The Ore Bin

COASTAL
SAND DUNES
ISSUE

Vol. 35, No. 5
May 1973

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin
Published Monthly By

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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Telephone: 229 - 5580

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Subscription rate - $2.00 per calendar year
Available back issues $.25 each

Second class postage paid
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State of Oregon
Department of Geology
and Mineral Industries
1069 State Office Bldg.
Portland Oregon 97201

The ORE BIN
Volume 35, No. 5
May 1973

OREGON COASTAL DUNES
BETWEEN COOS BAY AND SEA LION POINT

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Sand dunes that have formed since the end of the Ice Age, or within the last 10-15 thousand years, occupy approximately 140 of Oregon's 310 miles of coast. Dune areas vary in size from small patches a few hundred feet across to stretches tens of miles long. With the exception of Curry County south of Port Orford, dunes are a common landform along the Oregon coast.

Older dunes that were formed during the Pleistocene Epoch are now perched on Pleistocene marine terraces well above sea level. The original form of these dunes has been destroyed by erosion, and a soil layer that has developed on the sand supports a forest of large trees and dense brush; hence, this ancient dune terrain is not recognizable by surface configuration. The sand can be identified, however, by its soil zone and its cross-stratification, visible in many roadcuts along the coast highway.

This study is concerned with the post-Ice Age (Holocene) dunes in the coast segment between Coos Bay on the south and Sea Lion Point on the north (see accompanying maps). This is the longest strip of dunes along the Oregon coast and extends for a distance of about 55 miles. It is divided into three segments by the Siuslaw and Umpqua Rivers and is interrupted by numerous smaller streams that cross it. The strip has a maximum width of nearly 3 miles at Florence. At places it narrows to less than half a mile, but most of it is more than 2 miles wide. The area where the dunes attain their greatest size, abundance, and variety has been designated the Oregon Dunes National Recreational Area, an administrative division of the Siuslaw National Forest.

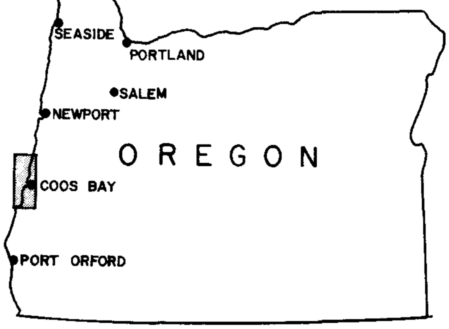
A definitive study of this dune strip was made by Cooper (1958) in his investigation of the coastal dunes of Oregon and Washington, and his work was a useful guide in the preparation of this article. The writer is grateful to Wilbur Ternyik, Chairman of the Oregon Coastal Conservation and Development Committee, for helpful information about the dunes and changes in the dune belt and to John Czemerys, Recreational Assistant, and Ed Whitmore, Planning Leader, of the Oregon Dunes National Recreational Area, who made aerial photographs of the Area available for study and offered helpful information about the dunes.

