PHYSICAL PROCESSES AND GEOLOGIC HAZARDS ON THE OREGON COAST

by

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The Beaches and Dunes Handbook for the Oregon Coast represents a compendium of a number of documents which together comprehensively address management and implementation techniques for Oregon's coastal beaches and dunes. As such, each document is prepared as an individual work for subsequent independent distribution. The various documents which together comprise the Beaches and Dunes Handbook fall into five general categories and are listed as follows:

BACKGROUND ON BEACH AND DUNE PLANNING:

AN INTRODUCTION TO BEACH AND DUNE PHYSICAL AND BIOLOGICAL PROCESSES
Christianna Crook, OCZMA Beaches & Dunes Study Team Research Associate

BEACH AND DUNE PLANNING AND MANAGEMENT ON THE OREGON COAST: A SUMMARY OF THE STATE-OF-THE-ARTS
Carl Lindberg, OCZMA Beaches & Dunes Study Team Project Director

BEACH AND DUNE IDENTIFICATION:

A SYSTEM OF CLASSIFYING AND IDENTIFYING OREGON'S COASTAL BEACHES AND DUNES
Christianna Crook, OCZMA Beaches & Dunes Study Team Research Associate

PHYSICAL AND BIOLOGICAL CONSIDERATIONS:

PHYSICAL PROCESSES AND GEOLOGIC HAZARDS ON THE OREGON COAST
Dr. Paul D. Komar, Dept. of Oceanography, Oregon State Univ.

CRITICAL SPECIES AND HABITATS OF OREGON'S COASTAL BEACHES AND DUNES
Bill Burley, Project Biologist, The Oregon Natural Heritage Program of The Nature Conservancy

MANAGEMENT CONSIDERATIONS:

DUNE GROUNDWATER PLANNING AND MANAGEMENT CONSIDERATIONS FOR THE OREGON COAST
Christianna Crook, OCZMA Beaches & Dunes Study Team Research Associate

MANAGEMENT CONSIDERATIONS, CONT.

IMPLEMENTATION TECHNIQUES:

ANNOTATED BIBLIOGRAPHY:

In addition to the various documents noted above, the Beaches and Dunes Study resulted in a slide show, "Managing Oregon's Beaches and Dunes" which is available through each of Oregon's seven coastal county planning departments. The brochure, "Planning and Managing Oregon's Coastal Beaches and Dunes" was prepared as a supplement to the slide show.

* Model Ordinances prepared under separate contract between the Oregon Department of Land Conservation & Development and the Bureau of Governmental Research, Eugene, for inclusion in the Beaches and Dunes Handbook.

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BACKGROUND OF THE STUDY

The basic objective of beach and dune planning and management is the balancing of multiple demands in order to improve the economy and liveability of the coastal area while protecting important environmental and social elements. Striving for such a balance necessitates that decision-makers evaluate both the immediate and long range impacts of proposals to ensure that sufficient choices and resources remain for future generations.

When planning for beach and dune areas, consideration should be given to their role as an integral part of the total resource of the coastal region. This view will ensure that all factors and resources, including their interactions and interdependencies, are considered in the decision-making process.

The Beaches and Dunes Handbook herein, addresses the importance of beaches and dunes from an aesthetic and recreational aspect. It focuses on the dynamic geologic and biologic nature of Oregon's living dunes. Attention is given to the limited sources of beach sand found along the Oregon coast, and the resultant potential impact of sand removal and/or beachfront protective measures. The crucial importance of foredunes for shorefront protection is repeatedly emphasized; the conclusion being drawn that all foredunes are subject to ocean undercutting and/or wave overtopping and thus are "active". Repeated attention is given to the importance of stabilizing vegetation in dune areas where development exists or is approved. Additionally, the potential impact(s) of development on groundwater, and conversely, the impact(s) of high water tables on development are examined. Finally, the study details implementation techniques to assist decision-makers and citizens in ensuring a balanced use of these unique resources while ensuring public health and safety and the protection or enhancement of natural resources.

Following approval of Oregon's Coastal Management Program and the four coastal goals in December of 1976, members of the Oregon Coastal Zone Management Association, Inc. identified the Oregon Beaches and Dunes Goal as warranting

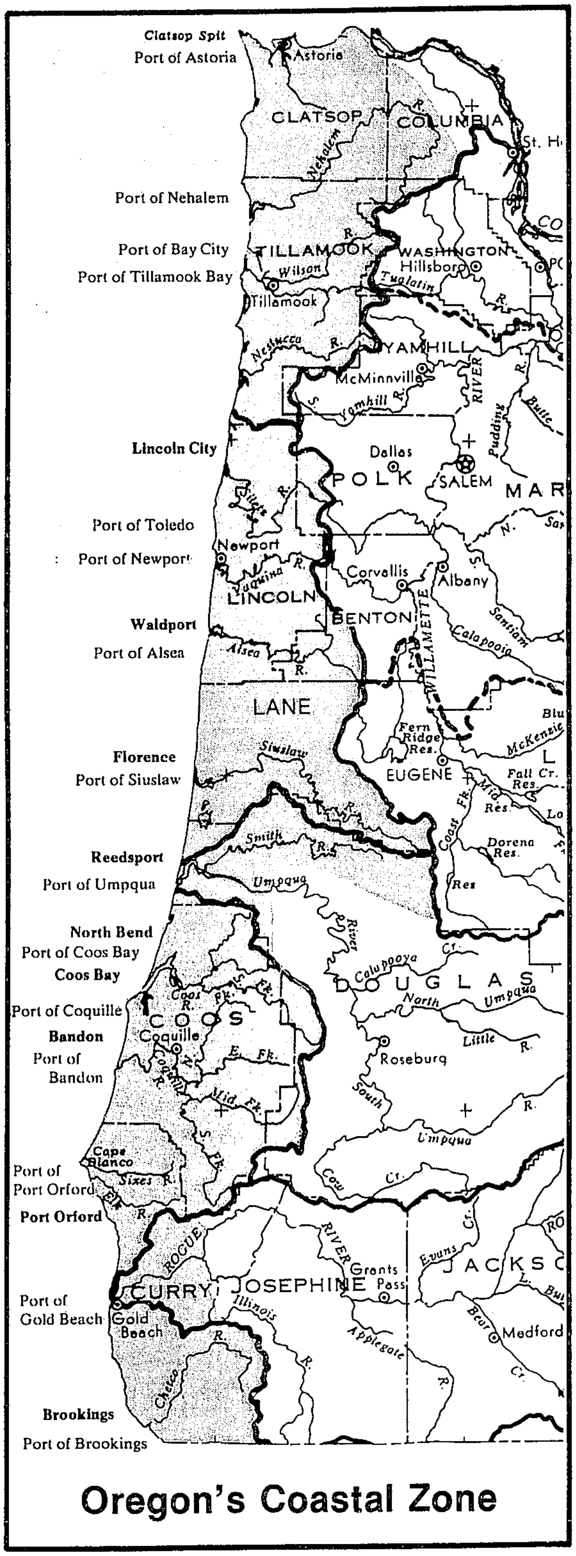


Figure 1. Oregon's Coastal Zone which contains the seven counties of (north to south) Clatsop, Tillamook, Lincoln, Lane, Douglas, Coos and Curry.

special attention if elected officials were to indeed comply with its requirements. A proposal for a comprehensive evaluation of beach and dune management considerations and implementation techniques was submitted to the Oregon Land Conservation and Development Commission in June of 1977, and in May of 1978, the proposal was approved. The area addressed by the study extends along the Oregon coastline from the State of Washington to the State of California, and includes Oregon's seven coastal counties and a number of coastal cities (Figure 1).

Because beaches and dunes are dynamic landforms, it was not the purpose of the project to identify specific locations for various beach and dune activities. Too, because Oregon's land use planning process requires extensive citizen's involvement, it was felt premature and inconsistent to make policy or specific implementation recommendations for beach and dune areas. Rather, the study focused on providing elected officials, planning commissions, planning staffs and citizens with the tools necessary to make knowledgeable land use decisions affecting beaches and dunes. The Beaches and Dunes Handbook is intended to provide basic physical, biological, and management information which will be applicable throughout the years, and which is easily understandable to the most novice in beach and dune planning.

While the Beaches and Dunes Study was intended to address the specific requirements of Oregon's Beaches and Dunes Goal, it is recognized that further technical study is needed in some instances to fulfill Goal requirements or to address issues not covered by the Goal.

Such research needs identified during the study include: the extent and impact of driftwood removal; potential for beach nourishment using dredge spoils and other techniques; specific building standards for dune areas; and specific information on groundwater quality and quantity in dune aquifers.

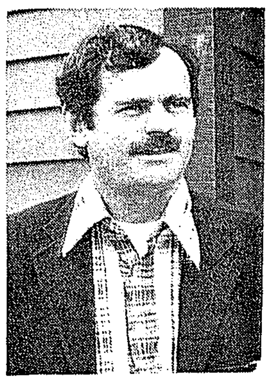
Lastly, it is recognized that in the future, coastal jurisdictions will, in all likelihood, require the assistance of personnel trained in the field of coastal resources to assist with site investigation report evaluations and other planning and implementation needs associated with Oregon's coastal beaches and dunes.

ABOUT THE CONTRIBUTORS

Kathy Bridges Fitzpatrick, Editor and Project Administrator, Oregon Coastal Zone Management Association, Inc.

The author of the Beaches and Dunes Study proposal, administrator of the project and editor of the products, Ms. Fitzpatrick also serves as Assistant Director of the Oregon Coastal Zone Management Association. A graduate of Utah State University, Logan, Ms. Fitzpatrick has finalized manuscripts for the International Biological Program.

Carl A. Lindberg, Project Leader, OCZMA Beaches and Dunes Study Team



Previously holding the position of planning director for the City of Lincoln City, Oregon, Mr. Lindberg has had extensive planning experience in Ohio, Missouri, and Iowa. Mr. Lindberg holds a Masters degree from the Center for Urban Affairs, Saint Louis University, Missouri.

Christianna Stachelrodt Crook, Research Associate, OCZMA Beaches and Dunes Study Team

With extensive experience in biophysical land classification and resource capability assessments, Ms. Crook contributed to the technical aspects of the project. Ms. Crook has held various positions at the University of Victoria and received her Masters from the University of Victoria specializing in resource management and environmental law.

Timms Fowler, WICHE Intern,
OCZMA Beaches and Dunes Study

As an intern with the Western Interstate Commission for Higher Education, Timms Fowler worked with the team concentrating his efforts on the off-road vehicle element of the project. A graduate in Environmental, Population and Organismic Biology from the University of Colorado, Mr. Fowler has had previous experience working with the Colorado Division of Wildlife.

Arlys Bernard, Project Secretary
OCZMA Beaches and Dunes Study

With a degree in elementary education and extensive background in public relations and clerical responsibilities, Ms. Bernard brought to the Study Team attributes of professionalism with attention to the finest of details.
(OCZMA also expresses appreciation to Ruby Edwards, Project Secretary during the first four months of the study.)

Wilbur E. Ternyik, Wave Beachgrass Nursery, Florence, Oregon

Having worked in the field of sand dune stabilization for over 30 years, Mr. Ternyik is a recognized authority for his work in stabilization techniques. As Chairman of the Oregon Coastal Conservation & Development Commission (1971-1975), as Executive Director of the Oregon Coastal Zone Management Association, and as a Siuslaw Port Commissioner and Florence City Councilman, Mr. Ternyik contributed invaluable practical expertise to the project.

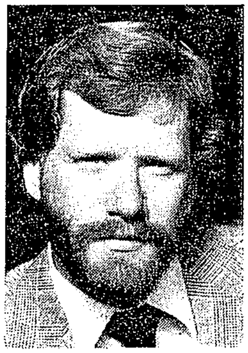
Dr. Paul D. Komar, Professor of Oceanography, Oregon State University, Corvallis

Author of the text, Beach Processes and Sedimentation and countless other publications. Dr. Komar is a recognized authority for his work concerning coastal shoreline erosion and sand transport processes. A graduate of Scrippts Institute of Oceanography, Dr. Komar's involvement in the project focused on coastal geologic hazards.

Bill Burley, Program Biologist, Oregon Natural Heritage Program, The Nature Conservancy

Utilizing its extensive data base, the Oregon Natural Heritage Program has conducted statewide inventories of unique habitats within Oregon. Through his involvement in the project, Mr. Burley identified critical beach and dune habitats and offered suggestions for management.

Doug Daggett, Clearwater Visuals, Eugene, Oregon

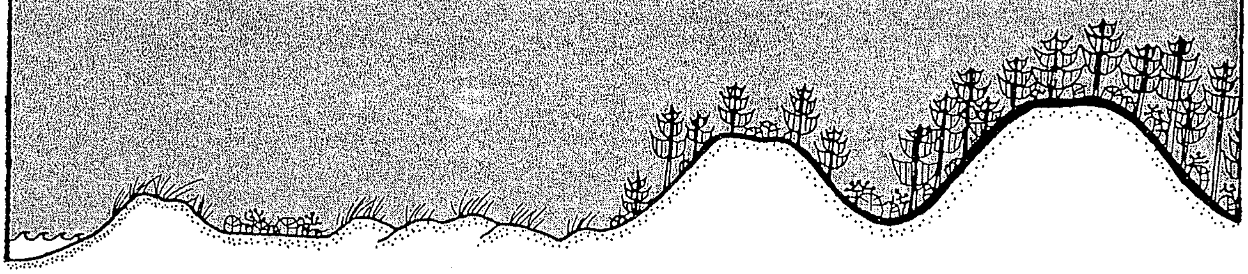


As owner of Clearwater Visuals audio-visual production firm, Mr. Daggett has had considerable experince in the field of public relations, business and industry advertising and production of educational programs. A graduate of the University of Oregon, Eugene, Mr. Daggett was responsible for preparation of the slide program and brochure which accompanied the study products.

Special appreciation is extended to Bob Cortright, Project Liaison and Coastal Specialist for the Oregon Department of Land Conservation and Development, Salem. Mr. Cortright was instrumental in serving as liaison between the state's interest and local concerns in beach and dune planning and management. A graduate of the University of Oregon, Eugene, Mr. Cortright holds a degree in Economics.

OCZMA is a voluntary intergovernmental association of coastal counties, cities, ports and soil and water conservation districts organized pursuant to Oregon statute for the purpose of remaining informed of and involved in the development and implementation of Oregon's Coastal Management Program.

An Introduction To Beach & Dune Physical & Biological Processes



Oregon Coastal Zone
Management Association, Inc.

This report was prepared as part of a larger document addressing various beach and dune planning and management considerations and techniques. Other segments of the document and additional materials are:

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*Beach and Dune Implementation Techniques: Model Ordinances**

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VII. EDUCATIONAL MATERIALS:

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*Prepared under separate contract between Oregon Department of Land Conservation and Development and the Bureau of Governmental Research, Eugene.

Illustrations by Lorraine Morgan, Newport, Oregon.

AN INTRODUCTION TO BEACH AND DUNE PHYSICAL AND BIOLOGICAL PROCESSES

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AN INTRODUCTION TO BEACH AND DUNE PHYSICAL AND BIOLOGICAL PROCESSES

I. Setting the Stage

Areas of sand landforms which occupy nearly fifty percent of the Oregon coastline, have their beginnings thousands of years ago during the Pleistocene glacial period (1,000,000 to 15,000 years ago). For thousands of years, sea level rose and fell in response to the amount of water locked up in polar ice sheets. When sea level was stationary for a period of time, wave action cut terraces into the coastal range foothills (Figure 1). At the same time, ocean currents distributed and deposited large quantities of sediment on the wave-cut terraces and other gently sloping land areas (Figure 2). Origins of these sediments are uncertain, however some may be glacial sediments from as far away as the Canadian Rockies. These ancient deposits persist today and are critical to the beaches and dunes of the Oregon Coast.

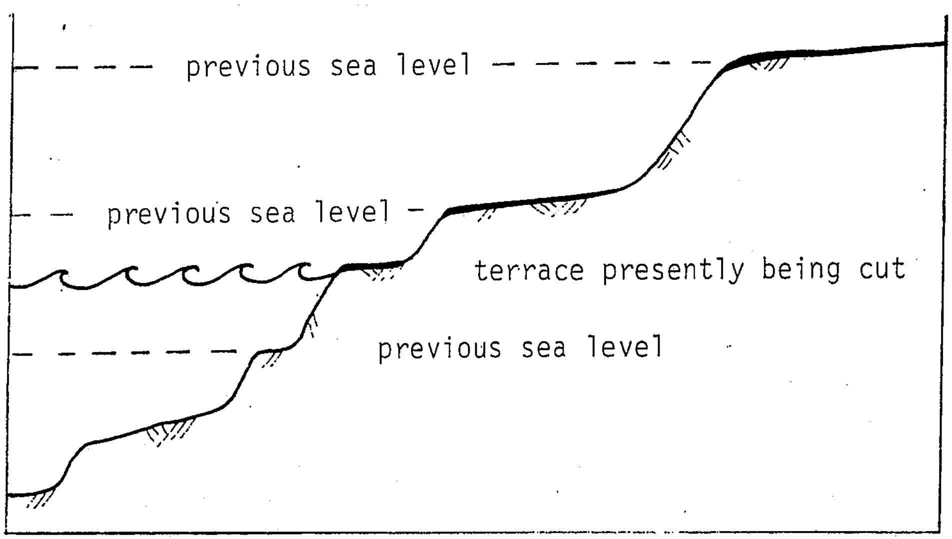


Figure 1. As a result of the Pleistocene glacial period, sea level rose and fell resulting in a series of terraces upon which sediments were deposited.

At some sites, sand deposits, particularly the surficial layers, have been repeatedly reactivated and thus are characterized by loose sands. Other, older deposits have been vegetated and stabilized for a sufficient length of time to allow the sands to become somewhat cemented or stabilized.

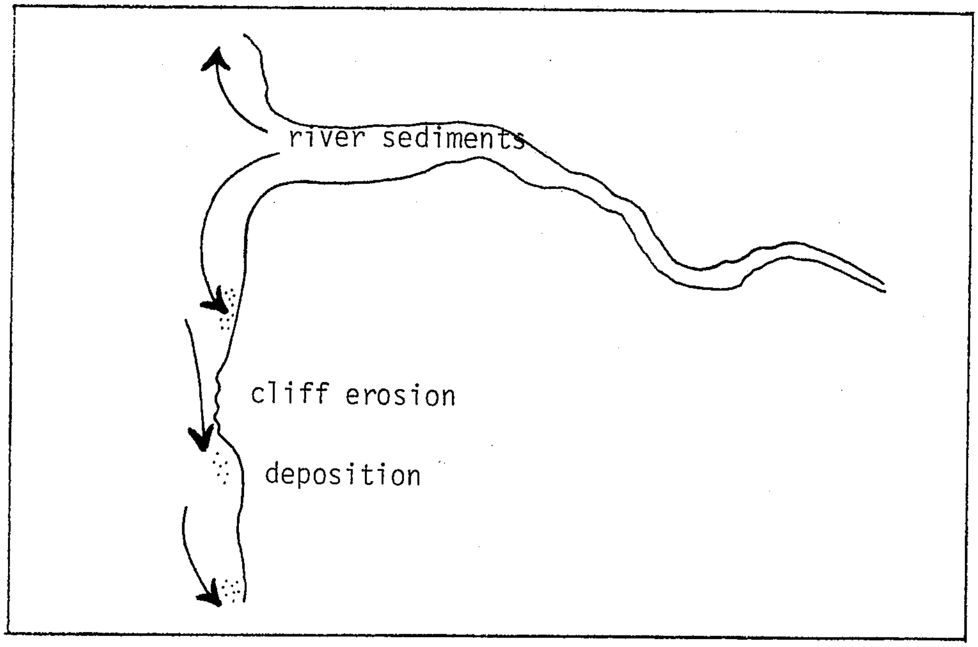


Figure 2. Sediments from rivers and coastal erosion were distributed and deposited along the wave-cut terraces, giving rise to the beach and dune materials we are familiar with today.

The coastal sand areas along Oregon are separated by numerous headlands made up of rocks more resistant to wave erosion. Even the headlands, however, experience continuous erosion as evidenced by the presence of small pocket beaches made up of black pebbles eroded from adjacent basaltic cliffs. These headlands appear to be sufficiently substantial to interrupt weak longshore currents which would otherwise distribute sands from one beach region to another. Thus, all new sand supplies to replace that lost to offshore areas and inland dunes must come from local sources.

Surprisingly, with the singular exception of the Columbia River, little coastal sand is derived from riverine sediments. This is primarily due to the existence of sizeable protected estuaries at river mouths which act as sand sinks, capturing the sediments before they reach the ocean. Only a few southern rivers, such as the Rogue and the Siuslaw, have sufficiently narrow estuaries to allow sediments to reach the beach area, but here deposits are insignificant. The major source of new sand available to the system for the maintenance of beaches and dunes comes from the erosion of ancient terrace deposits which persist today in a semi-cemented form. The loose beach and dune sands are also continuously eroded from one site and redeposited in another. Such deposits may be new to a site but are not new additions to the beach and dune system as a whole

II. Physical Processes

The interactions of a number of naturally occuring phenomenon create a range of sand dune landforms on the surface of the coastal sand deposits. The elements of concern here include wave action, wind, sand, moisture, and vegetation. The interaction of sand and wind comprise the most simplistic combination of elements in the formation of sand dunes. The specific results of this combination will vary somewhat depending on sand supply and nature of prevailing winds, but they are generally characterized by the repetition of uniform wave-like dune forms. For example, the transverse-ridge dune which develops in the open sand areas of the south-central Oregon coast during the dry summer months, is similar in form to the Saharan barcaan dune, characteristic of desert landscapes. In this instance, both dunes are characterized by a gently sloping windward side and a more steeply sloping lee side as an expression of the interaction between wind and open sand.

The addition of moisture as a third agent can result in significantly different landforms. Moisture, principally groundwater, acts as a sand binding agent, and because it exists in a relatively uniform pattern it tends to produce uniform landforms. The deflation plain, a low plain which develops inland from the foredune, is an example of a moisture controlled landform. In this situation, wind scours dry sand down to the water table where moisture binds sand particles together. A low uniform plain of deflation results.

The addition of vegetation as a controlling factor also produces characteristic forms but they commonly take a less uniform expression. Interior hummock dunes occur where beachgrass interrupts wind-blown sand, causing deposition. These dunes commonly exhibit relatively less uniform spacing and form than transverse-ridge dunes. Of course, wave action through the erosion and deposition of sedimentary materials is crucial to the very existence of beaches and dunes. Waves form beaches through the transport and deposition of sediments ranging from fine sands to pebbles and cobbles. Wave intensity contributes to the grain size deposited and the beach's angle of slope. Cusps or embayments in the beach are also created by waves and nearshore currents. Under certain conditions, these embayments can foster erosion of inland areas by allowing storm waves closer access.

III. Biological Processes

The landform types produced by the interaction of environmental factors in the beach and dune areas support a wide variety of biological habitats. The western snowy plover, considered rare in Oregon, nests in the upper beach adjacent to the drift log tangles. The deflation plain often supports a fresh water association, providing habitat for waterfowl including migratory species. Additionally, a number of wildlife species, including deer, racoon, fox and even bobcat, are found in the older forested dunes and often frequent the beach area.

IV. Dune Forms Characteristic of the Oregon Coast

Several regions along the Oregon coast have relatively broad sand borders ranging from one to four miles wide. This includes the Clatsop Plains, the Florence Dune Sheet and the Coos Bay Dune Sheet. Significant sand deposits also occur at Manzanita, Newport, Sand Lake, Bandon and Langlois. Numerous other deposits of local importance occur intermittently along the coast. The major and secondary sand areas in cross-section exhibit characteristic progressions of landforms from the beach landward. Because of varying environmental conditions, these landform progressions vary regionally along the coast. Areas of smaller sand deposits commonly display a somewhat limited selection of these sand landforms.

The Clatsop Plains probably exhibits the most uniform sand dune topography. It is comprised primarily of recently developed sand dune ridges which occur essentially parallel to the beach (Figure 3). Intervening deflation plains and swales are often occupied by streams and linear lakes and marshes. These ridges develop as foredunes adjacent to an accreting beach. The foredune is a ridge of sand which develops immediately above high tide line and parallel to the beach. It is created where the seaward-most beachgrasses, introduced by man, interrupt wind blown sand causing deposition and mound building. As the beach continues to advance seaward, new foredunes develop just landward of the new high tide line and seaward of the previous foredune. The foredune in Clatsop County exhibits a more gently sloping topography than its southern counterparts.

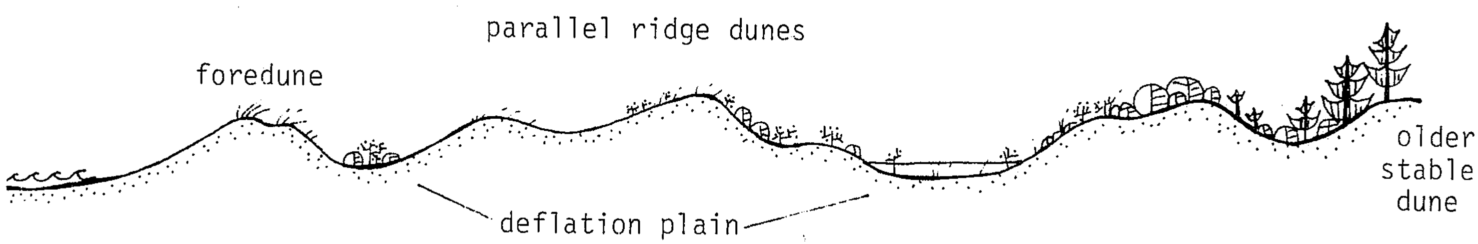


Figure 3. Dune cross-section of the Clatsop Plains dunes sheet illustrating parallel ridge dunes.

In all counties south of Clatsop, the well established foredunes often possess a steeper angle of slope (Figures 4 and 5). Just landward of the foredune, wind scouring occurs eroding sand down to the surface of the summer water table. This feature, known as the deflation plain, often exhibits standing water during the winter and may be occupied by marsh grass associations as well.

On the north-central Oregon coast, vegetated hummock dunes occur immediately inland from the deflation plain, or inland from the foredune when no deflation plain has developed (Figure 4). These dunes may be sparingly or thickly covered with beachgrass and a few other herbaceous and woody species. Like the foredune, hummock dunes are formed by the progressive deposition of sand where beachgrass interrupts wind-blown sand. While hummock dunes are generally found in Lincoln and Tillamook Counties, they occasionally occur in Curry County also.

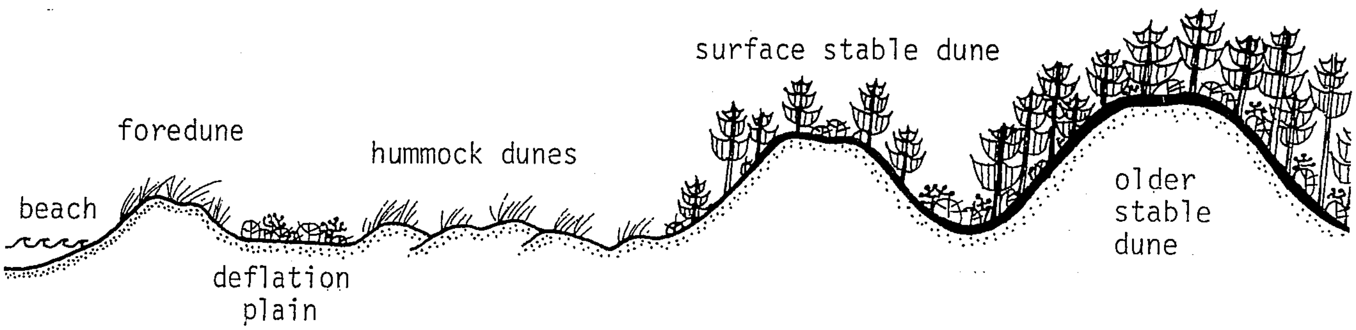


Figure 4. Dune cross-section, north-central coast, illustrating deflation plain and interior dunes.

At the same site in the south-central Oregon coast, transverse-ridge dunes occur in vast open sand sheets (Figure 5). Further inland, the transverse-ridge dunes commonly ride-up over the flanks of the massive oblique-ridge dunes (Figure 5). This dune form, which may reach nearly 200 feet in height, occurs only in the open sand areas common to Lane, Douglas and Coos Counties.

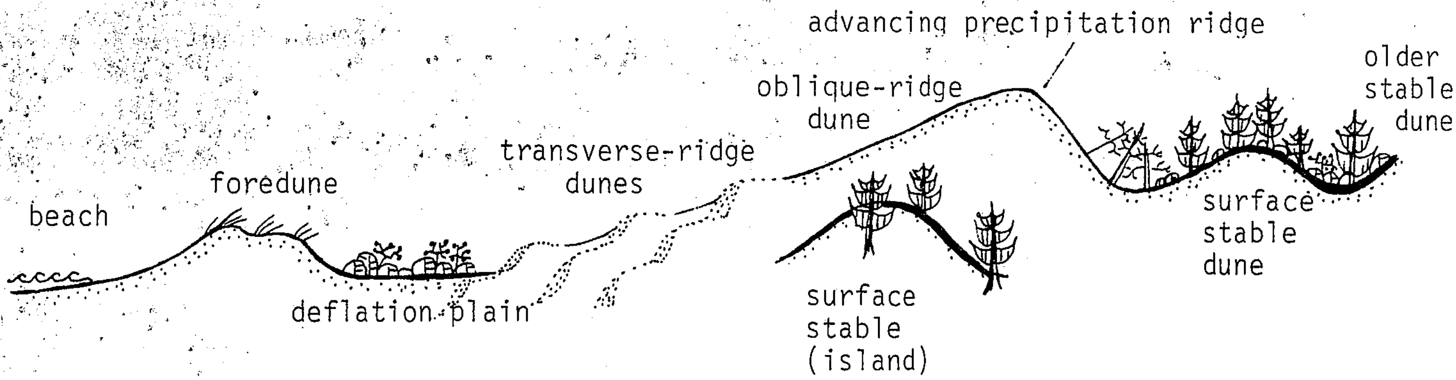


Figure 5. Dune cross-section, south-central coast, illustrating deflation plain, transverse-ridge and oblique-ridge dunes.

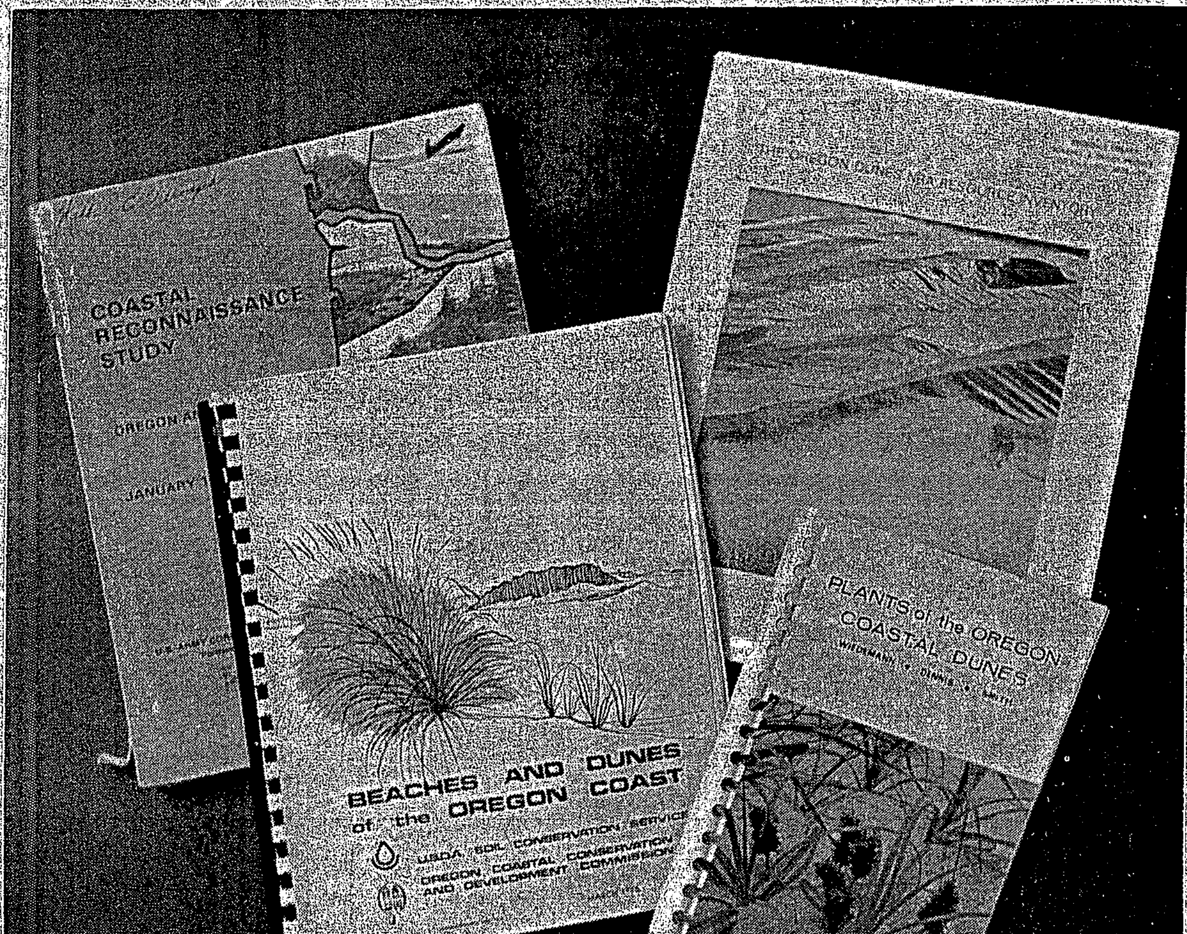
Landward of the hummock dunes of the north-central coast, and interspersed within the oblique-ridge dunes of the south-central coast, occur two varieties of forested soil-covered dunes (Figures 4 and 5). The first is the younger, surface stable dune which is underlain by loose sands and which can be easily activated when vegetation or soil cover are disturbed. The second variety, the older stable dune, exhibits semi-cemented underlying sands which will not commonly be reactivated except where they contain lenses of loose sand. The older stable dune will form a cliff where it is excavated but slumping is common. More resistant iron bands and older buried soils may be found within either of the soil covered dunes but most commonly in the older stable dune.

V. Beaches and Dunes: An Overview

The beaches and dunes of the Oregon Coast are unique and important geologic features which support a wide variety of biological habitats. These forms have evolved through geologic time from the interaction of natural coastal processes including wind, waves, vegetation, moisture and sand supply. Some sand dune landforms have been modified in recent years by man--an example is the introduction of European beachgrass in the foredune area. Management techniques which will allow man to utilize these unique sand dune landforms must take into consideration the dynamic forces at play in the beach and dune area.

Beach & Dune Planning & Management On The Oregon Coast:

A Summary Of The State-Of-The-Arts



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*Prepared under separate contract between Oregon Department of Land Conservation and Development and the Bureau of Governmental Research, Eugene.

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BEACH AND DUNE PLANNING AND MANAGEMENT ON THE OREGON COAST:

A SUMMARY OF THE STATE-OF-THE-ARTS

by

Carl A. Lindberg,

Project Leader

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Kathy Bridges Fitzpatrick

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PREFACE

The following report presents an overview of the state-of-the-arts of planning and managing Oregon's coastal beaches and dunes. This study was conducted by Carl Lindberg, Project Leader, with assistance from other OCZMA Beaches and Dunes staff members composed of Christianna Crook, Project Associate, Arlys Bernard, Project Secretary, Wilbur Ternyik, Project Coordinator, and Kathy Fitzpatrick, Project Administrator. This report constitutes one element of an overall analysis of planning for and managing coastal beaches and dunes as required by Oregon's Beaches and Dunes Goal.

OCZMA expresses appreciation to the following individuals for their contributions during the preparation of this report: Marilyn Adkins, City of Florence Planning Department; Phil Bredesen, Lane County Planning Department; Dave Crow and Bob Higbie, Curry County Planning Department; Keith Cubic, Douglas County Planning Department; Steve Goeckritz, Tillamook County Planning Department; Craig Hall, Mutual Aid Planning Service; Bruce Maltman, City of Gearhart; Kathy Mecone, Coos-Curry Council of Governments; Mike Morgan, Clatsop-Tillamook Intergovernmental Council; Philip Quarterman, Coos County Planning Department; and Curt Schneider, Clatsop County Planning Department.

Additionally, OCZMA acknowledges the following participants on the Beaches and Dunes Steering Committee, who contributed considerable time and effort throughout the project:

R. A. Corthell, U.S. Soil Conservation Service
Steve Stevens, U.S. Army Corps of Engineers
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Bob Cortright, Oregon Department of Land Conservation and Development
Jim Lauman, Oregon Department of Fish and Wildlife
Jim Stembridge, Oregon Department of Soil and Water Conservation
Steve Felkins, Port of Coos Bay
Rainmar Bartl, Clatsop-Tillamook Intergovernmental Council
Gary Darnielle, Lane Council of Governments
Kathy Mecone, Coos-Curry Council of Governments
Marilyn Adkins, City of Florence Planning Department
Phil Bredesen, Lane County Planning Department
Steve Goeckritz, Tillamook County Planning Department
Oscar Granger, Lincoln County Planning Department
Curt Schneider, Clatsop County Planning Department

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I. SETTING THE STAGE

In 1973, the Oregon Coastal Conservation and Development Commission (OCCDC) identified beaches and dunes as one of nine resource categories to be studied as part of the Oregon coastal planning program. The initial identification of beaches and dunes as a topical area and the formulation of original planning management policies were a product of Commission action based on information gained from participants in sixteen coastal workshops and from the assistance of eleven technical resource specialists.

The OCCDC drafted a set of preliminary policy statements and recommended actions which later served as the basis for the Land Conservation and Development Commission's Beaches and Dunes Goal (Goal #18).

In order to visualize the transition that occurred during the development of Goal 18, and perhaps to retrieve useful policies lost during years of debate, original preliminary policies and recommended actions are presented (Ternyik, 1974):

"Beaches and Dunes[1]

"Preliminary Policies - Phase 1

"Planning

"1. Special management guidelines shall be applied to areas specifically identified because of their inherent values, such as deflation plains, freshwater lakes within or adjacent to dune areas, and hummock dunes. (RS)

"2. Certain areas of deflation plains shall not be modified in such a manner as to preclude or reduce availability for wildlife. (RS)

"3. Breaching of a foredune for any purpose shall be controlled. (RS)

"Development

"4. Any development on dune areas (as defined in the OCCDC inventory)

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[1](PI) - means the source is public input, primarily workshops
(RS) - means the source is resource specialist input.
(CON) - indicates consensus between public and resource specialist input.

shall be subject to a site investigation conducted by a qualified specialist in the field and his report submitted prior to the granting of approval for the proposed action.

"5. Any individual, agency or organization proposing construction or development on dune areas shall submit a plan to the appropriate local authority. The plan shall include specifications for: (RS)

(a) the type of development intended;
(b) control of the area through temporary stabilization during construction;
(c) a permanent stabilization program;
(d) an on-going maintenance program;
(e) protection of existing vegetation while construction is in progress;
(f) water distribution and sewerage collection facilities; (EP) and
(g) protection of the surrounding area. (CON - RS; PI)

"6. Those proposing a development in dune areas shall be required to post a performance bond sufficient to cover the cost of making repairs to on-site or off-site areas damaged as a result of the development activity. (RS)

"7. Industrial uses including sand mining and mill sites as well as commercial sites shall be controlled in sand areas, but not eliminated. (PI)

"8. Removal of driftwood from beaches and dunes shall be controlled. (PI)

"9. Some undeveloped open sand areas shall be preserved as open space to allow continuance of active dune processes and maintenance of the aesthetic values. (PI)

"10. The effects of stabilization on adjacent land must be considered. (PI)

"11. Controlled sand removal shall be permitted where necessary.

"Access

"12. (Existing Policy). NOTE--In this section, the authority for planning and management of the state-controlled section of the beach west of the zone line was described. This authority is vested in the State Parks and Recreation Branch by ORS 390.

"13. Sand areas designated as conditionally stable or as a dune complex (as identified in the OCCDC inventory) shall be managed on a limited access basis. (RS)

"Recreation

"14. Pedestrians and vehicles shall be separated in sand dune areas. (CON - RS; PI)

" Beaches and Dunes

"Preliminary Recommended Actions

"Planning

"1. Planning should identify those areas to be protected and those suitable for development and shall recommend use restrictions, limitations or reglations for sand areas . (PI)

"2. Special management guidelines should be developed for areas specifically identified because of their inherent values, such as deflation plains, freshwater lakes within or adjacent to dune areas, and hummock dunes. (RS)

"3. Because of the special characteristics of some areas of deflation plains they should be identified and maintained for wildlife habitat.

"4. An educational program explaining dune processes should be developed and taken to the general public and to schools. (PI)

"Development

"5. Specifications for construction activity (such as excavations) in sand areas should be developed to prevent: (RS)

(a) moisture loss and plant root damage;
(b) exposing older sand areas to erosion; and
(c) creating or causing slope instability.

"6. Cutting and removal of timber and understory vegetation or ground cover should be conducted in such a manner that no threat to moisture loss is posed to the survival of the adjacent and surrounding plant communities. (RS)

"7. Existing channels and jetties should be maintained. (PI)

"8. Some undeveloped open sand areas should be identified for preservation as open space. (PI)

"Access

"9. Access to sand areas should conform to the physical characteristics of the site. (PI)

"Recreation

"10. Specified sand dunes areas should be designated for vehicles, and vehicles restricted from all other areas. (CON - RS; PI)

"11. ORVs (off-road vehicles) should be regulated by a permit system or special licensing program which applies fees for control and maintenance of their use areas. (PI)

"12. The impact of motor vehicles, pedestrians, and livestock use of beaches and dunes should be studied."

During the time when the OCCDC merged with the then-newly created Land Conservation and Development Commission (LCDC) in 1975, two informational sources were being developed:

(1) A series of state and county environmental geology reports were being compiled by the Oregon Department of Geology and Mineral Industries (DOGAMI) which included information addressing beach and dune problems and management suggestions.

(2) The U.S. Department of Agriculture, Soil Conservation Service was busily preparing an inventory of coastal beaches and dunes under contract with the OCCDC. About ten pages of the final document were devoted to existing and potential management problems.

In December of 1976, the Oregon Land Conservation and Development Commission approved the Beaches and Dunes Goal--the eighteenth of nineteen planning goals for the State of Oregon. The goal was adopted in conjunction with the state's involvement in the federal Coastal Zone Management Act of 1972, and as such applies only to Oregon's coastal zone[1]. The goal sets forth beach and dune planning and management objectives for coastal counties and cities (see Appendix A).

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[1]Oregon's coastal zone extends from the Washington border on the north to California on the south, seaward to the extent of state jurisdiction as recognized in federal law, and inland to the crest of the coastal mountain range. Three exceptions exist on the eastern boundary. They are:

1. The Umpqua River Basin, where the coastal zone extends to Scottsburg;
2. The Rogue River Basin, where the coastal zone extends to Agness; and
3. The Columbia River Basin, where the coastal zone extends to the downstream end of Puget Island (LCDC, 1976).

II. COASTAL JURISDICTION EFFORTS

Since the demise of OCCDC in 1975, coastal jurisdictions have been busy preparing local comprehensive plans pursuant to LCDC's nineteen statewide goals and guidelines. A survey of coastal jurisdictions in late September, 1978 indicated that the DOGAMI and OCCDC publications were the main printed sources of information used by planning staffs in planning and development review under the Beaches and Dunes Goal (#18). In response to written questionaires and follow-up telephone conversations, the following is a synopsis of the state-of-the-arts of beach and dune planning throughout the Oregon coast.

A. Clatsop County

Clatsop County, from the mouth of the Columbia River to the north to Tillamook Head on the south, contains a series of parallel-ridge dunes that extend approximately one and one-half miles inland. "A sand stabilization project was established in the Clatsop Plains area in 1935 by the Soil Conservation Service. In this program, 3,000 acres of shifting sand were progressively stabilized by forming a series of foredunes" (U.S.D.A., Soil Conservation Service and OCCDC, 1975, p. 74).

Since the massive sand stabilization program of the 1930's, the Warrenton Dune Soil and Water Conservation District has maintained a management program to ensure continuing stability of the Clatsop Plains dune sheet. A copy of the regulations adopted by the District are included in Appendix B.

Several recent planning studies have been conducted which address the county's dune areas, one of which covers the subject of dune stability. Dr. Leonard Palmer, a consulting geologist from Portland State University, prepared a draft report on the stability of Clatsop coastal dunes which recommends:

> "that developers be required to provide site-specific studies done by qualified experts in areas of potential hazard. Primary concerns are to define: the beach and dune rates of change; storm-tsunami tide and wave height; preservation of groundwater supplies; and proper vegetation maintenance" (Palmer, 1978, p. 2).

A zoning ordinance pertaining to uses on active dune areas and an exception for the Surf Pines area has recently been adopted by Clatsop County and is reproduced in Appendix B.

