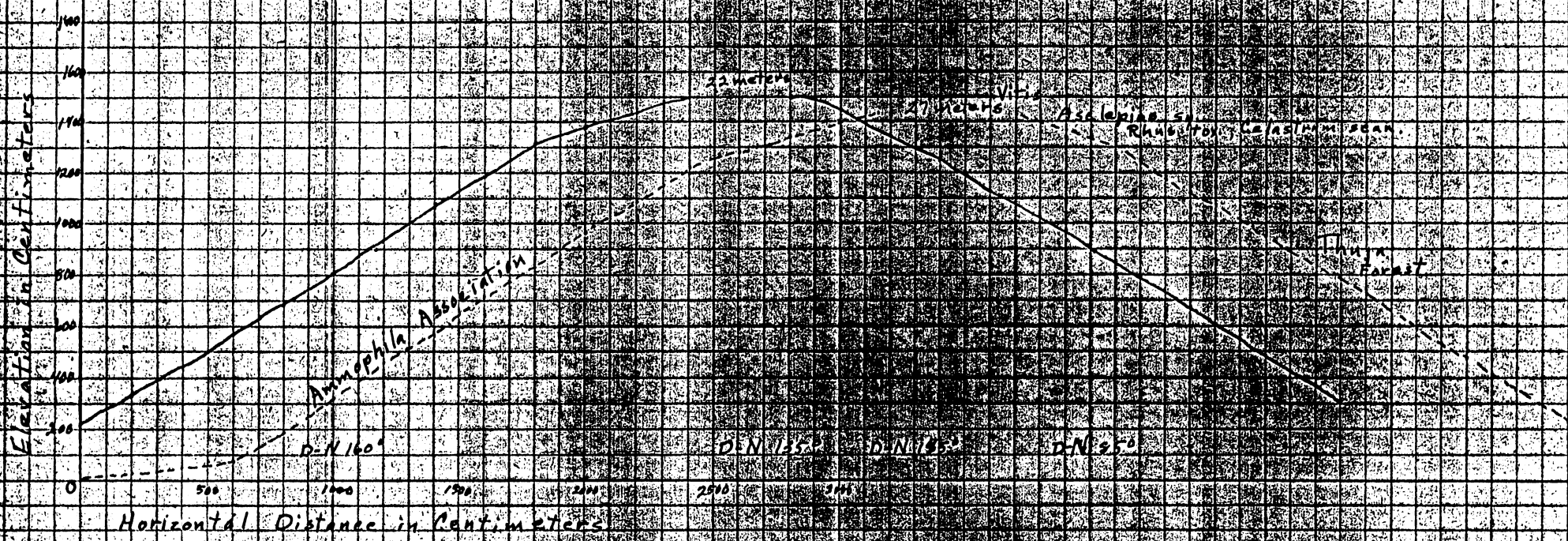


Figure 2-- Profiles of Coast Guard Dune, Sturgeon Bay



Profile C, 1941. ———
 Profile D, 1947. - - - -

Probably same to present at
 near to the top
 1947

Profile of the ground surface along the line of the dam

Profile A-B



Profile B-C

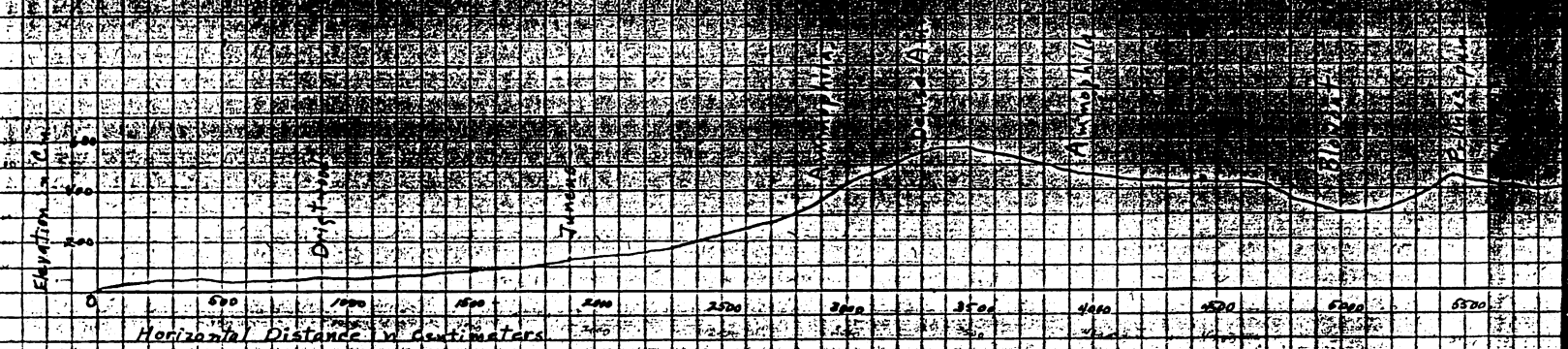
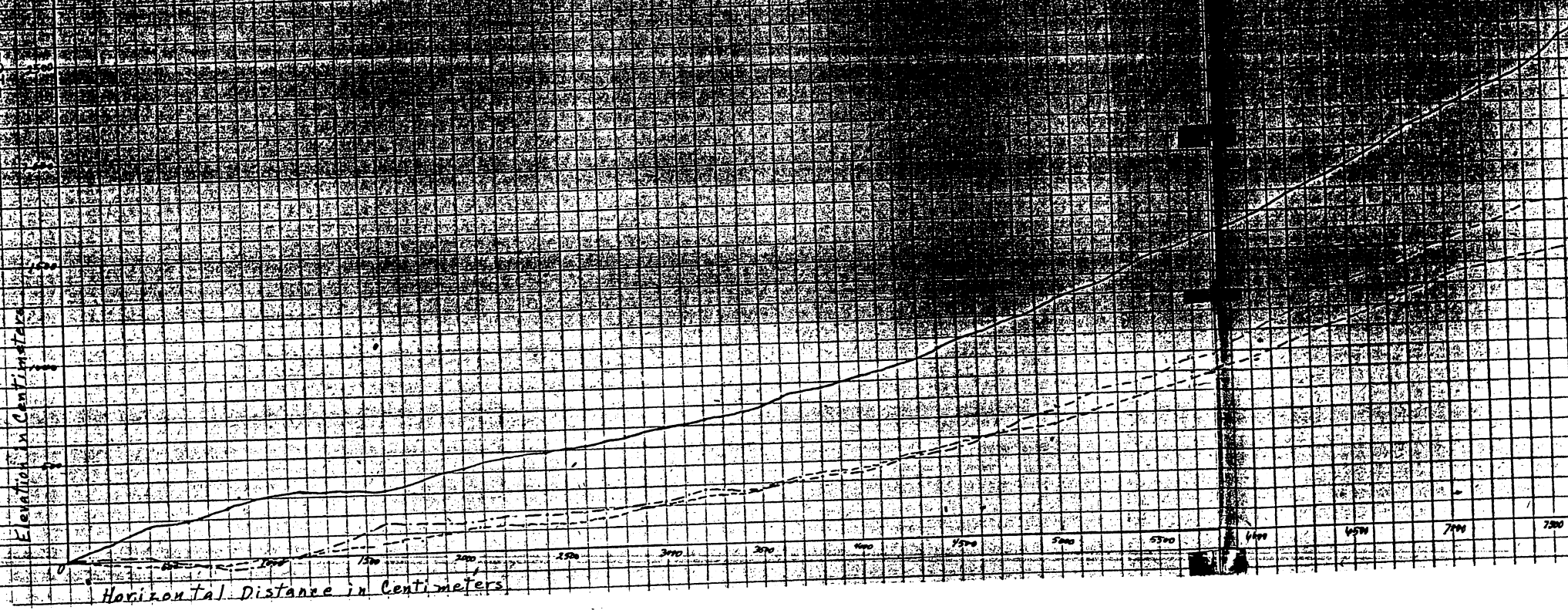


Fig. 23 - Profiles of Seward Bay Dune - taken in 1947

Profile E, 1947
Profile F, 1947
Profile G, 1947



Horizontal Distance in Centimeters

Table 1--Data for Sturgeon Bay Dunes.

COASTGARD DUNE, July 22, 1947.

1947

Ecology Class	Profile from log.	Profile, Fringing Dune from Lake Michigan
	N 160° 2-meter steps	N 110°
2 m	+20 cm	2m +20cm sand
2	+30 Juncus	2 +27 "
2	+25 mixture	2 +11 "
2	+120 Ammoph + Tan.Equiset	2 +26 driftwood
2	+130 " " "	2 +81 Ammophila in last 66 cm
2	+135 " " " Artem.	2 +56 " + Artemisia + Agropyron dasy