OREGON COASTAL DUNES BETWEEN

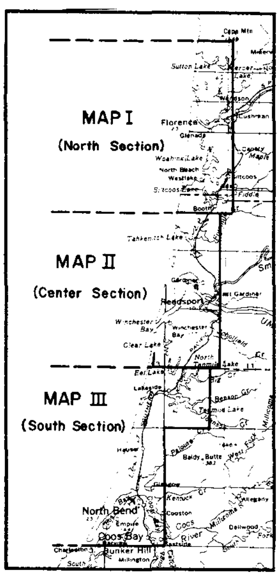
COOS BAY AND SEA LION POINT

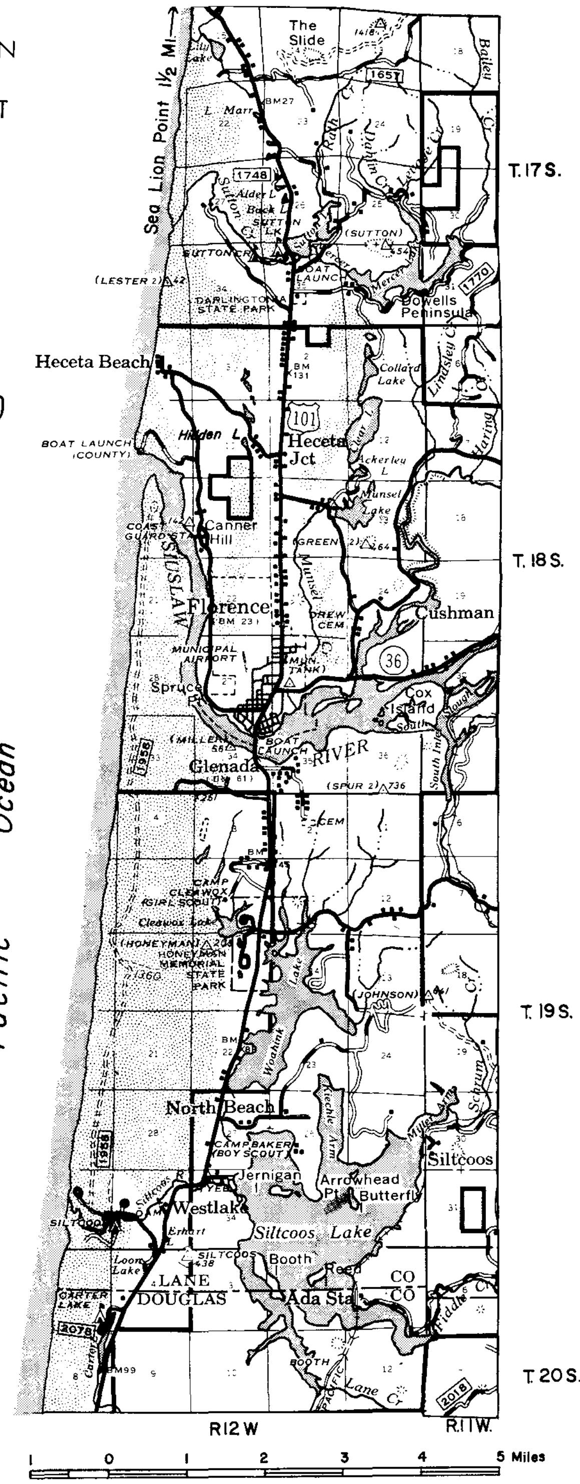
MAP I. NORTH SECTION

LOCATION MAP



INDEX MAP

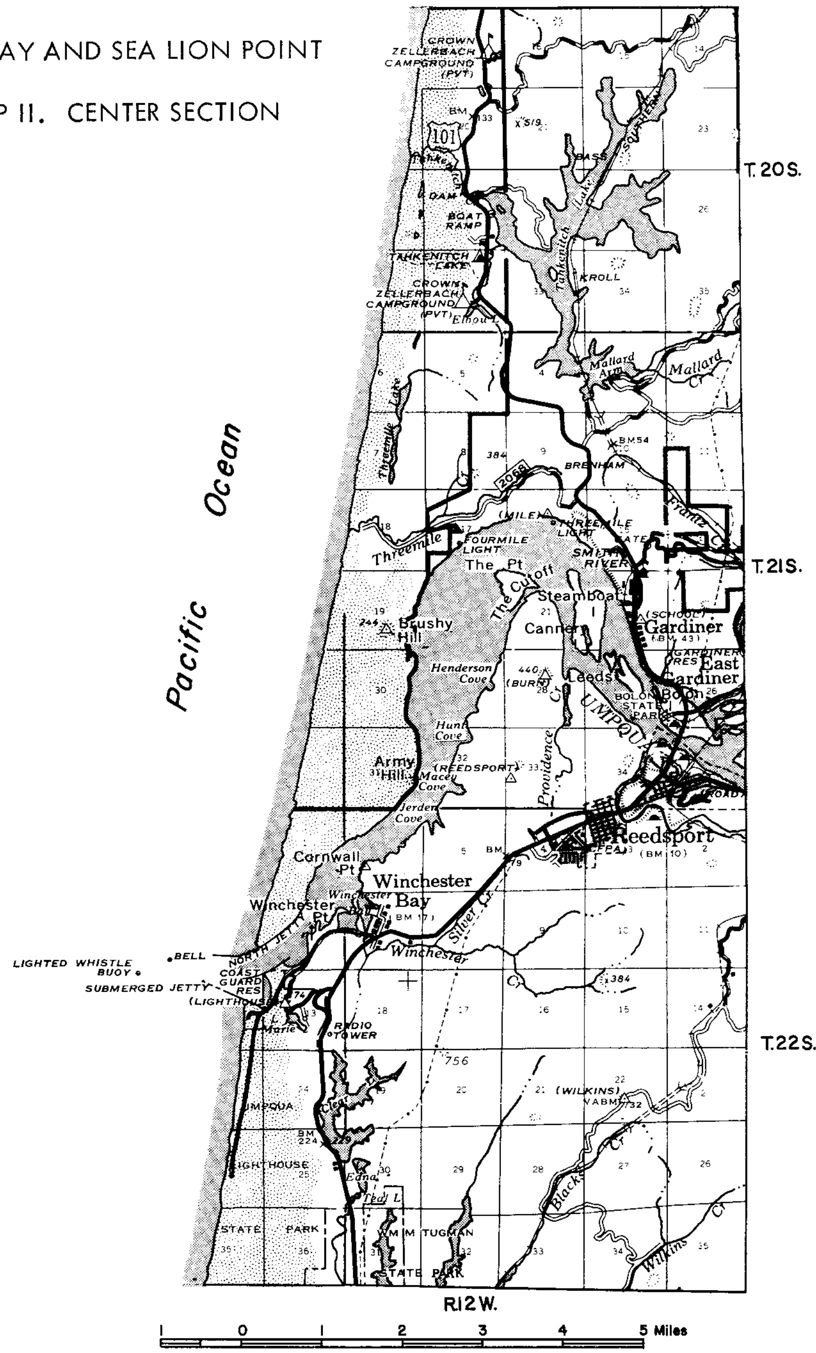




OREGON COASTAL DUNES BETWEEN

COOS BAY AND SEA LION POINT

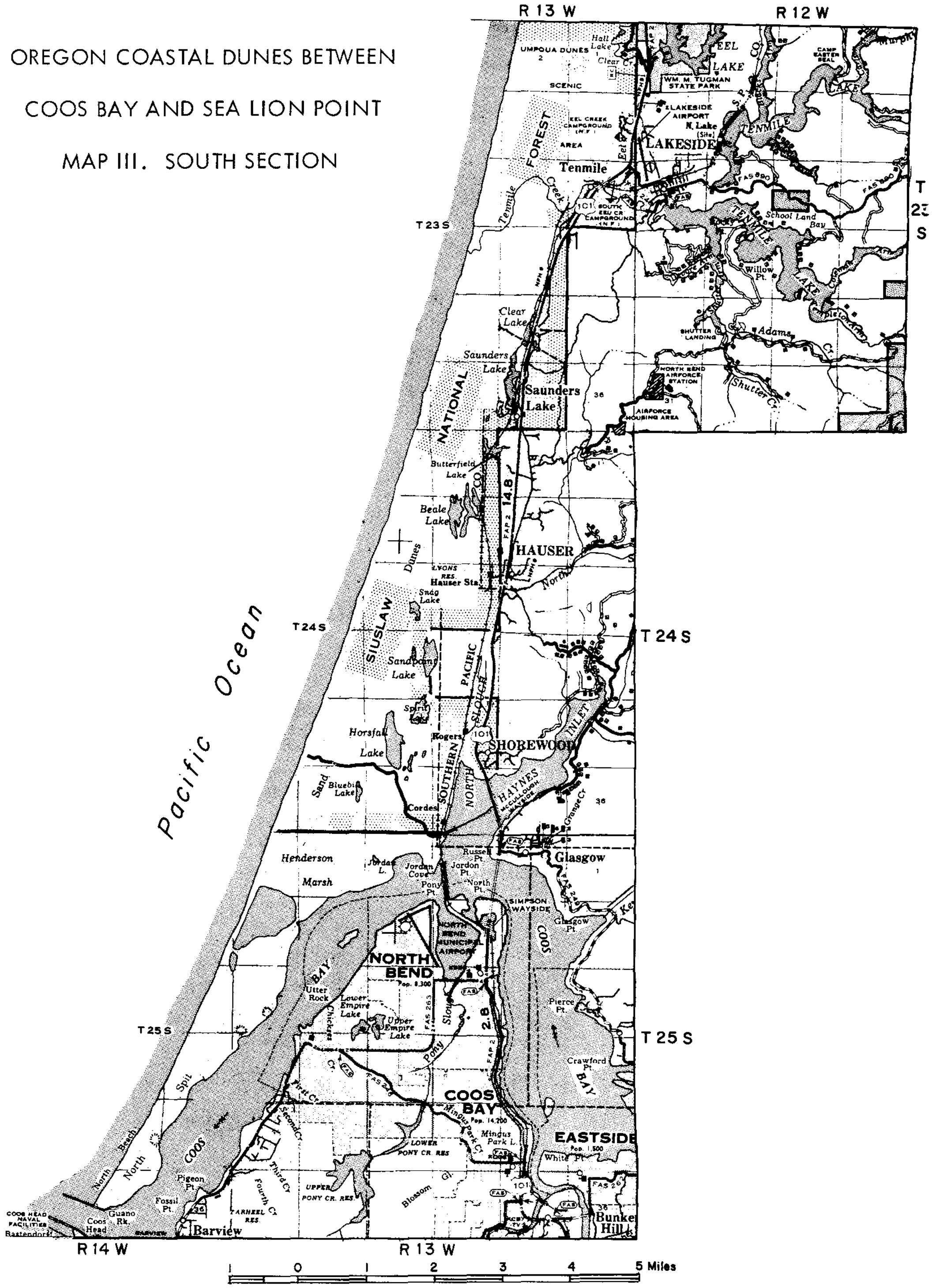
MAP II. CENTER SECTION



OREGON COASTAL DUNES BETWEEN

COOS BAY AND SEA LION POINT

MAP III. SOUTH SECTION



Conditions and Setting

The essential ingredients in dune formation are abundant loose sand, wind, and a favorable terrain. Other factors that play significant roles in the dune-forming processes are water and vegetation. To the extent that his activities affect the dune setting, man also has an influence on these processes.

Sand

The immediate source of sand for the coastal dunes is the beach, and the beach, in turn, receives its supply from the currents that move along the shore. These currents, that flow northward in winter and southward in summer, acquire their sand load by direct erosion along the shore and from sediment transported to the shore by streams. An ample supply of sand for dune building is available along the coast, and wherever the terrain is receptive to wind-blown sand, dunes have formed.

Wind

Winds along the Oregon coast have marked seasonal changes. The strongest summer winds come principally out of the sector between north and northwest; the strongest winter winds come from directions between south and southwest. Fall and spring are transitional periods when the wind comes from both southerly and northerly directions.