B. Tillamook County

Tillamook County has 53 miles of shoreline that consists of sand beach and dune areas between rocky headlands. Along with the state environmental geology study for the county and the OCCDC inventory, the county planning department uses SCS soils maps (1979) and has generated specific inventory and policy recommendations for its beach and dune areas. These proposed policies have been the topic of discussion during the citizen's involvement process and have been fairly well received. The draft policies address the Beaches and Dunes Goal requirements in six major policy areas: Geology and Geologic Hazards, Flood Hazards, Groundwater and Water Quality, Wildlife Habitat, Development and Recreation. A copy of the current working paper on these policies is included in Appendix C along with a Tillamook County handout which addresses the effect of the Beaches and Dunes Goal on home and property owners. Additionally, Tillamook County has developed extensive findings pertaining to beaches and dunes, critieria for site investigations, exceptions to the Beaches and Dunes goal and is preparing an ordinance for regulating beach and dune activities.

C. Lincoln County

Lincoln County has a shoreline of approximately 54 miles that is characterized by sandy beaches interspersed with rocky headlands and inlets. The county reported use of the state environmental geology report for the county (Schlicker, et al., 1973), the OCCDC Beaches and Dunes Inventory and a recent coastal shorelands and hazards study conducted by RNKR Associates of Corvallis, Oregon (1978). The county uses these resources, along with the LCDC goal requirements, agency concerns and basic planning techniques to classify sand landforms and produce findings-of-fact on individual proposed actions. Under the current county zoning ordinance, the county may require a geotechnical study be conducted in known or suspected hazards areas. On-site inspection by staff may also be required prior to issuing development permits along beaches and shorelands. The OCZMA Beaches and Dunes Study draft addressing uses was included in its entirety in Lincoln County's recently released draft comprehensive plan (Lincoln County Planning Department, 1979).

D. Lane County

Lane County has approximately thirty miles of shoreline with major dune areas to the north and south of the Siuslaw River. The county utilizes the Environmental Geology of Coastal Lane County (1974), soil surveys, and on-site inspections when identifying the location and extent of sand landforms. The Wilsey and Ham consulting firm has completed a coastal resource inventory for the county (1978). This inventory has a forty-two page section dealing with beaches and dunes covering such topics as nature and stability of dunes, patterns of land use and land ownership, aesthetic and scenic values, and recreational opportunities.

The county planning department has prepared a seven-page draft document on beach and dune policies that will be expanded after analyzing the Wilsey and Ham inventory and the forthcoming OCZMA Beaches and Dunes Study (Bredesen, 1979). Additionally, the county is exploring the use of alternative land use controls for implementation of the local comprehensive plan in rural areas.

E. Douglas County

Douglas County has only seventeen miles of shoreline, and almost all of that lies within public ownership (mostly within the Oregon Dunes National Recreation Area). Thus the county's planning priorities have been directed toward the non-coastal statewide planning goals (#1-15). Two inventories were identified by the county staff as being utilized in determining the location and types of sand landforms (Cubic, 1978):

(a) "Final Environmental Impact Statement, Oregon Dunes National Recreation Area Management Plan," by the U. S. Forest Service (1977), and

(b) "An Environmental and Socio-Economic Description of Coastal Douglas County (Draft)," by the Umpqua Regional Council of Governments (1978).

F. Coos County

The 1975 OCCDC study identified over 12,000 acres of active and conditionally stable beach and dune areas within Coos County, with wet deflation plains comprising the most extensive dune landform of over 5,820 acres (U.S.D.A., Soil Conservation Service and OCCDC, 1975). Coos County makes use of the OCCDC study, as well as aerial photography from the SCS and the 1974 "Coastal Reconnaissance Study" by the U.S. Army Corps of Engineers. The sand information is used in classifying sand landforms and no procedures have been developed for the production of findings-of-fact or for site investigations. A natural resource zone (1NR) has been used in a number of beach and dune areas to protect natural resources.

In February of 1978, a fifty-seven page rough-draft policy and inventory document was released for public review and comment. The document contains four sections dealing with beach and dune planning: natural resources, uses and activities, impacts and natural hazards related to dune activities, and coordination with other agencies dealing with beaches and dunes (Quarterman, 1978). The county has developed general policies directed toward uses of beaches and dunes and has been working on development of a Coastal Shorelands/Dune Lands Combining Zone (CSD).

G. Curry County

While having the longest stretch of coastline of any other coastal county in Oregon, Curry County has the smallest area of dune activity. Currently the county utilizes the OCCDC inventory, SCS soil surveys, the environmental geology report on Western Curry County (1976) and aerial photographs provided by the Oregon Highway Division for lands west of the vegetation line.

The OCCDC classification system was identified as the source of information used to classify beach and dune types. Neither general findings-of-fact relating to the existence of hazards, nor criteria for site investigations have been developed. The county has not initiated the preparation of any specialized implementation ordinances directed toward the Beaches and Dunes Goal (Higbie, 1978).

H. Clatsop-Tillamook Intergovernmental Council (CTIC)

The Clatsop-Tillamook Intergovernmental Council provides planning assistance to various jurisdictions within Clatsop and Tillamook Counties. Specifically, the Cities of Manzanita, Rockaway and Cannon Beach are affected by the Beaches and Dunes Goal and receive assistance through CTIC. The supplementary provisions of Manzanita's zoning ordinance No. 78-6 (adopted September, 1978) specify dune construction requirements, as does Rockaway's ordinance No. 143 (adopted January 1978). Cannon Beach in its adopted land use plan (March, 1979) has delineated specific policies for areas identified as hazardous, which includes provisions for beach-front property and addresses sand dune construction policies and beach-front protective structure policies, (see Appendix D).

CTIC has relied heavily on the OCCDC inventory, on the PhD thesis prepared by Jim Stembridge (1975), and on work conducted by Leonard Palmer. Additionally, CTIC contracted with a registered engineering geologist who conducted studies of each community and provided basic information for use in the planning process (Morgan, 1979).

I. Mutual Aid Planning Service, Lincoln County

The Mutual Aid Planning Service located in Lincoln County, serves the planning needs of the county and all cities within the county with the exception of the City of Yachats.

Depending on the finalization of urban growth boundaries, the City of Waldport is likely to be the only city affected by the beaches and dunes goal. Policy statements and implementing procedures have not been developed pending finalization of the OCZMA Beaches and Dunes Study (Hall, 1979).

J. Coos-Curry Council of Governments (CCCOG)

The Coos-Curry Council of Governments provides planning assistance to many of the communities within the two county area, however, only one of its client cities contains active dunes within its jurisdiction. On-site inspections and the use of aerial photographs are used in determining the location and extent of existing beach and dune landforms. Field inspections are used in determing the classification of sand landforms. Information from DOGAMI's environmental geology reports (1973 and 1976) and data from the SCS are used in producing findings-of-fact. No specific criteria has been developed for site investigations, nor have specific implementing ordinances been developed (Mecone, 1978).

K. City of Gearhart

The City of Gearhart has initiated an inventory of beach and dune areas, and has retained a consultant (Morgan, Ryan and Associates, Inc.) to assist with final preparation of the plan and the development of implementing ordinances. While the City has prepared several draft alternatives for beach and dune management, the City has not yet adopted policies or ordinances to implement the beaches and dunes goal (Maltman, 1979).

L. City of Florence

As early as 1968, the City of Florence adopted an ordinance addressing development on, or removal of, sand landforms within the City's jurisdictions.

Since that time, the City has been planning pursuant to the statewide goals. The draft plan contains several references to beaches and dunes within the context of recreation, scenic values, and housing. Beaches and dunes are being addressed within the plan in terms of the physical environment and land use constraints. An extensive study conducted by Wilsey and Ham included the City of Florence, and the City is presently awaiting the release of OCZMA's Beaches and Dunes Study to finalize its implementation techniques (Adkins, 1979).

M. City of Gold Beach

The City of Gold Beach has finalized its comprehensive plan policies and zoning ordinances, and has submitted its plan for acknowledgement by LCDC (Krogh, 1979). The plan identified 650 acres of beaches and dunes and maps active and stabilized dunes using 1970 SCS surveys (City of Gold Beach, 1978). Within the City's zoning ordinance, most active dune areas are designated as "conservation" which allows for the following outright permitted uses: (City of Gold Beach, 1979)

(1) Wildlife and water life sanctuaries.
(2) Recreational uses.
(3) Fishing and similar activities.
(4) Aquaculture and accessory facilities.
(5) Disposal of dredge spoils on sites described in permits issued by Federal and/or State Governmental agencies.

III. THE LONG AND WINDING ROAD

Pursuant to Oregon's statewide planning program and coastal management program, coastal jurisdictions have until July of 1980 to bring local plans and implementing ordinances into compliance with the Oregon Land Conservation and Development Commission's nineteen goals. Planning for beach and dune areas proves particularly cumbersome due to the dynamic nature of the landforms, associated hazards, and the difficult resolution of open space designations and property right issues. The ultimate use of Oregon's coastal beaches and dunes will be the result of extensive citizen's input, coupled with specific data and information regarding housing needs, recreational demands, and other projected uses, within the context of the dynamic nature of these living landforms.

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APPENDIX A

The Beaches and Dunes Goal

18. BEACHES AND DUNES *

GOAL

OVERALL STATEMENT

To conserve, protect, where appropriate develop, and where appropriate restore the resources and benefits of coastal beach and dune areas; and

To reduce the hazard to human life and property from natural or man-induced actions associated with these areas.

Coastal comprehensive plans and implementing actions shall provide for diverse and appropriate use of beach and dune areas consistent with their ecological, recreational, aesthetic, water resource, and economic values, and consistent with the natural limitations of beaches, dunes and dune vegetation for development.

INVENTORY REQUIREMENTS

Inventories shall be conducted to provide information necessary for identifying and designating beach and dune uses and policies. Inventories shall describe the stability, movement, groundwater resource, hazards and values of the beach and dune areas in sufficient detail to establish a sound basis for planning and management. For beach and dune areas adjacent to coastal waters, inventories shall also address the inventory requirements of the Coastal Shorelands Goal.

COMPREHENSIVE PLAN REQUIREMENTS

Based upon the inventory, comprehensive plans for coastal areas *shall:*

(1) identify beach and dune areas; and
(2) establish policies and uses for these areas consistent with the provisions of this goal.

Identification

Coastal areas subject to this goal shall include beaches, active dune forms, recently stabilized dune forms, older stabilized dune forms and interdune forms.

Uses

Uses shall be based on the capabilities and limitations of beach and dune areas to sustain different levels of use or development, and the need to protect areas of critical environmental concern, areas having scenic, scientific, or biological importance, and significant wildlife habitat.

IMPLEMENTATION REQUIREMENTS

(1) Local governments and state and federal agencies shall base decisions on plans, ordinances and land use actions in beach and dune areas, other than older stabilized dunes, on specific findings that shall include at least:

  (a) the type of use proposed and the adverse effects it might have on the site and adjacent areas;
  (b) temporary and permanent stabilization programs and the planned maintenance of new and existing vegetation;
  (c) methods for protecting the surrounding area from any adverse effects of the development; and
  (d) hazards to life, public and private property, and the natural environment which may be caused by the proposed use.

(2) Local governments and state and federal agencies shall prohibit residential developments and commercial and industrial buildings on active foredunes, on other foredunes which are conditionally stable and that are subject to ocean undercutting or wave overtopping, and on interdune areas (deflation plains) that are subject to ocean flooding. Other development in these areas shall be permitted only if the findings required in (1) above are presented and it is demonstrated that the proposed development:

*From Oregon Land Conservation and Development Commission, 1977.

(a) is adequately protected from any geologic hazards, wind erosion, undercutting, ocean flooding and storm waves; or is of minimal value; and
(b) is designed to minimize adverse environmental effects.

(3) Local governments and state and federal agencies shall regulate actions in beach and dune areas to minimize the resulting erosion. Such actions include, but are not limited to the destruction of desirable vegetation (including inadvertent destruction by moisture loss or root damage), the exposure of stable and conditionally stable areas to erosion, and construction of shore structures which modify current or wave patterns leading to beach erosion.

(4) Local, state and federal plans, implementing actions and permit reviews shall protect the groundwater from drawdown which would lead to loss of stabilizing vegetation, loss of water quality, or intrusion of salt water into water supplies.

(5) Permits for beach front protective structures shall be issued under ORS 390.605 -- 390.770, only where development existed on January 1, 1977. The Oregon Department of Transportation, cooperating with local, state and federal agencies shall develop criteria to supplement the Oregon Beach Law (ORS 390.605 -- 390.770) for issuing permits for construction of beach front protective structures. The criteria shall provide that:

(a) visual impacts are minimized;
(b) necessary access to the beach is maintained;
(c) negative impacts on adjacent property are minimized; and
(d) long-term or recurring costs to the public are avoided.

(6) Foredunes shall be breached only to replenish sand supply in interdune areas, or on a temporary basis in an emergency (e.g., fire control, cleaning up oil spills, draining farm lands, and alleviating flood hazards), and only if the breaching and restoration after breaching is consistent with sound principles of conservation.

GUIDELINES

The requirements of the Beaches and Dunes Goal should be addressed with the same consideration as applied to previously adopted goals and guidelines. The planning process described in the Land Use Planning Goal (Goal 2), including the exceptions provisions described in Goal 2, applies to beaches and dune areas and implementation of the Beaches and Dunes Goal.

Beaches and dunes, especially interdune areas (deflation plains) provide many unique or exceptional resources which should be addressed in the inventories and planning requirements of other goals, especially the Goals for Open Spaces, Scenic and Historic Areas and Natural Resources; and Recreational Needs. Habitat provided by these areas for coastal and migratory species of of special importance.

A. Inventories

Local government should begin the beach and dune inventory with a review of **Beaches and Dunes of the Oregon Coast,** USDA Soil Conservation Service and OCCDC, March, 1975, and determine what additional information is necessary to identify and describe:

1. The geologic nature and stability of the beach and dune landforms;
2. patterns of erosion, accretion, and migration;
3. storm and ocean flood hazards;
4. existing and projected use, development and economic activity on the beach and dune landforms; and
5. areas of significant biological importance.

B. Examples of Minimal Development

Examples of development activity which are of minimal value and suitable for development in conditionally stable dunes and deflation plains include beach and dune boardwalks, fences which do not affect sand erosion or migration, and temporary open-sided shelters.

C. Evaluating Beach and Dune Plans and Actions

Local government should adopt strict controls for carrying out the Implementation Requirements of this goal. The controls could include:

1. requirement of a site investigation report financed by the developer;
2. posting of performance bonds to assure that adverse effects can be corrected; and
3. requirement of re-establishing vegetation within a specified time.

D. Sand By-Pass

In developing structures that might excessively reduce the sand supply or interrupt the longshore transport or littoral drift, the developer should investigate, and where possible, provide methods of sand by-pass.

E. Public Access

Where appropriate, local government should require new developments to dedicate easements for public access to public beaches, dunes and associated waters. Access into or through dune areas, particularly conditionally stable dunes and dune complexes, should be controlled or designed to maintain the stability of the area, protect scenic values and avoid fire hazards.

F. Dune Stabilization

Dune stabilization programs should be allowed only when in conformance with the comprehensive plan, and only after assessment of their potential impact.

G. Off Road Vehicles

Appropriate levels of government should designate specific areas for the recreational use of off road vehicles (ORV's). This use should be restricted to limit damage to natural resources and avoid conflict with other activities, including other recreational use.

APPENDIX B

Clatsop County:

Warrenton Soil and Water Conservation District Regulations, and

Clatsop County Active Dune Overlay District

Warrenton Soil and Water Conservation District Regulations *

Ordinances prescribing land use regulations for the care, treatment, and operation of certain lands designated as Zones 1 and 2 within the Warrenton Dune Soil Conservation District.[16]

WHEREAS, the lands within the Warrenton Dune Soil Conservation District are basic assets of the district and their preservation is necessary to protect and promote the health, prosperity, and welfare of the people in the district; and some of the lands are extremely susceptible to erosion by wind that damages not only the land from which the soil is blown but also the lands and improvements of neighbors; and erosion of such lands can be prevented by the maintenance of a continuous vegetative cover; and, the removal or destruction of even a portion of such cover by any act or use of the lands may result in the initiation of erosion processes that spread to other lands, causing economic loss and a hazard to the use and occupancy of the lands of the district by man or his animals, and (here omitted from this copy of the ordinance is the legal description of Zones 1 and 2. These legal descriptions are available on request, and the attached map gives the general location of district and Zones 1 and 2).

NOW THEREFORE be it ordained by the landowners within the Warrenton Dune Soil Conservation District, and within the area known as Zone 1, that:

Section 1. Erosion will be controlled and the soil stabilized by vegetative and/or mechanical means on all lands of this area. After stabilization, continuous maintenance will be provided.

Section 2. No livestock may be grazed in the area.

Section 3. Vehicular and recurring pedestrian and equestrian traffic will be restricted to hard surfaced (plank, gravel bound with clay, asphalt, or other material of like character) roads or trails.

Section 4. No roads or trails may be built by other than the County, State, or Federal Government without a permit from the Warrenton Dune Soil Conservation District Board of Supervisors.

Section 5. No building may be constructed in the area.

Section 6. No other acts or land uses that result in destruction or serious deterioration of the ground cover will be permitted except under conditions approved by the District Board of Supervisors.

Section 7. Nothing in this ordinance shall be construed as prohibiting construction by Federal or State Governments necessary for national security or public health.

*From U.S.D.A., Soil Conservation Service and OCCDC, 1975, pp. 100-103

Section 8. The district Board of Supervisors is hereby authorized to request the State Soil Conservation Committee to appoint a Board of Adjustment, as provided in Section 109-313, O.C.L.A., consisting of three members who shall not be landowners in said district or of kin within the third degree to any person owning land in said district. Said Board of Adjustment shall have power to authorize variance from the terms of these land use regulations in accordance with substantial justice.

Section 9. Upon the approval of this ordinance by the favorable vote of three-fourths majority of all votes cast by landowners representing two-thirds of the land within the district approving the same, it shall immediately thereupon be in full force and effect.

NOW THEREFORE be it ordained by the landowners within the Warrenton Dune Soil Conservation District, and within the area known as Zone II, that:

Section 1. Erosion shall be controlled and the soil stabilized by vegetative and/or mechanical means on all lands of this area. After stabilization, continuous maintenance will be provided.

Section 2: Livestock may be grazed in the area with a permit from the Warrenton Dune Soil Conservation District Board of Supervisors. Livestock grazed within the area shall be confined by herding or fences to the land described in the permit, and the land shall not be grazed by a class of livestock, a greater number, or in excess of the period specified in the permit.

Section 3. Vehicular traffic and recurring equestrian traffic will be confined to hard surfaced (plant, gravel bound with clay, asphalt, concrete, or other material of like character) roads or trails.

Section 4. Vegetative cover specified by the Board of Supervisors of the district will be established where vegetation is destroyed during construction operations. All excavations, fills, or other disturbed land surfaces shall be prepared for planting and be planted to vegetation specified by the Board of Supervisors of the district during the planting period November through April immediately following such disturbance. After stabilization, continuous maintenance shall be provided.

Section 5. No other acts or land uses that result in destruction or serious deterioration of the ground cover will be permitted except under conditions by the Board of Supervisors of the district.

Section 6. The District Board of Supervisors is hereby authorized to request the State Soil Conservation Committee to appoint a Board of Adjustment, as provided in Section 109-313, O.C.L.A., consisting of three members who shall not be landowners in said district or of kin within the third degree to any person owning land in said district. Said Board of Adjustment shall have power to authorize variance from the terms of these land use regulations in accordance with substantial justice.

Section 7. Upon approval of this ordinance by the favorable vote of three-fourths majority of all votes cast by landowners representing two-thirds of the land within the district approving the same, it shall immediately thereupon be in full force and effect.

Clatsop County Active Dune Overlay District

Section 4.160. A Zone - Active Dune Overlay District. This section applies to all areas identified as active dunes (except for the provisions of Section 4.180) within the unincorporated areas of Clatsop County. (Added by Ordinance 78-26)

4.161. Purpose and Intent. The intent of this section is to regulate actions in active dune areas in order to protect the fragile nature of the dune. Should the regulations of this overlay zone be in conflict with the underlying primary zone or the regulations of the Clatsop Soil and Water Conservation District, the conflict(s) shall be resolved by the application of the more stringent regulation(s).

4.162. Mapping. Active dunes, conditionally stable dunes, and dunes subject to ocean undercutting and wave overtopping are identified on maps accompanying Stability of Coastal Dunes, January, 1978, report by Leonard Palmer.

Dune areas mapped in the study were identified by LCDC criteria (see report). Active dunes were defined by evidence from photographs, photo maps, soils, and landforms, to be active or to show recurrent activity in the context of approximately 100 years. The mapping is not intended to specify site conditions or stability, nor to replace site specific studies. The dune mapping is intended to be a preliminary working designation of areas in which further studies may be required. The boundaries mapped should be changed when on-site conditions are shown to have changed, or when improved data is obtained.

4.163. Definition of Terms. The following definitions are to be used for sections 4.160 and 4.180. Where definitions found in Section 2.020 conflict with the definitions of Section 4.163 those in Section 4.163 shall control.

4.163-1. ACCRETION - The build-up of land along a beach or shore by the deposition of waterborne or airborne sand, sediment, or other material.

4.163-2. BEACH - Gently sloping areas of loose material (e.g. sand, gravel, and cobbles) that extend landward from the low-water line to a point where there is a definite change in the material type or landform, or to the line of vegetation.

4.163-3. BEACH ACCESS, PUBLIC OR PRIVATE - Trails or roads which provide access for the public to the beach.

4.163-4. BREACHING - To make a hole or a gap through an area such as a foredune.

4.163-5. DUNE - A hill or ridge of sand built up by the wind along sandy coasts.

4.163-6. DUNE, ACTIVE - A dune that migrates, grows and diminishes from the force of wind and supply of sand. Active dunes include all open sand dunes, active hummocks, and active foredunes.

4.163-7. FOREDUNE, ACTIVE - An unstable barrier ridge of sand paralleling the beach and subject to wind erosion, water erosion, and growth from new sand deposits. Active foredunes may include areas with beach grass, and occur in sand spits and at river mouths as well as elsewhere.

4.163-8. RECREATION - Any experience voluntarily engaged in largely during leisure (discretionary time) from which the individual derives satisfaction.

4.163-9. RECREATION, LOW INTENSITY - does not require developed facilities and can be accommodated without change to the area or resource. e.g. boating, hunting, hiking, wildlife photography, and beach or shore activities can be low intensity recreation.

4.163-10. STABILIZATION - The process of controlling sand activity (i.e. stilling the movement of sand) by natural vegetative growth, planing of grasses and shrubs, or mechanical means (e.g. wire net, fencing).

4.163-11. STRUCTURE - Anything constructed or installed or portable, the use of which requires a location on a parcel of land.

4.164. Uses Permitted.

(1) Use of equipment needed to help stabilize and maintain the vegetation of the dune.

(2) Scientific study of natural and cultural systems such as dunes, dune stabilization, aquifer monitoring wells, archeological remains.

(3) Wildlife sanctuary.

(4) Low intensity recreation.

(5) Maintenance of existing structures and roads.

4.165. Uses Permitted Subject to Conditions.

(1) Hiking, equestrian and nature trails shall be approved by the Clatsop County Department of Planning and Development.

(2) Private beach access subject to approval of the Clatsop County Department of Planning and Development.

(3) Subsurface sewage disposal systems subject to the approval of the Clatsop County Sanitarian and the revegetation requirements approved by the Clatsop County Department of Planning and Development.

(4) Breaching of sand dune on a temporary basis in an emergency (e.g. fire control) only if the breaching, and restoration after breaching is consistent with sound principles of conservation. A restoration plan shall be approved by the Clatsop County Department of Planning and Development.

(5) Temporary open-sided structures subject to approval by Clatsop County Department of Planning and Development.

(6) Public beach access subject to the approval of the Clatsop County Planning Commission.

4.166. Uses Prohibited.

(1) Breaching of sand dune except for that listed in Section 4.165.

(2) Sand removal.

(3) Structure(s) except for Section 4.165(5).

(4) Grazing of livestock.

(5) Off-road vehicles.

4.167. Conditions for Approval of Uses. The Department of Planning and Development may include but not be limited to the placing of the following conditions on the approval of permits for uses in Section 4.165.:

(1) prescribing the extent of vegetation removal;

(2) prescribing the time, amounts and types of materials and the methods to be used in restoration of dune vegetation;

(3) prescribing setbacks greater than required in the underlying zone in order to comply with the intent of the Clatsop County Comprehensive Plan and the Clatsop County Zoning Ordinance No. 66-2, as amended;

(4) prescribing the location, design and number of proposed uses; and

(5) for the establishment of State public beach access points:

(a) public need must be shown; and, if it is determined that there is a public need, then

(b) the State must satisfactorily prove why this location for the proposed beach access, when compared with other locations best serves the public need.

All conditions shall be found by the Department of Planning and Development to provide for or protect the public health, safety or general welfare, protect the dune, and protect adjacent properties both present and in the future.

Conditions of approval shall be sufficient to protect the property from erosion by wind or water or both, the dune from the loss of stabilizing vegetation, and the permanent drawdown of the groundwater supply.

4.168. Guarantee of Performance. Clatsop County shall require the subdivider or developer of any subdivision to post a performance bond to assure that adverse effects that may occur can be corrected. For the guarantee of performance the following standards shall apply:

(1) Method of Guarantee. The subdivider or developer shall deposit cash, or other instrument readily convertible into cash at face value, either with the County, or in escrow with a bank. The use of any instrument other than cash, and, in the case of an escrow account, shall be subject to the

approval of Clatsop County. The amount of the deposit shall be at least twice the cost, as estimated by the subdivider or developer and approved by the County Engineer, of restoration or construction of required improvements.

In the case of an escrow account, the subdivider or developer shall file with the Department of Planning and Development an agreement between the financial bank and himself guaranteeing the following:

(a) that the funds of said escrow account shall be held in trust until released by Clatsop County and may not be used or pledged by the subdivider or developer as security in any other matter during that period; and

(b) that in the case of a failure on the part of the subdivider or developer to complete said improvements, then the bank shall immediately make the funds in said account available to the County for use in the completion of those improvements.

(2) Inspection and Certification. The County Engineer, or other knowledgeable official as specified by the Department of Planning and Development, shall regularly inspect for defects in the restoration or construction of required improvements. Upon completion of these improvements, the County Engineer shall file with the Department of Planning and Development a statement either certifying that the restoration or improvements have been completed in the specific manner or listing the defects in those improvements.

Upon completion of the restoration or improvments, the subdivider or developer shall file with the Department of Planning and Development a statement stipulating the following:

(a) that all required improvements are complete;

(b) that these improvements are in compliance with the minimum standards specified by the Department of Planning and Development for their construction;

(c) that the subdivider or developer knows of no defects from any cause, in those improvements; and

(d) that these improvements are free and clear of any encumbrance or lien.

(3) Release of Guarantee. If the County Department of Planning and Development and Engineer have certified that the contracted restoration or improvements are complete and free from defect, the County shall authorize the release of the restoration or improvement guarantee.

4.169. <u>Time Limits</u>. Prior to approval of the permit the subdivider or developer and the Department of Planning and Development shall agree upon a deadline for the completion of the required improvements, such deadline not to exceed one year from the time of the permit. The County shall have the power to extend the deadline for improvements for one additional year when the subdivider or developer can present substantial reason for doing so.

The subdivider or developer shall restore the vegetation within the first planting season (October to April) using the amounts and types of materials and methods as prescribed by the Department of Planning and Development.

The timing of the permits should be made so that restoration may be started as early in the planting season as possible.

4.170. <u>Warning and Disclaimer of Liability</u>. The degree of protection from erosion or accretion required by this ordinance is considered reasonable for regulatory purposes. Erosion is occurring from the South Jetty of the Columbia River south approximately three miles. Erosion of the dunes may occur south of this area sometime in the future.

This ordinance does not imply that land outside the A or SA zones or uses permitted within such areas will be free from erosion or accretion. This ordinance shall not create a liability on the part of Clatsop County or by an officer or employee thereof for any damages due to erosion or accretion that result from reliance on this ordinance or any administrative decision lawfully made thereunder.

4.171. <u>Permit Procedures</u>. Application for the construction of all structures and construction of uses permitted subject to conditions in Section 4.165 are required and shall be made to the Planning Director or his designate on forms prescribed by Clatsop County. The applicant shall be required to provide at least the following information:

(1) a map showing the location of the proposed use and surrounding uses including structures, vegetation, etc.;

(2) description of the extent to which a sand dune will be altered as a result of the proposed use; and

(3) other such information as is needed to determine conformance with this ordinance.

4.172. Appeal Procedure.

(1) An appeal of a ruling or interpretation of maps or a requirement of this Ordinance by the Planning Director shall be heard by the Clatsop County Planning Commission in accordance with the provisions of Article 11.

(2) The Planning Commission shall hear and decide appeals when it is alleged there is an error in any requirement, decision or determination in the enforcement or administration of this ordinance.

4.173. Penalties. Any person violating any of the provisions of this ordinance shall be subject to the provisions of ORS 215.180, 215.185 and 215.990. A violation of this ordinance shall be considered a separate offense for each day the violation continues.

Section 4.180 SA Zone - Structures Allowed, Active Dune Overlay District. This section shall apply to all areas identified as active dunes that are committed to development within the unincorporated areas of Clatsop County. (Added by Ordinance 78-26)

4.181. Purpose and Intent. The intent of this section is to regulate actions in active dune areas in order to minimize damage to the fragile nature of the dunes, property and structures that may occur as a result of accretion or erosion.

The purpose of this overlay zone is to comply with the Land Conservation and Development Commission Land Use Planning Goal (#2) Part II Exceptions as it relates to development in the active dune (Beaches and Dunes Goal #18). Should the regulations of this overlay zone be in conflict with the underlying primary zone or the Clatsop Soil and Water Conservation District regulations, the conflict(s) shall be resolved by the application of the more stringent regulation(s).

4.182. Mapping. Active dunes, conditionally stable dunes, and dunes subject to ocean undercutting and wave overtopping are identified on maps accompanying Stability of Coastal Dunes, January, 1978, report by Leonard Palmer.

Dune areas mapped in the study were identified by LCDC criteria (see report). Active dunes were defined by evidence from photographs, photo maps, soils, and landforms, to be active or to show recurrent activity in the context of approximately 100 years. The mapping is not intended to specify site conditions or stability, nor to replace site specific studies. The dune mapping is intended to be a preliminary working designation of areas in which further studies may be required. The boundaries mapped should be changed when on-site conditions are shown to have changed, or when improved data is obtained.

4.183. Definition of Terms. The definitions described in Section 4.163 shall also pertain to Section 4.180. Where definitions found in Section 2.020 conflict with definitions in Section 4.163, those in 4.163 shall control.

4.184. Uses Permitted Subject to Conditions.

(1) Uses permitted, accessory uses and conditional uses listed in the primary zone subject to Sections 4.185 and 4.186.

(2) Hiking, equestrian and nature trails shall be approved by the Clatsop County Department of Planning and Development and Sections 4.186 and 4.188.

(3) Private beach access subject to approval of the Clatsop County Department of Planning and Development and Sections 4.187 and 4.188.

(4) Subsurface sewage disposal systems subject to the approval of the Clatsop County Sanitarian and the revegetation requirements approved by the Clatsop County Department of Planning and Development and Sections 4.187 and 4.188.

(5) Breaching of sand dune on a temporary basis in an emergency (e.g. fire control) only if the breaching, and restoration after breaching is consistent with sound principles of conservation. A restoration plan shall be approved by the Clatsop County Department of Planning and Development and comply with Sections 4.187 and 4.188.

(6) Temporary open-sided structures subject to approval by Clatsop County Department of Planning and Development and Sections 4.187 and 4.188.

(7) Public beach access subject to the approval of the Clatsop County Planning Commission.

4.185. Uses Prohibited.

(1) Breaching of sand dune except for that listed in Section 4.165.

(2) Sand removal.

(3) Grazing of livestock.

(4) Off-road vehicles.

4.186. Conditions for Approval of Uses. The Department of Planning and Development may include but not be limited to the placing of the following conditions on the approval of permits for uses in Sections 4.184 and 4.185:

(1) prescribing the extent of vegetation removal;

(2) prescribing the time, amounts and types of materials and the methods to be used in restoration of dune vegetation;

(3) prescribing setbacks greater than required in the underlying zone in order to comply with the intent of the Clatsop County Comprehensive Plan and the Clatsop County Zoning Ordinance No. 66-2, as amended;

(4) prescribing the location, design and number of proposed uses; and

(5) for the establishment of State public beach access points:

(a) public need must be shown; and, if it is determined that there is a public need, then

(b) the State must satisfactorily prove why this location for the proposed beach access, when compared with other locations best serves the public need.

All conditions shall be found by the Department of Planning and Development to provide for or protect the public health, safety or general welfare, protect the dune, and protect adjacent properties both present and in the future.

Conditions of approval shall be sufficient to protect the property from erosion by wind or water or both, the dune from the loss of stabilizing vegetation, and the permanent drawdown of the groundwater supply.

4.187 Guarantee of Performance. Clatsop County shall require the subdivider or developer of any subdivision to post a performance bond to assure that adverse effects that may occur can be corrected. For the guarantee of performance the following standards shall apply:

(1) Method of Guarantee. The subdivider or developer shall deposit cash, or other instrument readily convertible into cash at face value, either with the County, or in escrow with a bank. The use of any instrument other than cash and, in the case of an escrow account, shall be subject to the approval of Clatsop County. The amount of the deposit shall be at least twice the cost, as estimated by the subdivider or developer and approved by the County Engineer, of restoration or construction of required improvements.

In the case of an escrow account, the subdivider or developer shall file with the Department of Planning and Development an agreement between the financial bank and himself guaranteeing the following:

(a) that the funds of said escrow account shall be held in trust until released by Clatsop County and may not be used or pledged by the subdivider or developer as security in any other matter during that period; and

(b) that in the case of a failure on the part of the subdivider or developer to complete said improvements, then the bank shall immediately make the funds in said account available to the County for use in the completion of those improvements.

(2) Inspection and Certification. The County Engineer, or other knowledgeable official as specified by the Department of Planning and Development, shall regularly inspect for defects in the restoration or construction of required improvements. Upon completion of these improvements, the County Engineer shall file with the Department of Planning and Development a statement either certifying that the restoration or improvements have been completed in the specific manner or listing the defects in those improvements.

Upon completion of the restoration or improvements, the subdivider or developer shall file with the Department of Planning and Development a statement stipulating the following:

(a) that all required improvements are complete;

(b) that these improvements are in compliance with the minimum standards specified by the Department of

Planning and Development for their construction;

(c) that the subdivider or developer knows of no defects from any cause, in those improvements; and

(d) that these improvements are free and clear of any encumbrance of lien.

(3) Release of Guarantee. If the County Department of Planning and Development and Engineer have certified that the contracted restoration or improvements are complete and free from defect, the County shall authorize the release of the restoration or improvement guarantee.

4.188. Time Limits. Prior to approval of the permit the subdivider or developer and the Department of Planning and Development shall agree upon a deadline for the completion of the required improvements, such deadline not to exceed one year from the time of the permit. The County shall have the power to extend the deadline for improvements for one additional year when the subdivider or developer can present substantial reason for doing so.

The subdivider or developer shall restore the vegetation within the first planting season (October to April) using the amounts and types of materials and methods prescribed by the Department of Planning and Development.

The timing of the permits should be made so that restoration may be started as early in the planting season as possible.

4.189. Warning and Disclaimer of Liability. The degree of protection from erosion or accretion required by this ordinance is considered reasonable for regulatory purposes. Erosion is occurring from the South Jetty of the Columbia River south approximately three miles. Erosion of the dunes may occur south of this area sometime in the future.

This ordinance does not imply that land outside the A or SA zones or uses permitted within such areas will be free from erosion or accretion. This ordinance shall not create a liability on the part of Clatsop County or by an officer or employee thereof for any damages due to erosion or accretion that result from reliance on this ordinance or any administrative dicision lawfully made thereunder.

4.190. Permit Procedures. Application for the construction of all structures and construction of uses permitted subject to conditions in Section 4.165 are required and shall be made to the Planning Director or his designate on forms prescribed by Clatsop County. The applicant shall be required to provide at least the following information:

(1) a map showing the location of the proposed use and surrounding uses including structures, vegetation, etc.;

(2) description of the extent to which a sand dune will be altered as a result of the proposed use; and

(3) other such information as is needed to determine conformance with this ordinance.

4.191. Appeal Procedure.

(1) An appeal of a ruling or interpretation of maps or a requirement of this Ordinance by the Planning Director shall be heard by the Clatsop County Planning Commission in accordance with the provisions of Article 11.

(2) The Planning Commission shall hear and decide appeals when it is alleged there is an error in any requirement, decision or determination in the enforcement or administration of this ordinance.

4.192. Penalties. Any person violating any of the provisions of this ordinance shall be subject to the provisions of ORS 215.180, 215.185 and 215.990. A violation of this ordinance shall be considered a separate offense for each day the violation continues.

APPENDIX C

Tillamook County:

Working Paper, Draft II, Beaches and Dunes Goal #18 and

Information for People Who Own Property On Active Foredunes

WORKING PAPER

DRAFT POLICIES

A. POLICIES - GEOLOGY AND GEOLOGIC HAZARDS

(1) The removal of sand and gravel from beaches except for extenuating circumstances shall be prohibited. Such material is involved in the longshore transport and its removal from this system is likely to enhance erosion somewhere else along the coast.

(2) The removal of sand and gravel from the backdune areas is prohibited except under unusual circumstances in order to preserve the stable nature of these landforms. If sand is removed it should be taken only from the least sensitive areas or the backdune. Disturbed areas must be revegetated.

(3) Filling in the deflation plain is prohibited since it alters the flood plain function of these land formations, alters groundwater infiltration and changes the hydrolic characteristics of the dune system, affecting plant communities and ultimately the stability of the dune system.

(4) The stabilization of accreted sand in association with jetties or groins shall be prohibited except where necessary for the maintenance of these structures. Unnecessary stabilization of active sand areas oftentimes interferes with the sand budget of the coastal zone and may affect the processes which maintain the protective foredune barrier.

(5) Log debris plays an important role in the formation and maintenance of foredunes. Therefore, driftwood removal from sand areas and beaches for both individual and commercial purposes should be regulated so that dune building processes and scenic values are not adversely affected.

B. POLICIES - FLOOD HAZARDS

(1) Development in areas subject to ocean flooding shall be prohibited. An exception shall be taken to those areas that are "irrevocably" committed to development.

(2) Where development within the beach and dune flood areas is allowed, all new construction and substantial improvements shall be constructed by methods and practices that minimize flood damage (flood proofing).

(3) Flood regulations shall be based on the most current and reliable flood data and meet the requirements established by the Federal Insurance Administration.

C. POLICIES - GROUNDWATER AND WATER QUALITY

(1) The withdrawal of groundwater from the dune area shall be limited to levels which will inusre that a proposed activity(ies) will not result in the drawdown of the groundwater supply which could lead to any of the following: loss of stabilizing vegetation, loss of water quality, saltwater intrusion into the water supply or result in the drawdown of dune lakes.

(2) In order to avoid groundwater polution, development in dune areas with high water tables and/or impermeable subsurface soil horizons shall be allowed only where sanitary sewer systems are available.

(3) To assure that recharge areas for groundwater aquafirs are protected from polution, waste discharge operations such as land fills, septic tanks and industrial waste lagoons are not recommended for these areas.

(4) Draining the deflation plain wet areas is discouraged since this will affect the water table level of adjacent dunes, their plant communities and ultimately dune stability.

STANDARDS - GROUNDWATER AND WATER QUALITY

Steps for preventing saltwater intrusion include conducting adequate hydrology studies to define the proper spacing and yield of water wells and a commitment to base development on the results of these studies.

D. POLICIES - WILDLIFE HABITAT

(1) Sandspits in Tillamook County shall be managed to enhance the preservation of their values as recreational, scenic and wildlife habitats.

(2) Due to their poor suitability for development and high value as wildlife habitats, wet deflation plains to the greatest extent possible shall be maintained in their natural state.

(3) Areas of importance for rare species should not be designated for any vehicle activity; if such an area is nearby, management techniques should be employed to protect it.

(4) To reduce disruption in identified nesting areas of the rare snowy plover, apprioriate management agencies should implement a closure period to the more remote (few access points) beach areas for the nesting period April through June.

STANDARDS - WILDLIFE HABITAT

Waterfowl habitat in the reflation plain can be greatly enhanced by planting hannchen barley for feed. (OCC&DC p. 26)

E. POLICIES - DEVELOPMENT:

(1) Residential developments and commercial and industrial buildings are prohibited in areas designated as active or conditionally stable foredunes. Foredunes which are subject to wave overtopping, plains) that are subject to ocean flooding, except for areas where Tillamook County is requesting an "exception" to the Beaches and Dunes Goal No. 18.

(2) Site specific investigations by a qualified person such as a geologist, soil scientist or geomorphologist may be required by the county prior to the issuance of new developments, or building permits in open sand areas on the ocean front in steep hillsides of dunes and in any other dune areas which may be subject to wind erosion or other hazard potential.

(3) No foredune shall be breached or modified from its natural condition except as part of a dune stabilization program or as part of an authorized sand-bypass program. Removal of the foredunes barrier causes increased ocean flooding of inland areas.

(4) Extensive modification of other dunes is strongly discouraged because such activities are difficult to stabilize.

(5) Development in active sand areas is strongly discouraged and will be allowed only after the area has been stabilized by vegetative plantings.

(6) The use of pavement and other hard surfaced coverings to stabilize active sand areas is discouraged.

(7) Roads in dune areas shall, as much as possible, be routed along troughs between dune ridges. Roads shall not be located in the vegetative area along the face or top of the foredune.

STANDARDS:

(1) During construction in sand areas slopes should not be excavated to steepness of greater than 30 degrees. This is the natural angle of repose for sand and excavations with slopes greater than this are highly subject to slumping.

(2) Vegetated slopes of steepnesses greater than 30 degrees in dune areas should not be cleared. As the slope of bare sand will then exceed its natural angle or repose and a slump or slide will occur.

(3) Grading of the dune landform must be kept to a minimum with all banks leveled to a slope not exceeding 30 degrees. Due to the shallow angle of repose of unconsolidated sand.

(4) Adequate setbacks for structures must be provided for by considering the rate of erosion together with the anticipated life of any structures.

(5) To maintain the aesthetic value and visual integrity of beach and dune areas subject to new development all service lines shall be placed underground.

(6) Removal of vegetation during construction in any sand area shall be kept to the minimum required for building placement or other valid purpose.

(7) Removal of vegetation should not occur more than 30 days prior to grading or construction.

(8) Permanent revegetation shall be started at the site as soon as practicable after construction. Final grading or utility placement time limitations will be dependent upon circumstances.

(9) All setbacks shall be measured from the line of erosion not from the state zone line or property boundaries.

(10) The linear arrangement of structures on dune ridges is discouraged. As this arrangement leads to variations in air flow characteristics which in turn can affect the stability of the dune system.

(11) Any proposals for development in beach and dune areas must be accompanied by a description of the dune stabilization program.

F. POLICIES - RECREATION

(1) Because of their sensitivity and exceptional importance for their value as recreational areas, scenic resources and wildlife habitat, all sandspits in public ownership shall maintain a low development posture. The management of these areas as Natural or Conservation units is greatly facilitated by their relative isolated position along the coast.

(2) Access trails to the beach should be clearly marked to reduce the number of people meandering through the dunes looking for access to the beach, trespassing on private property and breaking down sensitive plant communities in the process.

(3) Because of the sensitive nature of active and conditionally stable dunes, vehicular traffic and recurring pedestrian and equestrian traffic shall be, where practicable, limited to hard surface roads and trails.

(4) Public safety hazards and annoyance factors indicate that ORV's are often incompatible with pedestrian and equestrian use. With increasing numbers of people participating in these activities, it is necessary in some areas such as Sand Lake to separate these uses and designate areas for off road vehicle use.

(5) The open sand areas at Sand Lake under State Forestry Department jurisdiction shall be maintained in its natural unstabilized state in order to preserve this open dune system for its scenic and recreational values.

(6) To maintain the ecological and aesthetic qualities of Sand Lake, ORV use shall be controlled within a special management area. The development of a ORV management plan is recommended. The plan shall consider designated ORV use areas, user capacity, management technicques, access control and adjoining land use compatibility conflicts.

STANDARDS - RECREATION

In areas of high pedestrian traffic or great fragility, slightly elevated boardwalks are suggested as an effective means of traffic containment.

Additionally, revisions to the policies were recommended by the various Citizen Advisory Committees and other agencies and organizations.

Tillamook County

OFFICE OF PLANNING COMMISSION
Tillamook, Oregon 97141

INFORMATION FOR PEOPLE WHO OWN PROPERTY ON ACTIVE FOREDUNES

QUESTION: WHAT IS AN "ACTIVE FOREDUNE"?