2	+120 " Tan, Art	2 +51 " + Cirsium pitcheri
2	+125 " Art Lathyrus	2 +66 " + Artemisia caudata
2	+125 " Art Rosa	2 +72 " + Agropyron + Cirsium
2	+130 " Art Lathy	2 +63 Artemisia + Cirsium
2	+135 " Achillea	6cm +15
2	+125 " Art	7cm 0 Ammophila + Art + Lathyrus mar. + ?
	N 135°	187cm -31 Sand
2	+65 " Art Lath	2 m -104 Ammophila
2	+55 " Art	2 - 91 " Smilicina stellata + Lathyrus m.
2	+56 " Art Lath	70cm - 7 Arctostaphylos uvaursi
1.5	+40 Vitis mixture	60cm m +26 sand
	n 145°	2 m +32 Juniperus communis depressa
84 ft.	-55 shattered top.	2 +57 " + Cornus stol. + Arctostaphylos
	N 85°	2 +85 " Ammophila + "
2 m	-80cm Ammophila + Asclep	2 +100 Art + Arcto + Ammoph + Pop del + Celast
2	-120 " " "	2 -142 Prunus virg + "
2	-115 " " "	13cm +53 Sand + Rosa
2	-115 " Ascl + Rhus tox Celas	157cm +14 Rhus toxicodendron.
2	-120 Thuja forest	
2	-115 " "	
2	-120 " ends in 1934 Thuja	
2	-120 " "	
2	-125 " "	
2.3	-125 bottom	