No quantitative data are available on which to base a comparison of the effectiveness of the summer and winter winds in moving sand. Cooper (p. 54), however, by applying the principle of parallelogram of forces in which mean winter and summer wind directions and velocities of 16 miles per hour and greater are the force vectors, concludes, "...the competency of the summer wind in transport of sand is thus about twice that of the winter wind." Conversely, Ternyik (oral communication) and others who have observed the dunes over a period of years believe that more sand is moved by southerly winds than by those out of the north. The writer favors the latter view, that winds from the south are the more effective and bases his opinion partly on the shape of the large dune ridges. These ridges are asymmetrical (Figure 1), with the steeper slope on the north side, and characteristically the steeper slope of a dune ridge is on the leeward side. If the gross form of the dune is determined by the southerly winds, the conclusion is drawn that they also move the greatest amount of sand. The southerly winds have the advantage of more time, for the period of south and southwest winter winds is considerably longer than the period of north to northwest summer winds. Further, the winter storms are of longer duration and their winds reach higher velocities.

Figure 1. Oblique dune ridges south of the Umpqua River. Black patches in the dune area are remnants of older, forest-covered dunes. Tenmile Lake is in the upper left-hand corner of the photograph. View is to the south. (Oregon State Highway Div. photo)

Figure 2. Oblique dune ridges and Cleawox Lake south of the Siuslaw River. Small, dark areas on the dunes are patches of wet sand. (Oregon State Highway Div. photo)

Terrain

A favorable terrain for dune formation is one that permits the movement of sand, ideally over a level surface; vertical surfaces are prohibitive. Some surface irregularity is tolerable, for if the sand can move around obstacles it will eventually create its own surface by deposition and adjustment of slopes to local wind conditions. Much of the Oregon coast is not receptive to dune formation because it is bounded by sea cliffs composed of basalt or other hard rock masses. Where the coast is most receptive, the bedrock along it is composed of easily eroded sedimentary material.

During periods of higher sea level in the Pleistocene Epoch, indentations were formed in the coastline along areas of sedimentary bedrock, and a wave-cut platform or bench was eroded on the rock. A thin layer of sediment was deposited over the platform, and subsequent changes in sea level allowed these areas to be exposed as low, narrow coastal plains that sloped gently from the upland front to the sea's edge.

The lowland strip of coast between Sea Lion Point and Coos Bay is underlain along most of its length by the Eocene Tyee Formation, a sandstone. At the southern end, similar but somewhat younger rocks of the Coaledo Formation make up the bedrock. Bedrock is exposed in roadcuts where U.S. Highway 101 turns inland and passes over a hilly terrain between Tahkenitch Lake on the north and Clear Lake, south of Winchester Bay, on the south. Bedrock crops out in a single known shore locality near the base of the peninsula north of Winchester Bay.