An unstable barrier ridge of sand paralleling the beach and subject to wind erosion, water erosion, and growth from new sand deposits. Active foredunes may include areas with beach grass, and occur in sand spits and at river mouths as well as elsewhere.

QUESTION: HOW DOES THE NEW OREGON BEACHES AND DUNES GOAL AFFECT ME?

In most cases, the goal prohibits residential development and commercial and industrial buildings on active foredunes, conditionally stable foredunes subject to ocean undercutting or wave overtopping, and on deflation plains subject to ocean flooding. (SEE page 2 for cases where special conditions apply)

In addition, the goal requires that "local governments and state and federal agencies shall base decisions on plans, ordinances and land use actions in beach and dune areas, other than older stabilized dunes, on specific findings that shall include at least:

a) the type of use proposed and the adverse effects it might have on the site and adjacent areas;

b) temporary and permanent stabilization programs and the planned maintenance of new and existing vegetation;

c) methods for protecting the surrounding area from any adverse effects of the development; and

d) hazards to life, public and private property, and the natural environment which may be caused by the proposed use."

Other important provisions require local governments and state and federal agencies to:

1) regulate actions in beach and dune areas to minimize the resulting erosion;

2) protect the groundwater from drawdown;

3) issue permits for beach front protective structures (ie.; rip rap) only where development existed on January 1, 1977.

QUESTION: HOW DOES THE NEW OREGON BEACHES AND DUNES GOAL AFFECT ME IN TERMS OF ITS EFFECTIVE DATE; JANUARY 1, 1977?

CASE #1: If a building permit was issued prior to January 1, 1977:

[The Beaches and Dunes Goal does NOT apply

CASE #2: If a building permit was NOT issued prior to January 1st but the individual lot owner demonstrated intent to develop his property through documented permit applications, contract obligations, or purchase agreements (ie.; application for a building permit, contracts for architectural designs or engineering feasibility studies, or purchase of rip rap, etc.):

[The Beaches and Dunes Goal DOES apply...
However, approval of building permits can be granted based on demonstrated intent prior to January 1, 1977, provided that other provisions of the goal are complied with.

CASE #3. If a building permit was NOT issued and intent to develop property could NOT be demonstrated prior to January 1st, and if special circumstances exist which may warrant that certain provisions of the goal be waived:

[The Beaches and Dunes Goal DOES apply...
However, approval of building permits can be granted if a valid need for an exception can be demonstrated based on the exceptions clause contained in Statewide Planning Goal #2. All other goal provisions would remain in effect.

CASE #4: If none of the above conditions can be satisfied:

[The Beaches and Dunes Goal DOES apply in its entirety.
Building permits can not be granted until the foredune is stabilized and adequate hazard protection is provided.

QUESTION: WHAT DOES THE EXCEPTIONS CLAUSE IN STATEWIDE PLANNING GOAL #2 REQUIRE?

[A public hearing must be held. Compelling reasons and facts must be provided to show why the exception should be granted including reasons stating why the use should be allowed; what alternative locations in the area could be used for the proposed development; what the long term environmental, economic, social and energy consequences will be; and how the proposed development will be compatible with adjacent uses.

APPENDIX D

Cannon Beach Comprehensive Plan

Manzanita Zoning Ordinance No. 78-6

Rockaway Zoning Ordinance No. 143

CANNON BEACH COMPREHENSIVE PLAN *

HAZARDS POLICIES

1. The City shall make reasonable efforts to protect life and property from natural disasters and hazards. Measures employed by the City shall be the Plan, Zoning and Subdivision Ordinances, the Uniform Building Code (Chapter 70) and other city ordinances.

2. As reliable information on the location and nature of building hazards becomes available, it shall be included in the Comprehensive Plan background data, and shall form the basis for City policies regulating development in these areas.

3. A "Master Map" delineating areas of natural hazards shall be kept on file in City Hall, and shall be available to inform citizens of the locations of hazards, The Master Map shall contain the most up-to-date information available on mass movement, ocean or stream flooding, weak foundations soils, or other hazards the Planning Commission or City Council may designate.

AREA SPECIFIC POLICIES

1. The Curves Area (Tolovana Hill):

   Further development within the large active landslide on either side of Hemlock must be carefully planned and closely monitored.

2. The North End Area:

   a. Topographic map coverage is important for the evaluation of the area's buildability. At the present time, this coverage is not feasible due to the dense vegetation that covers most of the area. Proposed developments, through their site investigations, should provide more detailed topographic mapping.

   b. Development could be allowed on certain steep slopes where the thick basalt sill occurs as bedrock near enough to the surface for footings to be anchored in solid, fresh basalt without extensive (preferably no) excavation of soil. Efforts shall be made to retain the natural conditions of steep slopes.

   c. The remainder of the north end area shall be designated low density, with the allowable units per acre based on percentage of slope.

3. Beach Frontage:

   a. Excavation of sand from the beach shall be prohibited. This practice oversteepens sections of the seaward slope of the dunes and exposes them to erosion by storm waves, and to a lesser extent, by high tides. The blowing of sand up onto Ocean Avenue could better be controlled by maintaining adequate vegetation cover between the street and the sand buffer. Removal or destruction of vegetation in this area shall be strictly prohibited.

* From Morgan, 1978.

b. In order to control foot traffic across protective dune barriers and to reduce blowing onto the street and adjacent property, access trails to the beach shall be maintained and clearly marked.

OVERALL POLICIES: GEOLOGIC HAZARDS

1. A site specific investigation performed by a ualified expert shall be a prerequisite for the issuance of any building permit in the following areas, and delineated on the Master Map:

   a. Those areas consisting of landslide topography developed in Tertiary sedimentary rocks (TOMS).

   b. Any property containing, or adjacent to all or part of, an active landslide.

   c. Any property having beach frontage.

   d. The area south of Maher Street underlain by the Astoria Formation (Tma units).

2. Development requirements for the City are:

   a. Structures should be planned to preserve natural slopes. Cut and fill methods of leveling lots shall be discouraged.

   b. Access raods and driveways shall follow the slope contours to reduce the need for grading and filling.

   c. Removal of vegetation shall be kept to a minimum for stabilization of slopes.

   d. Drainage patterns shall not be altered in steeper areas. Roof drains shall be channeled into natrual drainage or storm sewers.

   e. No development shall be allowed to block stream drainageways, or to increase the water level or water flow onto adjacent property.

FLOOD HAZARD POLICIES

1. The City shall continue its participation in the Federal Flood Insurance Program, thourgh the enactment and enforcement of a Flood Hazards Ordinance. All new construction and substantial improvements shall be planned to minimize flood damage.

2. Where development within the floodplain is allowed, assurance to the City shall be given that the development will not be expected to raise adjacent flood heights and increase public safety hazards.

3. Development in areas subject to severe ocean erosion or flooding (the velocity zone) shall be constructed in such a way that hazards are minimized. A site specific investigation by a qualified expert shall be a prerequisite for all construction in the velocity zone.

4. Shore protective devices (seawalls, riprap) shall be planned by a qualified person so that it is permanent, and does not adversely affect adjacent property.

5. Filling of wetlands or natural drainages shall be prohibited unless it is adequately demonstrated that it will not affect adjacent property, and the wetlands area is not, in the view of State or Federal resource agencies, valuable biologically.

SAND DUNE CONSTRUCTION POLICIES

1. In accordance with the State Beaches and Dunes Goal (#18), construction on active foredunes, on other dunes which are conditionally stable and are subject to ocean undercutting or wave overtopping, and on interdune areas (deflation plains) that are subject to ocean flooding, shall be prohibited.

2. Permitted uses in these areas shall be those which are of very low intensity, (such as raised wooden walkways), which do not contribute to the removal of sand or vegetation, which could be easily removed in the event of ocean flooding or other hazards, and are of minimal value.

3. Removal of vegetation during construction in any sand area shall be kept to the minimum required for building placement or other valid purpose. Removal of vegetation should not occur more than 30 days prior to construction. Permanent revegetation shall be started on the site as soon as practical after construction, final grading or utility placement. Storage of sand or other materials should not suffocate vegetation.

4. In open sand areas which are being revegetated, and in open sand areas created during construction, revegetation must be closely monitored and carefully maintained, including restriction on pedestrian traffic. In all other sand areas from which vegetation is removed, the revegetation program should return the area to its original level of stability. A revegetation program with set time limits should be included in the developer's application for building permits for subdivision.

5. Site specific investigations by a qualified expert shall be required for the issuance of building permits in open sand areas, on hillsides in sand areas regardless of the type of dune or its present stability, and in those conditionally stable dunes not subject to ocean hazard, but which in the view of the building official have potential for wind erosion or other damage. Site reports shall be paid for by the developer, and the City may submit the reports to State and Federal agencies for evaluation.

6. Excavation and grading in sand areas shall be carefully controlled by the building official, through enforcement of Chapter 70 of the Uniform Building Code and the above policies.

7. The developer or party initiating action in sand areas shall be responsible for preventing adverse impacts on adjacent property, city streets, or utilities. Where necessary, the City may cause such impacts to be corrected at the expense of the developer, and place a lien on the property.

8. Breaching of foredunes shall only be done in extreme cases and when necessary for an emergency such as fire fighting or cleaning up oil spills.

9. Wells in dune areas shall not be permitted, in order to prevent the drawdown of groundwater and possible destruction of vegetation.

BEACHFRONT PROTECTIVE STRUCTURES POLICIES

1. In accordance with the Beaches and Dunes Goal, criteria for placement of beachfront protective structures shall provide that:

   a. Visual impacts are minimized;

   b. Access to the beach is maintained;

   c. Impacts on adjacent property are minimized;

   d. Long-term or recurring costs to the public are avoided.

2. The previous criteria shall apply to protective structures both on the public beach and east of the State zone or vegetation line.

3. Protective structures shall be properly engineered to reduce the need for future maintenance, and shall be the minimum necessary to protect the shoreline. Riprap shall be preferred over concrete seawalls as a protective device, and be as unobtrusive as possible.

4. Lots or parcels which have been subdivided shall be considered "developed" under the meaning of the State Goal and the Plan.

MANZANITA ZONING ORDINANCE NO. 78-6 *

Article 4. Supplementary Provisions

Section 4.050 Dune Construction Requirements.

(1) Removal of vegetation during construction in any sand area shall be kept to the minimum required for building placement or other valid purposes. Removal of vegetation should not occur more than 30 days prior to grading or construction. Permanent re-vegetation shall be started on the construction site as soon as practical after construction, final grading or utility placement. Storage of sand and other materials should be done so as not to suffocate vegetation.

(2) In open sand areas which are being re-vegetated, and in open sand areas created during construction, re-vegetation must be closely monitored and carefully maintained, including restrictions on pedestrian traffic. In all other sand areas from which vegetation is removed, the minimum acceptable re-vegetation program should return the area to its pre-construction level of stability (such as conditionally stable, or stabilized). This would entail the planting of trees in addition to ground cover such as beach grass. A re-vegetation program with set time limits should be included in the developers application for building permits or subdivisions.

(3) Site-specific investigations by a qualified engineering geologist or soils engineer may be a prerequisite for the issuance of building permits in open sand areas, on hillsides of over 20% , in sand areas regardless of the type of dune or its present stability, and in thos conditionally stable dunes not subject to ocean hazard, but which in the view of the building official have potential for wind erosion or other damage. Site investigations shall be done at the developer's expense. The City may submit any site reports to the State Department of Geology and Mineral Industries or other agency to assess its completeness.

(4) Excavation and grading in sand areas shall be carefully controlled by the building official, either through enforcement of Chapter 70 of the Uniform Building Code or the above policies.

* From Morgan, 1978.

ROCKAWAY ZONING ORDINANCE NO. 143 *

Section 4.044. DUNE CONSTRUCTION POLICY.

(1) Removal of vegatation during construction in any sand area shall be kept to the minimum required for building placement or other valid purposes. Removal of vegetation should not occur more than 30 days prior to grading or construction. Permanent re-vegetation shall be started on the construction site as soon as practical after construction, final grading or utility placement. Storage of sand and other materials should be done so as not to suffocate vegetation.

(2) In open sand areas which are being re-vegetated, and in open sand areas created during construction, revegetation must be closely monitored and carefully maintained, including restrictions on pedestrian traffic. In all other sand areas from which vegetation is removed, the minimum acceptable revegetation program should return the area to its preconstruction level of stability (such as conditionally stable, or stabilized.) This would entail the planting of trees in addition to ground cover such as beach grass. A revegetation program with set time limits should be included in the developers application for building permits or sub-divisions.

(3) Site-specific investigations by a qualified expert (refer to the appendix for guidelines) may be a prerequisite for the issuance of building permits in open sand areas, on hillsides in sand areas regardless of the type of dune or its present stability, and in those conditionally stable dunes not subject to ocean hazard, but which in the view of the building official have potential for wind erosion or other damage. Site investigations shall be done at the developer's expense. The City may submit any site reports to the State Department of Geology and Mineral Industries or other agency to assess its competeness.

(4) Excavation and grading in sand areas shall be carefully controlled by the building official, either through enforcement of Chapter 70 of the Uniform Building Code or the above policies.

*From Morgan, 1978.

A System Of Classifying & Identifying Oregon's Coastal Beaches & Dunes

Oregon Coastal Zone Management Association, Inc.

This report was prepared as part of a larger document addressing various beach and dune planning and management considerations and techniques. Other segments of the document and additional materials are:

I. BACKGROUND ON BEACH AND DUNE PLANNING:

Background of the Study

An Introduction to Beach and Dune Physical and Biological Processes

Beach and Dune Planning and Management on the Oregon Coast: A Summary of the State-of-the-Arts

II. BEACH AND DUNE IDENTIFICATION:

A System of Classifying and Identifying Oregon's Coastal Beaches and Dunes

III. PHYSICAL AND BIOLOGICAL CONSIDERATIONS:

Physical Processes and Geologic Hazards on the Oregon Coast

Critical Species and Habitats of Oregon's Coastal Beaches and Dunes

IV. MANAGEMENT CONSIDERATIONS:

Dune Groundwater Planning and Management Considerations for the Oregon Coast

Off-road Vehicle Planning and Management on the Oregon Coast

Sand Removal Planning and Management Considerations for the Oregon Coast

Oregon's Coastal Beaches and Dunes: Uses, Impacts and Management Considerations

Dune Stabilization and Restoration: Methods and Criteria

V. IMPLEMENTATION TECHNIQUES:

Beach and Dune Implementation Techniques: Findings-of-Fact

Beach and Dune Implementation Techniques: Site Investigation Reports

*Beach and Dune Implementation Techniques: Model Ordinances**

VI. ANNOTATED BIBLIOGRAPHY:

Beach and Dune Planning and Management: An Annotated Bibliography

VII. EDUCATIONAL MATERIALS:

Slide show: *Managing Oregon's Beaches and Dunes*

Brochure: *Planning and Managing Oregon's Coastal Beaches and Dunes*

*Prepared under separate contract between Oregon Department of Land Conservation and Development and the Bureau of Governmental Research, Eugene.

Illustrations prepared by Lorraine Morgan, Newport, Oregon
Cover photo by Christianna Crook, Newport, Oregon

A SYSTEM OF CLASSIFYING AND IDENTIFYING OREGON'S COASTAL BEACHES AND DUNES

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PREFACE

The following report presents the results of an in-depth analysis of beach and dune identification and classification systems conducted by the Oregon Coastal Zone Management Association, Inc. This report constitutes one element of an overall analysis of planning for and managing beaches and dunes as required by Oregon's Beaches and Dunes Goal.

This report was prepared by Christianna Crook, OCZMA Beaches and Dunes Study Team Research Associate, with assistance from other Study Team members composed of Carl Lindberg, Project Director, Wilbur Ternyik, Project Coordinator, Arlys Bernard, Project Secretary, and Kathy Fitzpatrick, Project Administrator.

In addition, valuable review and comments were made by the Beaches and Dunes Steering Committee composed of:

R. A. Corthell, U.S. Soil Conservation Service
Steve Stevens, U.S. Army Corps of Engineers
Sam Allison, Oregon Department of Water Resources
Peter Bond and John Phillips, Oregon Department of Transportation, Parks and Recreation Division
Bob Cortright, Oregon Department of Land Conservation and Development
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Steve Felkins, Port of Coos Bay
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Cathy Mecone, Coos-Curry Council of Governments
Marilyn Adkins, City of Florence Planning Department
Phil Bredesen, Lane County Planning Department
Steve Goeckritz, Tillamook County Planning Department
Oscar Granger, Lincoln County Planning Department
Curt Schneider, Clatsop County Planning Department

Additionally, OCZMA extends special appreciation to the following individuals for their valuable input and direction and for their significant contributions to this report:

Bill Burley, Program Biologist, The Oregon Natural Heritage Program of the Nature Conservancy
Don Leach, District Conservationist, U.S.D.A., Soil Conservation Service

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Cathy Mecone, Planning Research Associate, Coos-Curry Council of Governments
Dr. Leonard Palmer, Department of Earth Science, Portland State University
Dr. James Stembridge, Coastal Resource Specialist, Oregon State Soil and Water Conservation Commission, and
Wilbur Ternyik, Owner/Operator, Wave Beachgrass Nursery

Finally, OCZMA expresses its sincere appreciation to the University of Washington Press for permission to reprint illustrations from Vascular Plants of the Pacific Northwest by C. Leo Hitchcock, et. al., (1955-1969).

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I. INTRODUCTION

Beaches and dunes are found on those accumulations of sand which occur intermittently along the Oregon coast. They range in size from small pocket beaches between headlands to expansive dune sheets more than twenty miles long and three to four miles wide. Varying combinations of physical factors (e.g. wind, vegetation, and moisture, etc.) are capable of producing widely diverse beach and dune landforms. Each landform exhibits discrete physical capabilities as well as characteristic sensitivies to man's activities.

Dune forms exhibit varying states of stability. Areas of *open sand* occur where dune topography is controlled only by sand and wind. Lightly vegetated areas are considered to be in an *active* state and are continuously subject to erosion and accretion. Dunes are *conditionally stabilized* when they have sufficient vegetative cover to withstand wind erosion. Other dune forms can be *surface stabilized* or *older* (semi-cemented) *stable*. That is, they may exhibit vegetation with a thin layer of soil, or may have vegetation and extensive soil layer with semi-cemented underlying sands.

This report classifies, describes and discusses the physical and biological nature and general capabilities of coastal Oregon sand landform types.[1] In addition, a checklist of physical and biological features characteristic of each type is included to assist with field identification. A glossary of terms used in this report is presented in the concluding section.

II. BEACH

A relatively narrow, sloping zone of unconsolidated materials extending from the low tide line landward to the uppermost line of effective wave or tidal action.

A. Geomorphology

Beach materials range in size from fine sand, to pebbles and even small boulders and are supplied from the erosion of coastal cliffs, the reworking of ancient and recent coastal sand deposits, and from riverine sediment loads. Sand supply and beach formation processes occur in seasonal cycles in which beaches commonly experience sand removal during the winter and are rebuilt by the more gentle wave action associated with summer weather activity. Beaches are the coastline's

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[1] Illustrations indicate the degree of magnification or reduction.

primary defense against the erosive action of storm waves.

Sand dunes, cliffs and drift log accumulations may occur at the landward side of beaches. Some parts of the coastline are repeatedly interrupted with headlands, creating small pockets of cobble beaches. Elsewhere the seaward margins of vast dune sheets create extensive beaches.

1. Stable beaches

In terms of sand availability, beaches may be stable, eroding or accreting. A stable form is one which experiences neither a net loss nor gain in beach materials on an annual basis. Gentle summer waves replace the same amount of sand on the beach as was lost offshore during winter storms. Beaches which are presently stable include Sand Lake in Tillamook County and the region between the mouth of the Umpqua in Douglas County and mouth of the Coquille River in Coos County.

2. Eroding beaches

An eroding beach is one which annually experiences net sand loss. This can result from continuous excessive erosion, diminishing beach sand supplies, or both. Erosion occurs primarily during vigorous winter storms and may be heightened by such factors as a high spring tide which effectively increases wave height. A reduction in beach sand supply may result from dams, riprap, jetties, commercial removal, or other structures or activities which modify beach material transport or near shore currents.

Eroding beaches can often be recognized in their earlier stages by the development of a steeper than usual profile (Figure 1). Some

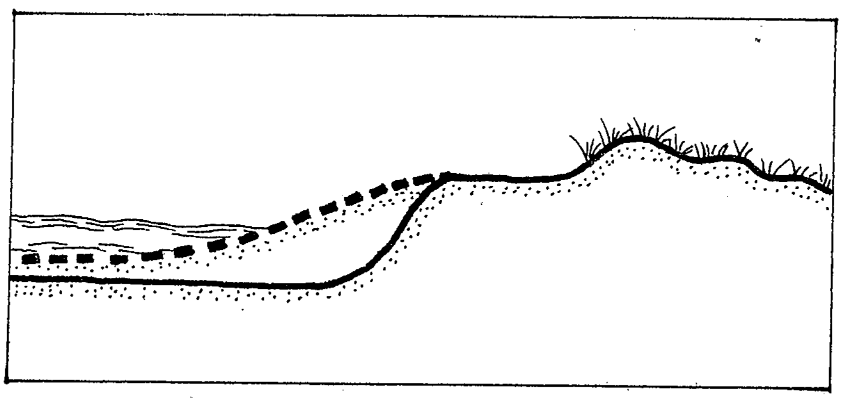


Figure 1. Steepened profile characteristic of an eroding beach.

eroding beaches may contain noticeable eroded embayments, or cusps, which are the result of local rip currents carrying sand away from the beach (Figure 2). Beaches presently in an eroding state include the beach from Peter Iredale Park, north to the Columbia River south jetty in Clatsop County and the area between Blacklock Point and Floras Lake in Curry County.

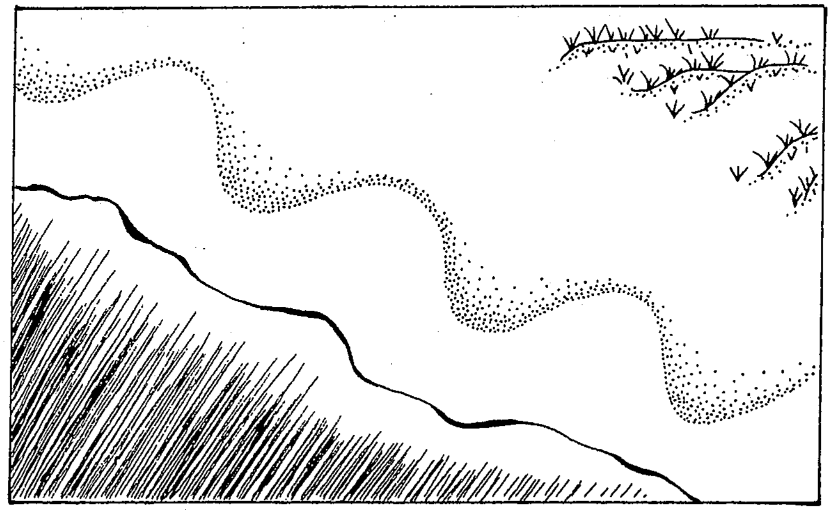


Figure 2. Beach cusps.

3. Accreting beaches

Any beach which has a low-tide margin experiencing net seaward growth due to an annual increase in sand supply is considered to be accreting. The development of small persistent dunes seaward of the foredune is indicative of this sand accumulation process. With continued accretion, the developing dunes will eventually grow and join to form a new foredune seaward of the previous one. Accretion at a site may be the result of escalated erosion elsewhere, beach or spit migration, natural and/or induced changes in off-shore currents, or structures and activities which modify beach material transport. To a limited extent, a beach may experience accretion due to the sand-trapping ability of dune grass. This is only likely to occur, however, when the near shore environment already favors accretion. Examples of accreting beaches include the area adjacent to the community of Surf Pines in Clatsop County, the north end of South Beach in Lincoln County, and just north of Gold Beach in Curry County.

B. Vegetation

High winds, waves and cyclic tidal inundation severely restrict vegetative growth in the beach zone. However, many types of seeds germinate easily in wet sand and a few hardy species may be found on the higher beach slopes in the summer and fall (Wiedeman, et. al., 1974, p. 25). Such plants are not found growing in great profusion. In fact, it may be that only one or two species, if any, will occur in a given beach area. These may occur as isolated individuals, and will commonly experience burial or destruction during the period of winter storms.

Three species which occur most commonly on the beach include American sea rocket (Cakile edentula), European sea rocket (Cakile maritima) and honkenya (Honkenya peploides). Although not peculiar to beaches, European beachgrass (Ammophila arenaria), sea lyme-grass (Elymus mollis) and seashore bluegrass (Poa macrantha) are occasionally found in this zone.

C. Attractions and Limitations

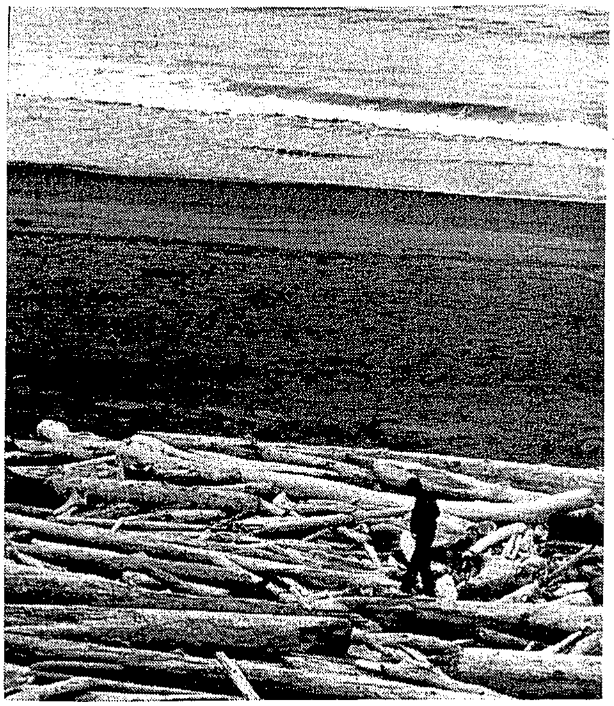
The beach is a highly attractive site for numerous recreational activities ranging from beachcombing to operation of off-road vehicles. It lends itself well to both solitary and group activities and, as a geologic feature, seems to be relatively tolerant of most transient activities. Management of this landform should consider such issues as (1) the desirability of allowing vehicle traffic and significant pedestrian use in the same areas, and (2) harrassment of shore bird species by various recreational activities.

D. Identification Checklist

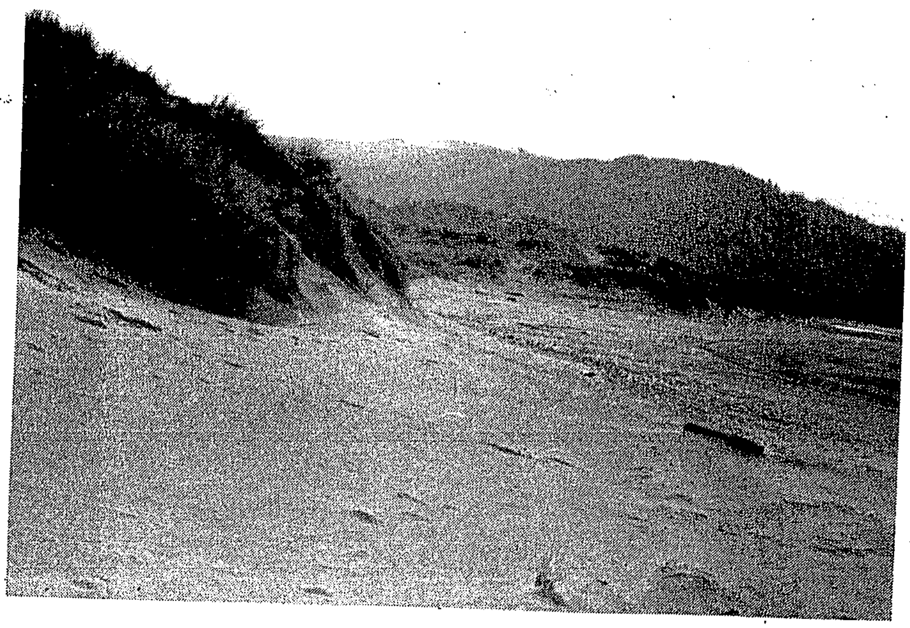
The beach can be recognized by the following characteristics:

1. The landward boundary of the beach may be characterized by one of the following:

   a. drift log accumulations,

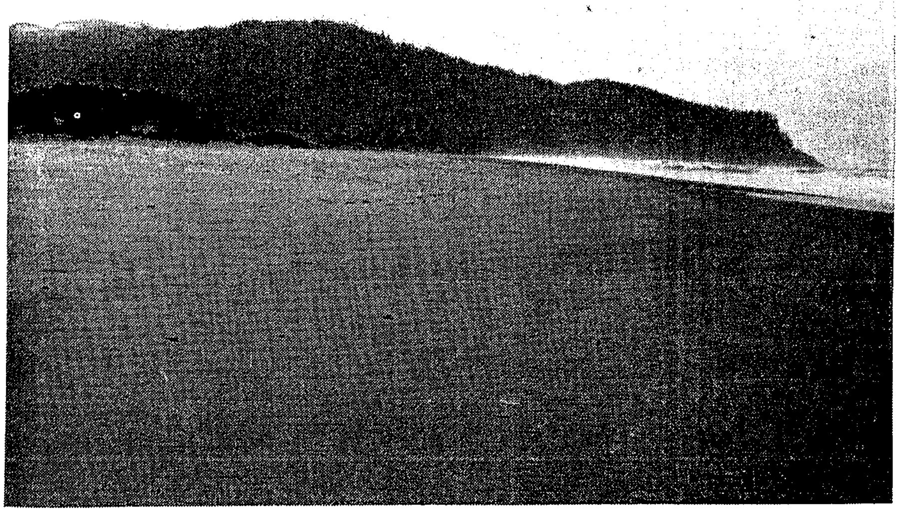


   b. foredune ridge, or

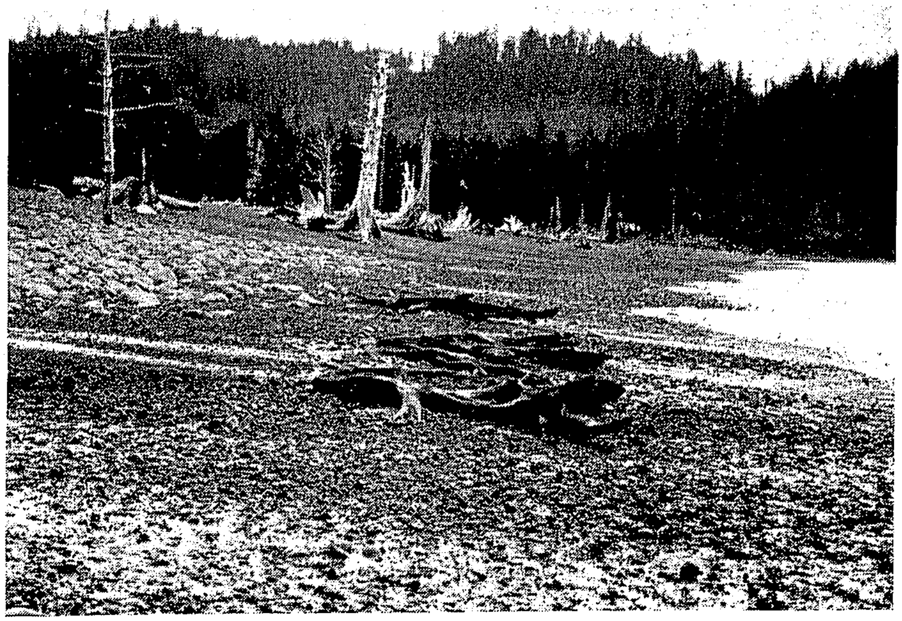


c. cliffs

2. Beaches may consist of fine to medium grained sands and exhibit a relatively gentle slope.



3. A steeper slope profile is exhibited by those beaches which consist of pebbles and/or boulders.

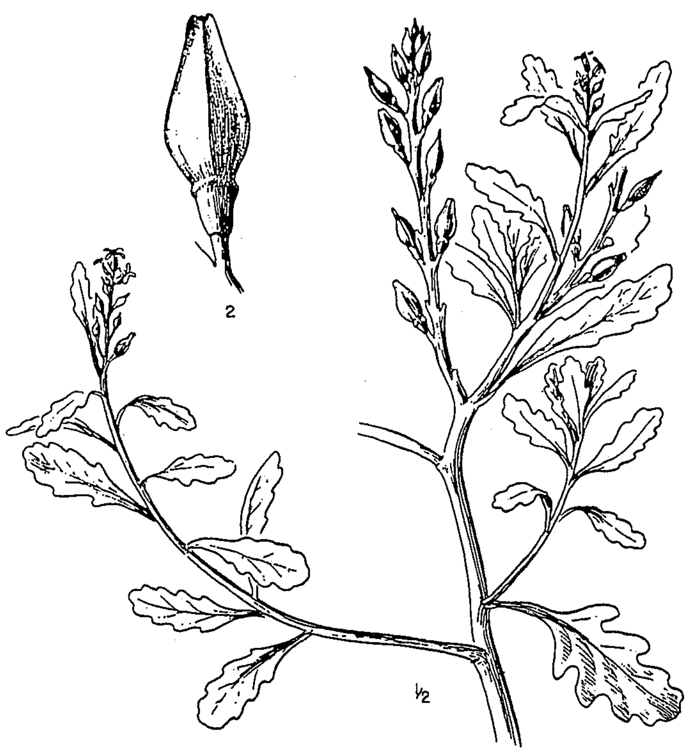


4. Erosion is sometimes caused by stationary rip-currents which eat embayments or cusps into the beach and foredune.

5. Accreting beaches may often be recognized by the development of embryo dunes seaward of the foredune.

6. The most commonly occurring beach vegetation includes the following:

a. American sea rocket (Cakile edentula),



flowers - purple to white

b. European sea rocket (<u>Cakile maritima</u>), similar to <u>Cakile edentula</u> except for the fruit, and

c. Honkenya (<u>Honkenya peploides</u>).

flowers - greenish to white

III. FOREDUNE

First ridge of sand situated immediately above the high tide line and parallel to the beach.

A. Geomorphology

The present day foredune of the Oregon coast has developed primarily in the last forty years as a result of the introduction of European beachgrass (Ammophila arenaria). First introduced for sand stabilization in the Coos Bay area in 1910 and the Clatsop Plains in 1935, this species became naturalized to the coastal sand areas. It spread along the coast forming a nearly continuous barrier ridge along the shore. European beachgrass prefers sites of continuous sand deposition. It grows seaward until it is halted by wave action at the high tide line. Embryo dunes form here at the landward edge of the beach in conjunction with vegetation and drift log accumulations where the velocity of the wind decreases suddenly, depositing the sand load (Figure 3). Continued

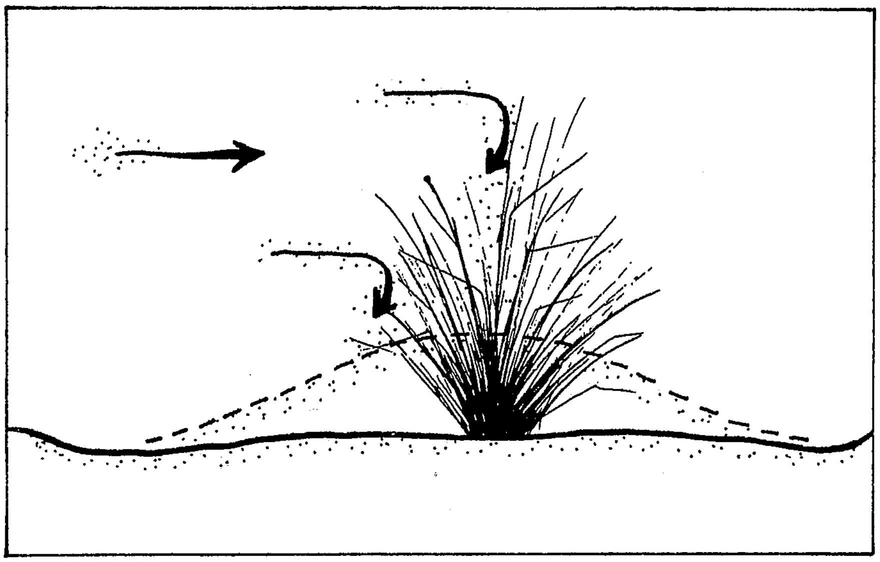


Figure 3. Sand deposition around a beach grass windbreak.

deposition may lead to the burial of the original obstacle. The driftlogs remain buried forming the base of the foredune but European beachgrass (Ammophila arenaria) can survive seasonal sand burial of up to three feet and for that reason is the primary foredune building agent. As sand builds up around the base of the plant, new roots and shoots grow from the stem joints (Figure 4). This traps more wind-blown sand above, while holding underlying sand within the complicated root network below.

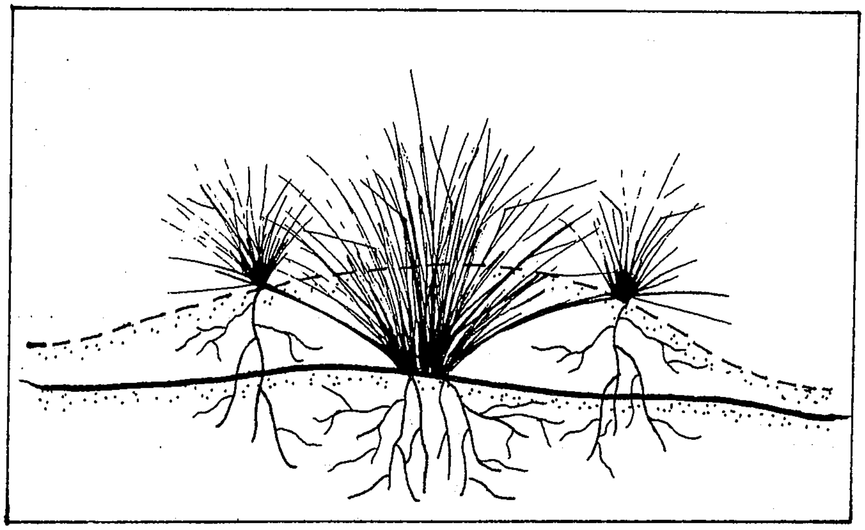


Figure 4. As European beachgrass is buried, new shoot and root growth develops at the dune surface.

The dune thus increases in height and width until it merges with adjoining dunes to form a barrier ridge along the upper beach. This dune-ridge area stops and holds most of the sand blowing in from the beach and continues to grow until it reaches the maximum height dictated by local conditions, usually up to twenty-five or thirty feet. It may be bounded on the east by deflation plains, interior dunes, cliffs, marshes, lakes or estuaries.

The foredune is a naturally occurring geomorphic feature which, to some degree, acts as a dike during ocean storms. It's function transcends that of a simple barrier-wall because it has a sponge-like ability to absorb and mute the force of storm waves. Hitting the foredune, wave energy is dissipated over, around and, most critically into the dune. However, while it can act as an effective shock absorber, the foredune can occasionally sustain considerable damage during storms and may be unable to provide sufficient storm protection to inland sites, thus allowing adjacent deflation plains or hummock dunes to be exposed to the full force of maritime storms. In such instances, the area of potential hazard is extended beyond the foredune to include additional inland sites. Any excavation into, or construction modification of the foredune may increase this hazard potential.

Foredunes are among the most dynamic of landforms and will naturally vacillate between periods of being active (subject to wind and wave erosion and breaching) and being conditionally stable (wind stable but subject to wave erosion and breaching).

The term "foredune" is applied to this dune ridge wherever it occurs along the Oregon coast. This feature varies considerably in appearance, however, and to some degree in function, between the north coast (Clatsop County) and the central-south region.

The foredune ridge which occurs in the central and southern counties commonly varies between ten to thirty feet in height, is twenty to fifty feet wide at the base and often appears as a distinctive sea-wall ridge particularly when viewed from the beach. Storm hazard in this area is primarily associated with erosive storm waves and wind, impact from solid debris carried by the waves, and flooding of inland sites.

The foredune in the Clatsop area is commonly an extremely broad, low appearing feature. While it may reach heights of more than twenty-five feet, the gradient is so gentle, often five degrees or less, that it has a less distinctive sea-wall appearance. Storm hazard on the north coast (north of Seaside) is more commonly associated with inundation from sand than from erosion or debris impact. Wave run-up may be considerably reduced by the extensive traverse associated with the long, shallow, off-shore area and the extreme width of the foredune. However, storm-velocity winds are capable of transporting generous quantities of sand available in this region considerably inland. The gentle gradient common to Clatsop foredunes may also offer less obstruction to the wind. Thus, the "functional" width of the foredune (or the area impacted by maritime storms) in the Clatsop area can be as great as 800 feet depending on local conditions (Leach, 1978). The "foredune" under this designation, may contain more than one "ridge" so the term "foredune area" may be more applicable (Ternyik, 1978). Furthermore, while storm associated sand deposition can cause sand-blasting type damage and may result in subsequent excavation costs, this activity may be more aptly designated as "nuisance" rather than true "hazard" to life or property.

1. Active foredunes

Sand dunes are in an active state when they possess insufficient vegetative cover to retard wind erosion. In this condition the sand dune is experiencing active accretion and/or erosion.

On a static or accreting beach, an active foredune will commonly evolve towards the conditionally stable state. As the active foredune grows in height (up to thirty feet), it becomes an increasingly effective barrier and progressively less sand is deposited on the lee side of the dune and other sites inland. This offers somewhat greater protection from storm winds, but also seriously limits all fresh beach sand supplies to interior open sand areas.

Active foredunes may be most numerous in central and north coast areas. They occur, for example, in Clatsop County west of Slusher and Sunset Lakes and in Tillamook County at Neskowin North.

2. Conditionally stable foredunes

When foredunes exhibit sufficient vegetative cover to retard the erosive effects of the wind, they are termed conditionally stable. Obviously, the stability of a given foredune is conditional upon the maintenance of the vegetative cover.

While the conditionally stable foredune may not have any greater resistance to wave erosion than does an active foredune, it appears to recover more quickly from wave overtopping (Ternyik, 1978). However, any conditionally stable sand dune is prone to reactivation upon disturbance of the vegetative cover.

Examples of conditionally stable foredunes presently occur between Sunset beach and Gearhart in Clatsop County and at the community of Bayshore in Lincoln County.

B. Vegetation

1. Active foredunes

The active foredune receives such a substantial sand supply that it is occupied almost exclusively by European beachgrass (Ammophila arenaria). Some native dune grasses such as sea lyme-grass (Elymus mollis) may be found here but occur less commonly as they are less tolerant of continual sand burial.

2. Conditionally stable foredunes

The increasing height of the conditionally stable foredune restricts the inland passage of salt spray and sand. A new environment is thus created on the crest and the lee side of the foredune which is reflected in the vegetation at this site. European beachgrass (Ammophila arenaria), the most significant species which occurs on the foredune, becomes less important because it prefers the more fertile sites of sand deposition. Other species less tolerant of salt spray and sand deposition become established. The first to become established include, among others, such herbs as beachpea (Lathyrus japonicus), coast strawberry (Fragaria chiloensis) and seashore lupine (Lupinus littoralis). Later successional species may include such woody shrubs as salal (Gaultheria shallon), or kinnikinnick (Arctostaphylos uva-ursi) and an occasional shore pine (Pinus contorta).

The lee side of a foredune may exhibit vegetation characteristic of conditional stability and yet be experiencing erosion and undercutting on its windward side. Such circumstances indicate that the foredune was formerly in a conditionally stable state long enough for some vegetative succession to take place, and has only recently begun to experience erosion. The remaining foredune ridge has apparently been able to provide sufficient protection to the lee side to maintain existing vegetation. Should the oceanward side experience temporary in-filling with logs, sand and beach grass during the summer it could deceptively give the appearance of a completely conditionally stable foredune.

C. Attractions and Limitations

While the foredune may not be a primary recreational attraction in itself, it nonetheless experiences moderate recreational traffic. This is partially because it is a barrier which must be traversed in order to reach the beach. It is also used as a sheltered 'base camp' from which forays to the beach are made. However, because of its hummocky, semi-stable surface and the sharp tips of the European beachgrass, pedestrian traffic usually follows open pathways. This activity, referred to as "trailing", results in the development of open mobile sand trails. However, the continual replenishment of fresh sand in active dune areas commonly maintains sufficient fertility for beach grass regeneration. Thus, trailing is not necessarily a serious problem unless it is desirable for the active foredune to become conditionally stable (OCCDC, 1975). Conversely, the trailing which results from the passage of motorbikes and other off-road vehicles inhibits beach grass regeneration and creates troughs from which blowouts can develop.