Line-Interception 1/3 way up s
from A Thuja west side.
5 meters occ. (mm)
Ammophila breviligulata 17 (65mm)
Arctostaphylos uvaursi 4 (12)
Artemisia caudata 1 (1)
Aster laevis 1 (3.5)
Equisetum variegatum 1 (3)
Smilicina stellata 2(7)
Board over sand (154)
Dead Grass (634)
Bare sand 4120)

Line-Interception Lake side Ammophila Dune
AMMOPHILA LEVEL N 15° 5 meters
Ammophila breviligulata 24 (805mm)
Artemisia caudata 4 (235mm)
GROUND LEVEL
Ammophila breviligulata 5 (16.5mm)
Artemisia caudata 3 (40.5)
Cirsium pitcheri 1 (50 mm)
Debris 64 (308 mm)
Bare sand (4585 mm)

Root system of Ammophila dug up from
1 square meter surface had
51 green culms
141 pieces of rhizomes totaling 61.36 m length
77 first order roots 20.06 m 1/5 of stringers
counted.

On one sq meter surface of Ammophila ~~fringing~~
fringing dune wave cut into were ~~120~~
120 green culms of Ammophila and ~~59.49~~
59.49 meters of main rhizomes + ~~1~~
1 Lathyrus maritimus with 65 cm of rhizome.
and a great wealth of fine roots.
Karsten - MacLennan, - Murchie - Sturgeon -
Watson.

Belcher
Bradley
Burgat
Hunter
James

Excavations of 1946 one no above plants
the other with 5 culms of Ammophila in a line
across the place.
Excavation of 1945 & earlier not discernable.

1947

Profile SLEEPING BEAR Dune, Leelanau Co., Michigan
Ecology Class July 25, 1947

Vertical rises in cm for 2 meter horizontal lengths unless otherwise indicated
From Lake Michigan crest N 65° -15 -3 -9 -4.5 forward 85cm -3, +23 +21 +22
+25 +34 +24 0 +12 +24 +41 +22 +56 +23 +27 +34 +23 +54.5 +48 +44 +34 +63 +75.5 +51
+58 +57 +76 +74 +78 +66 +70 +65 +48 +34 +36 +63 +69 +75 +82.5 +79 +94 +94 +97
+106 +121 +83 direction to N 125° +129 +148 crest in dead Cornus etc. no more trees.

The same July 24, 1937

All forward steps are 2 meters each. elevations in centimeters,
+80 +82 +12 +75 +55 +10 0 0 +50 +50 +50 +25 logs, +20 +50 +35 +30 +35 +65 X
+45 +55 +55 +70 +60 +92 +75 +80 +95 +70 +75 +90 +95 +35 +110 +110 +95 +85 +85
+185 +100 +100 +95 +125 +105 +75 +30

Quadrats on the perch dunes of Sleeping Bear Pt. July 24, 1947

Group	1	159	8	0	0	0	0	0	0
"	2	33	28	0	1	0	0	0	0
"	3	90	0	0	0	26	0	0	
"	4								
"	5	125	0	0	1	85	101		

POINT-OBSERVATION Sleeping Bear Point July 22, 1938

Open Ammophila										
Ammophila breviligulata	2	2.2	1	1.1	2.5	2	1.8	1.4	2.5	3
Dense Ammophila										
Ammophila breviligulata	10	8.5	11	16	18	5	4.5	6	7	4.5
Agropyron dasystachyum		.1	.1				.5			
Lathyrus maritimus	29	19	12.5	9	12	9	12	9	7	15
Other forbs		.3	6.5	.3	3	1				

100 Quadrats in Ammophila association on Sleeping Bear Pt both sides of old Coast Gard Road. July 19, 1940.

Achillea millefolium	F.I. 1	in
Ammophila breviligulata	88	with 15 ft. but not in quadrats.
Anemone multifida	2	
Arabis lyrata	4	Arenaria stricta
Artemisia caudata	45	Asclepias syriaca
Andropogon scoparius	5	Cirsium pitcheri
Aster laevis	4	Fraxinus americana
Calamovilfa longifolia	41	Thalesis or Anoplanthus fasciculata
Corispermum hyssopifolium	11	Vitis vulpina
Koeleria cristata	24	Zygadenus chloranthus
Lathyrus maritimus	53	
Melilotus alba	3	
Oenothera muricata	2	
Solidago racemosa gilmani	26	

At STURGEON BAY, Emmet Co., Michigan July 24, 1940.

Ammophila breviligulata			
Culms west side of fringing dune	135 per sq m	5 (3.01)	1 mm in diameter
" east " " "	108	11 (3.36)	0.8 mm "
" Coastgard Dune 2/3rds up	232	6 (3.5)	1 mm "

Sand present on vegetation from the base of Coastgard dune for 51 meters, in considerable quantity for 11 meters.