The dune belt occupies most of this low coastal region. Landward the dunes lap onto terrace deposits and older dune sands. In places where the terrace is missing, they lap onto Tertiary bedrock. The coast highway is on the Pleistocene terrace and follows along the edge of the dune belt almost continuously from Honeyman State Park to Tahkenitch Lake.

Water and vegetation

Water and vegetation reduce the rate at which sand shifts about. In summer, a thin outer layer of dry sand covers the dune, but windstorms may lay bare wet sand on the windward side of the dunes and in interdune valleys (Figures 2, 8). In winter, most of the sand movement is over a moist surface; cohesion between grains on a wet surface greatly reduces the erosion effect of the wind, but unless the sand is completely saturated with water, particles will be jarred loose and a sheet of sand set in motion over the surface. The wet sand lends itself to wind-sculpturing into weird and interesting forms.

Where deflation (removal of loose particles by wind) lowers the land surface to the summer ground-water level, erosion stops and vegetation soon moves in (Figure 3). Among the first plants to get established on the deflation surface are the yellow monkey flower and marram grass, the beach grass

Figure 3. Vegetation encroaching on the deflation surface that lies along the active dunes south of the Siuslaw River. View is to the northeast.

Figure 4. Lobe on one of the oblique dunes near Cleawox Lake in Honeyman State Park. Marks of sand streams that have corrected an oversteepened summer slipface are visible. (Oregon State Highway Div. photo)

introduced from Europe to stabilize dunes on the West Coast. Where this happens along the western edge of the active dune belt, it usually marks the end of dune activity, and a plant succession begins that culminates in a conifer forest of shore pine and spruce.

Where stabilization is required, marram grass is planted because of its resistance to the abrasive effects of moving sand, ability to withstand burial, and high rate of reproduction. This grass survives and propagates itself so well it now grows profusely in dune areas all along the Oregon coast and has brought about marked changes in these areas.

Dune Forms

Oblique ridge

The dominant dune form of the area included in this study is the oblique ridge (Figure 1). It is a large northwest-trending, asymmetrical feature that lies at an angle to the shoreline and also to both the southwest winds of winter and the northwest winds of summer. In cross section, the steepest side is generally on the north, and, although the surface configuration changes from season to season, the ridge itself does not migrate. The oblique dunes create a pattern of more or less parallel ridges, and they occur in Oregon only in this segment of the coast.

The oblique dune ridges vary considerably in both height and length. They are largest and most numerous between the Siuslaw and Siltcoos Rivers and between the Umpqua River and Tenmile Creek, where they present an impressive expanse of bare, rolling terrain. The highest lie between the Umpqua River and Tenmile Creek; one is more than a mile long. Cooper reports the average length of ten major ones is 1250 meters (about eight-tenths of a mile) and the highest 112 meters (about 367 feet) above sea level and 56 meters (about 185 feet) above its base. Most ridges increase in height landward.

During the summer the northwest winds sweep sand up the north slope of the dune ridge without appreciably changing the slope angle. The sand moves over the crest, part of it accumulating on the slipface, a steep surface that is developed on the leeward side of the dune. A sharp break in the slope marks the upper edge of the slipface, and on many oblique dunes this coincides with the dune crest.

The rate of accumulation on the slipface is greatest along the upper edge, which causes oversteepening of the slope. This unstable condition is corrected from time to time by sand flowage, in which sand streams down the slope until the stable angle of repose (about 30° to 35°) is restored (Figure 4). Because this manner of slope adjustment is possible only when the sand is dry, it is mainly a summer phenomenon. The summer slipface may attain a height of 40 feet or more along the highest parts of the dunes. At the seaward ends, the oblique dune ridges merge with the transverse dunes described in the following section.

Figure 5. Slump area about 50 feet wide on leeward side of oblique dune west of Honeyman State Park. Slumping corrects oversteepened slopes in winter.

Figure 6. Wind sculpturing on the crest of an oblique dune west of Honeyman State Park. These sculptured ridges (yardangs) that trend across the oblique dunes are winter forms. They are about 15 feet high.

During the winter the slipface shifts to the north side of the dune. The summer accumulation on the south side is largely removed and transferred to the north side. This transfer of sand is well under way by mid-November. Adjustment of oversteepened slipfaces in winter is by a slumping action: a mass of sand breaks loose and moves slowly down the slope as a unit (Figure 5).