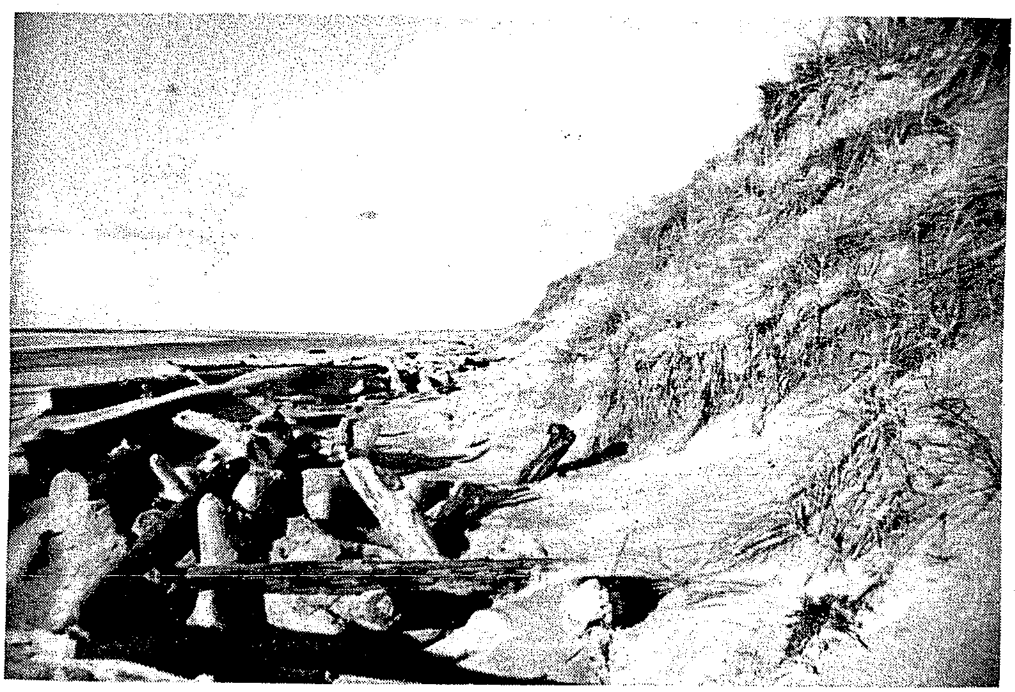
The proximity of this landform to the ocean renders it at once highly attractive and yet extremely hazardous as a site for permanent structures. Construction of permanent structures which either project onto the beach or require any excavation of the foredune endangers the site and adjacent areas. Erosion intensification, interruption of natural sand movement, and wind-blown mobile sands are potential hazards associated with such disturbance. Additionally, the installation of riprap to protect structures impedes the natural flow of beach and foredune materials, possibly resulting in beach starvation at the site or elsewhere. Goal 18 specifically addresses the problem of development on active and other foredunes. No active dune, by definition, should harbor permanent structures as they may be subject to inundation or undermining due to moving sand. Permanent structures should be reserved for permanent landforms. Management of this landform should consider the highly dynamic mobile nature of this land/sea interface area.

D. Identification Checklist

The foredune can be identified by the following characteristics:

1. A sparsely or thickly vegetated sand dune ridge five to twenty-five feet high, running parallel to the beach.

2. The foredune is bordered by the beach and possibly drift logs on the west.



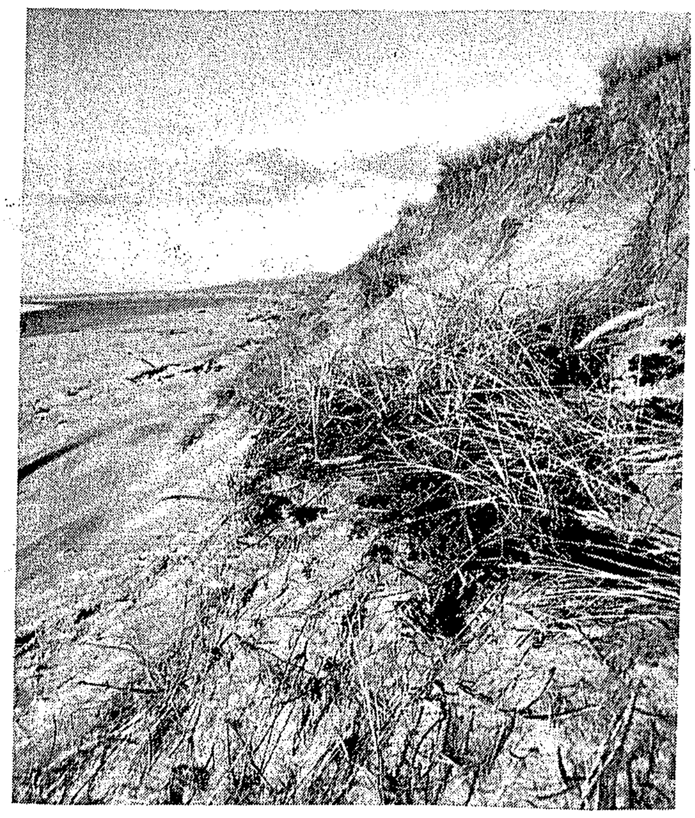
3. It commonly occurs adjacent to:

   a. hummock dunes, or

   b. the deflation plain on the east.

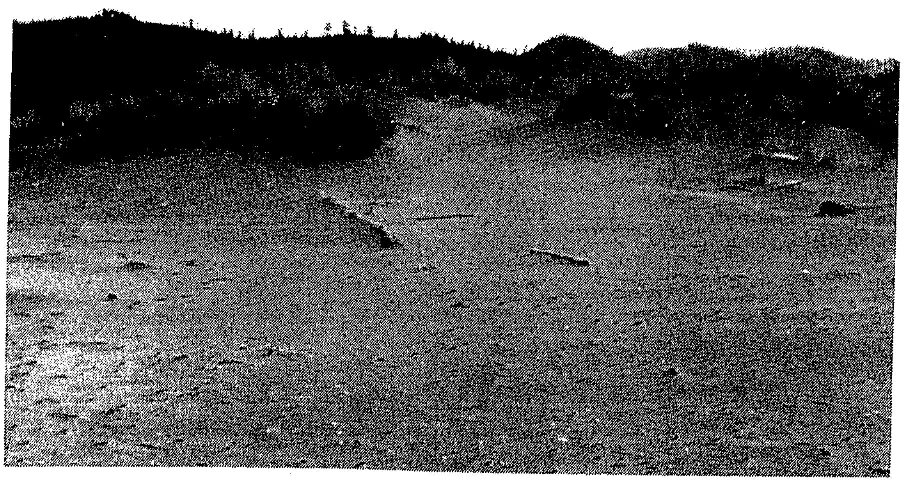
4. The active foredune may exhibit storm surge cuts. Logs and debris may be found here.

5. An eroding, formerly conditionally stable foredune may continue to exhibit vegetation characteristics of its conditionally stable state. (Coast strawberry is shown on the eroding face of a formerly conditionally stable foredune.)



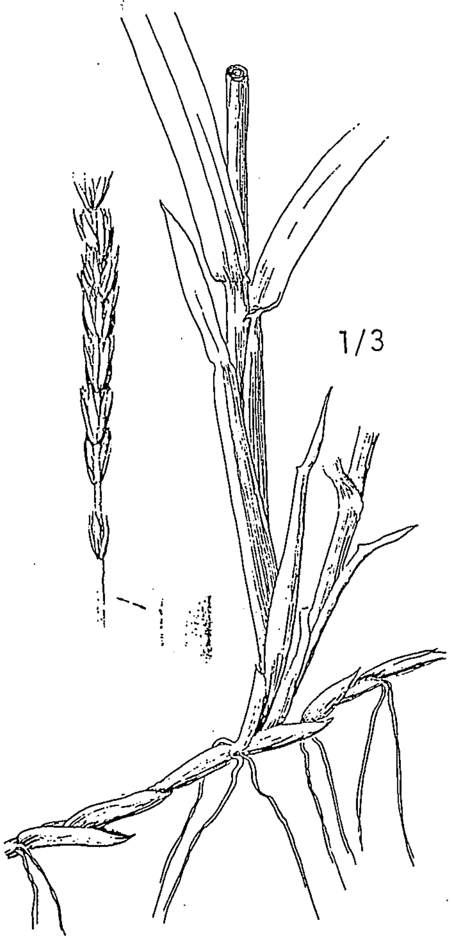
6. Drift logs may be exposed at the base of the windward face of the active foredune, particularly in the winter.

7. The vegetative cover of the active foredune is rather sparse and consists almost exclusively of European beachgrass (Ammophila arenaria).



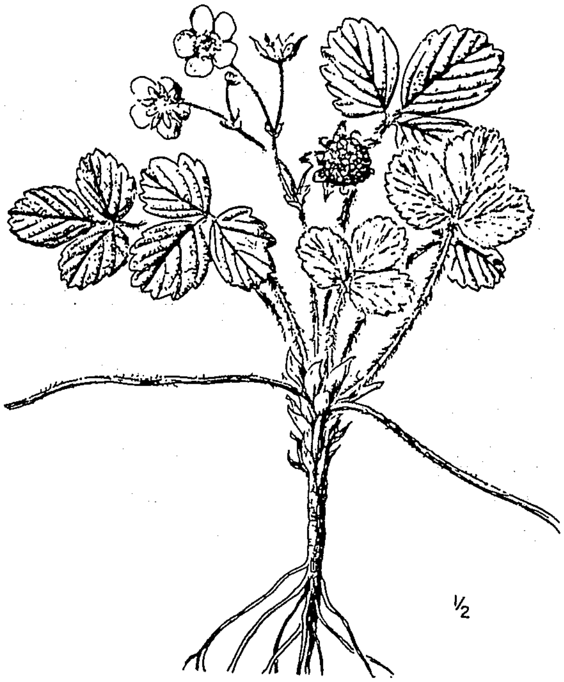
8. The conditionally stable foredune exhibits a very dense vegetative cover.

9. Sea lyme-grass (Elymus mollis) may also occur occasionally on the foredune in lesser amounts.



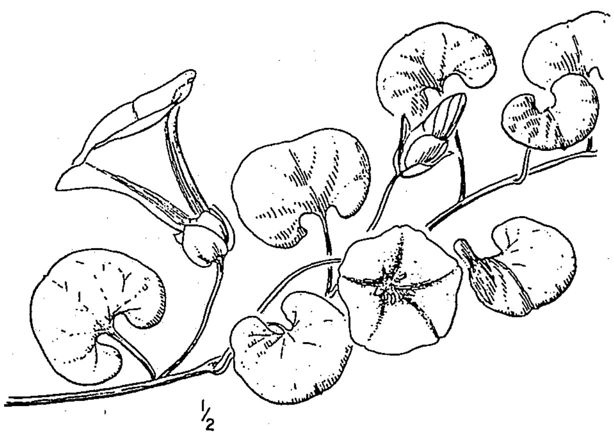
10. Species of the pioneer community found on the lee side of the conditionally stable foredune include:

a. coast strawberry (Fragaria chiloensis),



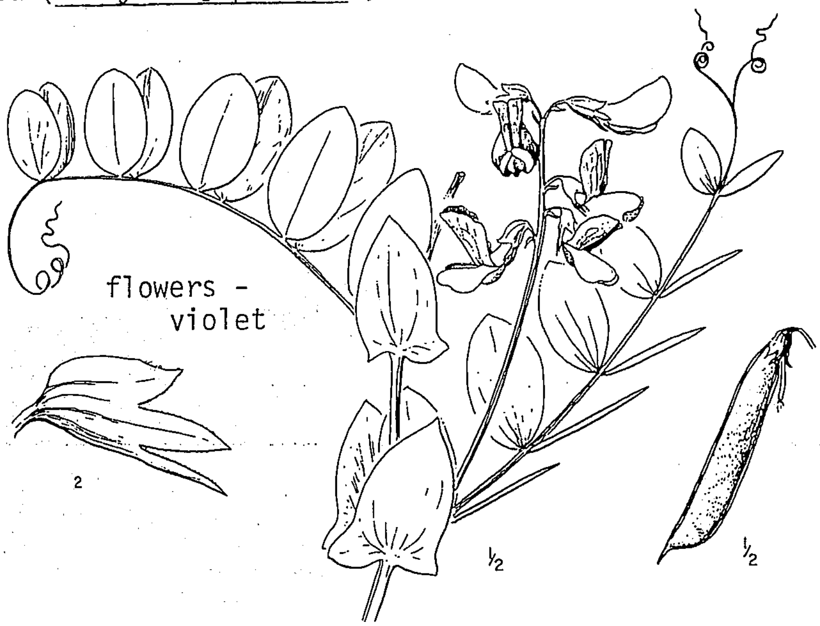
flowers - white to pinkish

b. beach morning-glory (Convolvulus soldanella),



flowers - light pink to rose

c. beachpea (Lathyrus japonicus), and

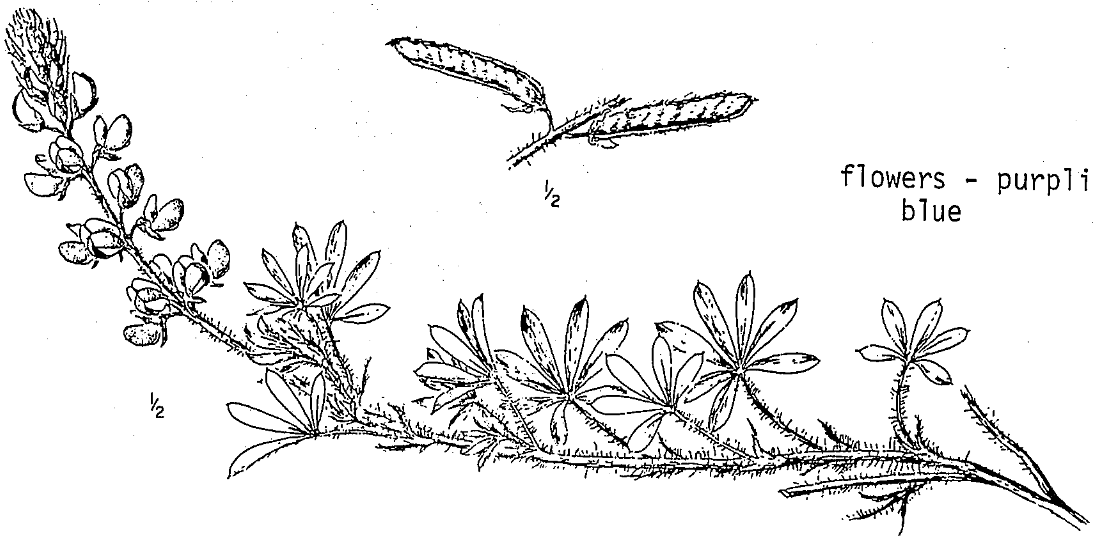


d. gray beachpea (Lathyrus littoralis).

flowers - white
to pink or
purple

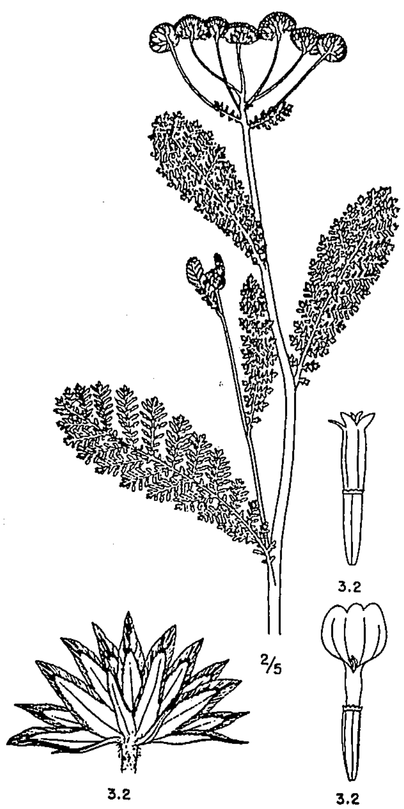
11. Four species appearing later in succession include:

a. seashore lupine (Lupinus littoralis),



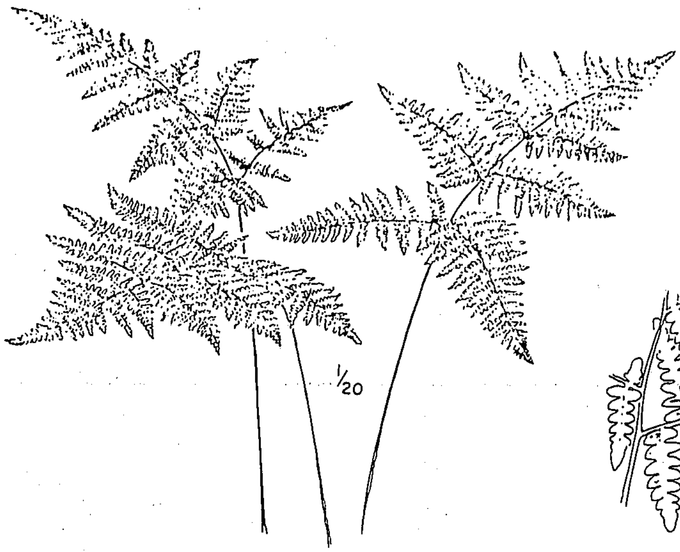
flowers - purplish blue

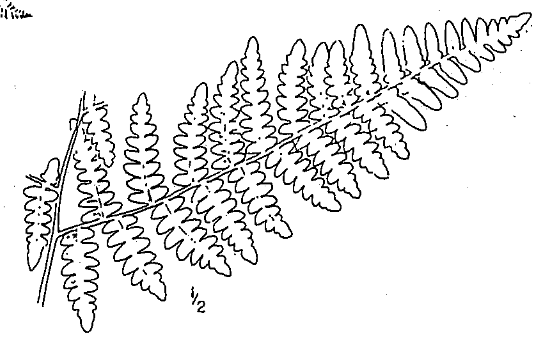
b. seaside tansy (Tanacetum douglasii),



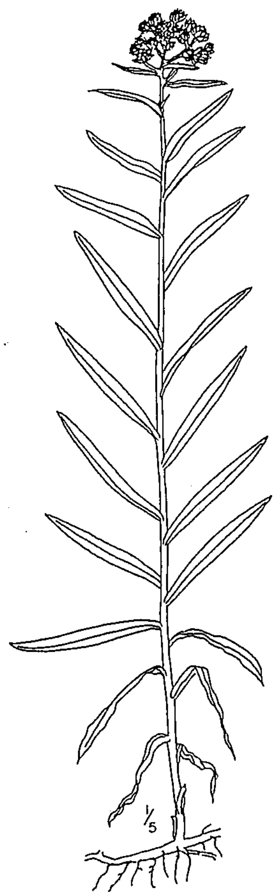
flowers - yellow

c. western bracken fern (<u>Pteridium aquilinum</u>)





d. pearly everlasting (<u>Anaphalis margaritacea</u>)

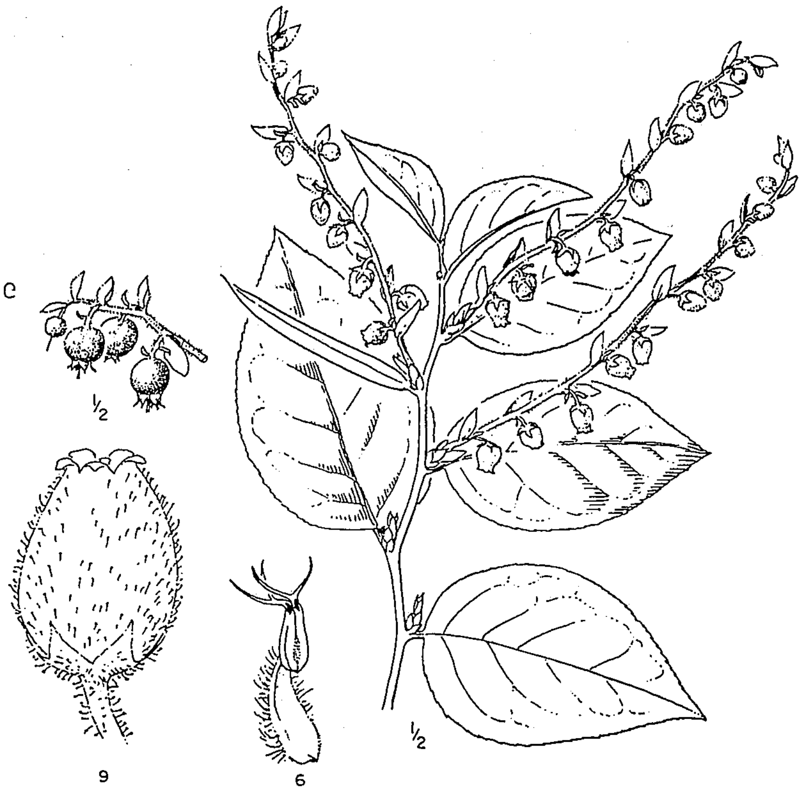


heads - white

12. By the time the later successional species appear, many of the pioneer species are no longer apparent. The following shrub species belong to this latter successional group:

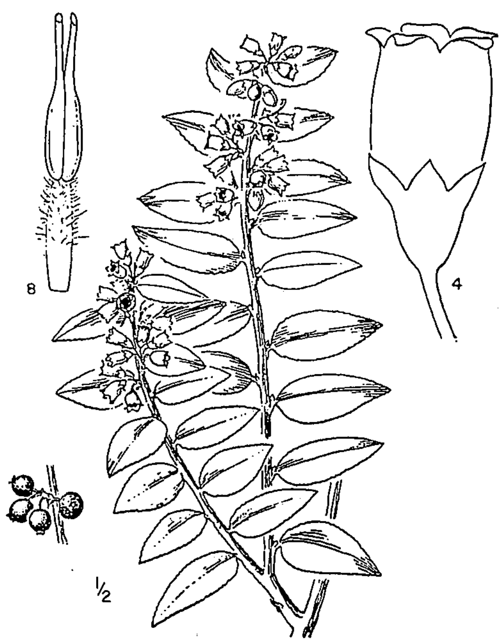
a. salal (Gaultheria shallon),

fruit - dark purple to black



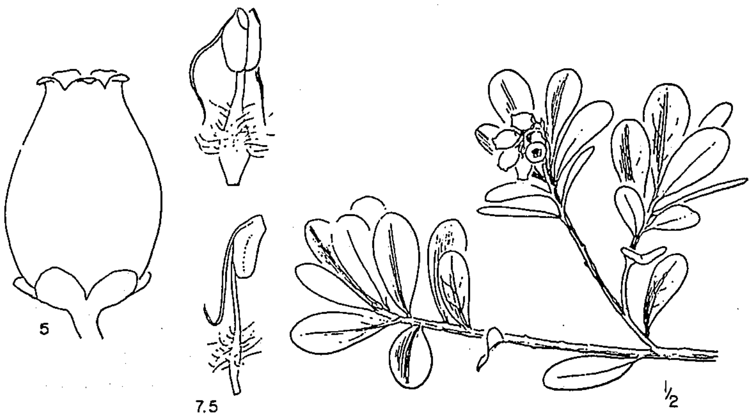
flowers - white to pink

b. evergreen huckleberry (Vaccinium ovatum),



flowers - white to pink

c. kinnikinnick (Arctostaphylos uva-ursi)



flowers - white to pink

d. hairy manzanita (Arctostaphylos columbiana)

flowers white to pale pink

IV. INTERDUNE FORMS

Interdune forms include those low areas between dunes which are often subject to the controlling factors of wind action, and/or high water table.

A. Deflation Plain

Broad plain which develops immediately inland from the foredune and is wind scoured to the level of the summer water table.

1. Geomorphology

A deflation plain is created by wind removal of dry sand particles inland from the foredune. Sand is thus removed only down to the lowered summer water table, because groundwater moisture binds sand particles together at this level. This may result in standing water during the winter when the water table is naturally higher. Sand transported inland from the deflation plain is deposited in interior dune regions. The best conditions for development of this landform probably occur behind a conditionally stable foredune, where the inland flow of sand, which could otherwise contribute to dunal development at this site, is cut off and the wind has more available energy for transport. If an active foredune exists, sand supplies are more readily passed over the ridge to form hummock dunes or open-sand dunes.

Examples of old, inactive deflation plains occur in some areas considerably inland from the foredune area. These are commonly occupied by forest communities and the water table is still quite high. These features probably developed adjacent to a foredune, but merged inland by subsequent beach accretion.

2. Vegetation

Components of the vegetation communities in the deflation plain vary according to specific site factors and the stage of successional development. In the early successional stages, grass, rush, and sedge communities occupy progressively wetter sites. Later successional stages are characterized by a low scattered shrub community, followed by the development of tall shrub thickets and eventually a shore pine forest (U.S.D.A., 1972, pp. 84-98). Water stands at, or near the surface most of the year in these sites.

The grass community occurs where water stands on the surface for two to three months of the year (vegetation covers about 80% of the ground). A few scattered shrubs and dwarfed shore pine are occasionally found in this community.

The rush community is found in sites where the water table stands on the surface for three or four months of the year (vegetation covers about 90% of the ground). Isolated shrub and tree seedlings also occur here. Coast willow (Salix hookeriana) seedlings are the most numerous.

Water stands on the surface of the sedge community for at least six months of the year. Vegetation covers about 95% of the ground.

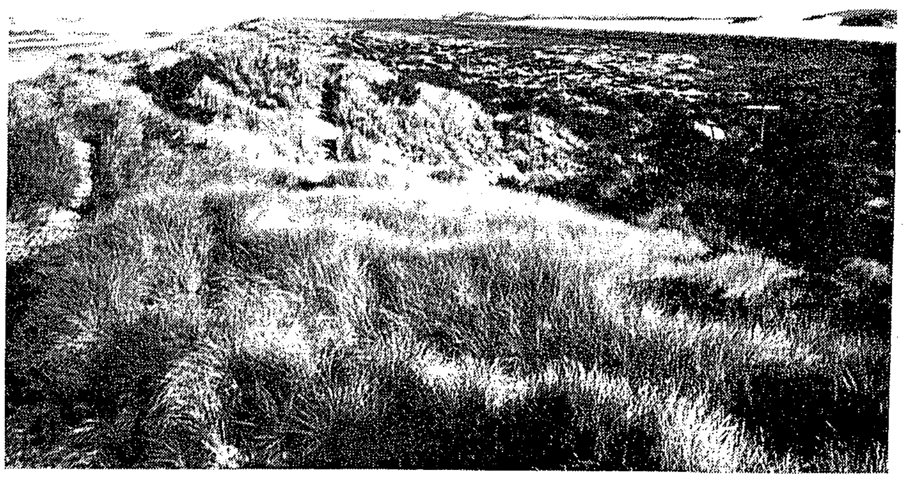
3. Attractions and limitations

The primary attractions of the deflation plain appear to be the viewing of waterfowl and, when drained, the development of housing. Many deflation plain marsh communities provide habitat for a number of waterfowl, which is lost when the site is developed. Even when drained, the water table remains quite high and septic tanks, drainfields, and other buried structures may not be appropriate. Flotation and failure of such structures could occur with resulting pollution.

4. Identification check-list

The deflation plain may be identified by the following features:

1. It is a low plain bordered on its ocean side by a foredune.



2. The deflation plain may be bordered on the eastern boundary by:

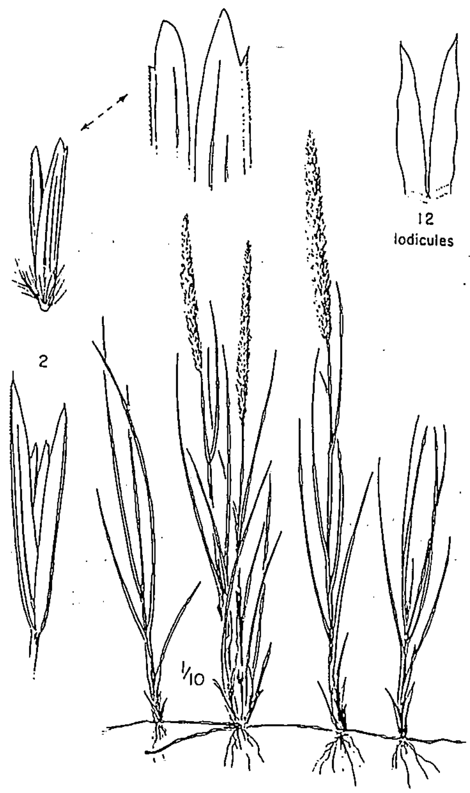
   a. hummock dunes or,

   b. transverse-ridge dunes.

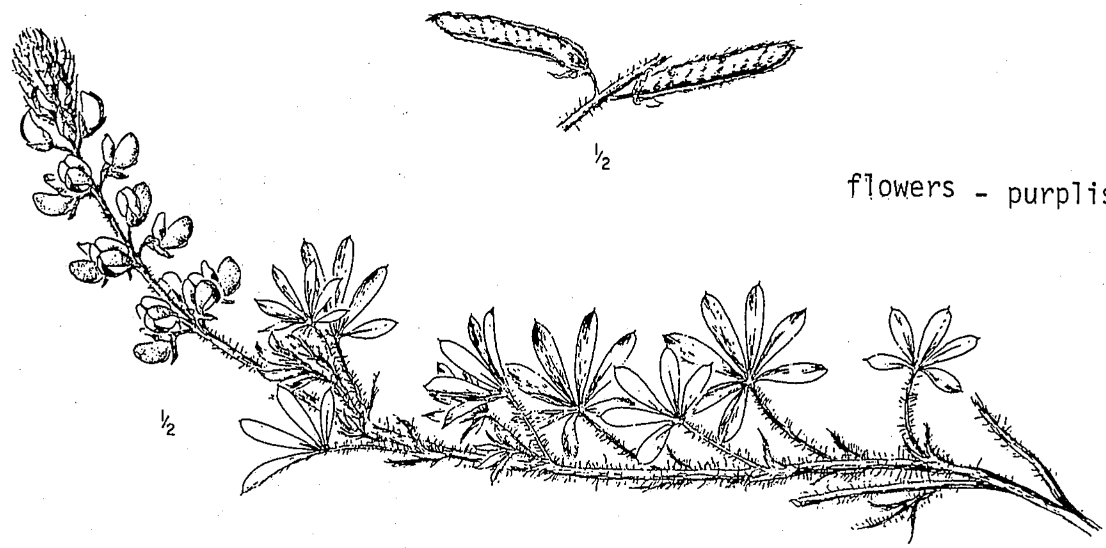
3. It may contain standing water several months of the year.

4. Important species of the deflation plain grass community include:

a. European beachgrass (<u>Ammophila arenaria</u>),

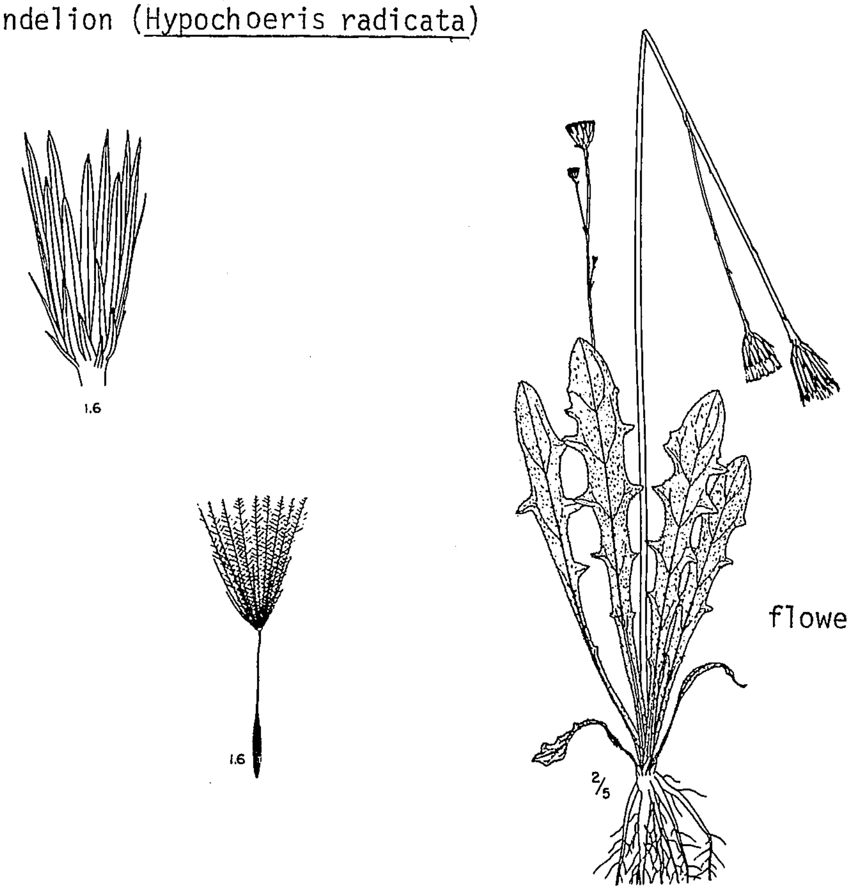


b. seashore lupine (Lupinus littoralis)



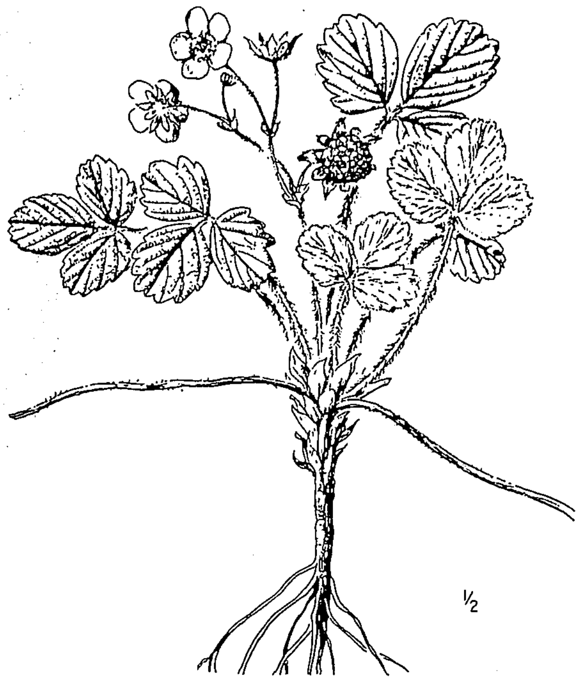
flowers - purplish blue

c. false dandelion (Hypochoeris radicata)



flowers - yellow

d. coast strawberry (Fragaria chiloensis)

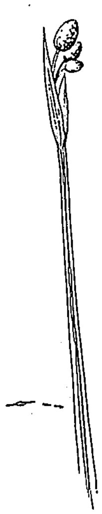


½

flowers - white to pinkish

e. yellow-eyed grass (Sisyrinchium californicum)

flowers - yellow



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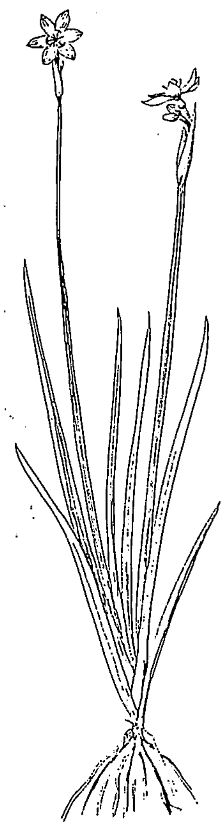

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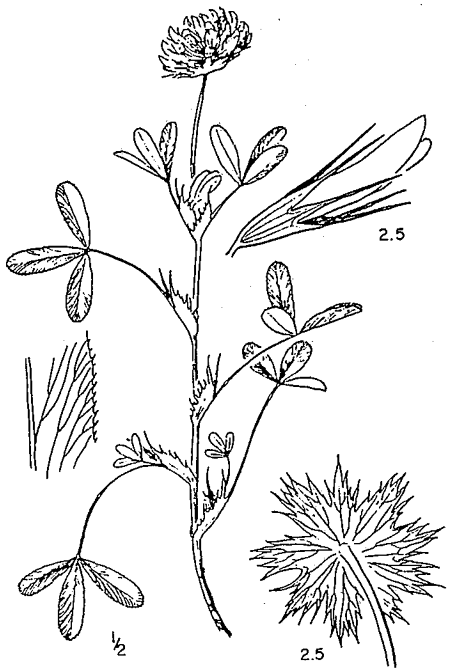
5. The following plants are most common in the rush community:

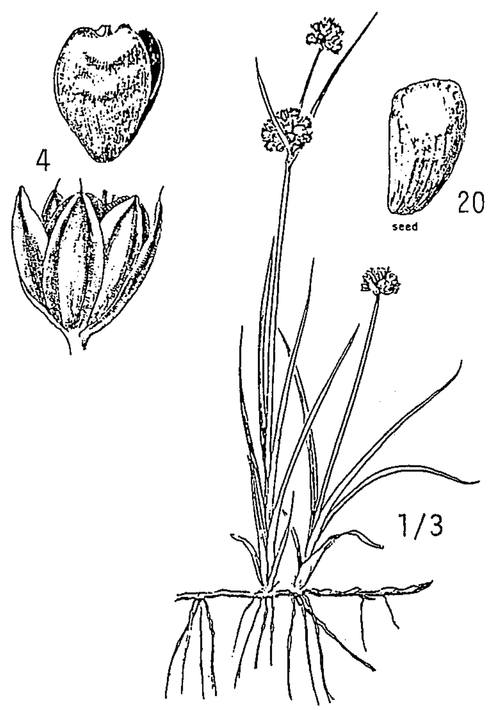
   a. spring-bank clover (<u>Trifolium wormskjoldii</u>).



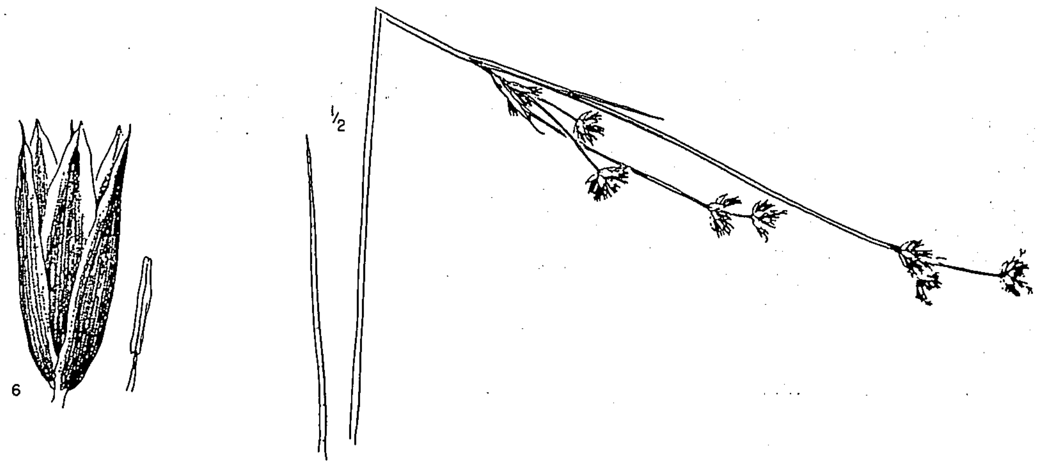
flowers - purplish-red
often white-tipped

   b. Rushes are important here. (They may be identified by a round stem.)

      (1) sickle-leaved rush (<u>Juncus falcatus</u>)



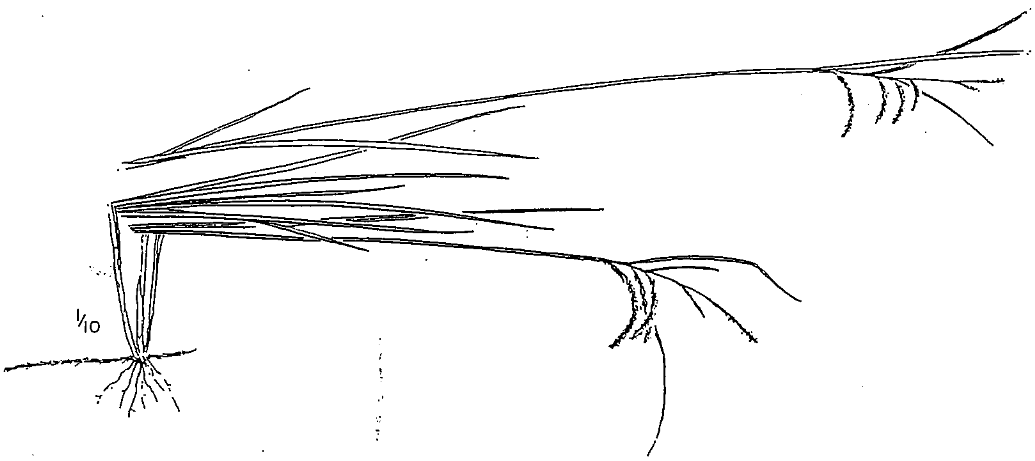
(2) brown-headed rush (Juncus nevadensis)

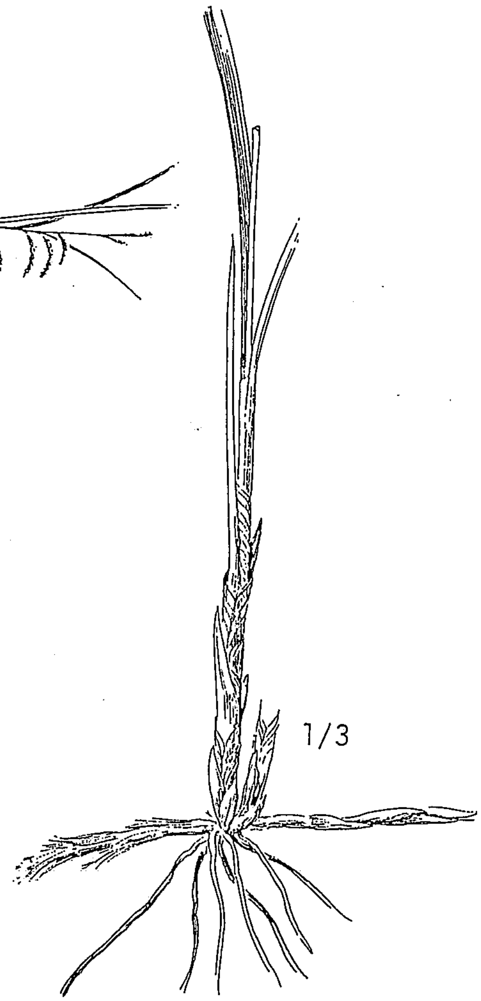


6. The most important species of the sedge community are:

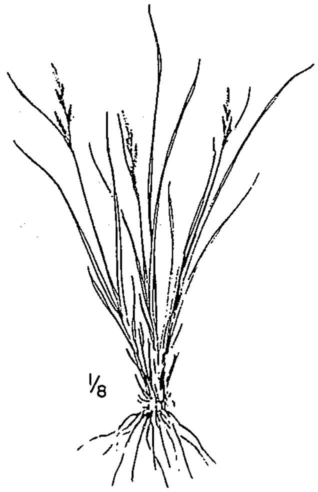
a. Sedges (which have stems with edges) are the most critical species. They include:

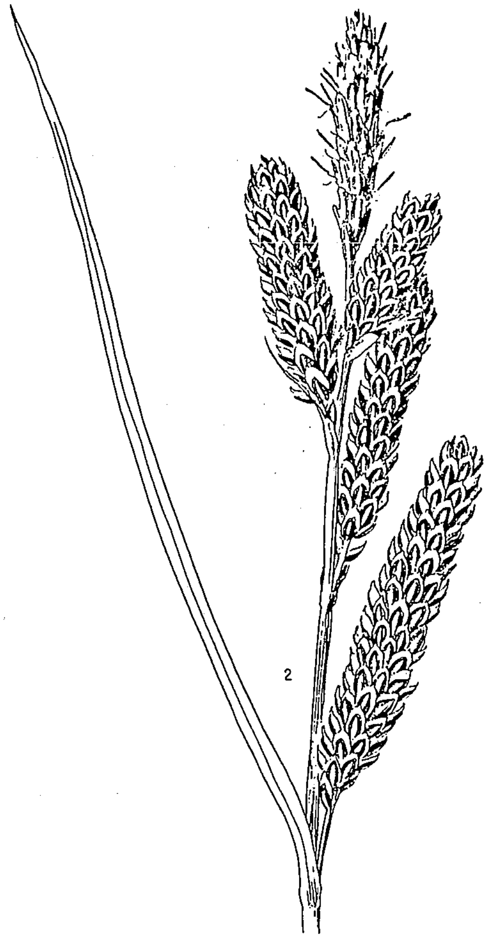
(1) slough sedge (Carex obnupta)



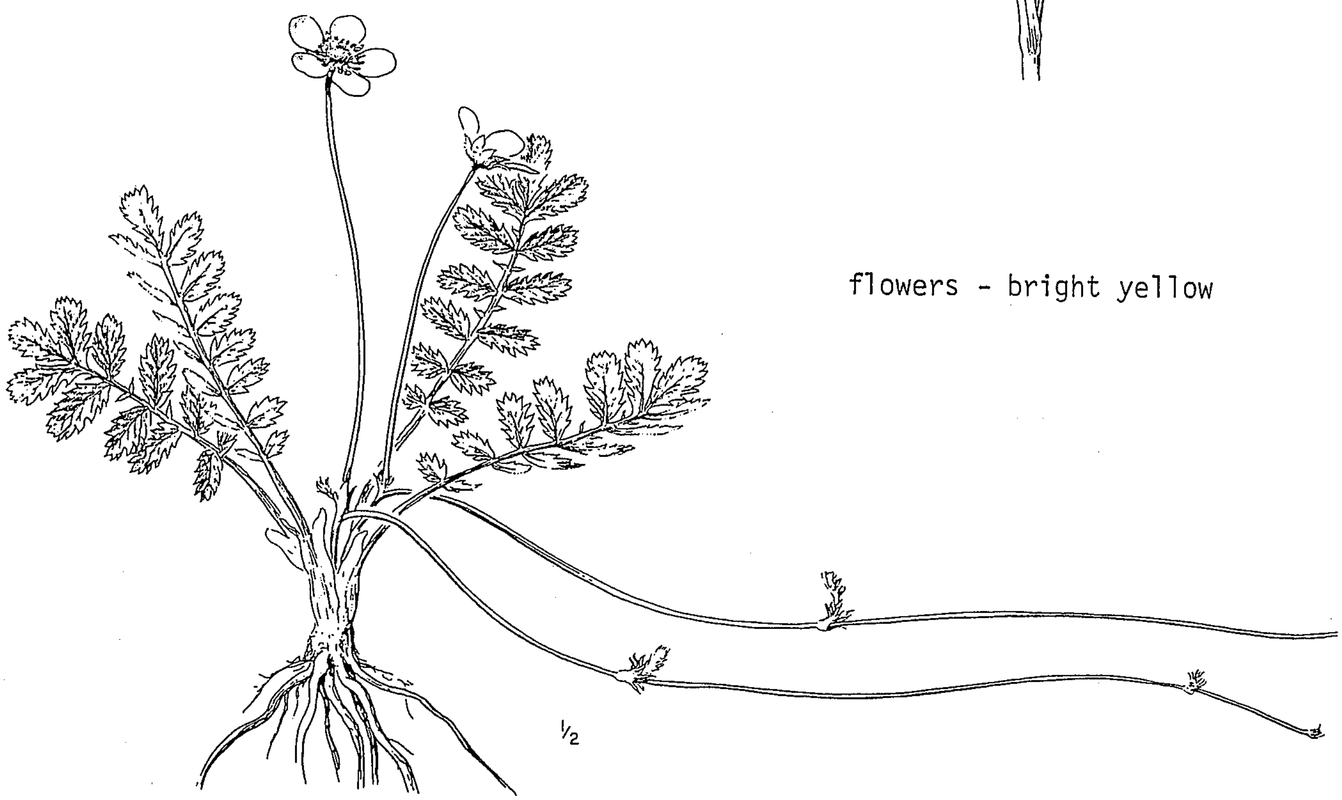


(2) hindis sedge (Carex hindsii)



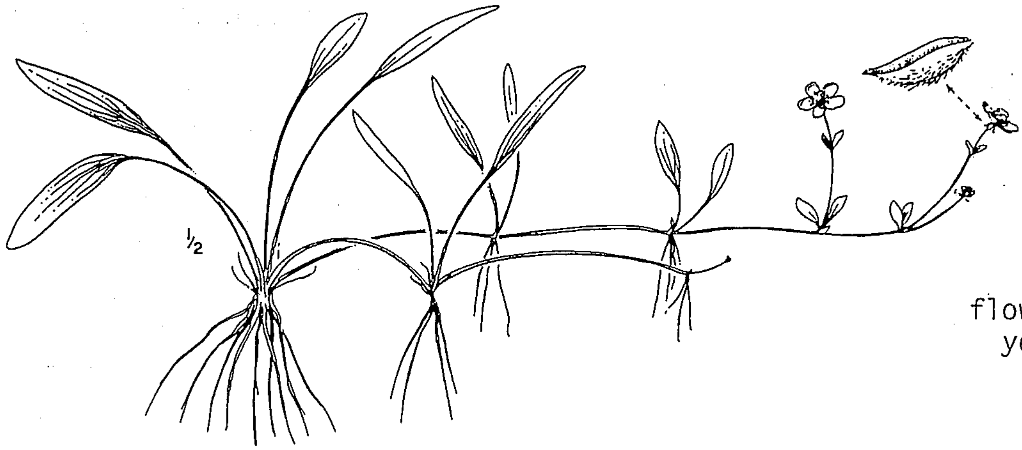


b. Pacific silver weed (Potentilla pacifica)



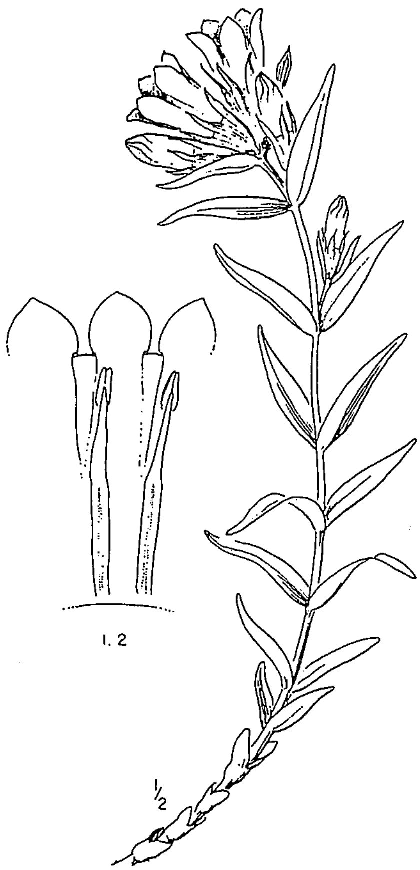
flowers - bright yellow

c. creeping buttercup (Ranunculus flammula)



flowers - yellow

d. king's gentium (Gentiana sceptrum)



flowers - blue to purplish-blue

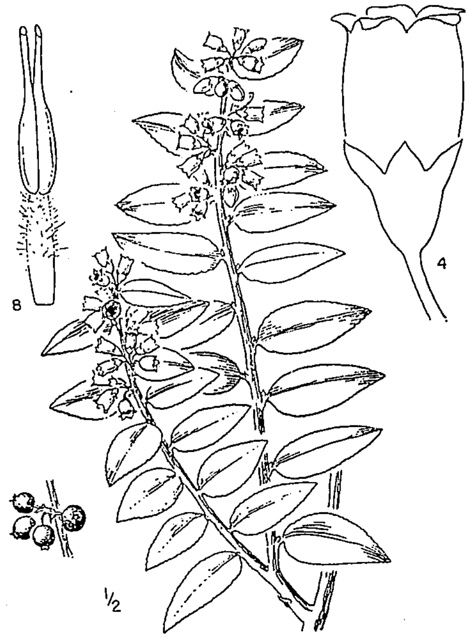
7. The low, scattered shrub community is characterized by the following species up to six feet in height:

   a. coast willow (Salix hookeriana) dominates,

   b. salal (Gaultheria shallon),

flowers - white to pink

c. evergreen huckleberry (Vaccinium ovatum),

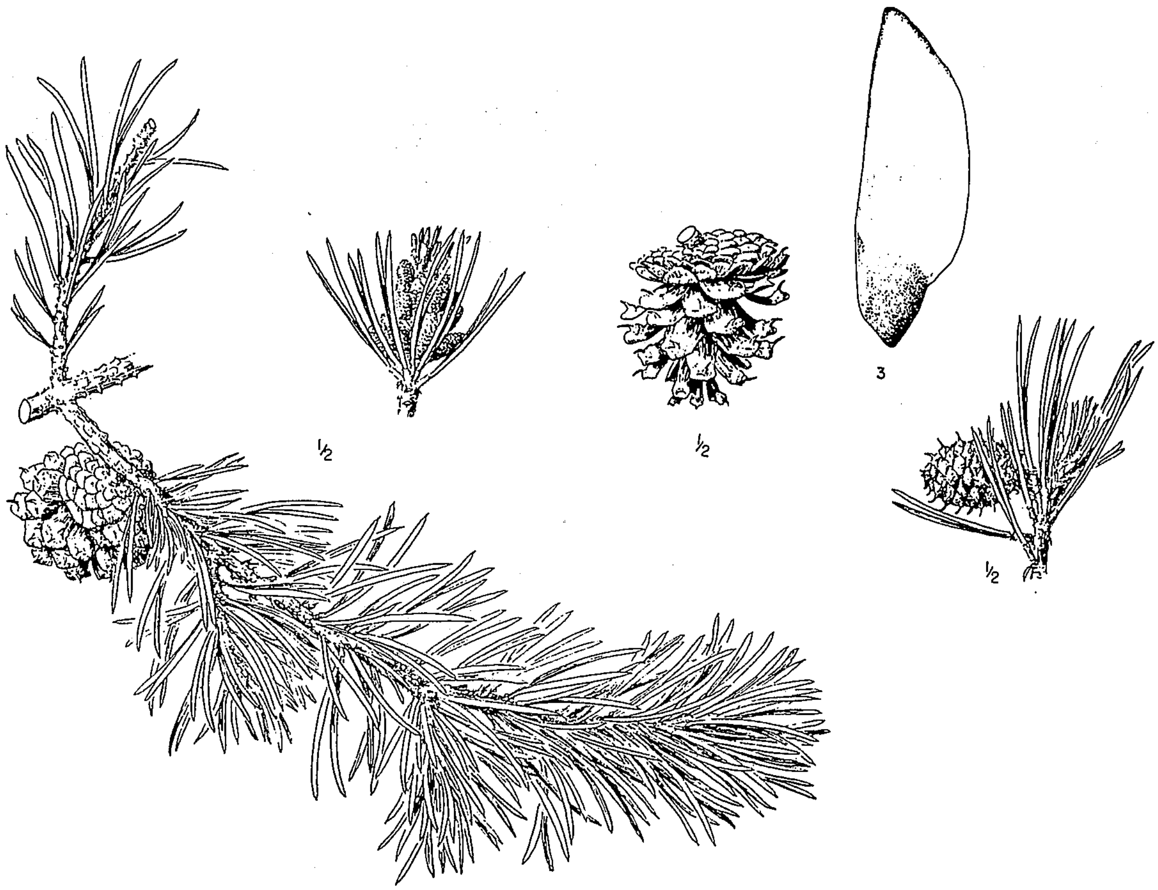


flowers - white to pink

d. wax myrtle (Myrica californica), and

fruit - reddish-brown

e. shorepine saplings (Pinus contorta).

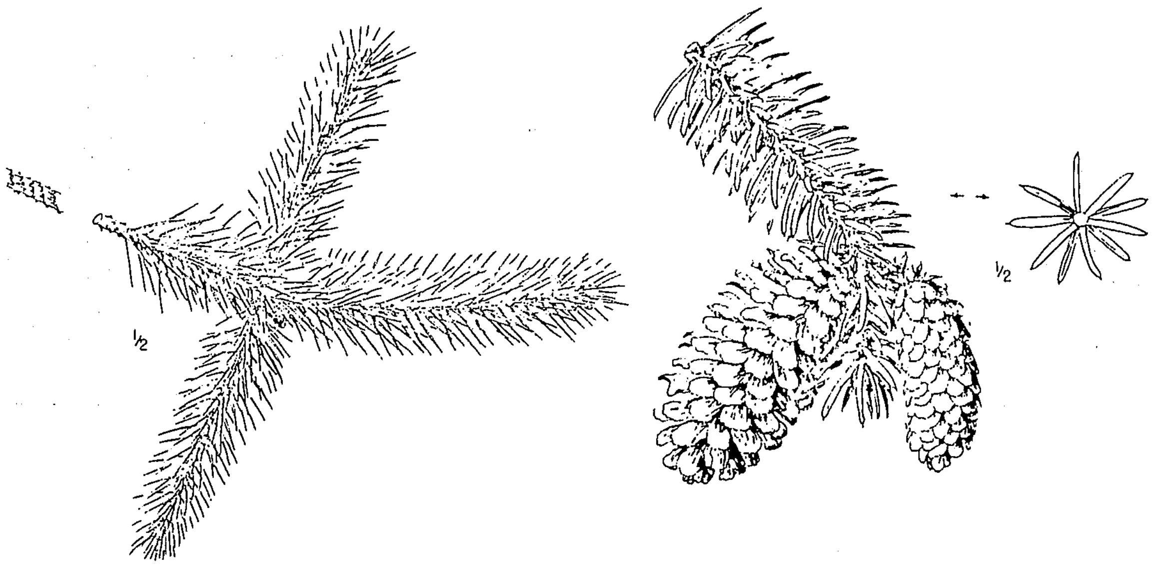


8. The tall shrub thickets follow the low, scattered shrub association and is composed of the foregoing shrubs and trees ranging in height from six to twenty feet.

9. The next successional stage on the deflation plain is the shorepine forest. The plant community includes the following:

   a. shorepine dominates (Pinus contorta). See drawing above.

b. sitka spruce (Picea sitchensis)



c. occasionally trees of:

(1) wax myrtle (Myrica californica), and

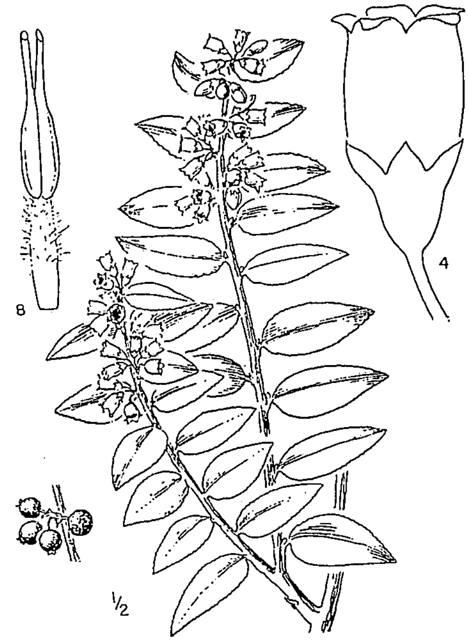
(2) coast willow (Salix hookeriana)

d. a sparce occurrence of shrubs:

(1) salal (Gaultheria shallon), and

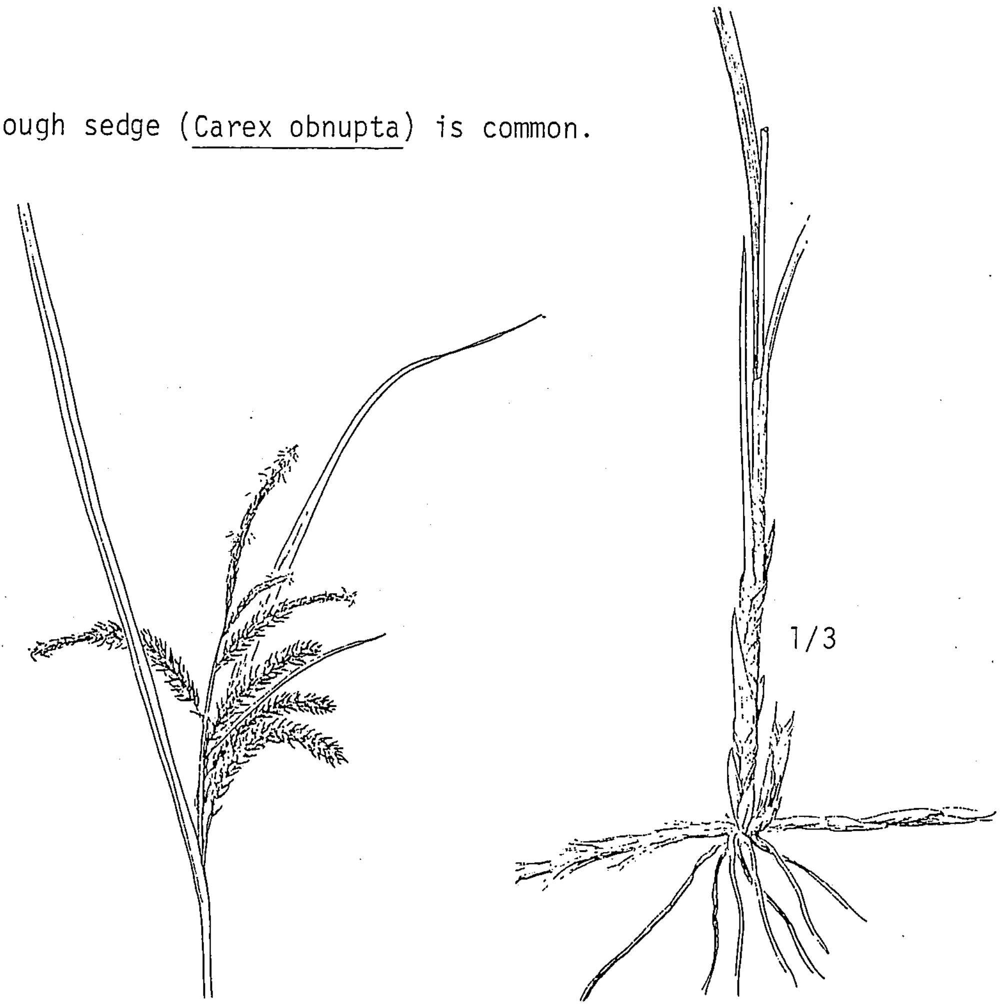
flowers - white to pink

(2) evergreen huckleberry (Vaccinium ovatum)



flowers - white to pink

e. slough sedge (Carex obnupta) is common.



B. Seasonally Wet Interdune Area

Interdune sites which are commonly occupied by standing water only part of the year.

1. Geomorphology

Low lying sites which contain surface water during some part of the winter are found in association with many sand landform types. Swales between oblique-ridge dunes, the basal area between hummock or transverse-ridge dunes, and low areas within older stable dune units, all provide examples of sites which may be wet part of the year. Water table is probably high even during the summer when all trace of surface water has disappeared.

2. Vegetation

Although the surface can range from bare sand through marsh associations to mature forest, some vegetative cover is most common. Any of those communities occurring in the deflation plain may be found here. Some sites may exhibit mottled clayey soils indicative of prolonged saturation.

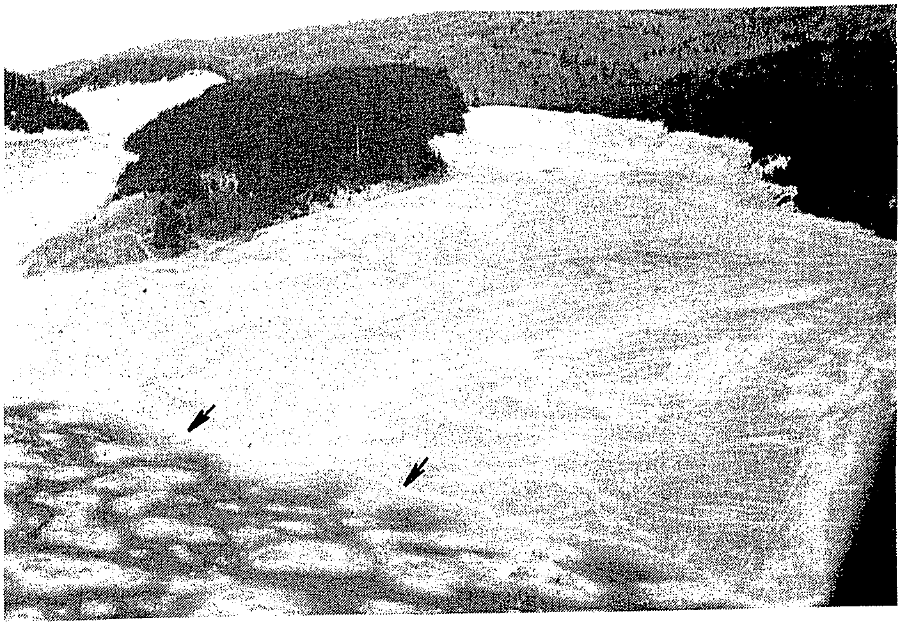
3. Attractions and limitations

Characteristic attractions and limitations of these sites would be similar to those of the deflation plain. Any development proposals for occasionally wet areas in older stable dune forms should address the potential water table limitations here.

4. Identification check-list

Occasionally wet interdune sites may be identified by the following characteristics:

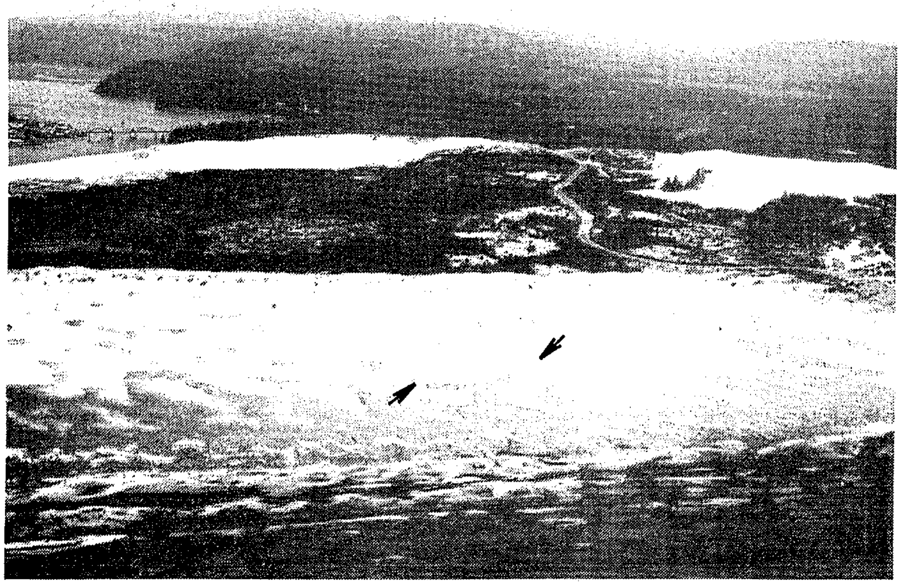
1. The site exhibits standing surface water during only part of the



2. Occasionally wet interdune areas may occur as follows:

a. vegetated areas between open sand dune ridges,

b. nonvegetated sites between open sand dune ridges, or



c. swales between parallel-ridge dunes,

d. low sites in older forested dunes (may be affected by underlying impermeable iron lenses), or

e. swales between hummock dunes which may be a functional extension of the adjacent deflation plain.

V. INTERIOR DUNE FORMS - VEGETATED

A. Hummock Dunes

Fields of vegetated sand dune mounds most commonly occuring inland from the foredune or deflation plain.

1. Geomorphology

Hummock dunes, like the foredune, are primarily created by the mound building activities of European beachgrass (Ammophila arenaria). These dunes form as fields of hillocks rather than linear ridges because there is no natural linear vegetation and sand accumulation boundary (such as the beach), and sand supply and wind patterns are rendered inconsistent and discontinuous by the foredune barrier ridge.

Hummock dunes most commonly occur either immediately inland from the active foredune or inland from the deflation plain. Sand is supplied from either or both of these source regions. Patches of hummock dunes are also found within open sand areas on occasion. In general, hummock dunes range from ten to thirty feet in height and twenty to thirty feet at the base. In their active form they may be only sparcely vegetated and thus actively migrating. Active hummock dunes occur in the southwestern region of Bayocean Spit in Tillamook County and west of Lily Lake in Lane County. A vegetative cover sufficient to make hummock dunes wind stable creates a conditionally stable form, examples of which are found at the north end of Bayocean Spit in Tillamook County and at South Beach in Lincoln County.

2. Vegetation

The most prevalent vegetation found on hummock dunes is European beachgrass (Ammophila arenaria). Other secondary components include seashore lupine (Lupinus littoralis), seashore bluegrass (Poa macrantha), and coast strawberry (Fragaria chiloensis). Later successional growth is similar to that on the lee side of the conditionally stable foredune and may frequently exhibit shrubs or dwarfed trees in the more protected sites. The depressions in those hummock dune areas which have a high winter water table may be occupied by marsh vegetation including sedges and rushes.

3. Attractions and limitations

This area has attractions to both pedestrian and off-road vehicle recreation. Some areas have been used for home sites.

The proximity of active hummock dunes to the active foredune and their natural interaction is of critical importance. Often one blends into the other imperceptably and the boundary is somewhat hypothetical. One cannot be managed in isolation from another.

Hummock areas are often used by off-road vehicle recreationalists but limited visibility can create hazards, particularly for pedestrians.

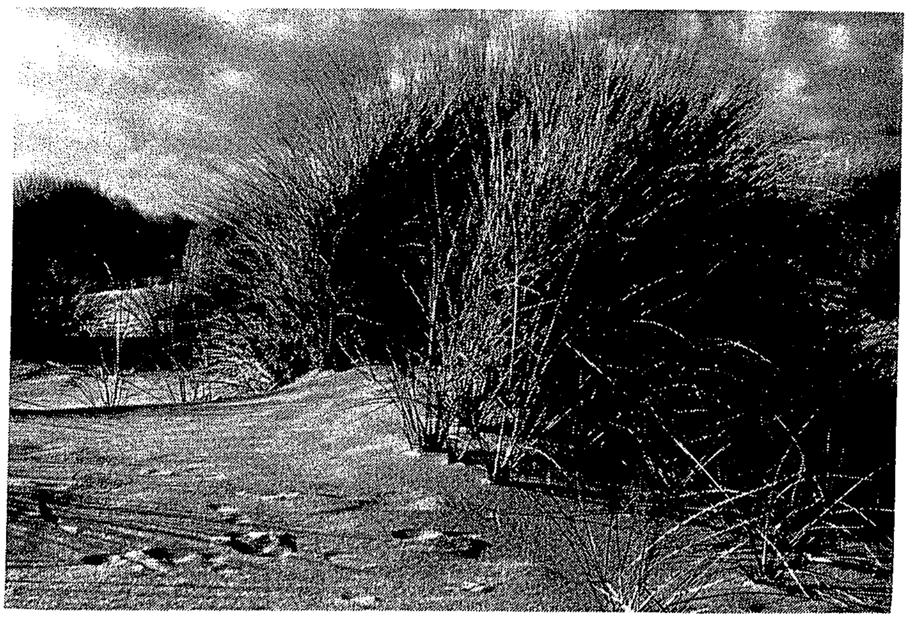
Those areas which have a high winter water table may develop "quicksand-like" conditions in the low areas (U.S.D.A., 1972, p. 76). High water table areas are also highly sensitive to development and would be particularly unsuitable for either septic tanks or buried pipelines due to the possibility of structure flotation and failure (Ibid, p. 83).

High wind scour and blowout potential also limit the development possibilities of this dune landform. Stabilization planting should be undertaken and consistently maintained during and after any construction.

4. Identification check-list

Hummock dunes can be identified by the following characteristics:

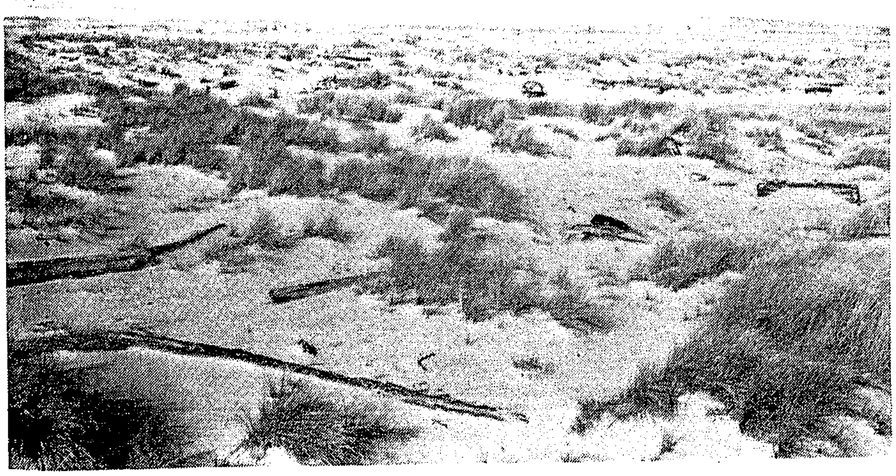
1. Hummock dunes occur where clumps of vegetation cause deposition of windblown sand



2. They occur as fields of individual, vegetated sand hummocks

3. Hummock dunes occur either:

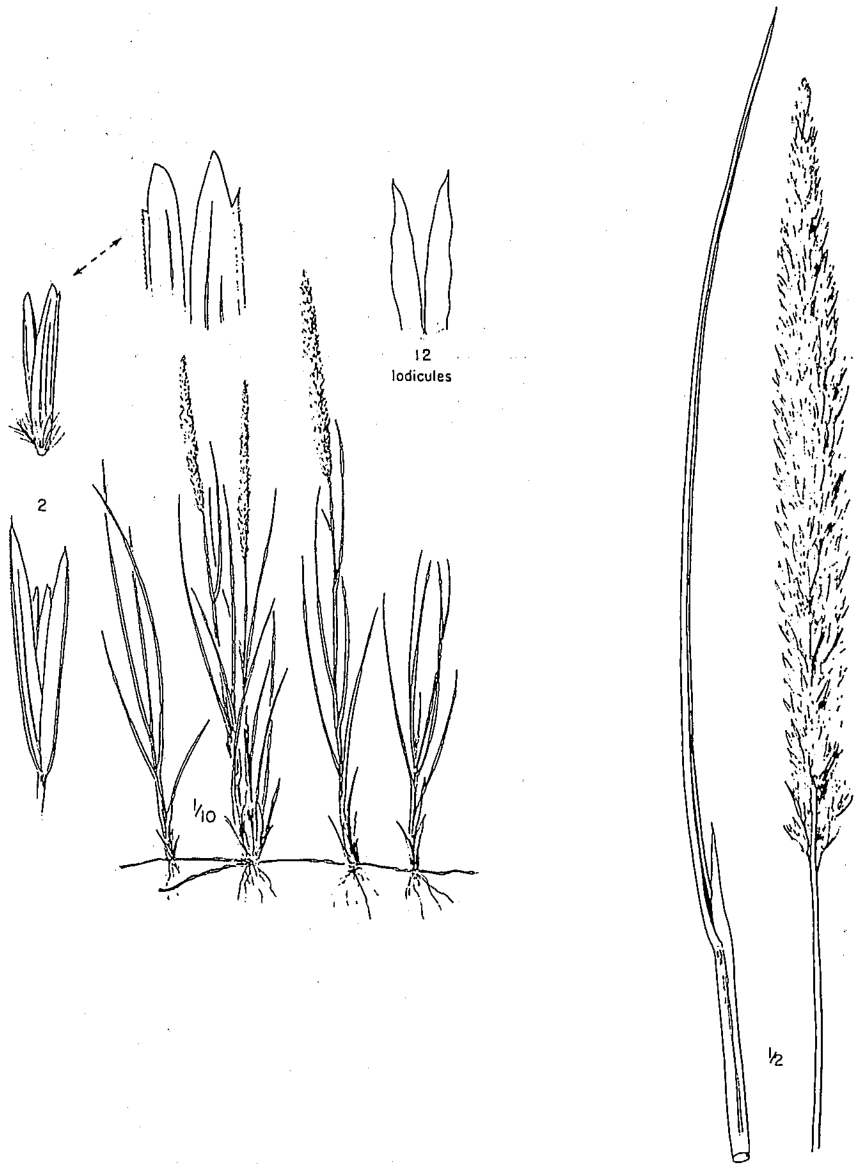
   a. leeward of an active foredune, or



b. inland from the deflation plain, or

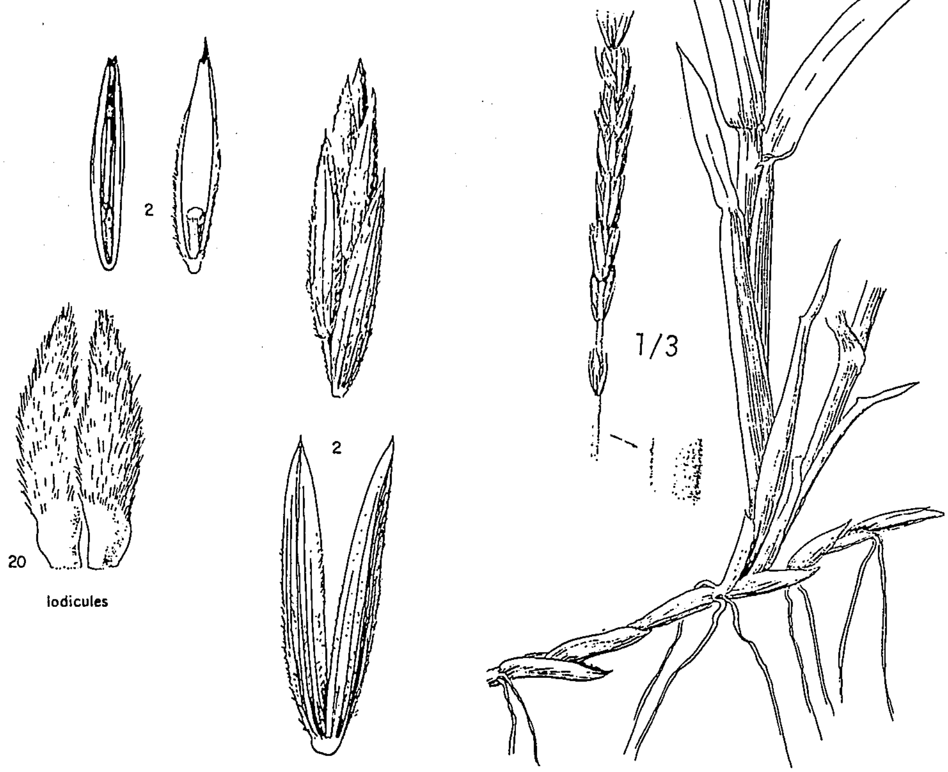
c. in isolated hummock fields within open sand areas.

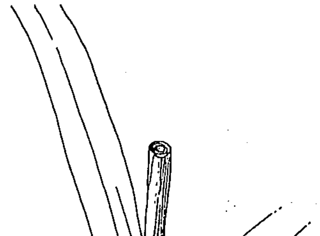
4. European beachgrass (<u>Ammophila arenaria</u>) forms the primary component of the vegetation community of active hummocks.



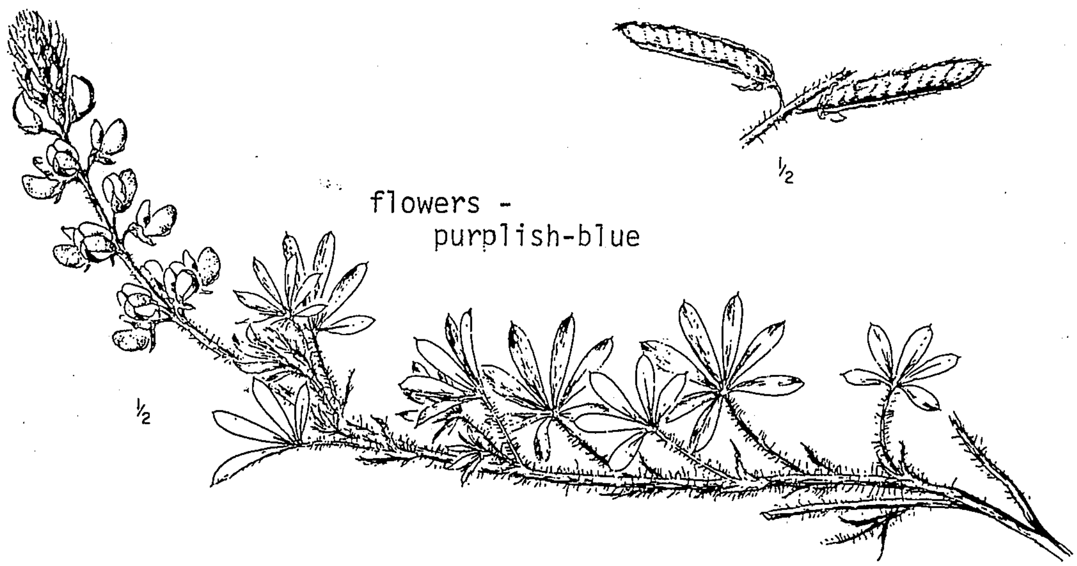
5. Other species which may occur here include:

a. sea lyme-grass (<u>Elymus mollis</u>)

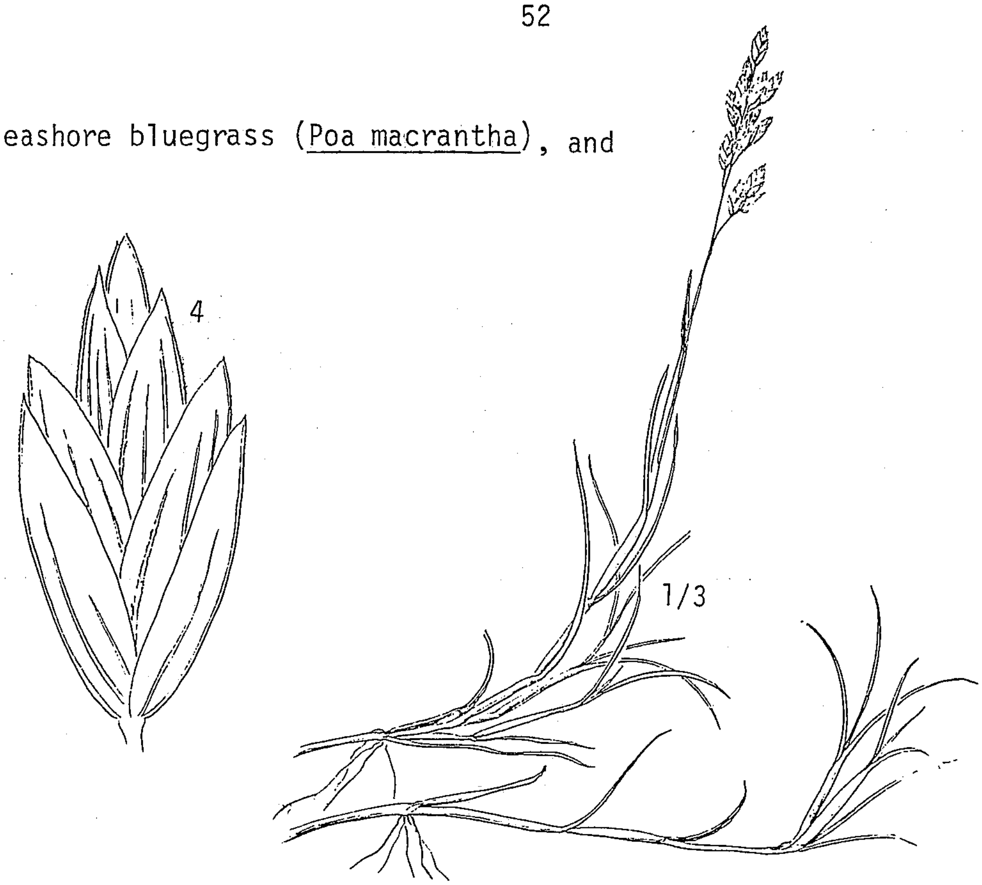




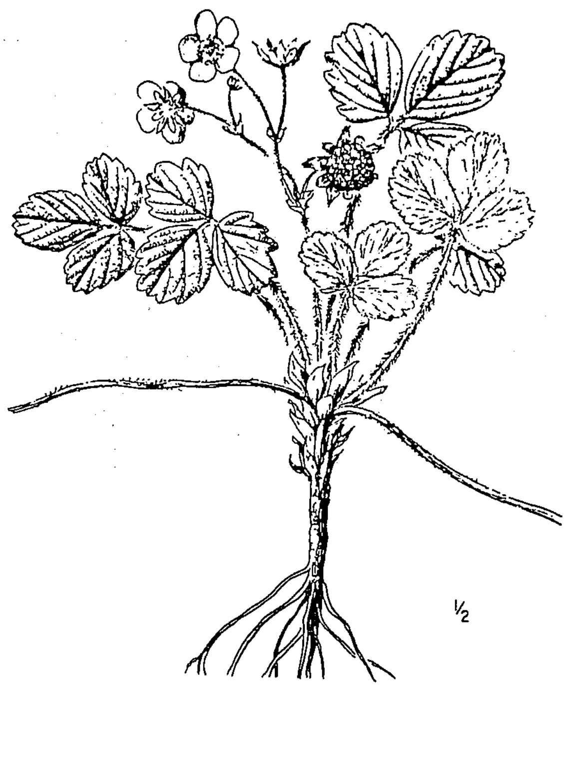
b. seashore lupine (<u>Lupinus littoralis</u>)



c. seashore bluegrass (Poa macrantha), and



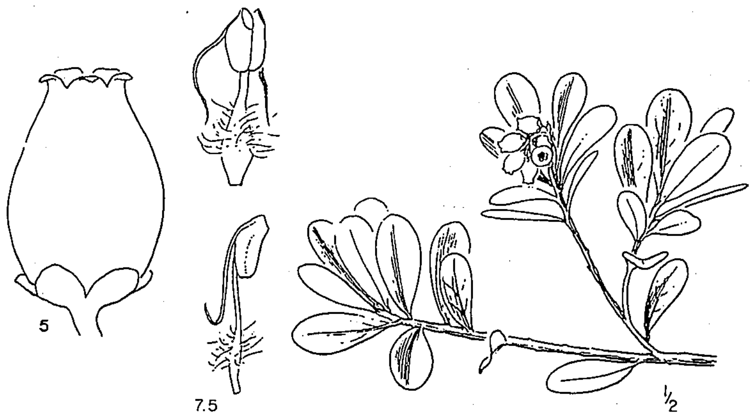
d. coast strawberry (Fragaria chiloensis).



flowers - white to pinkish

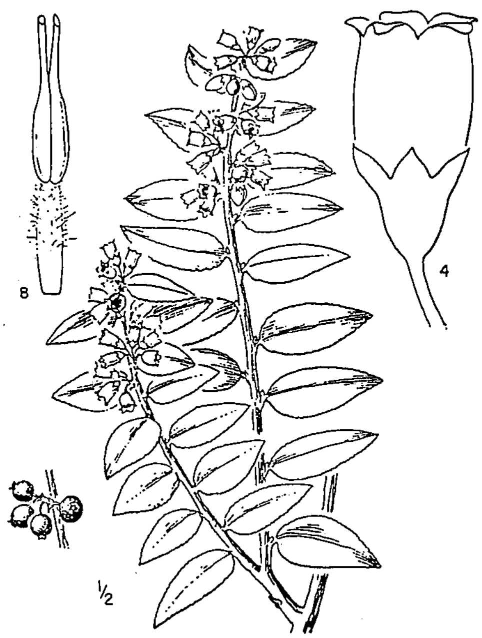
·. Hummock dune areas which have experienced prolonged successional growth indicating conditional stability may display the following species:

a. kinnikinnic (Arctostaphylos uva-ursi),



flowers - white to pink

b. evergreen huckleberry (Vaccinium ovatum),

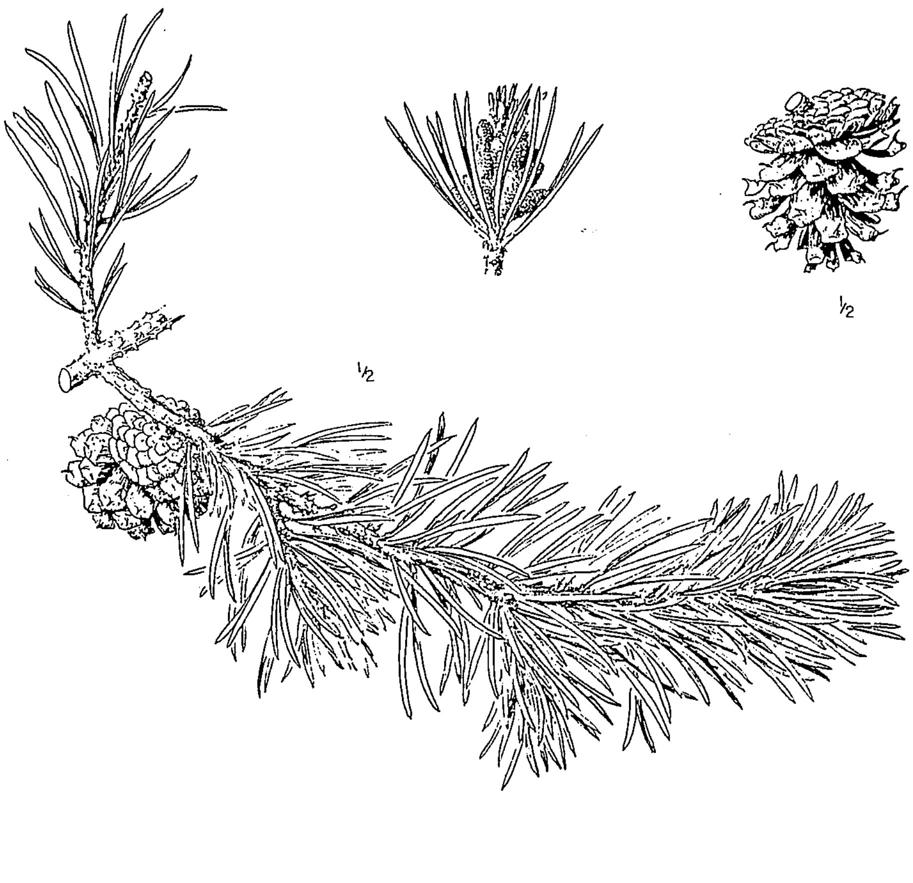


flowers - white to pink

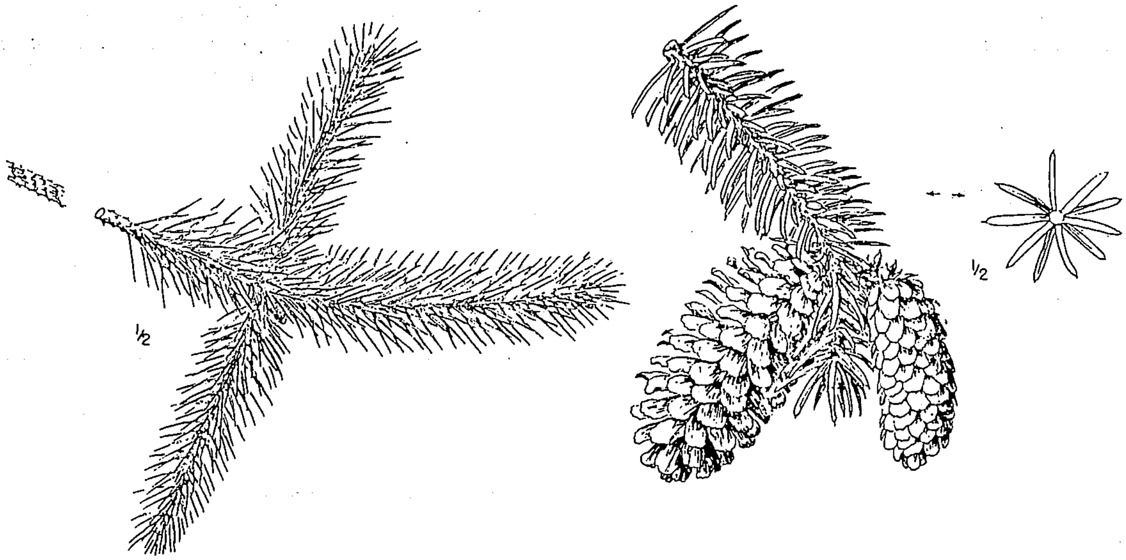
c. salal (<u>Gaultheria shallon</u>),

flowers -
white to pink

d. shore pine (<u>Pinus contorta</u>), and



e. sitka spruce (Picea sitchensis).