Winter wind erosion performs considerable sculpturing along the dune crest, and in places cuts the crest into short segments separated by troughs. These crest remnants, known as yardangs, reach heights as much as 15 feet above the bottom of the adjacent troughs (Figure 6). Sand removed between the yardangs accumulates in tongues downwind from the troughs, imparting an undulating pattern.

Because both the winter and summer winds have a landward component, the edge of the oblique dune system is migrating landward several feet a year by the accumulation of sand along a slope on the inner boundary of the active dune belt. Cooper applied the name "precipitation ridge" to this feature where sand is encroaching onto a forest (Figure 7). A precipitation ridge from an earlier dune-building episode lies just west of the highway along much of the distance between Woahink and Elbow Lakes, and active slipfaces on precipitation ridges can be seen from the highway at many places between the Siuslaw River and Coos Bay. As the dune belt migrates landward, forested patches of older dunes become isolated and surrounded by active dunes; they are referred to as "islands" (Figures 1,17).

Transverse dunes

Transverse dunes (Figure 8) are somewhat sinuous ridges that lie approximately at right angles to the summer wind directions. Their growth and migration take place only during the summer months. During the winter they are either completely obliterated or greatly subdued.

Prior to the introduction of marram grass and the formation of a grass-covered ridge along the shore, transverse dunes extended from the beach into the lower part of the oblique ridge system. Their area has been greatly reduced in the past 30 years and continues to shrink; however, they still cover large areas on the sand peninsulas and low areas in from the shore where deflation has not yet reduced the surface to the lower limit of wind erosion. They form in the interdune valleys and on the gentle south slopes of the oblique dunes. Active dunes north of the Siuslaw River are mostly transverse.

Transverse dune ridges lie approximately parallel to each other, but they commonly run together. Their length varies greatly, and a single ridge may be more than half a mile long. The ridge crests are not uniform in height, but, rather, form a succession of high and low places. On their leeward sides are slipfaces with slope angles of about 30 degrees. At the high places in the ridge the slipface is concave; at the low places it is

Figure 7. Sand encroaching on the forest along a precipitation ridge at Carter Lake.

Figure 8. Transverse dunes west of Honeyman State Park. Dark area in the lower part of the photograph is a smooth surface on wet sand.

Figure 9. Cross-bedding exposed in a yardang on the crest of an oblique dune. Hat shows scale.

Figure 10. Cross-bedding on a horizontal surface at the western edge of the active dunes west of Honeyman State Park. Dark spot is 2-inch lens cap.

convex. On the windward sides the transverse dunes have long gentle slopes inclined generally less than 10 degrees.

As the transverse dune migrates forward, it moves into the area formerly occupied by the dune ahead of it. Layers of sand that are deposited on the slipface of the advancing dune make an angle with the layers that remain from the windward part of the dune ahead. This produces a bedding pattern known as cross-bedding, and because of the sinuosity of the dune ridges, the undulations on the windward surfaces, and the irregularities along the dune front, the cross-bedding may be very complex. Cross-bedding can be exposed in cross section where there has been wind sculpturing in set sand (Figure 9) or on horizontal surfaces where deflation has occurred (Figure 10).

A minor feature associated with the transverse dunes is a small ridge on the lee side of the dune. It begins in the concavities along the ridge and terminates against the windward slope of the dune ahead. Cooper names these small ridges "lee projections" and attributes them to local conditions in the wind pattern.

Blowouts and parabolic dunes

A blowout is a more or less elongate deflation basin or trough in a sand area. An individual blowout may be no more than a few feet across and 10 to 15 feet long, or it may be hundreds of feet across and more than a mile long. Small blowouts are very common in areas that are only partly stabilized by grass, and in places the direction of the influencing wind is clearly shown by the pattern of the blowouts and grass clumps (Figure 11).

The large blowouts are along the eastern edge of the active dune belt, where they project into forested, hilly terrain. There are two localities where one can see excellent examples. One is west of Tahkenitch Lake and north of Elbow Lake, where several blowouts have been shaped by northwest winds. The other is west of Clear Lake south of Winchester Bay; there several blowouts are influenced by southerly winds (Figures 12, 13). The westernmost is the longest and extends for a distance of about a mile in an almost due north direction. At one place, the narrow ridge that separates it from the active dune strip behind the shore has been breached, and at the lower end of the blowout the substratum of Pleistocene sand over which the post-Ice Age dune sand was deposited has been exposed.