B. Surface Stabilized Dunes

Dunes of any form which possess a weakly developed thin soil and underlying unconsolidated sands.

1. Geomorphology

These dunes have been stabilized with vegetation long enough for soil to begin forming. This process may have taken hundreds or possibly a few thousand years.

Surface stable dunes are wind stable so long as the weakly developed soil is not seriously disturbed. The underlying sand materials are prone to reactivation, particularly if excavations are oriented toward prevailing winds. Parabola dunes commonly occur in this landform. Occasionally, buried soils and iron bands may impede permeability. Surface stable dunes occur in the central portion of the Tillamook Spit in Tillamook County and are intersperced throughout the dune sheets in Lane, Douglas and Coos Counties.

2. Vegetation

Forest associations occur most commonly in this unit although meadow communities are not unknown. Native herbs, shrubs and trees, not unlike the later successional species found on conditionally stable foredunes, are found here although species proportions, size of individuals and biomass density are considerably different. Because of the favorable environment provided by an abundance of moisture, mild climates and surrounding forest productivity, coastal forests, particularly the shrub layer, may be nearly impenetrable.

3. Attractions and limitations

The forested surface-stabilized dunes offer attractive sites for a number of man's activities because they are sheltered and somewhat more stable than most other dune forms. Such reactional activities as camping and picnicking, as well as the placement of dwellings and other structures, are popular activities.

Caution must be used in developing these sites, however, because of some inherent limitations. The dunes are only surface stabilized and are prone to reactiviation if the surface vegetation and soil are disturbed. Furthermore, windfallen trees are common along the edge of new clearings posing potential hazard for development.

Many surface stable dunes are underlain by older, buried soils and iron lenses which restrict vertical permeability. This is typical of the subsurface stratigraphy in open dune sand and older stable dunes as well. Septic tank viability could be threatened by local high water due to these impermeable lenses.

Water drawdown could also be a problem in this unit if stabilizing vegetation is affected. Pollution of the groundwater is also a potential problem for the development of this landform.

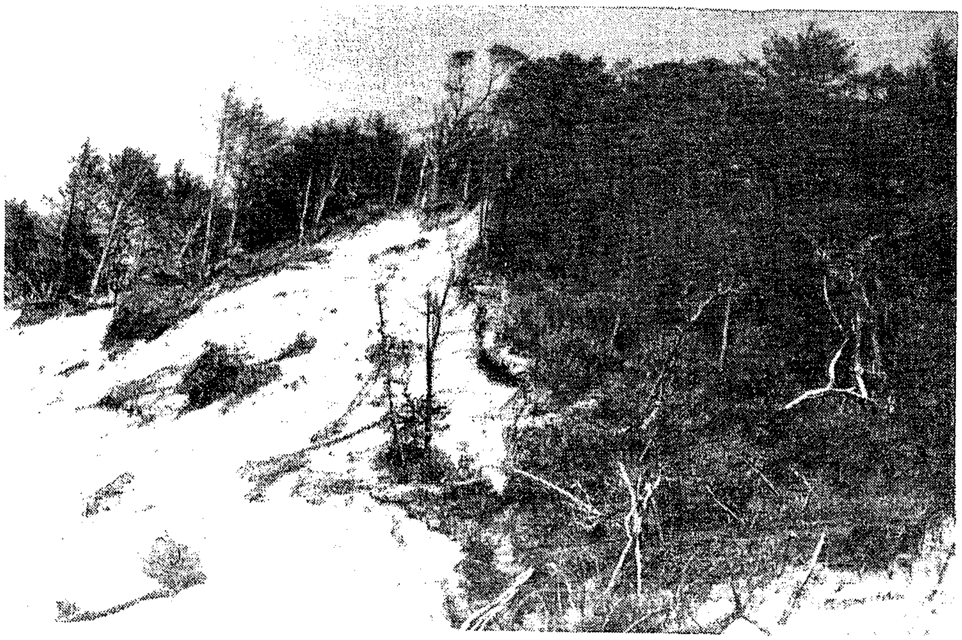
4. Identification check-list

Surface-stable dunes can be identified by the following characteristics:

1. Dunes having a thin, weakly developed soil.

2. The sands underlying the soil are unconsolidated and will easily reactivate with sufficient disturbance.

3. Forests most commonly cover the surface-stable dunes.



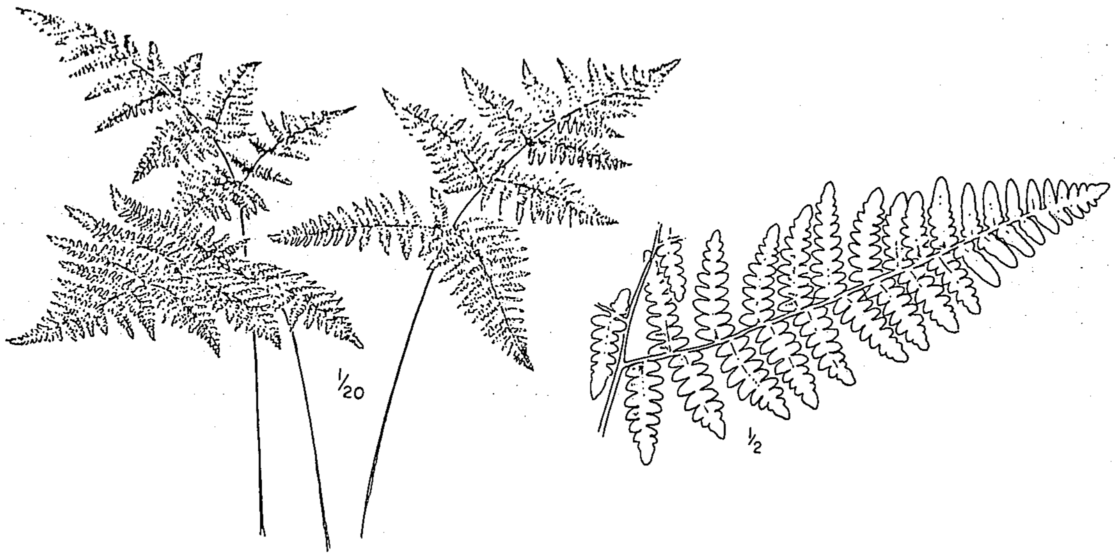
4. The forested, surface-stable dune is characterized by the following vegetation:

   a. The understory may consist of:

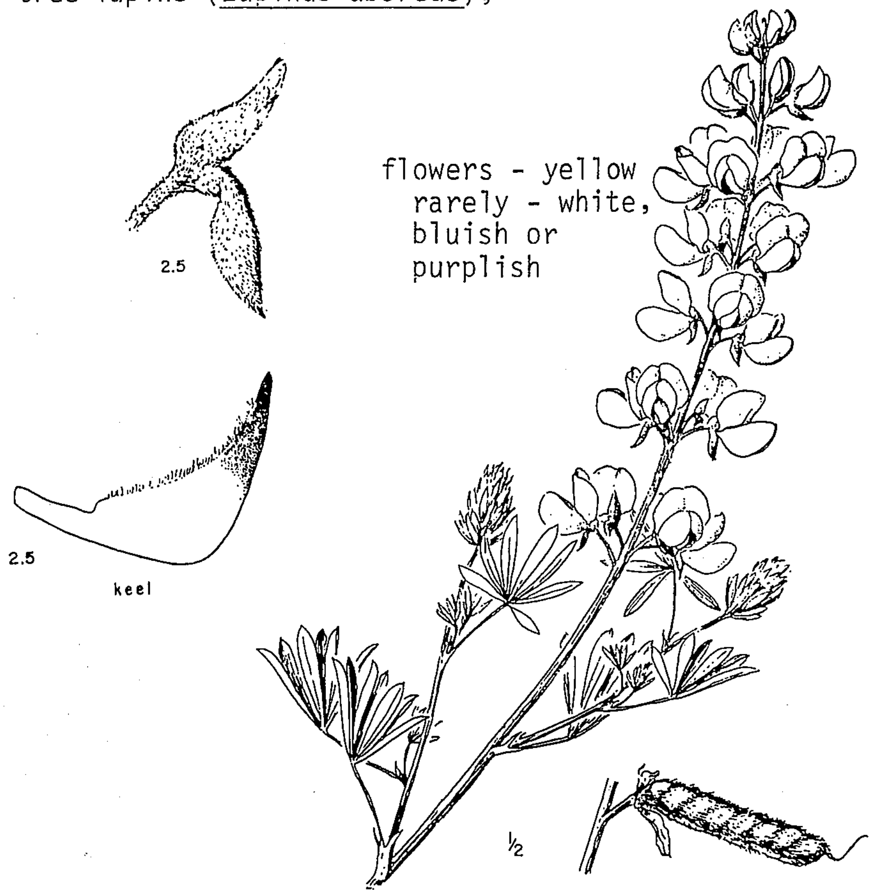
      (1) salal (<u>Gaultheria shallon</u>)

      flowers - white to pink

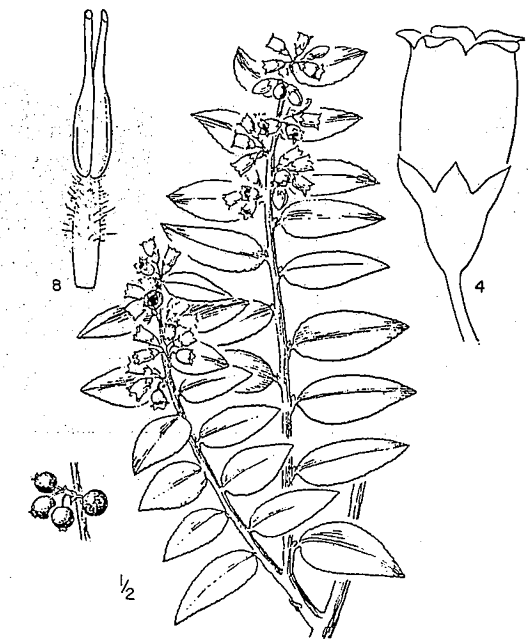
(2) western bracken fern (<u>Pteridium aquilinum</u>)



(3) tree lupine (<u>Lupinus aboreus</u>),

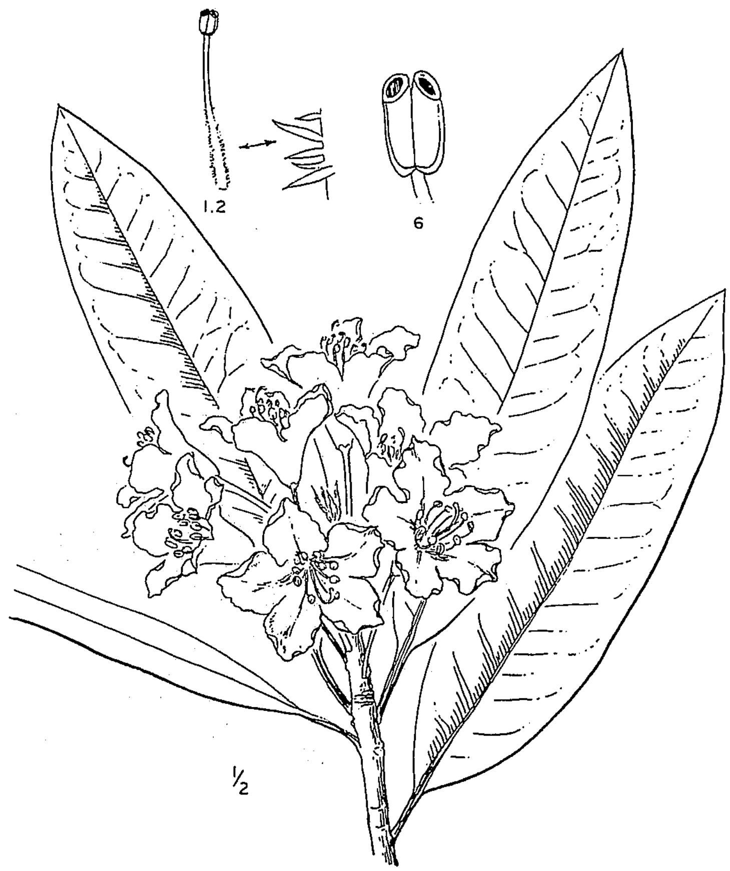


(4) evergreen huckleberry (Vaccinium ovatum) and



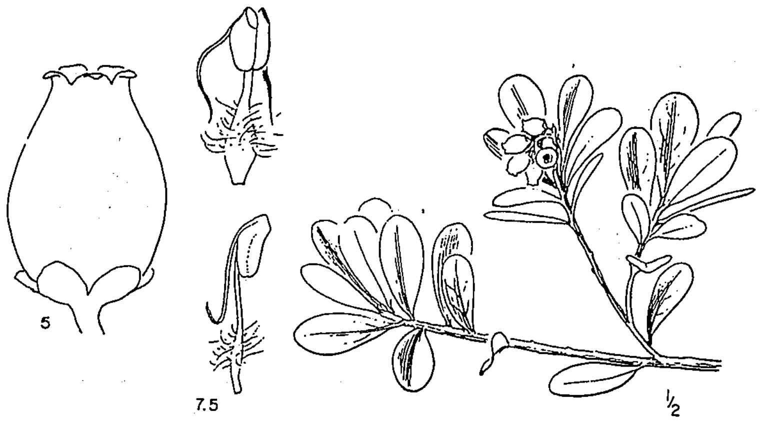
flowers - white to pink

(5) western rhododendron (Rhododendron macrophyllum).



flowers - pink to deep rose rarely white

(6) The more open sites may contain kinnikinnick (<u>Arctostaphylos uva-ursi</u>) and

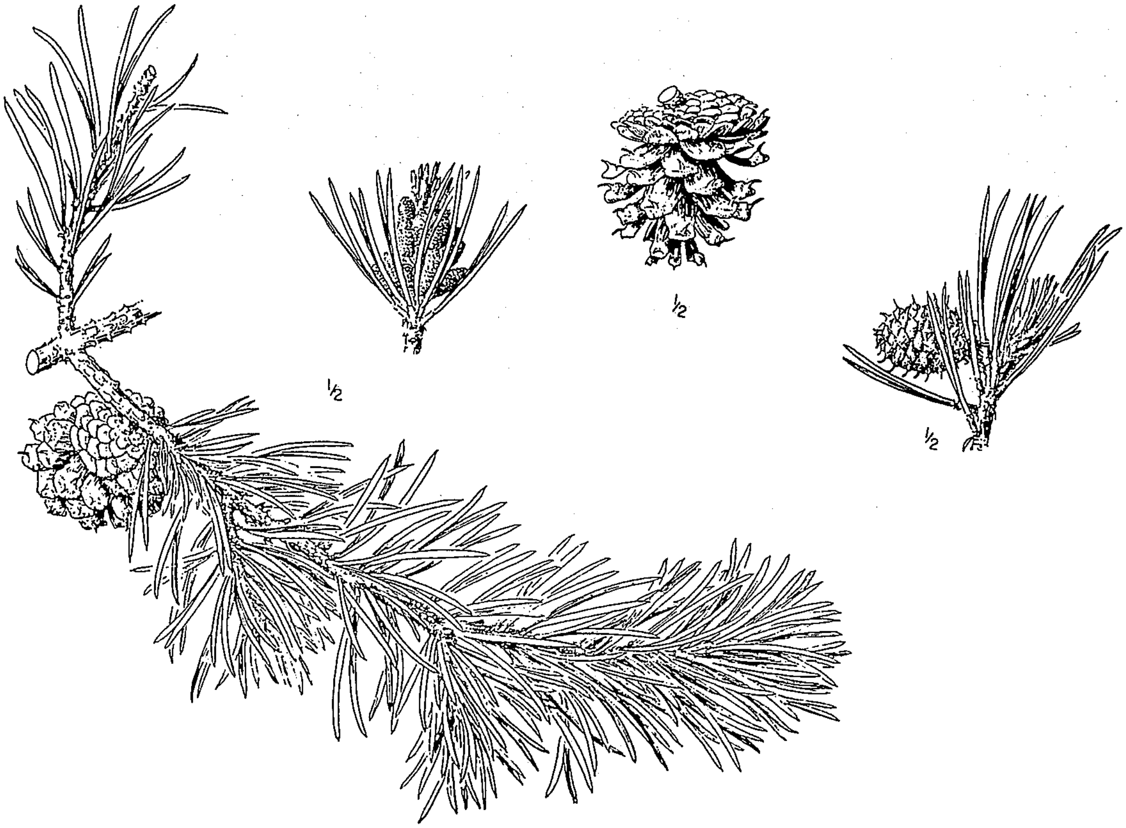


flowers - white to pink

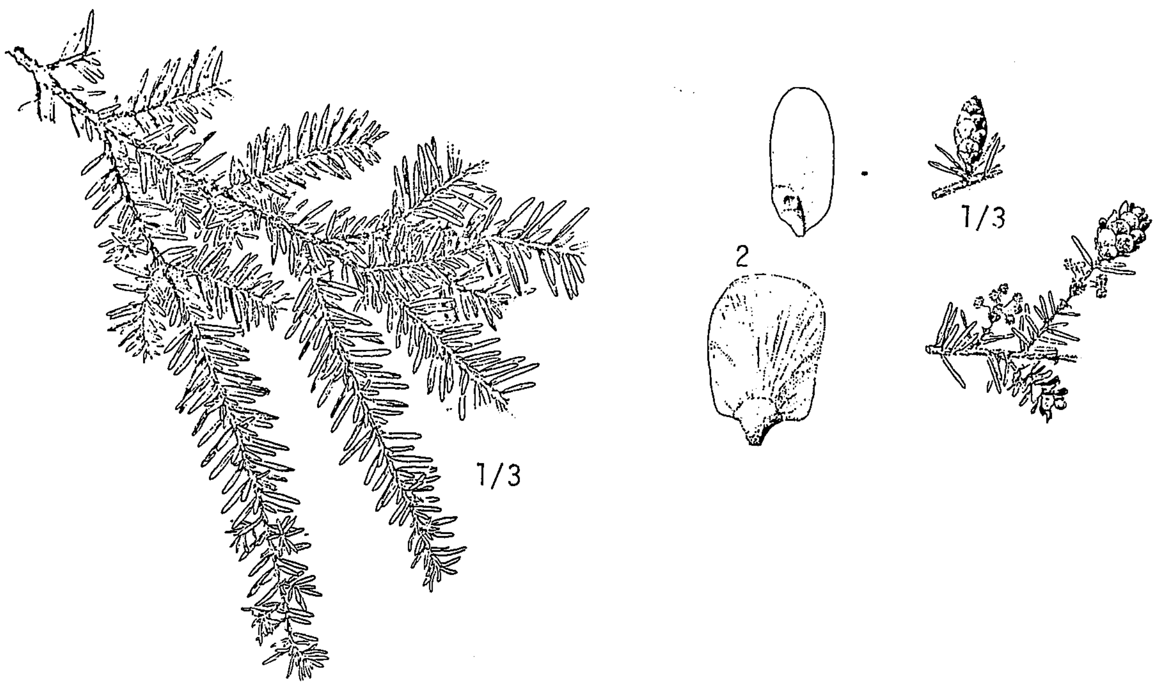
(7) hairy manzanita (<u>Arctostaphylos columbiana</u>).

flowers - white to pale pink

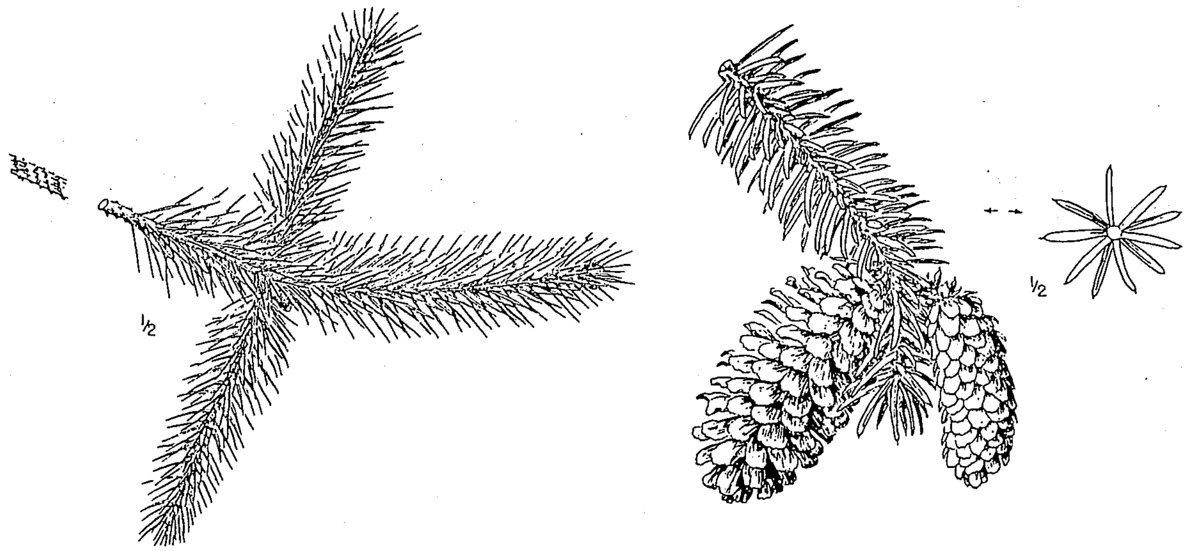
b. The forest canopy consists primarily of shore pine (<u>Pinus contorta</u>) but also may include:



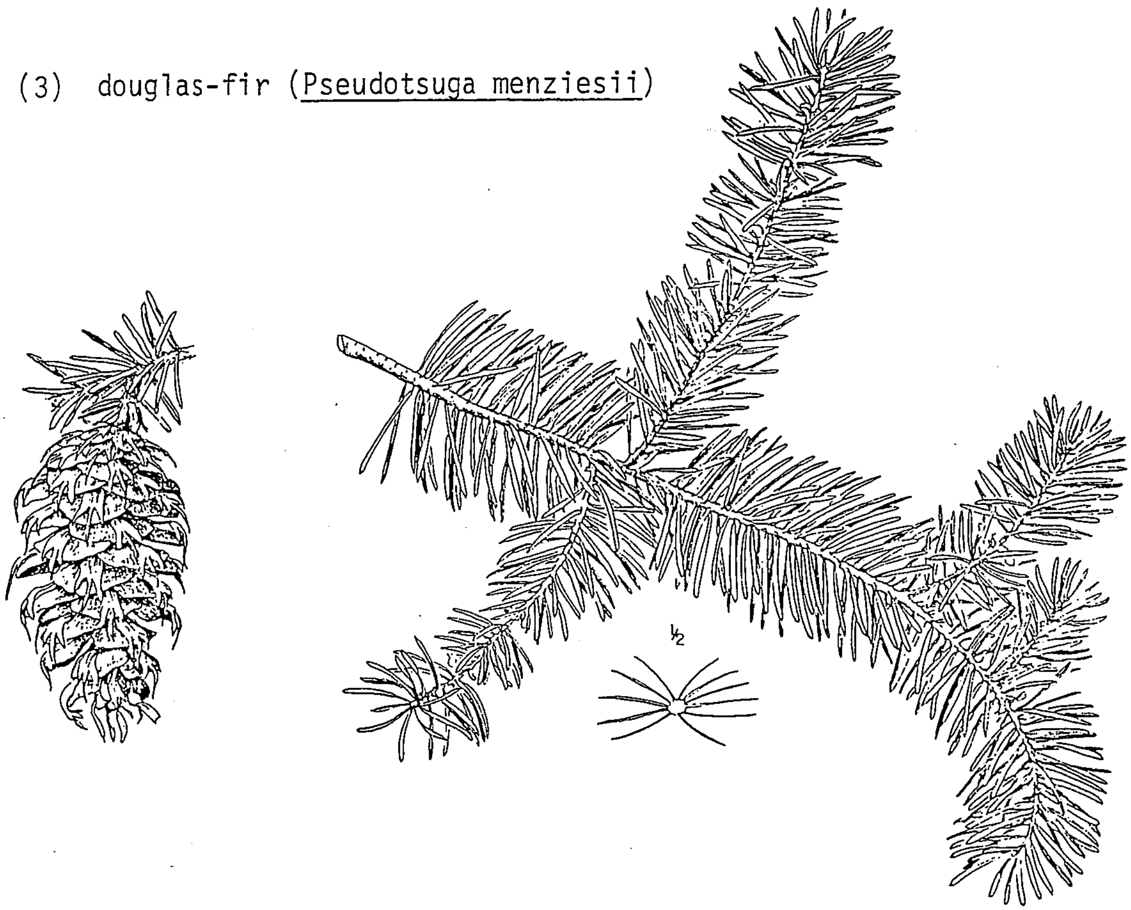
(1) Western hemlock (<u>Tsuga heterophylla</u>) in moist sites,



(2) sitka spruce (Picea sitchensis)

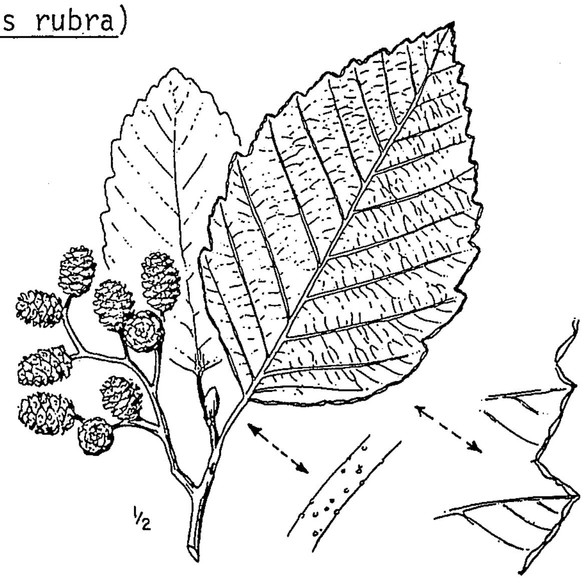


(3) douglas-fir (Pseudotsuga menziesii)



(4) western red cedar (Thuja plicata) and

(5) red alder (Alnus rubra)



C. Older Stable Dunes

Older sand dunes of any form which possess both a deep, well-developed soil and moderately cemented underlying sand.

1. Geomorphology

This dune type has been stabilized with a vegetative cover long enough for a relatively deep soil to develop and for the underlying sands to acquire some stability. The sub-surface sands exhibit varying degrees of cementation. The iron bands and buried soils which are found in the surface stable dune occur more frequently here and are more pervasive.

Although these sands will form a cliff where excavated, sloughing and landsliding are common. This is often intensified when saturation occurs due to subsurface impermeable iron lenses.

This landform may contain layers of loose sand overlying or underlying the semi-cemented strata but it is wind stable throughout the cemented layers.

2. Vegetation

Forests, often the coastal climax forest, most commonly occur here although natural grass areas may be found as well. The same species as occur in the surface-stable dune classification also occur here. A more even mixture of forest species is often found with less predominance of shore pine, and the forest canopy may be more dense with a resulting less dense shrub layer.

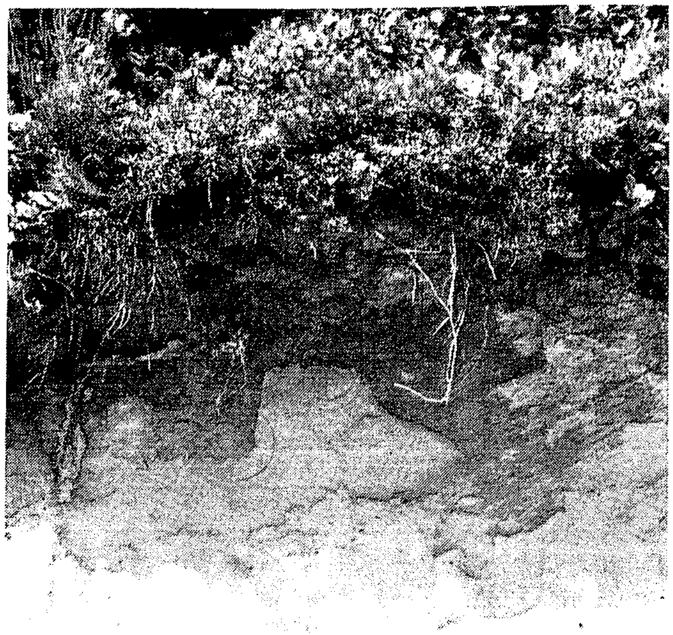
3. Attractions and limitations

The older stable dune presents an attractive site for recreational activities and residential development. The limitations associated with mobile sands do not exist with this landform. When excavated, the semi-cemented sands will maintain a cliff and are wind stable. However, sloughing is common, particularly in the winter months. This tendency is accentuated during groundwater recharge months by the impermeable iron bands which commonly run horizontally through this unit. Infiltering groundwater is concentrated above these bands, saturating the sands causing collapse where cliffs exist. This same phenomenon, which forms a perched water table, results in conditions highly unfavorable to septic tank siting, consequently, septic tank failure is not uncommon in this landform.

4. Identification check-list

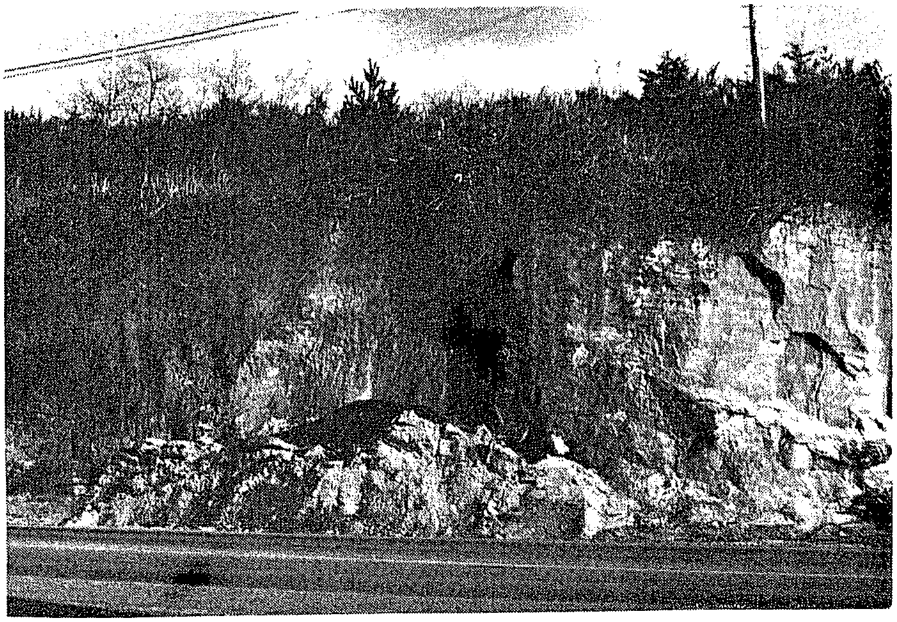
Older stable dunes can be identified by the following characteristics:

1. The presence of a moderately well developed soil.



2. The underlying sands are somewhat consolidated and often exhibit horizontal iron bands which offer varying resistance to erosion and impede vertical percolation of groundwater.

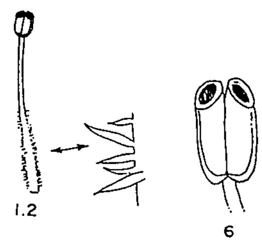
3. Underlying sands will form a cliff where cut, but sloughing is common.



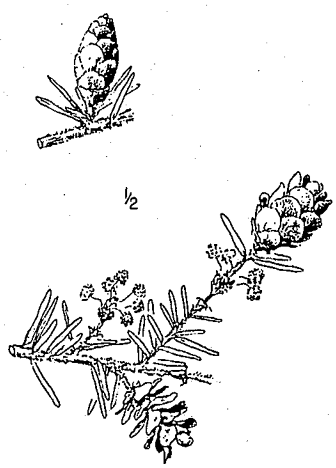
4. Vegetation species which occur on the older-stable dune are essentially the same as the surface-stable dune but species proportions vary. Shore pine and salal are less dominant. The following species are common to this landform:

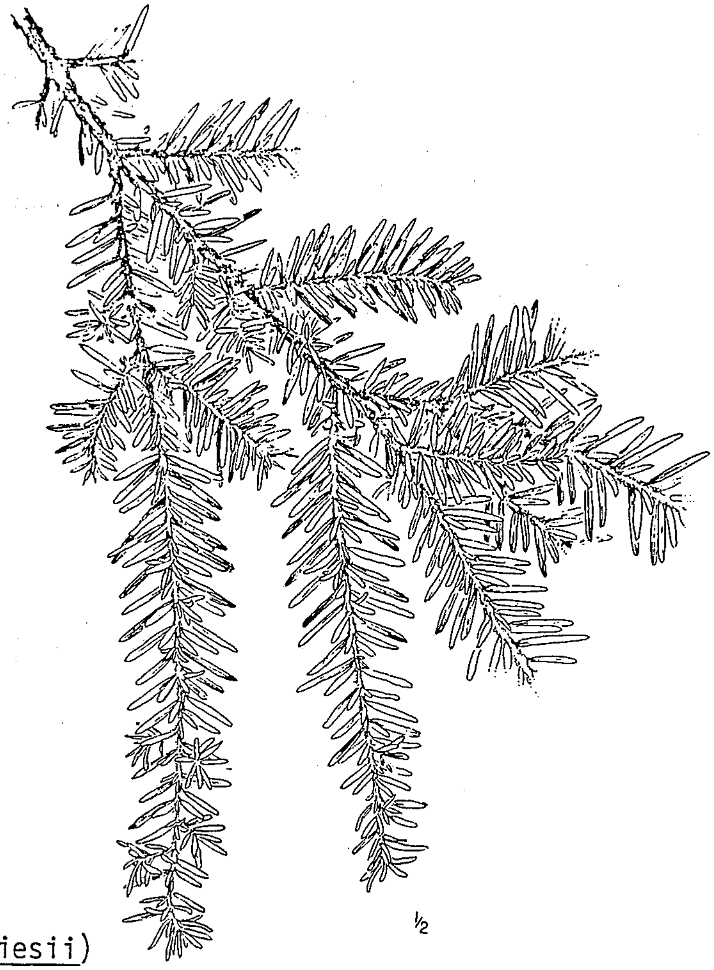
a. western rhododendron (Rhododendron macrophyllum)

flowers - pink to deep rose, rarely white

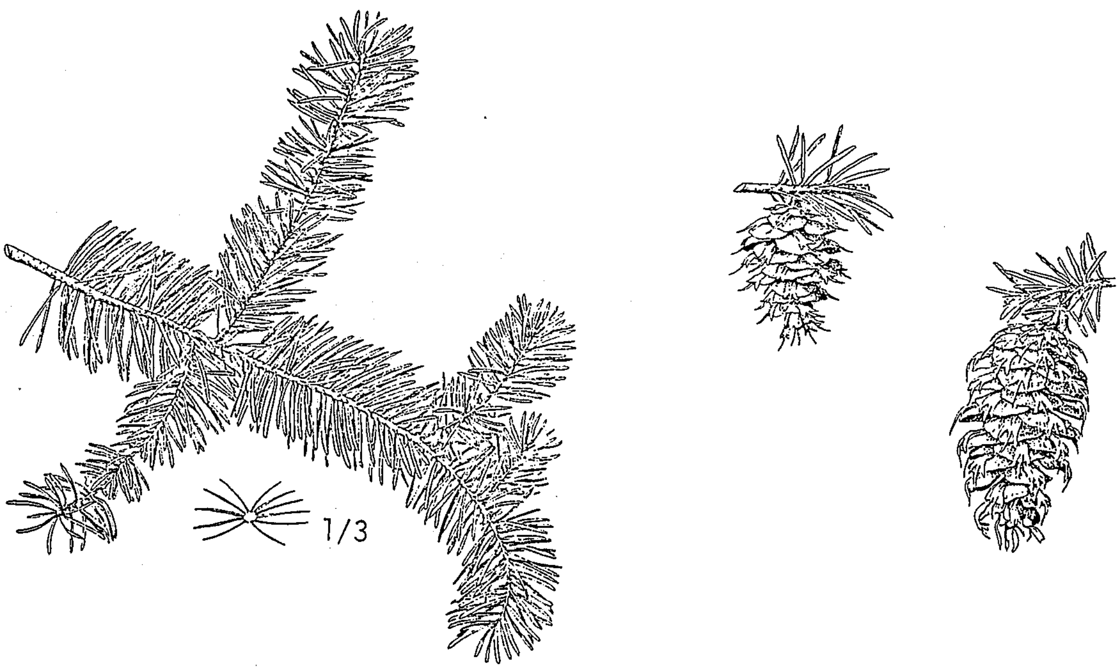


b. western hemlock (Tsuga heterophylla)

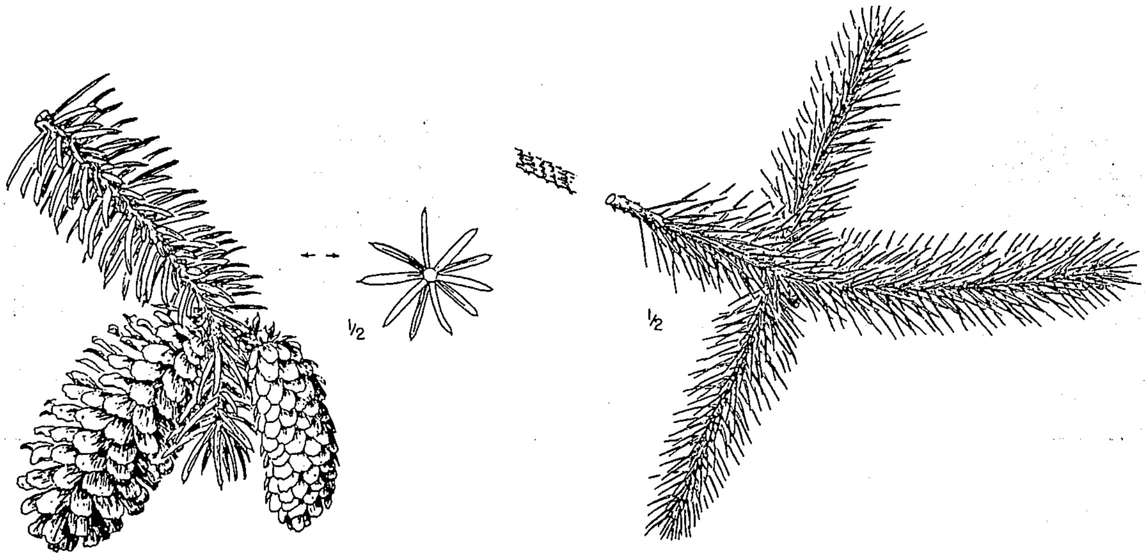




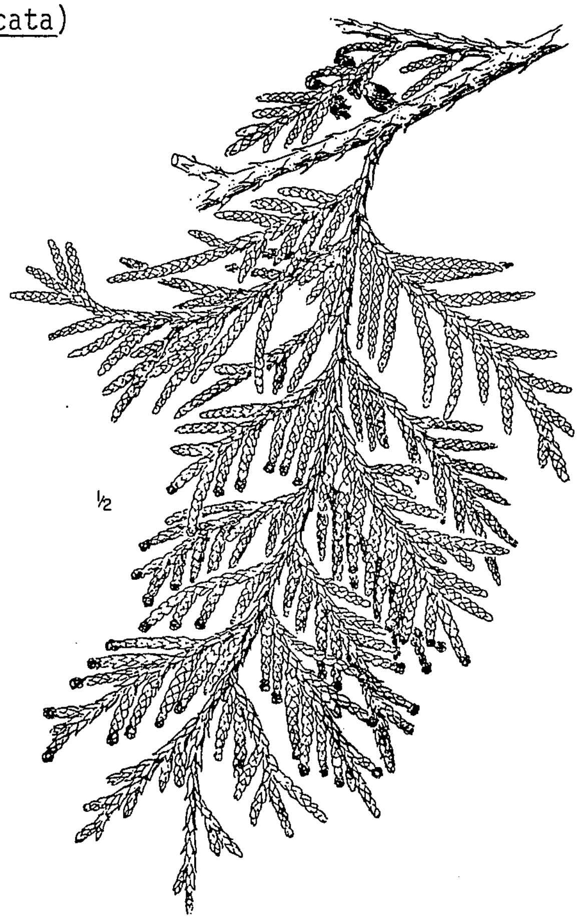
c. douglas-fir (Pseudotsuga menziesii)



d. sitka spruce (Picea sitchensis)



e. western red cedar (Thuga plicata)



D. Parallel-Ridge Dunes

Multiple sand dune ridges which occur more or less parallel to, and inland from, the foredune.

1. Geomorphology

Each ridge in a group of parallel-ridge dunes originally formed as a foredune on an accreting beach. As the beach grew seaward, vegetation advanced to keep pace with the upper beachline. New dune mounds and eventually a new foredune developed oceanward of the previous one. Continued accretion resulted in the eventual development of a series of parallel ridges bordering the beach. The sand dunes of the Clatsop Plains are classic examples of this type. Here the dunes are very broad, gently sloping features aligned in a general north-south direction, parallel to the beach. Other, often discontinuous examples occur in association with accreting beach areas, such as in those areas of jetty construction. Parallel-ridge dunes appear to be developing at the north end of South Beach in Lincoln County. A very pronounced example of this feature occurs adjacent to the north end of Heceta Beach in Lane County. These are extremely steep ridges, unlike the Clatsop Plains variety.

2. Vegetation

Vegetation associations in parallel-ridge dunes become increasingly diverse and mature progressing inland, and range from European beachgrass (Ammophila arenaria) on the existing foredune, landward through native herbs, shrubs and forest species, many of which have been planted through sand stabilization projects (e.g. Clatsop Plains).

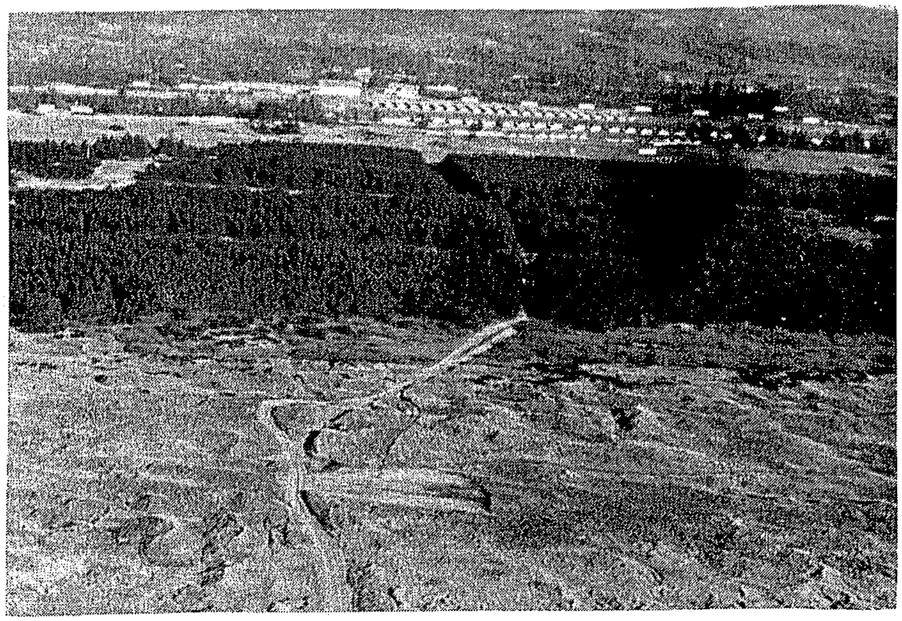
3. Attractions and limitations

This landform probably has the same attractions and limitations as conditionally stable hummock dunes and surface stabilized dunes. Due to reactivation of a major portion of the sand in the Clatsop Plains, most examples of this landform are in a conditionally-stable state although areas of surface-stabilized conditions do occur.