Sand removed from a blowout area accumulates at the downwind end in a U-shaped mass referred to as either a U-shaped dune or a parabolic dune. The greatest accumulation is at the end, and from there the limbs of the U extend along the sides of the blowout (Figure 12). As a blowout grows longer, the sand that accumulates along its edges forms long ridges. This is the origin of a series of forested ridges that trend obliquely to the beach in a southeast direction north of Heceta Beach community.

Figure 11. Aligned hillocks in the dunes along the north end of Heceta Beach reflect the influence of the northwest winds. Small blowouts lie between grassy hillocks. (Oregon State Highway Div. photo)

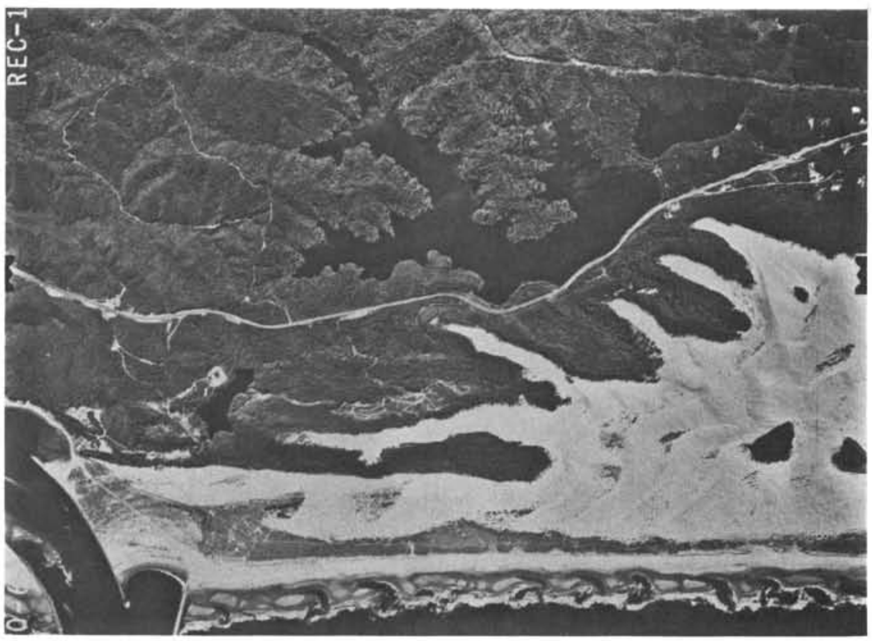


Figure 12. Large blowouts penetrate forested hills south of Umpqua River. The sand is blown out around edges in U-shaped parabolic dunes. Irregular-shaped Clear Lake was formed where dunes dammed a creek. (U.S. Forest Service aerial photo)

Hillocks and the foredune

Where sand moving across a smooth surface meets an obstruction, eddy currents and turbulence in the air behind the obstruction cause sand to be deposited (Figure 14). This can be seen in summer at many places along the dry sand part of the beach where a log or some other object checks the wind. Logs and native plants have always stopped enough sand to create a low beach ridge, but much of the sand was able to move past the ridge and enter the dune-building activity behind the shore. However, with the introduction of European beach grass on the West Coast, the conditions along the shore underwent a pronounced and rapid change, and in the past 25 or 30 years a foredune has built up along the shore that has effectively shut off movement of sand from the beach at all but a few places along the Oregon coast.

Marram and other beach grasses can survive burial, and as sand builds up around them, new roots and growth come out at the joints. Marram apparently has survival qualities that make it superior to native beach grasses, for it has been much more effective in sand stabilization. As sand accumulates around it, the mound gets higher and the grass adds on a new "story" at the same time the cluster gets larger. The mound thus increases in height and girth until it becomes a small hillock. With a steady sand supply, the hillock gets larger and soon merges with other hillocks to form an area that is completely stabilized with grass and other types of vegetation that can grow once the sand stops moving.

The foredune (Figure 15) is a ridge of coalesced hillocks superimposed on an earlier, low beach ridge. The hillocks nearest the beach stop most of the sand and continue to grow while the ones farther from the beach stay about the same size or grow slowly. During winter storms, waves reach the base of the foredune ridge and erode it back to an abrupt edge (Figure 16). Thus in places, banks several feet high are formed which become an additional obstacle to the shifting sand, increasing the effectiveness of the foredune as a barrier.