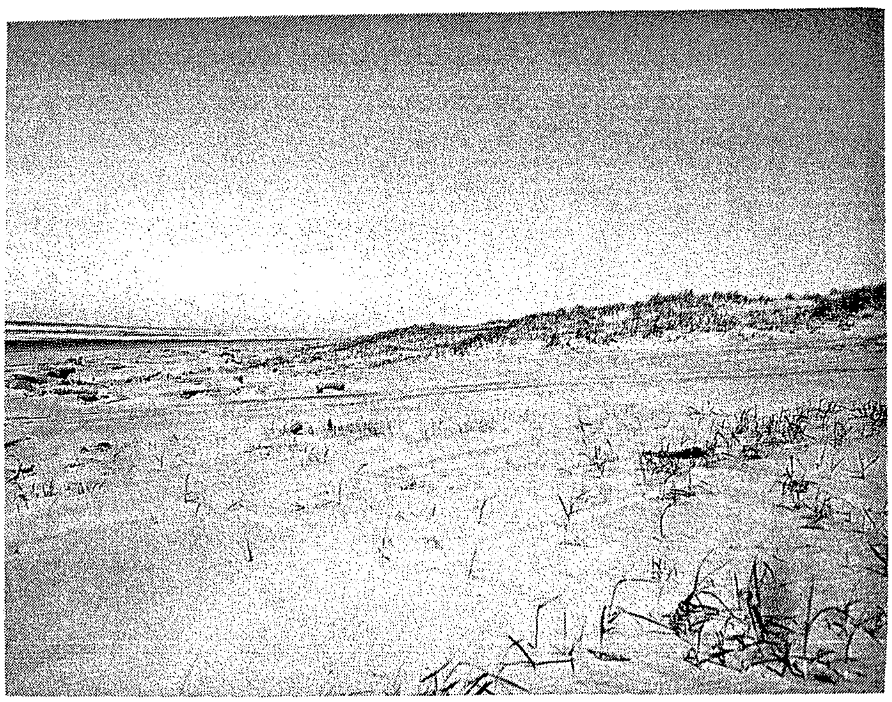
4. Identification check-list

Parallel-ridge dunes can be identified by the following characteristics:

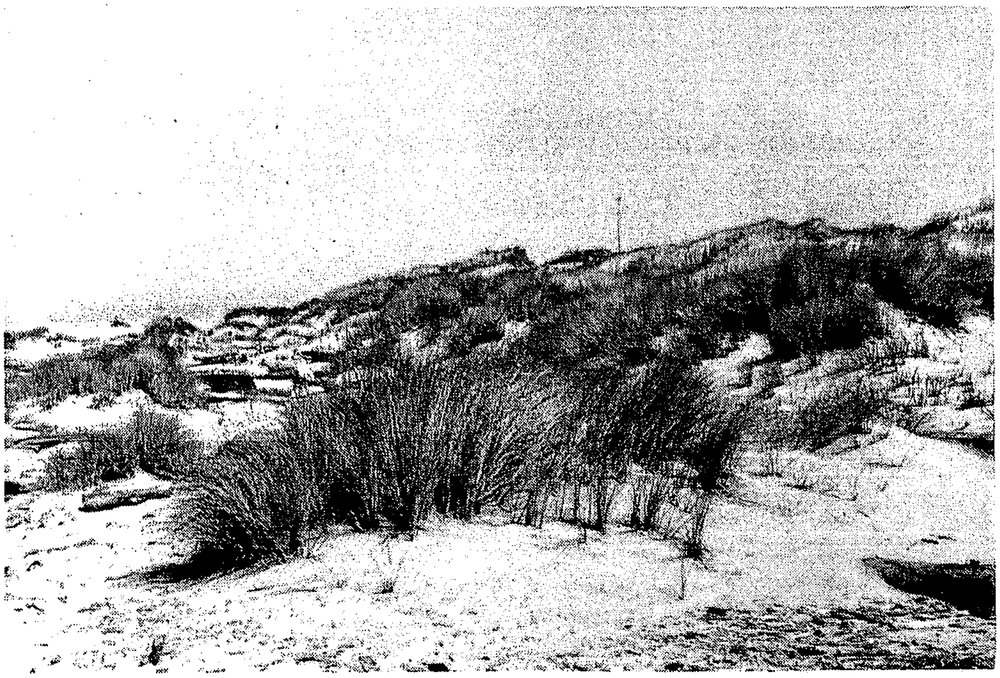
1. They occur in groups, running more or less parallel to the beach.



2. The Clatsop Plains variety commonly possess a very gentle angle of slope, whereas limited occurrences on the central and south coast are steeper.



3. Because they occur in a region of accreting beaches, portions of a newly forming foredune may occur seaward of the present foredune.



VI. INTERIOR DUNES - NONVEGETATED

This category includes those large areas of active sand which are located primarily on the sand sheets (sand deposits of considerable depth and breadth overlying subsurface coastal terraces) along the central Oregon coast. These dunes are mostly vegetation free and therefore, are formed primarily in response to wind and sand supply. Moisture and topographic factors provide morphological controls of secondary importance.

The western boundary of open dune sand areas is generally located east of the deflation plain, but is occasionally found immediately adjacent to the foredune. The western section is essentially a nonvegetated equivalent of the hummock dunes. Open sand areas derive their sand supply from the deflation plain and foredune (Figure 5). However, open sand

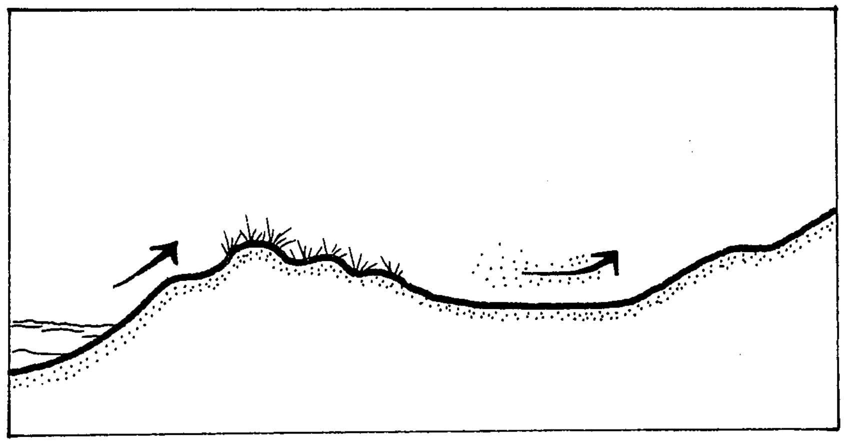


Figure 5. Beach, foredune and deflation plain supply sand to interior open sand areas.

landforms located downwind from conditionally stable foredunes or vegetated deflation plains could dwindle due to sand starvation because little sand escapes beyond these well-vegetated landforms. Open sand dunes move inland under the influence of onshore winds while the sand supply is captured by the foredune. Consequently, open sand areas are growing ever smaller, as increasingly large deflation plains are formed in their wake.

The pattern of dune development and reactivation is nowhere more complicated than on the open sand sheets. Sand deposited in these areas during Pleistocene and post-Pleistocene sea level fluctuations has been "reworked" several times, varying from one area to another. Because of this, buried soils, iron bands, islands of mature forest, and actively eroding older dune strata are common features coexisting within active sand areas.

A. Transverse-ridge Dunes

Low northeast/southwest oriented, nonvegetated sand dune ridges which most commonly migrate in a southeasterly direction.

1. Geomorphology

Transverse-ridge dunes are primarily features of the summer environment. They are undulating, sinuous ridges which are formed essentially perpendicular to the northwest winds of summer and which are greatly modified in shape during winter storms. Their orientation is northeast/southwest; migration takes place in semi-parallel ridges moving in a southeasterly direction (Figure 6).

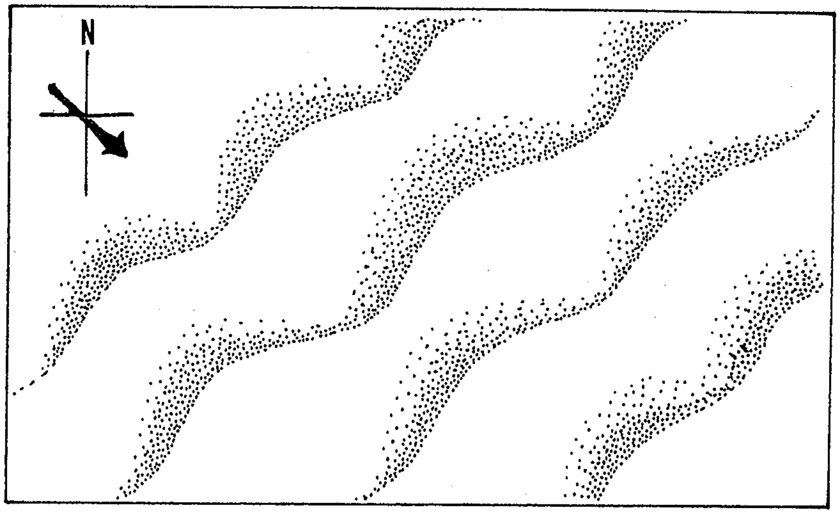


Figure 6. Transverse-ridge dunes form approximately perpendicular to northwest summer winds.

Transverse-ridge dunes are a low relief feature, five to twenty feet high composed of a gentle sloping windward face (five to twenty-five degrees) and a relatively steeper slip face (sixty to seventy degrees). The distance between crests is highly variable, but generally ranges between seventy-five and 150 feet. Where breaches occur, these dunes reveal a highly complex interior cross-bedding. This feature is produced when layers of sand from an advancing dune are deposited obliquely on the dune in its path.

Transverse-ridge dunes occur in groups. They are commonly found on the eastern fringe of the deflation plain. However, Lund (1973) reports that thirty years ago transverse dunes often extended from the beach east into the lower part of the oblique-ridge dunes. This occurred prior to the introduction of European beachgrass (Ammophila arenaria).

A zone of seasonally wet transverse-ridge dunes is often found on the eastern fringe of a deflation plain with a high winter water table. Transverse-ridge dunes commonly extend from the eastern edge of the deflation plain into the zone of the massive oblique-ridge dunes, often "riding" up over the surface of the latter.

Transverse-ridge dunes occur in Lane County on the major open sand strip between the Siuslaw and Siltcoos rivers and on the open sand areas west of north Ten Mile Lake in Coos County.

2. Vegetation

Although transverse-ridge dunes comprise a basically open dune sand unit, isolated areas of vegetation may occur in the depressions between crests. These are primarily associated with the deflation plain and will consist of the various plant types associated with that landform.

3. Attractions and limitations

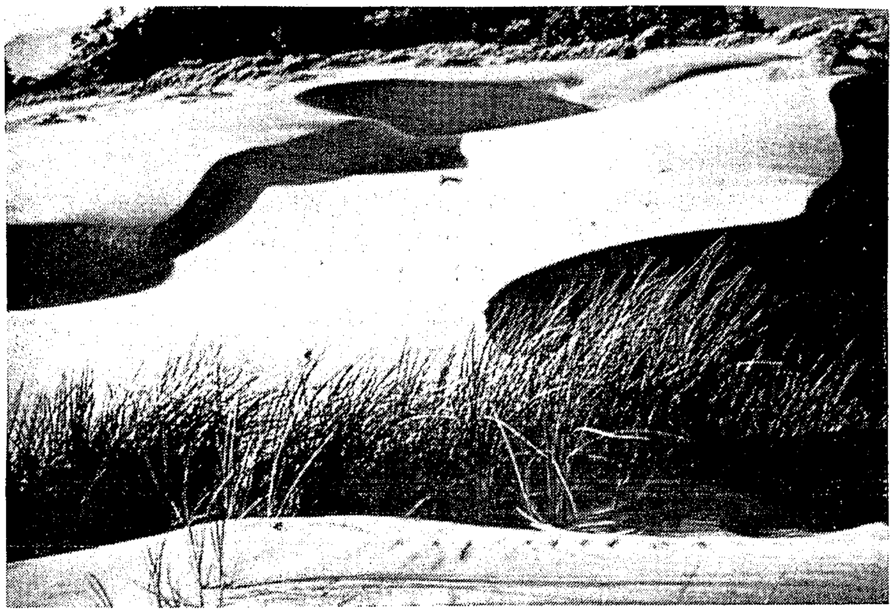
This unit appears to be highly attractive to off-road vehicle users and, to a lesser extent, pedestrian traffic. It has a high tolerance level to most recreational activities, however, facilities such as parking lots and road construction are not suited to this formation. (In some cases stabilization plantings could render such developments feasible; however, these are commonly relatively infertile sand areas (U.S.D.A., 1972, p. 105).

Factors which could create hazards are occasional areas of quicksand in wet depressions between transverse dune ridges, poor visibility in an area used by both off-road vehicle enthusiasts and pedestrians, and inundation or undermining of structures by moving sand.

4. Identification check-list

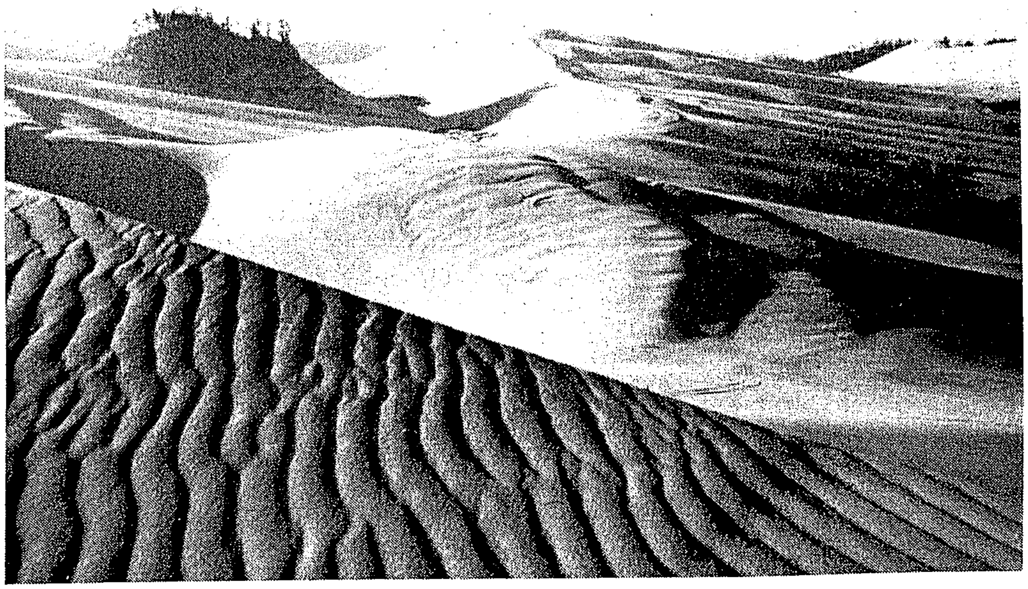
Transverse dunes may be identified by the following features:

1. This dune form occurs as a low (five to twenty-five foot) sinuous ridge with a gently sloping (five to twenty-five degree) windward face and a steeper (sixty to seventy degree) lee face.



2. Transverse-ridge dunes exhibit a northeast/southwest trend and occur in groups on the large, open sand areas along the south central coast.

3. Transverse-ridge dunes often ride up over the western flanks of the massive oblique-ridge dunes.



4. Marsh-type vegetation may occur between ridges where these dunes overlap onto the deflation plain.

B. Oblique-Ridge Dunes

Massive, generally easterly trending and migrating, nonvegetated ridge dunes found on central Oregon coastal sand sheets.

1. Morphology

The most dominant and obvious dune form in the open sand is the oblique-ridge type. Like the transverse-ridge, it is dynamic in nature. However, unlike the transverse-ridge, which is produced by unidirectional wind flow, the oblique dune is formed both by the northwest summer and southwest winter winds, experiencing its most energetic movement during winter storms (Ternyik, 1978). Its somewhat sinuous axis is oriented at an angle (obliquely) to both dominant seasonal wind sources (Figure 7). Primary controlling factors in the development of the oblique-ridge dune

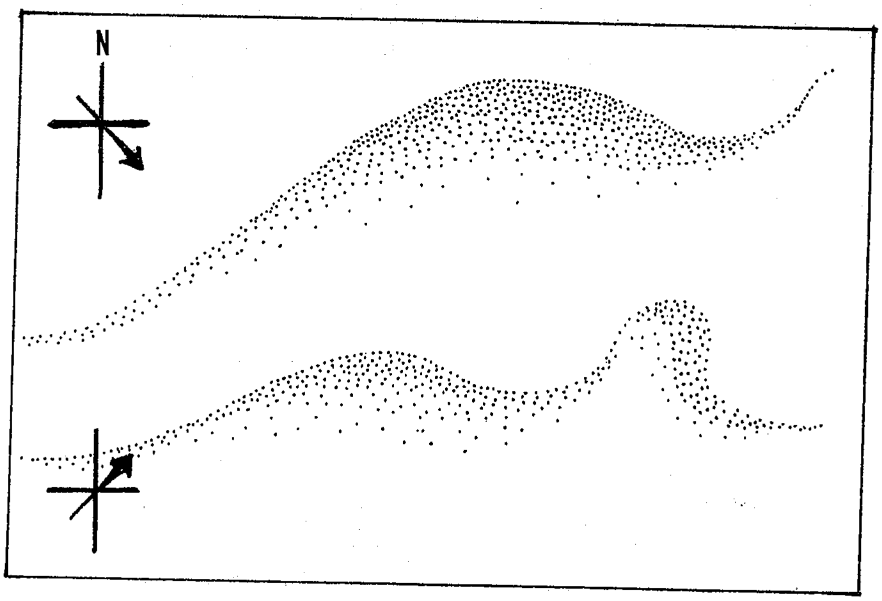


Figure 7. Oblique-ridge dunes form obliquely to both northwest and southwest dominant seasonal winds.

are an abundant sand supply, nearly constant onshore winds and coastal forests which act as wind breaks (Cooper, 1958).

Sands are moved inland by the onshore winds both in the summer (northwest wind) and the winter (southwest wind). Coastal forests which exist on the sand sheets break the flow of the low-level winds, causing them to deposit their sand load at the forest margin. Sand is thereby deposited at a site until the height of the dune thus produced equals or exceeds that of the windbreak. Sand is then precipitated over the eastern face of the dune (of the precipitation ridge) by onshore winds (Figure 8). In this way, the dune moves slowly inland inundating the

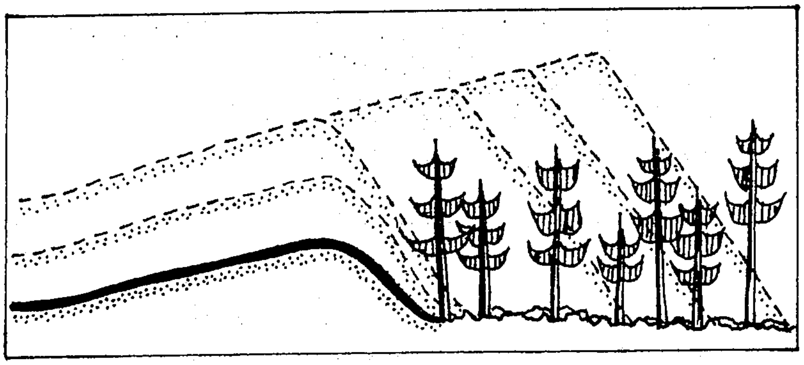


Figure 8. Accumulation and advance of the oblique-ridge dune.

forest as it goes (Cooper, 1958). The ridge does not actually migrate, but the ridge crest operates rather like a stationary transverse dune, the upper lee face of which develops to the south in the summer and to the north in the winter in response to dominant seasonal wind direction (Figure 9). The windward face has a gentle slope (five to thirty degrees)

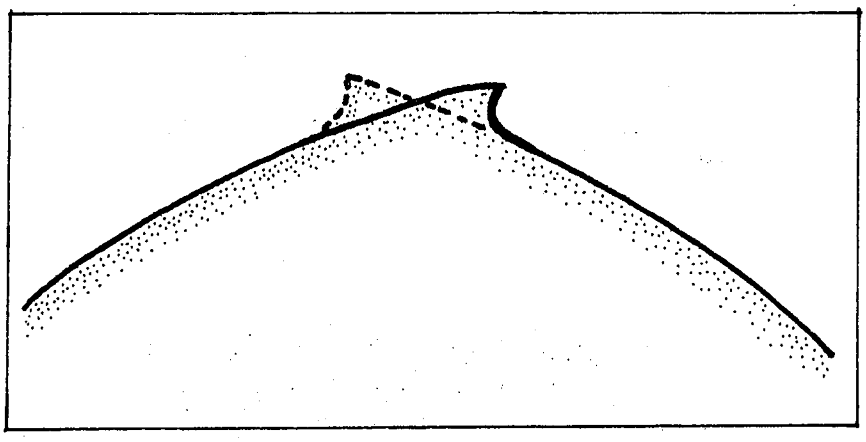


Figure 9. The ridge position of the oblique dune is modified by seasonal winds.

while the lee face is considerably steeper with a gradient of sixty to seventy degrees.

The oblique dunes may reach heights of 180 feet along the eastern edge and may occur in groups with 500 feet or more between ridges. They attain great lengths, averaging over 3,000 feet while some are nearly a mile long (Cooper, 1958). They are commonly bounded on their ocean-ward side by transverse-ridge dune systems and often terminate at their eastern extremity in a precipitation ridge, actively invading older forested dunes (Figure 10). A system of oblique-ridge dunes may form a

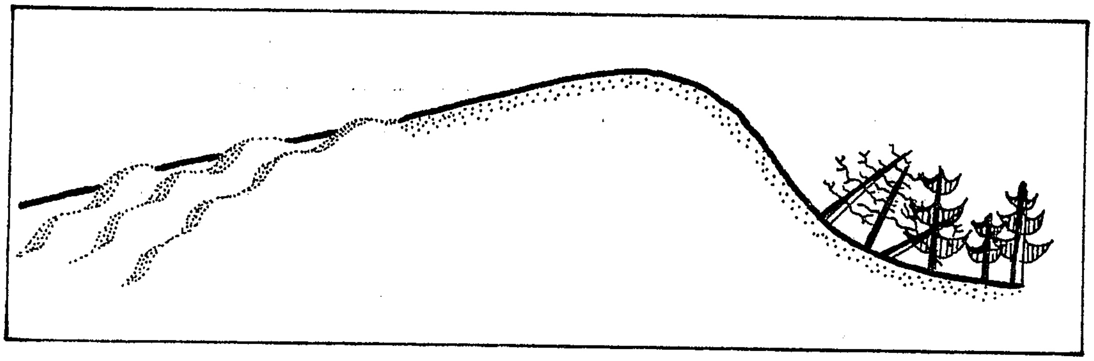


Figure 10. Transverse-ridge dunes riding up over the flanks of an oblique-ridge dune which terminates in a precipitation ridge.

nearly continuous eastward advancing precipitation ridge, often called the active ridge.

The world's distribution of the oblique-ridge dune is limited to the central Oregon coast and occurs on the sand sheets of Lane, Douglas and Coos Counties. Good examples are found between the Siuslaw and Siltcoos Rivers in Lane County and just north and south of the Douglas-Coos Counties boundary.

2. Vegetation

Sparse, marsh-type vegetation may occasionally occur in the depressions between ridges within this landform. These are areas of high water table and are classified as occasionally wet interdune areas. Isolated areas of hummock dunes may also occur on the surface of this landform.

3. Attractions and limitations

Recreationalists use the oblique-ridge dunes on foot, on horseback and in off-road vehicles. These dunes dominate the landscape and capture the imagination of visitors. Impact of recreationalists on this landform is reportedly negligible (U.S.D.A., 1972) although research on Atlantic Coast dunes indicates that considerable sand transport can occur from ORV traffic. This phenonemon would not commonly be considered a serious problem in areas of open windblown sand, however, it could prove to be a contributing factor to such problems as rapid dune advance on interdune lakes, such as at Cleawox Lake in Lane County where ORV traffic is quite heavy.

Oblique-ridge dunes do, however, pose potential hazards for recreationalists from naturally camouflaged tree cast openings in the ground.

Although the oblique-ridge dune is poorly suited to the development of permanent structures (U.S.D.A., 1972), some development has occurred here. Stabilization plantings, if carried out and maintained properly, can alleviate potential development problems. A primary obstacle, however, is that due to the oblique-ridge dunes' mobility and incompatability with legal boundaries, access to key downwind sites for the purpose of stabilization plantings may not be readily available to the developer. Water table limitations mentioned in relation to the surface stabilized and older stable dunes also apply to this dune form.

Recently, concern has been expressed for the survival of these unique dune forms. It has been predicted that these features could disappear within seventy-five years due to sand starvation (U.S.D.A., 1972, p. 110). Those processes, both natural and man-induced which threaten this feature include:

1. The eastward expansion of the deflation plain due to foredune stabilization which cuts off sand supply to the area (Figure 11).

2. Stabilization plantings for developmental and protection purposes.

3. Natural revegetation of the open dune sand areas. The sand sheets of the central Oregon coast, on which these dunes occur have experienced several periods of dune reactivation and subsequent revegetation in the last few thousand years (Cooper, 1958). Sands which were reactivated, probably by fires, experienced restabilization through the natural readvance of indigenous species. This pattern of revegetation could well repeat itself today.

Due to the combination of foredune development and resulting deflation plain advance, stabilization plantings and natural revegetation, the oblique-ridge dunes will almost certainly disappear in the foreseeable future, unless man intervenes.

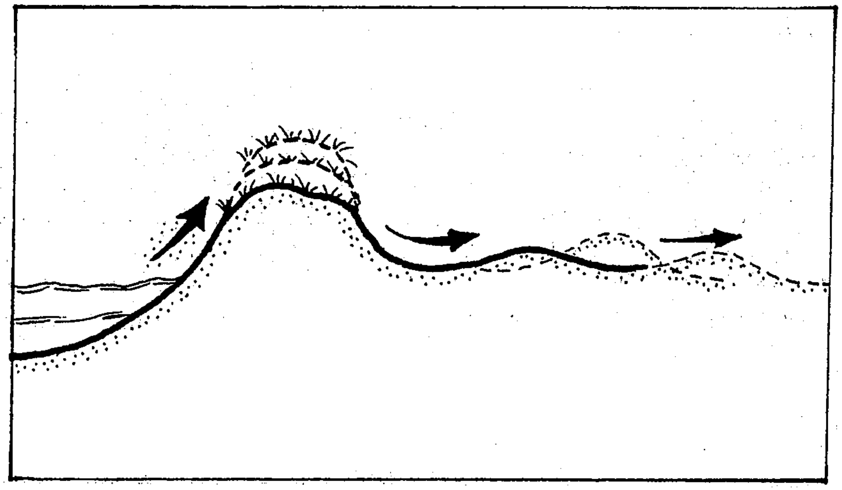
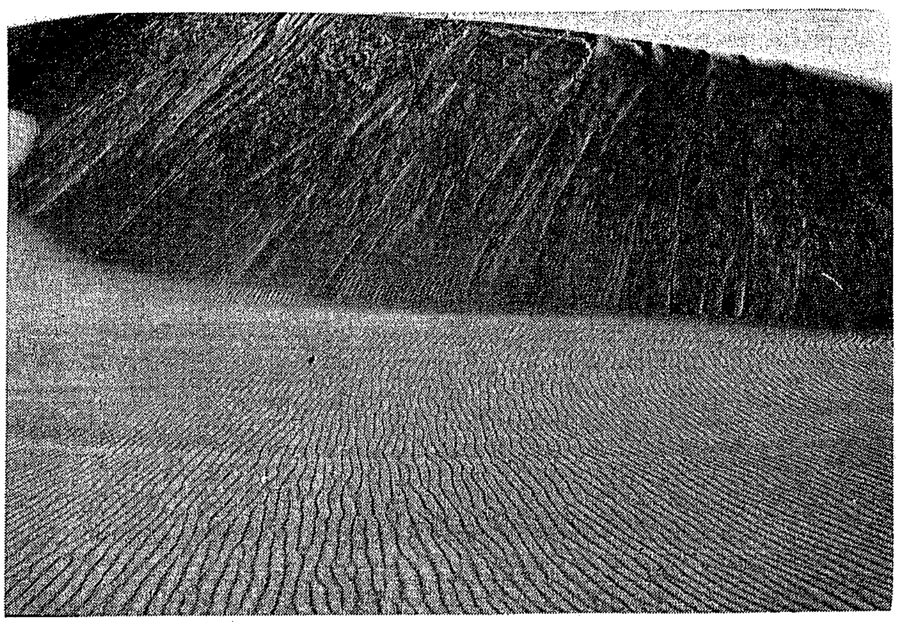


Figure 11. Eastward expansion of deflation plain. Sand supply is interrupted by the growing foredune.

4. Identification check-list

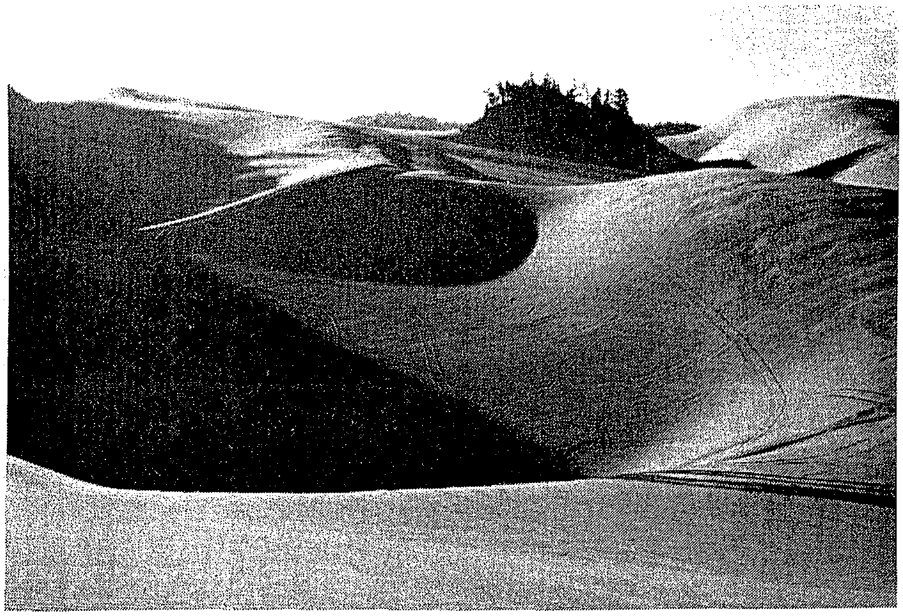
The oblique-ridge dune can be identified by the following characteristics:

1. The massive size of the oblique ridge dune is probably its most distinctive characteristic.



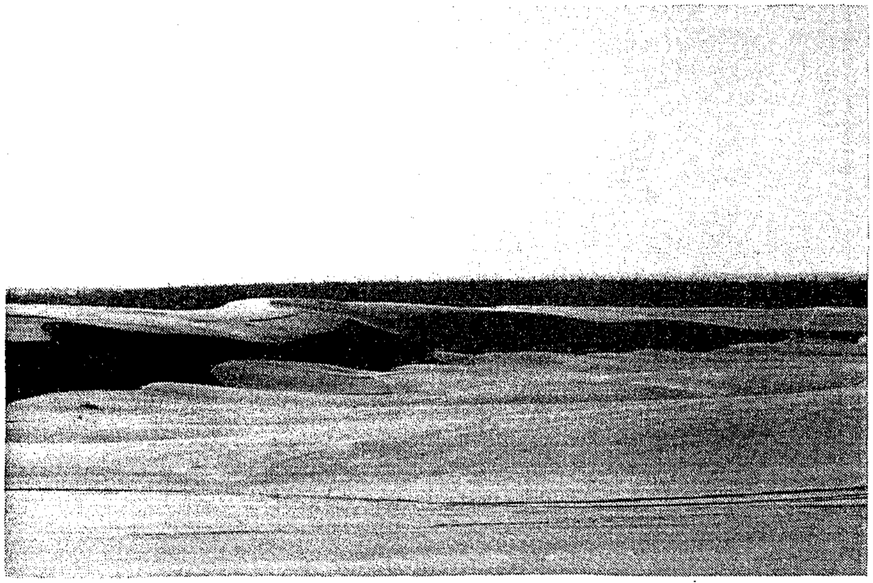
2. It consists of:

   a. a long, sinuous inland moving ridge gently sloping on its windward flanks, and

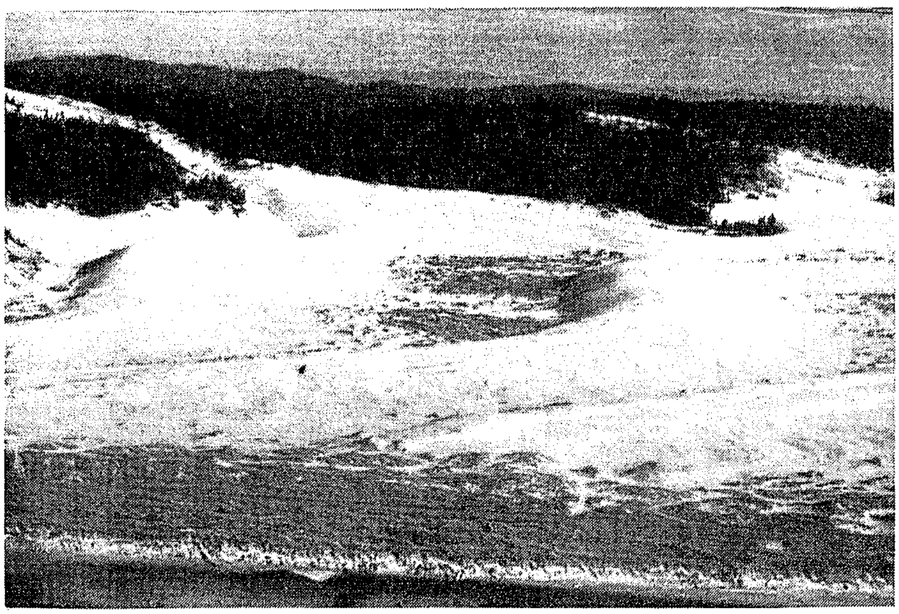


   b. very steeply sloping at its high eastern terminus where it may be encroaching on older forested dunes.

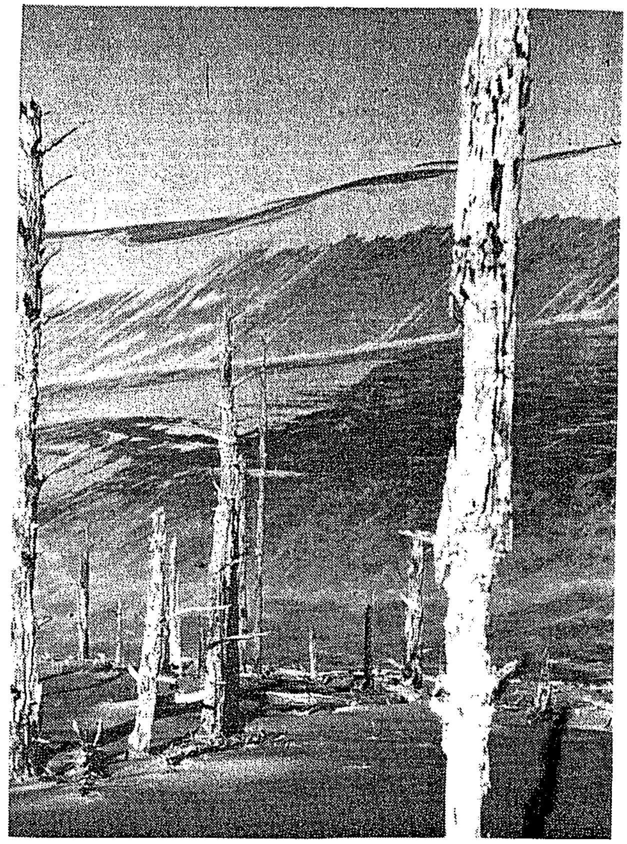
3. The slopes of this dynamic landform are most commonly vegetation-free.



4. The oblique dune landscape appears as a series of undulating waves of sand.



5. Passage of the precipitation ridge may leave exhumed forests in its wake.



6. Islands of surface stable dunes are occasionally found within this open sand landscape.

C. Recently Reactivated Forms

Reactivation of active, conditionally stable and surface stable dunes can occur when binding vegetation and/or the protective soil layer is removed and the site is exposed to erosive winds. The amount of disturbance required for reactivation varies from site to site. Sensitivity to reactivation will depend upon those factors which influence sand cohesiveness, including vegetative cover and cementation such as that which often occurs within the older stabilized dunes. The orientation of the disturbed site to prevailing winds is also of critical importance.

1. Blowout

Localized zone of moving sand within an otherwise vegetated area, which forms a depression from wind erosion on its windward side and an area of accumulation at its terminus.

a. Geomorphology

A blowout is the result of wind scouring within an otherwise conditionally stable or surface stable dune (Figure 12). A blowout

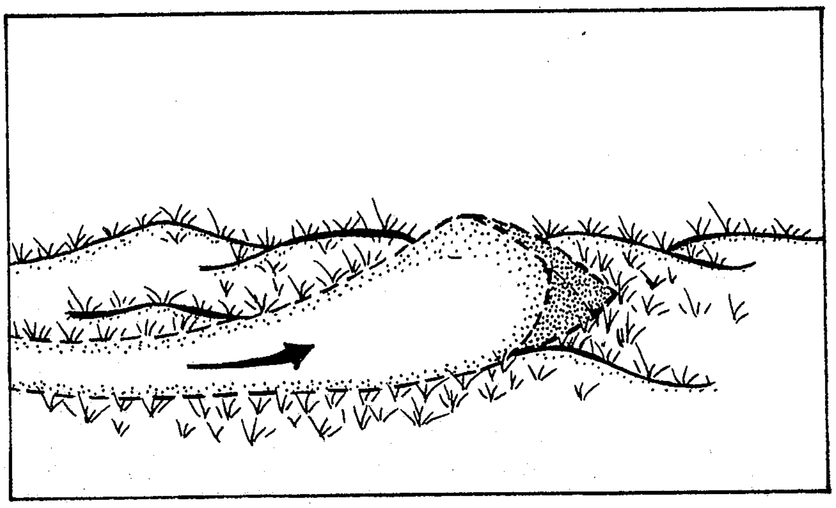


Figure 12. Small blowout within beach grass environment.

may breach the host dune and threaten others in its path. This feature may be only a few feet across and several feet long in the early development stages. However, it can develop into a landform hundreds of feet across and more than a mile long (parabola dune). Smaller blowouts are relatively common features of recently stabilized areas. Once a blowout is begun, especially in the foredune, the trough created tends to funnel the wind, increasing its velocity, and thereby enlarging the blowout.

b. Vegetation

This is a vegetation free landform which is surrounded by vegetated dunes on at least three sides.

c. Attractions and limitations

This feature is probably not suitable for any particular activity or structure.

The potential impacts of a blowout on downwind sites include sand blasting, sand burial and/or heightened storm impact. Areas which may be prone to blowout activity (i.e. recently planted sites or beach grass areas which experience considerable use) should be carefully watched particularly if significant impact inland is probable.

d. Identification check-list

A blowout may be identified by the following features:

1. A blowout is a somewhat elongated, mobile sand landform which occurs within otherwise surface stable or conditionally stable dunes.

2. Parabola Dune

Massive unidirectional trough of deflation terminating in a zone of accumulation within an otherwise vegetated area.

a. Geomorphology

A parabola is essentially a trough blowout of major size which is enclosed on three sides by older vegetated dunes and on the fourth, its source area, by open sand usually of the oblique-ridge type (Figure 13). The initial development of a parabola requires a stable vegetated

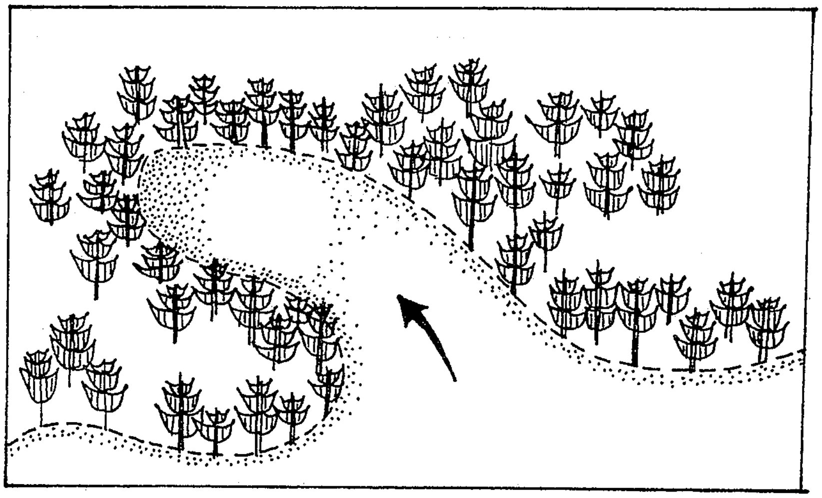


Figure 13. Parabola blowout moving through forested dunes.

site downwind with a point of weakness for the moving sand to break through, considerable volume of source sand, and a unidirectional wind source. Parabolas move inland from their open sand source, through the vegetated area, in a direction parallel to the unidirectional wind source. They can be seen oriented either to the northwest winds of summer or the southwest winds of winter. They may be a hundred feet or more across and extend to nearly a mile in length. Parabolas are named for the similarity that their perimenter bears to the parabolic curve.

b. Vegetation

This is essentially a vegetation free landform although less active forms may exhibit occasional vegetated hummocks.

c. Attractions and limitations

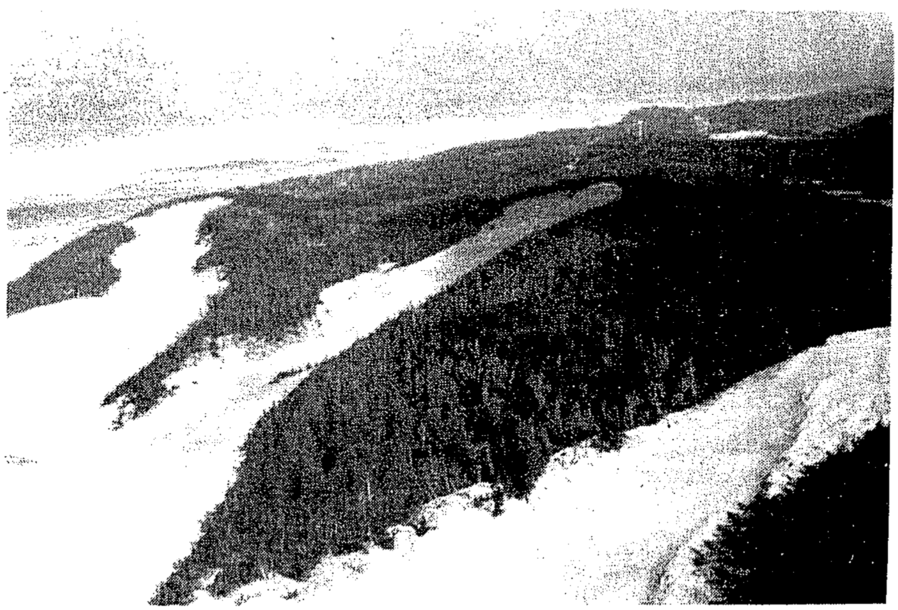
Recreationalists are attracted to this landform for walking, viewing, riding horses, and operating off-road vehicles. The only limitations on these activities are the sensitivity of the fringe-areas' vegetation to trampling and the possible nuisance of sand blasting.

Any development involving permanent structures would be subject to the same limitations as those associated with the oblique-ridge dunes although sand blasting may be a greater problem in this landform.