The foredune has now completely cut off the supply of sand to the dunes along most of the Oregon coast and the interior dunes are now "feeding on themselves." The inland advance of the dune is thus at the expense of the western part of the strip behind the foredune (Figure 3). The body of sand in the dune strip is roughly wedge-shaped in cross section, with the thick edge of the wedge on the landward side. Hence for every foot of advance made by the front, the thin western edge must recede several feet. The dune strip is thereby becoming narrower. As the dune strip narrows, the zone where deflation has reached base level (lower limit of erosion) widens and the belt of vegetation increases in width accordingly. In places, strips of open sand have narrowed by nearly half in the past 30 years.

Figure 13. Large blowout south of the Umpqua River.

Figure 14. Sand accumulating around a clump of marram grass on a deflation surface west of Honeyman State Park.

Figure 15. Foredune ridge along the beach formed by the coalescing of grass-stabilized hillocks. (U.S. Forest Service photo)

Figure 16. Bank along a foredune formed by wave erosion. (U.S. Forest Service photo)

Most of the lakes that lie in and along the dune strip owe their origins to the dunes. Exceptions are several small bodies of water that occupy abandoned river channels, the largest an oxbow lake in an abandoned meander loop of the Siltcoos River at the Siltcoos Forest Camp.

Only a few of the lakes impounded by dunes are entirely within the dune strip. The largest of these are on deflation plains, and smaller ones are in interdune valleys and low areas around the edges of "islands."

Horsefall, Spirit, Sandpoint, and Beale Lakes north of Coos Bay are broad shallow bodies of water occupying low places on a deflation plane where a rise in ground-water level has created an area of lakes and marshland. Beale Lake is at a little higher elevation than the others and appears to be partly on a deflation surface and partly in interdune valleys.

Adjacent to the "islands," usually on the west side, are narrow crescent-shaped valleys. Most of these valleys hold shallow bodies of water during the wet season, and a few have ponds that survive the summer, small though they may be by the end of the dry season (Figure 17).

Figure 17. Small crescent-shaped lake partly encircles an "island" south of Honeyman State Park. The lake lies in a depression between migrating dunes and an isolated remnant of an older forested dune.

Interdune lakes in this dune belt are few and small. Some valleys between the oblique ridges hold shallow ponds during the wet season, but these dry up in the summer. Numerous small, shallow water bodies occupy interdune troughs in the stabilized part of the dune area north of the Siuslaw River, but they usually dry up or are reduced to marshland during the summer. Hidden Lake, which lies west of Heceta Junction and north of Heceta Beach Road, maintains sufficient depth through the year to support fish.

The lakes along the margin of the dune strip are impounded on or against either Pleistocene terrace sandstone or Tertiary bedrock. Carter and Threemile Lakes, long narrow bodies of water between Siltcoos and Umpqua Rivers, lie between the inner dune ridge and the terrain on Pleistocene sediments. The southern part of Sutton Lake at the north end of the dune strip, Cleawox (Figure 2) and Woahink Lakes south of the Siuslaw River, and Saunders Lake north of Coos Bay are on the terrace sediments. Siltcoos, largest of the lakes, is partly on Pleistocene terrace sediments and partly on Tertiary bedrock. The large branching lakes, such as Mercer Lake at the northern end of the dune strip, Tahkenitch Lake between Siltcoos and Umpqua Rivers, and Clear (Figure 12), Eel, and Tenmile (Figure 1) Lakes south of the Umpqua River, occupy the flooded lower ends of stream systems. Elbow Lake, a small lake west of Tahkenitch, is also of this origin. Numerous other lakes, such as Clear and Munsel Lakes north of the Siuslaw River, occupy low areas in the erosional surface on Tertiary bedrock.

The large lakes that are in the flooded stream valleys and the bays at the mouths of Coos, Umpqua, and Siuslaw Rivers have a point in common with respect to origin. All are related to the post-Ice Age rise in sea level. There are numerous indications along the coast that the sea rose to a level somewhat higher than the present, and although it has dropped below its maximum, the level is still high enough that the ocean encroaches on the rivers to form estuaries, the bays at the river mouths.

The larger rivers have sufficient volume to maintain sea-level channels through the dune strip to the ocean, and the impounded and enlarged water bodies at the "drowned" lower ends are subject to the inflow of salt water from the sea. The smaller streams, on the other hand, are incapable of maintaining a sea-level channel across the dune strip and so become dammed up behind the sand barrier. Fresh-water lakes are thereby formed at their "drowned" lower ends.

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Cooper, W. S., 1958, Coastal sand dunes of Oregon and Washington: Geol. Soc. America Memoir 72, 169 p.

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