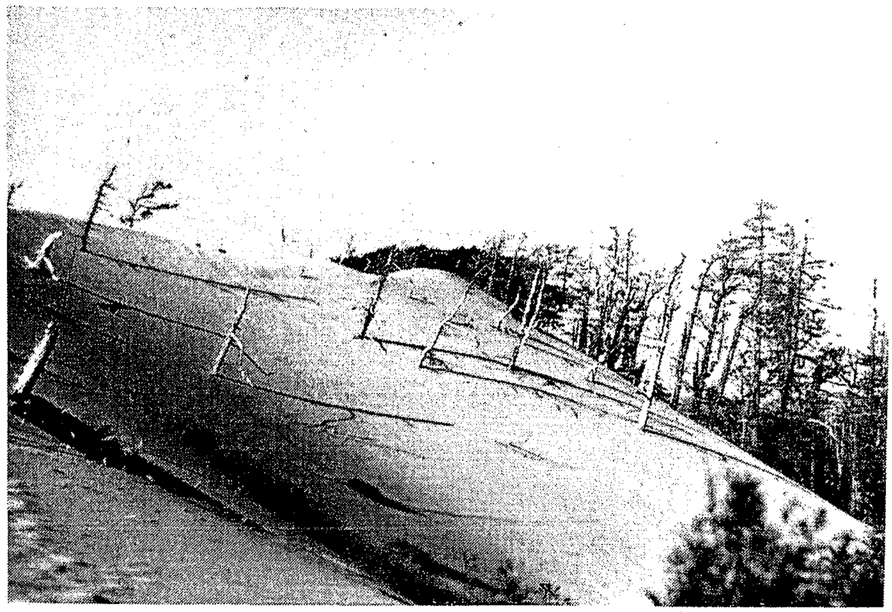
d. Identification check-list

A parabola dune may be identified by the following characteristics:

1. This feature creates an elongate finger of sand cutting through old forested dunes.



2. The terminus (advancing end) of well-developed parabola dunes commonly creates a precipitation ridge advancing on older forested dunes.



VII. GLOSSARY OF TERMS

Accretion: Oceanward advancement of the beach through the ongoing accumulation of sand at its edge.

Active Dunes: Partially vegetated dunes that migrate, grow and diminish according to wind, sand supply and vegetation cover. (May apply to the foredune or hummock dunes.)

Beach Cusps: Embayments of various widths and slopes cut into the beach by the cellular circulation of onshore and offshore currents.

Blowout: Localized zone of deflation within an otherwise vegetated area.

Conditionally Stable Dune: A dune which presently has sufficient vegetation cover to retard wind erosion but which is vulnerable to reactivation upon disturbance of this cover.

Deflation: The erosion of sand or soil by the wind.

Embryo Dune: Low, newly forming dune mounds.

Erosion: To wear away by the action of water, waves or wind.

Lee: The side that is sheltered from the wind.

Older Stable Dune: Dunes of any form which possess both a deep, well-developed soil and semi-cemented underlying sand.

Onshore Winds: Winds which are moving toward or onto the shore from open water.

Precipitation Ridge: High, steeply sloping slip face of large oblique-ridge and parabola dunes.

Rip Current: A strong relatively narrow current flowing outward from a shore which results from the inland flow of waves and wind-driven water.

Sandsheet: Sand deposits of considerable depth and breadth overlying sursurface coastal terraces.

Surface Stabilized Dune: Commonly forested dunes which possess a thinly developed soil and are underlain by loose unconsolidated sands.

Wind Stable Dune: Those dunes which possess sufficient vegetation and/or soil cover to retard wind erosion.

Windward: The side or direction from which the wind is blowing.

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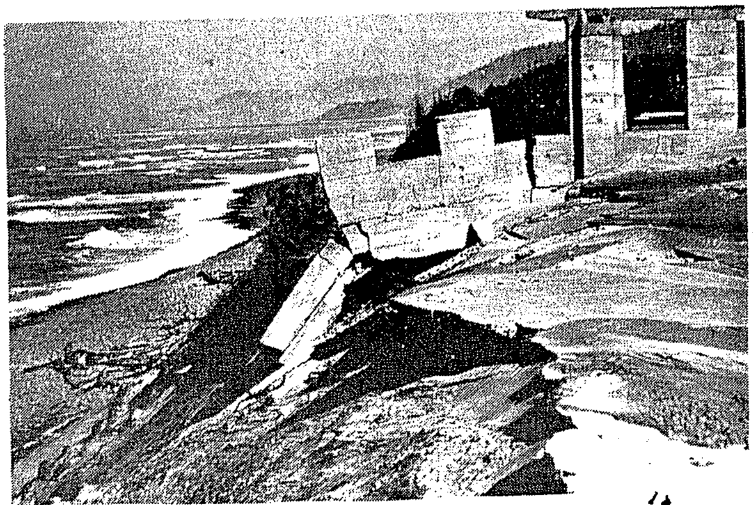
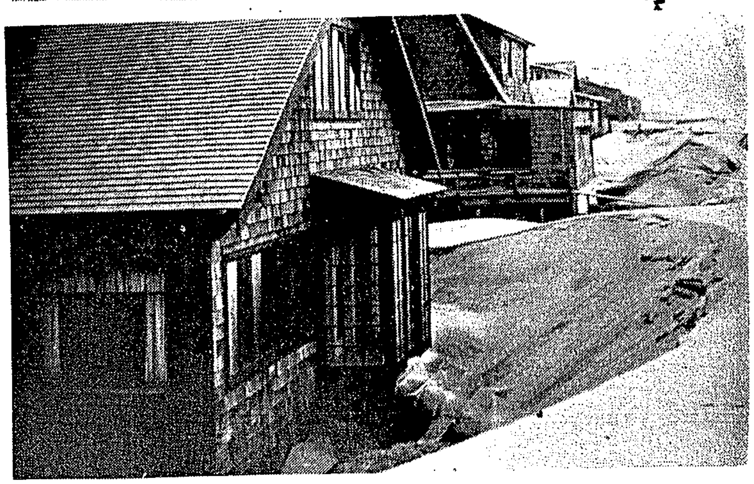
Physical Processes & Geologic Hazards On The Oregon Coast





Oregon Coastal Zone Management Association, Inc.

This report was prepared as part of a larger document addressing various beach and dune planning and management considerations and techniques. Other segments of the document and additional materials are:

I. BACKGROUND ON BEACH AND DUNE PLANNING:

Background of the Study

An Introduction to Beach and Dune Physical and Biological Processes

Beach and Dune Planning and Management on the Oregon Coast: A Summary of the State-of-the-Arts

II. BEACH AND DUNE IDENTIFICATION:

A System of Classifying and Identifying Oregon's Coastal Beaches and Dunes

III. PHYSICAL AND BIOLOGICAL CONSIDERATIONS:

Physical Processes and Geologic Hazards on the Oregon Coast

Critical Species and Habitats of Oregon's Coastal Beaches and Dunes

IV. MANAGEMENT CONSIDERATIONS:

Dune Groundwater Planning and Management Considerations for the Oregon Coast

Off-road Vehicle Planning and Management on the Oregon Coast

Sand Removal Planning and Management Considerations for the Oregon Coast

Oregon's Coastal Beaches and Dunes: Uses, Impacts and Management Considerations

Dune Stabilization and Restoration: Methods and Criteria

V. IMPLEMENTATION TECHNIQUES:

Beach and Dune Implementation Techniques: Findings-of-Fact

Beach and Dune Implementation Techniques: Site Investigation Reports

*Beach and Dune Implementation Techniques: Model Ordinances**

VI. ANNOTATED BIBLIOGRAPHY:

Beach and Dune Planning and Management: An Annotated Bibliography

VII. EDUCATIONAL MATERIALS:

Slide show: *Managing Oregon's Beaches and Dunes*

Brochure: *Planning and Managing Oregon's Coastal Beaches and Dunes*

*Prepared under separate contract between Oregon Department of Land Conservation and Development and the Bureau of Governmental Research, Eugene.

Cover design by Arlys Bernard, Newport, Oregon. Photos depict accretion at Clatsop Plains and erosion at Bay Ocean, Oregon.

PREFACE

The following report presents the results of an overview of beach and dune processes and erosion on the Oregon Coast. The study was conducted by Dr. Paul D. Komar, Associate Professor at Oregon State University, Corvallis under contract with the Oregon Coastal Zone Management Association, Inc. and with assistance from OCZMA's Beaches and Dunes Study Team composed of Carl Lindberg, Project Leader, Christianna Crook, Project Associate, Arlys Bernard, Project Secretary, Wilbur Ternyik, Project Coordinator and Kathy Fitzpatrick, Project Administrator. This report constitutes one element of an overall analysis of planning for and managing coastal beaches and dunes as required by Oregon's Beaches and Dunes Goal.

OCZMA extends special appreciation to Dr. Komar for the professional and timely manner in which this report was conducted. Additionally, OCZMA acknowledges the valuable review and comment made by the Beaches and Dunes Steering Committee composed of:

R. A. Corthell, U.S. Soil Conservation Service
Steve Stevens, U.S. Army Corps of Engineers
Sam Allison, Oregon Department of Water Resources
Peter Bond and John Phillips, Oregon Department of Transportation, Parks and Recreation Division
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Steve Felkins, Port of Coos Bay
Rainmar Bartl, Clatsop-Tillamook Intergovernmental Council
Gary Darnielle, Lane Council of Governments
Cathy McCone, Coos-Curry Council of Governments
Marilyn Adkins, City of Florence Planning Department
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Oscar Granger, Lincoln County Planning Department
Curt Schneider, Clatsop County Planning Department

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I. INTRODUCTION

The coast of Oregon is made up of stretches of sandy beaches separated by rocky headlands jutting out into the sea (Figure 1). The major headlands such as Cape Blanco, Arago, Perpetua, Foulweather, Cascade Head, Lookout, Meares, Falcon and Tillamook Head are composed of hard basalt, resistant to wave attack. The stretches of beach vary in length from small pocket beaches nestled amongst the rocky headlands to the 50-mile long beach extending from Heceta Head south to Cape Arago near Coos Bay. The beaches are backed in part by sea cliffs cut into lithified sedimentary rocks, sandstones and mudstones, in all cases much less resistant than the basaltic headlands. In some areas the beaches are backed by foredunes consisting of loose sand; such foredune areas show little resistance to wave attack even when well vegetated. Sand spits, such as Coos, Siletz, Nestucca, Netarts, Bayocean and Nehalem, are almost all loose sand and have thus shown the greatest amounts of erosion when attacked by waves. Because sand spits are also particularly attractive building sites with views both of the ocean and bay, the most dramatic examples of erosion destruction have occurred there.

This report will examine particular erosion problems associated with the various sites on the Oregon coast and what can be done from a coastal planning viewpoint to minimize future problems. Sand spits and foredune erosion have presented the greatest erosion problems and therefore have been most extensively studied. The problems associated with dwelling construction in active foredune areas will be considered, followed by an examination of the longer-term erosion of the sedimentary sea cliffs, the erosion of which is important to communities such as Brookings, Bandon, Waldport, Newport, Lincoln City, Cannon Beach and many others.

Erosion of the Oregon coast cannot be understood properly without reference to the physical processes causing that erosion: the ocean waves, tides, nearshore currents, tsunami and winds. For that reason this report will begin with a discussion of these factors and what is known about physical processes on the Oregon coast. At the same time the sources of sand to the beaches and dunes and their general morphology will be examined.

II. COASTAL PROCESSES AND LAND FORMS

A. Beaches

Like most other continental beaches, the beaches of Oregon are composed mainly of quartz and feldspar sand grains derived originally from the weathering of granitic-type rocks. But within the beach sands are lesser amounts of dark heavy minerals such as hornblende, magnetite, augite, garnet and epidote, having shades of green, pink and black.

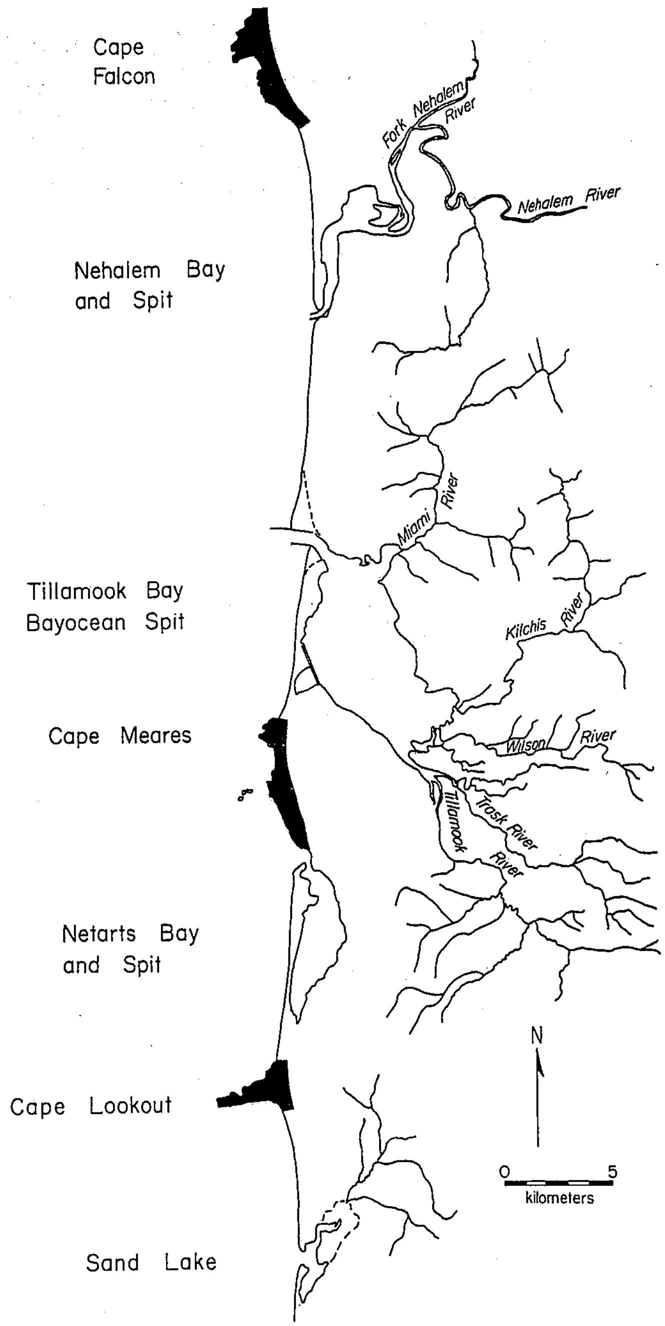


Figure 1. A portion of the north Oregon coast illustrating how it consists of a series of pocket beaches separated by pronounced rocky headlands.

At times these heavy minerals can become locally concentrated so that the beach sand appears greenish-black rather than having the tan color of the quartz and feldspar grains. In certain south Oregon beaches there are 'black sands' containing grains of gold, platinum and chromite, as well as the usual quartz, magnetite, etc. (Twenhofel, 1946). The gold and platinum attracted the attention of prospectors as early as 1852, and little now remains of those minerals in the black sands. The strategic mineral chromite was mined during World War II; although uneconomical to mine now, some chromite remains as a resource.

The beach sands generally have median grain diameters in the range 0.2 to 0.5 mm (fine to medium sand)(Wentworth, 1922), depending upon location. The overall grain size of the beach sand has important effects on the morphology of the beach and its response to erosion. In general, the coarser the beach sand the steeper its offshore slope (Komar, 1976, p. 303-8). Thus the beaches on Siletz Spit and at Gleneden Beach to the south, with a median grain size of about 0.4 mm, are much steeper (average slope - 3.1 degrees) than the more common finer grained beaches (0.2 to 0.3 mm) with average slopes of about 1.7 degrees (Figure 2). As shown by the study of Aquiler and Komar (1978) at two such beaches, a coarse-sand beach also has a higher rate of erosion when attacked by storm waves and a greater amount of total erosion. This in part explains, for example, why Siletz Spit in particular has suffered much erosion.

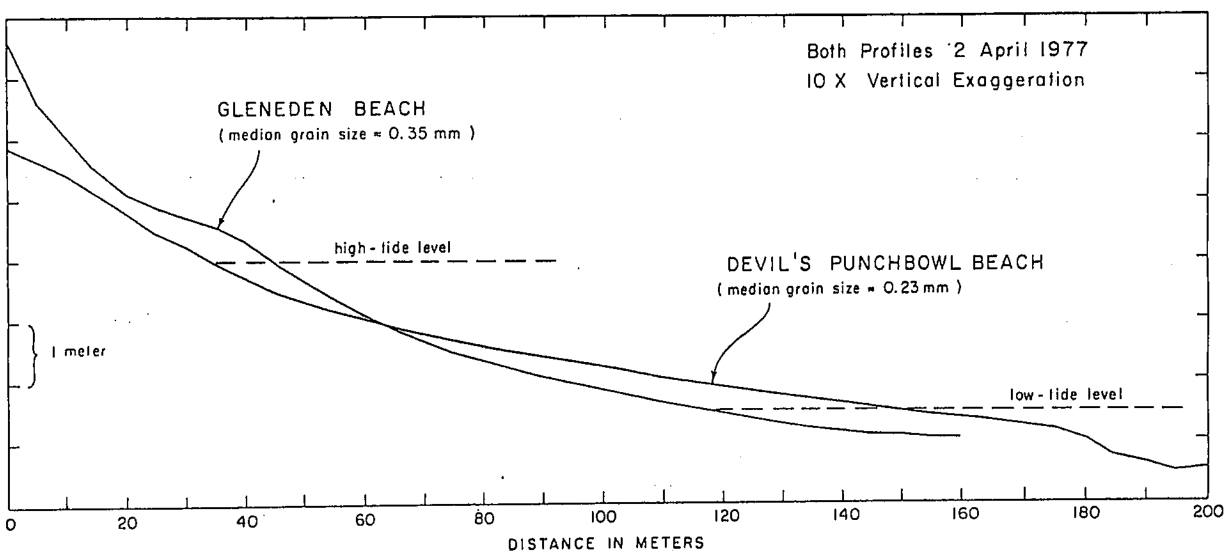


Figure 2. The effects of beach sand grain size on the profile, Gleneden Beach being much coarser and thus having a steeper slope than does the beach to the south of Devil's Punchbowl, Otter Rock.

Small pocket beaches in headland areas usually consist of basalt pebbles and cobbles (4 to 250 mm), the wave energy being too great for sand to remain on the beach. Continuing the trend of increasing beach slope with increasing grain size, these cobble beaches reach slopes of 5 to 25 degrees. Basaltic cobbles and pebbles are also found as a steep storm ridge along the flanks of headlands, backing the otherwise sandy beach (Figure 3). Such cobble ridges form a natural protective barrier from wave attack, important to such areas as Neahkahnie Beach south of Cape Falcon (Figure 3).

Figure 3. The beach at Neakahnie Beach with a steep cobble storm ridge of large rocks derived from the nearby basalt headland, backing an otherwise sandy beach. The cobble ridge offers protection to the coastal property.

B. Sources of Beach Sands

Management of beaches and coasts requires a knowledge of the natural sources and losses of beach sands. For example, if the principal source is sand brought to the coastal zone by rivers, then damming of the rivers would cut off much of that source, resulting in the long-term diminishing of the size of the beach and an increase in coastal erosion.

Such problems are best approached through a consideration of the budget of sediments (Bowen and Inman, 1966; Komar, 1976, Chapter 9). Such a budget involves assessing the sedimentary source contributions (credits) and losses (debits) and equating these to the net gain or loss (balance of sediments) for a given beach. The balance between gains and losses is reflected in local beach erosion or deposition. Table 1 summarizes the usual possible sources and losses of beach sands.

Table 1. The budget of littoral sediments

Credit	Debit	Balance
Longshore transport into area	Longshore transport out of area	Beach deposition or erosion
River transport	Wind transport out	
Sea cliff erosion	Offshore transport	
Onshore transport	Deposition in submarine canyons	
Biogenous deposition	Solution and abrasion	
Hydrogenous deposition	Mining	
Wind transport onto beach		
Beach nourishment		

Unfortunately, the sources and losses of sands to the Oregon beaches are generally only poorly known and usually cannot be quantitatively assessed. On most coasts, rivers are the principal sources, but this does not appear to be true for the majority of Oregon beaches. Many of our rivers pass through sizeable estuaries before reaching the ocean. The river sands are deposited in the estuaries rather than reaching the ocean beaches (Kulm and Byrne, 1966). This can be seen in Figure 4 which shows the areas of sand accumulation in Yaquina Bay and the sources of those sands. In that example the river sands do not reach the ocean beaches, and in fact beach sand is transported into the bay through the inlet so that the estuary represents a loss of beach sands in the budget of sediments. Although more study is needed of other bays and estuaries to determine whether they have similar sand depositional patterns, wide bays such as Coos, Siletz and Tillamook are probably all sinks of river sands so that those rivers do not provide sand to the beaches. Narrow river estuaries such as the Rogue, Umpqua and Siuslaw may be able to transport sand out onto the beaches. However, dredging activities in those estuaries may also remove them as sources of river sands to the beaches. Minor streams (without estuaries) do provide sands to the beaches, but in most cases they are quantitatively minor.

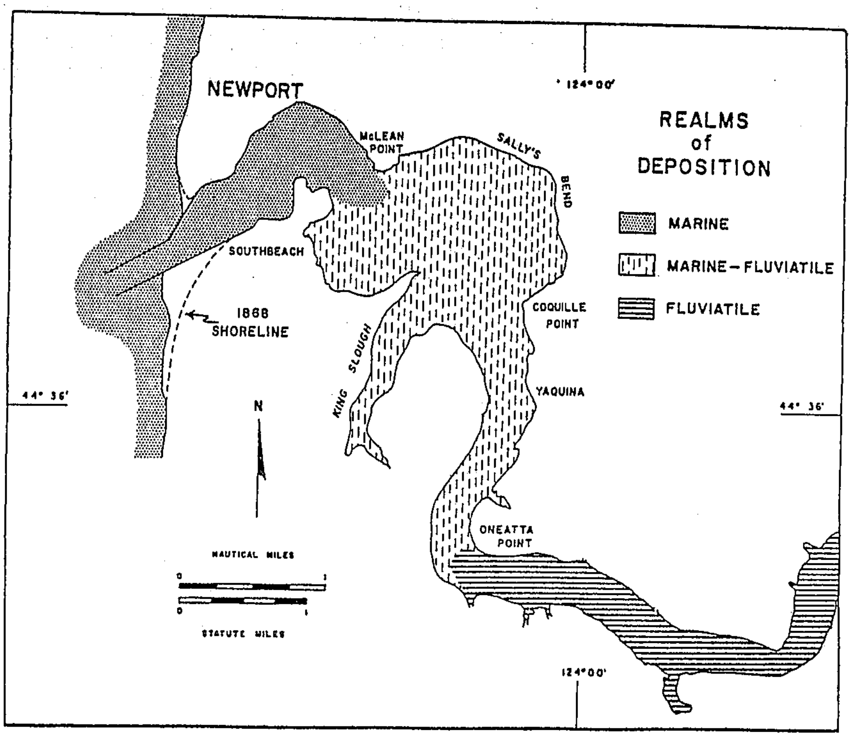


Figure 4. Areas of sand accumulation in Yaquina Bay indicating that the river sands deposit before reaching the ocean and that marine sands are transported through the inlet and also deposited in the bay (from Kulm and Byrne, 1966).

Of major importance to most Oregon beaches is the sand derived from sea cliff erosion. This is especially true where Pleistocene terrace sands form part of the sea cliffs. Removal of this source by the placement of riprap or sea walls (comparable to building a dam on a river) will lead to the long-term decrease in the size of the beach and an increase in coastal erosion.

At present the principal losses of beach sand are by winds blowing the sand inland to form dunes or by losses to the offshore deeper waters. The offshore losses are long-term; as the sand is abraded while on the beach, progressively decreasing in grain size, it may become sufficiently fine to be carried far enough offshore during a storm that it is unable to return to the beach.

Along most of the Oregon coast the sources and natural losses of beach sands are quantitatively small. For this reason, removal of beach sand by sand and gravel companies or others may have a major impact on the beach, this unnatural loss being a major factor in the total budget of sediments. An example of this was the impact of the removal of sand from the beach at Gleneden Beach south of Siletz Spit. An approximate budget of sand for the area is shown schematically in Figure 5. The principal source of sand to this beach has been from sea cliff erosion, estimated to contribute 16,000 cubic meters per year (that volume represents only sand coarse enough to remain on the beach, finer sediments being lost offshore). A study of the mineralogy and grain size of the sands shows that sand brought to the coast by the Siletz River does not contribute to the beach (Rea, 1975). The Salmon River and other small coastal streams contribute a minor amount. Prior to sand mining on the beach (1965 to 1971), the beach appears to have

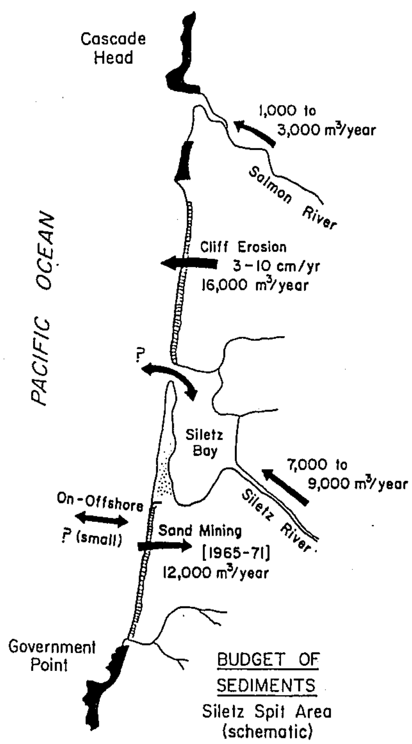


Figure 5. An approximate budget of beach sands for the stretch of coast fronting Lincoln City, south past Siletz Spit to Lincoln Beach. Shown are estimates of the sources and losses of sand from the beach, including that due to sand mining.

neither increased nor decreased in overall width over the years, indicating the natural losses of sand approximately balanced the gains from the sources; these losses must have been to the offshore, to the dunes on Siletz Spit, and some beach sand movement into Siletz Bay. The sand mining during the years 1965-71 removed an average of 12,000 cubic meters per year, an amount nearly the same as that contributed to the beach by sea cliff erosion. Presumably the natural losses remained the same, so that the sand mining represented a net loss of beach sands and a decrease in its total volume. Such a decrease would result in the progressive lessening of the beaches' ability to protect the coastal properties from erosion. As discussed in Section IV, the sand mining at Gleneden Beach was not the primary contributory factor in the recent erosion of Siletz Spit, but most certainly was an aggravating factor in causing increased amounts of erosion.

C. Dunes

Sand dunes, active or vegetated, occupy approximately 140 of Oregon's 310 miles of coast, or about 45 percent (Cooper, 1958; Lund, 1973). The largest area of active dunes with little or no vegetation extends for a distance of 55 miles between Coos Bay on the south to Heceta Head on the north (Figure 6). This strip averages about 2 miles in width, reaching a maximum width of 3 miles at Florence. A major portion of this active dune sheet lies in the Oregon Dunes Recreational Area, a division of the Siuslaw National Forest. A second area of important active dunes is present to the immediate north of Sand Lake on the northern coast.

There are extensive areas of older, well-vegetated dunes, commonly covered with forests of large trees and dense brush. The dune origin of the underlying sands is not always readily apparent; dune sands are best identified by the cross-stratification of sands exposed in roadcuts or other excavations. These vegetated dunes were formed during the Pleistocene Epoch, and are now perched on marine terraces well above sea level. They are common along the Oregon coast with the exception of Curry County south of Cape Blanco.

There are many problems concerning the management of these coastal dune areas. Particularly susceptible to erosion problems are the foredunes which immediately back many beaches. Such foredunes are usually active or only conditionally stabilized by dune grasses. Therefore the sands of the foredunes are often rapidly moved about by the strong coastal winds. In addition, because the foredunes are adjacent to beaches they may be eroded rapidly by waves.

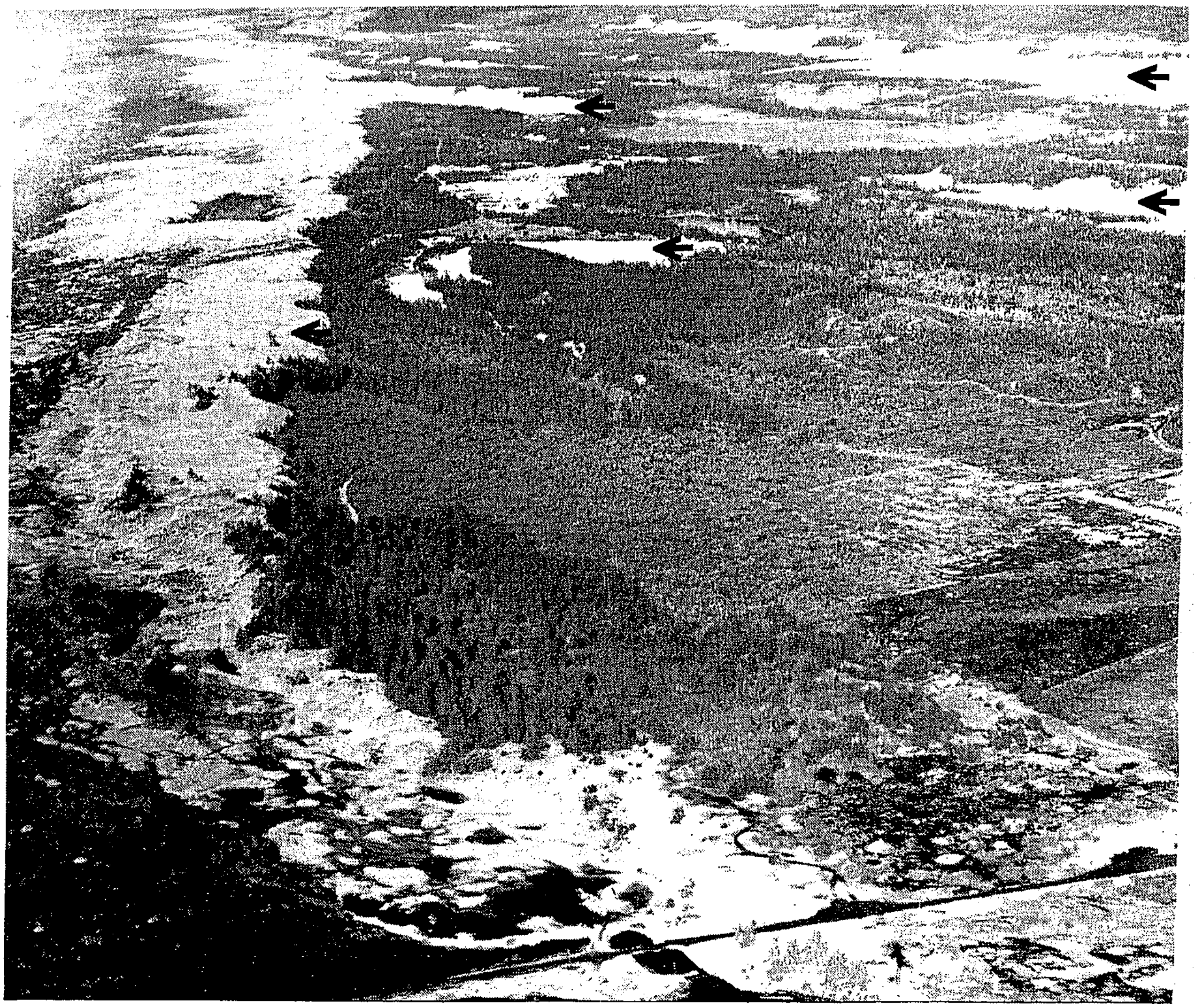


Figure 6. The active dune field of the Coos Bay dune sheet which stretches for some 55 miles along the mid-Oregon coast (photo courtesy of U.S. Army Corps of Engineers, Portland District).

D. Climate

Climate exerts a major influence on Oregon coastal beaches and dunes. In large part, rains govern the surface moisture in the dunes which in turn partly control whether the sands can be moved by winds. The direction and strength of the wind then determines the direction and rate of the resulting sand transport and dune migrations. The coastal winds are also important in wave generation and in the creation of nearshore currents along the beaches.

The climate of the Oregon coast is highly seasonable, more so than most other midlatitude coasts. During the winter months, storm systems move inland from the north Pacific bringing rains and a predominance of strong winds out of the south to southwest. The summer months are dry with milder winds, mainly from the north to northwest (Cooper, 1958).

Water runoffs in the coastal rivers and streams closely follow the seasonal variations in rainfall, discharges in the winter months being 30 to 50 times greater than during the summer (Figure 7). The Columbia River is the one exception to this discharge pattern in that it has two periods of maximum discharges, one during the winter due to the rains, and a second in May and June due to snow melt in the Cascade Mountains.

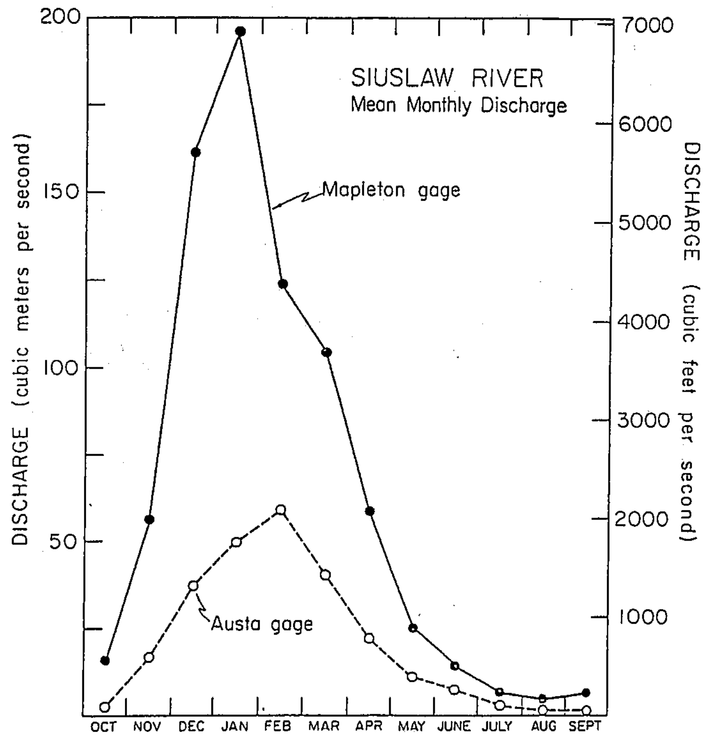


Figure 7. An example of the seasonality of river discharge with large winter discharges and negligible summer discharges, following the seasonality of rainfall.

E. Wave Conditions

Wave conditions along the coast of Oregon also follow a seasonal pattern in response to the parallel changes in weather patterns and wind speeds. This is to be expected as it is the wind that generates the waves; the greater the wind speed the higher the waves produced (Komar, 1976, Chapt. 4). Other factors in wave generation are the duration of the winds and the extent of water area (fetch) over which the winds blow. Not all waves reaching the Oregon coast come from local storm systems adjacent to the coast. An example is shown in Figure 8 from a storm that occurred over the north Pacific during 20-25 December 1972, a storm which generated 23-foot high breaking waves along the coast, resulting in much erosion, especially on Siletz Spit. It is seen that the winds that generated these exceptionally high waves blew across a major portion of the Pacific but were not particularly strong at the Oregon coast itself.

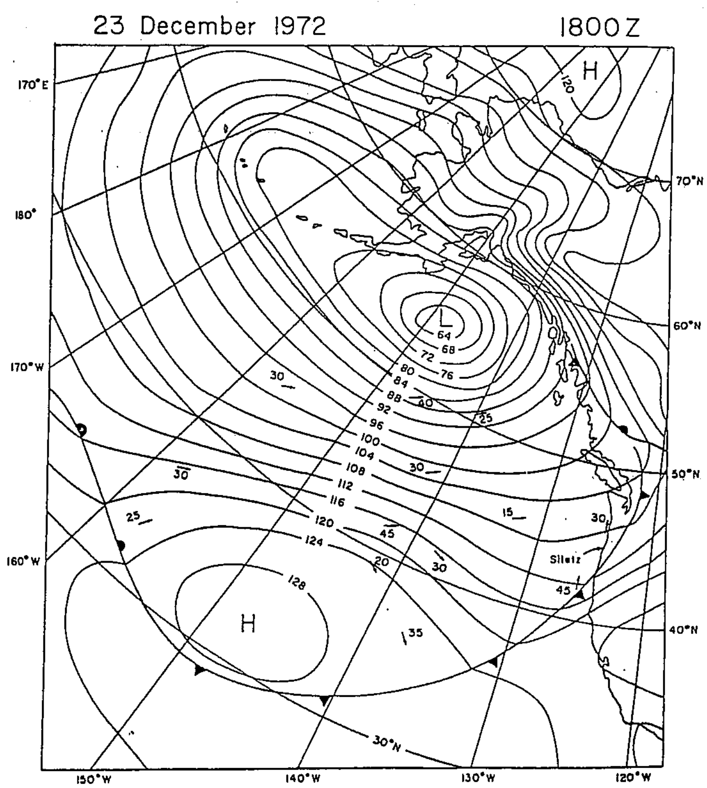


Figure 8. Storm system on December 23, 1972 with winds blowing across most of the Pacific and directed toward Siletz Spit. This storm generated unusually high waves along the Oregon coast which caused major erosion at Siletz Spit and elsewhere.

Waves reach Oregon from storms in the far South Pacific as well, although they are not nearly as large as those generated by storms in the North Pacific. Komar and McKinney (1977) analyzed storms such as that of Figure 8 and their role in generating waves and beach erosion on the Oregon Coast.

Ocean wave conditions have been measured daily at Newport by a seismic recording system that detects microseisms produced by the waves. This yields a measure of the highest one-third of the waves, as well as the periodicity of the wave motions. This system has been in operation since November 1971, measuring waves four times daily. This wave data set is the longest and most complete available for wave conditions on the Oregon coast, and has been summarized by Komar, et al. (1976b) and Creech (1977).

Figure 9 gives an example of the annual changes in wave heights and periods, this example extending from July 1972 through June 1973. The solid lines give the average wave breaker heights and periods for

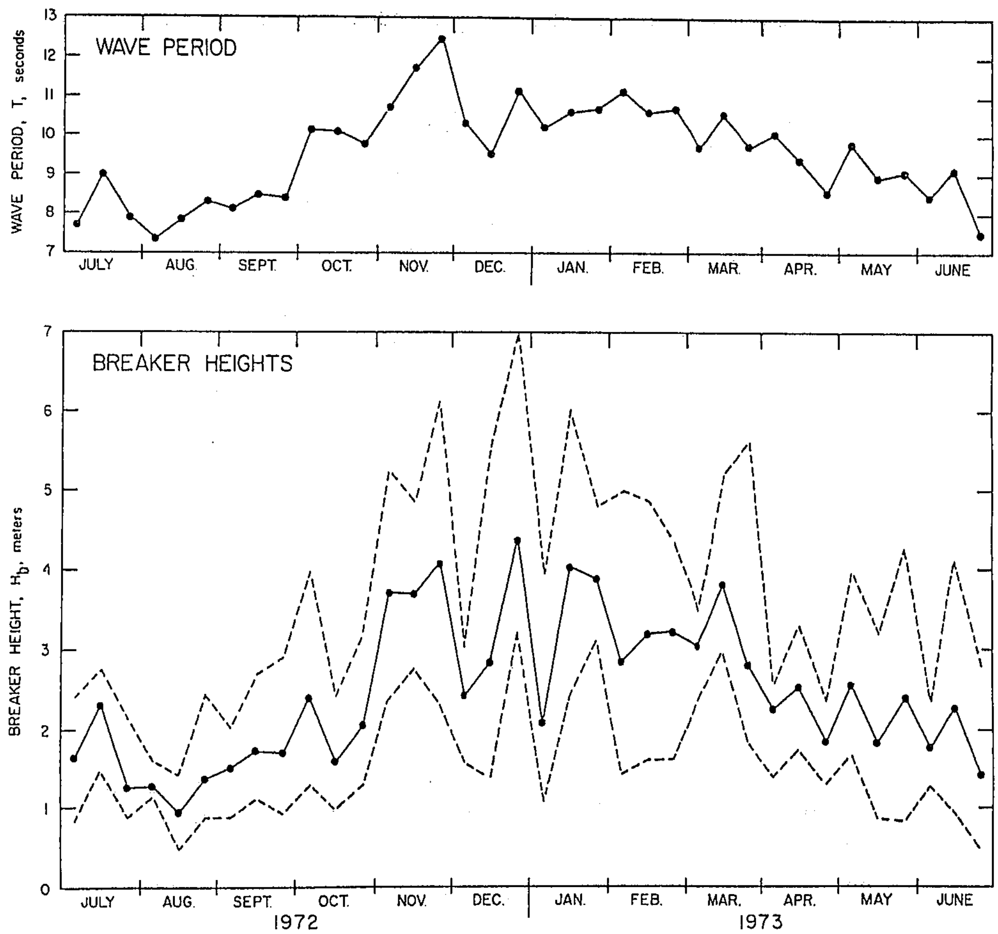


Figure 9. Significant wave breaker heights and periods measured at Newport during July 1972 through June 1973. Each datum point gives the average for one-third month. The dashed lines give the maximum and minimum breaker heights during those one-third month intervals. Note the arrival of large storm waves during the last part of December 1972, caused by the storm of Figure 8.

each one-third month. Also given are the maximum and minimum wave breaker heights that occurred during those one-third month intervals (the dashed lines). It is seen that much larger breaking waves prevail during the winter months, reaching an average of about 15 feet. However, individual storms produce maximum daily waves with significant heights of some 23 feet. Such storm waves occurred in the last one-third of December 1972, (Figure 9), associated with the storm system of Figure 8. Breakers of 23-foot height are truly exceptional. The seismometer system has measured such high waves only three times since its installation in 1971--in December 1972, October 1977 and February 1978. Each instance was marked by severe beach erosion along the coast. Thus, not unexpectedly, unusually high waves are largely responsible for the episodes of coastal erosion.

F. Beach Cycles

Beaches respond to seasonally changing wave conditions as schematically illustrated in Figure 10 and for the beach at Gleneden Beach in Figure 11. During the summer months of low waves, sand moves onshore forming a wide berm--the nearly flat exposed portion of the beach (Figure 10). During the stormy winter months of high waves, sand is eroded from the berm and moves offshore, depositing there in offshore bars. Such seasonal cycles of the beach profiles occur on most beaches, and have been documented by Aguilar and Komar (1978) on two Oregon beaches (Figure 11). Komar (1977) reviews the Oregon beach profiles obtained during 1945-6 by the U.S. Navy using an amphibious DUKW (pronounced "duck"). Only with such an amphibious vehicle have profiles been obtained over the deep outer bars of Oregon beaches.

Although the cycle between the two beach profile types of Figure 10 is approximately seasonal, they are really a response to high storm waves versus low regular swell waves such as occur most commonly during the summer. But if low waves should occur during the winter, sand will move onshore and the berm widen so that the two types of profiles are not always strictly seasonal.

The principal importance of this cycle of beach profiles is that the swell (summer) profile with its berm helps protect the sea cliffs and foredunes from wave attack and erosion. In contrast, the absence of a berm in the storm (winter) profile allows the waves to swash up against the coastal property, producing erosion. This is one of the principal reasons that wave erosion of coastal properties on the Oregon coast is limited mainly to the winter months.

It is seen that an important role of the beach is that it acts as a buffer between the ocean waves and the coastal property, causing the waves to break offshore and dissipate most or all of their energy before reaching the coastal property. With a wide berm the waves are not able to reach the coastal property at all. Removal of sand from the beach by sand mining, as mentioned earlier, will reduce the total volume of beach material and hence the winter waves have less sand to

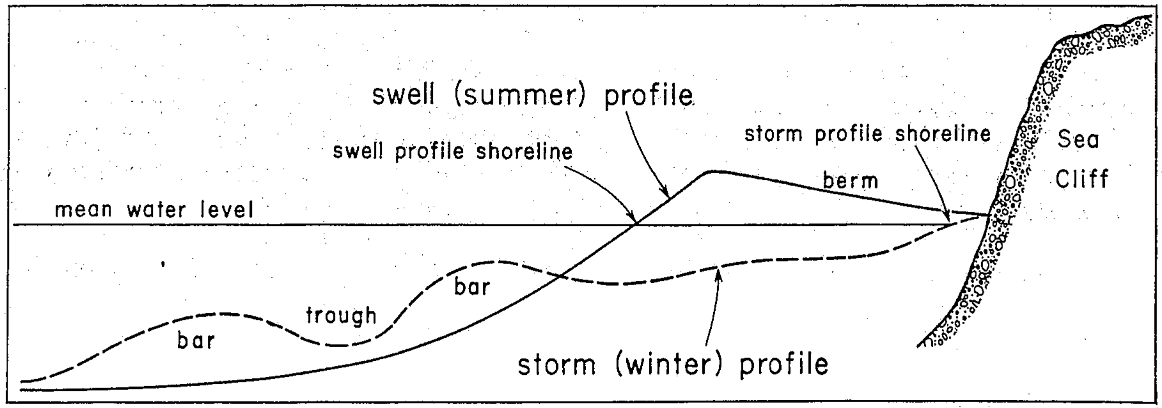


Figure 10. Schematic illustration of the beach profiles produced by storms versus gentle swell waves. On the Oregon coast these profile changes are approximately seasonal due to our storms occurring principally during the winter months.

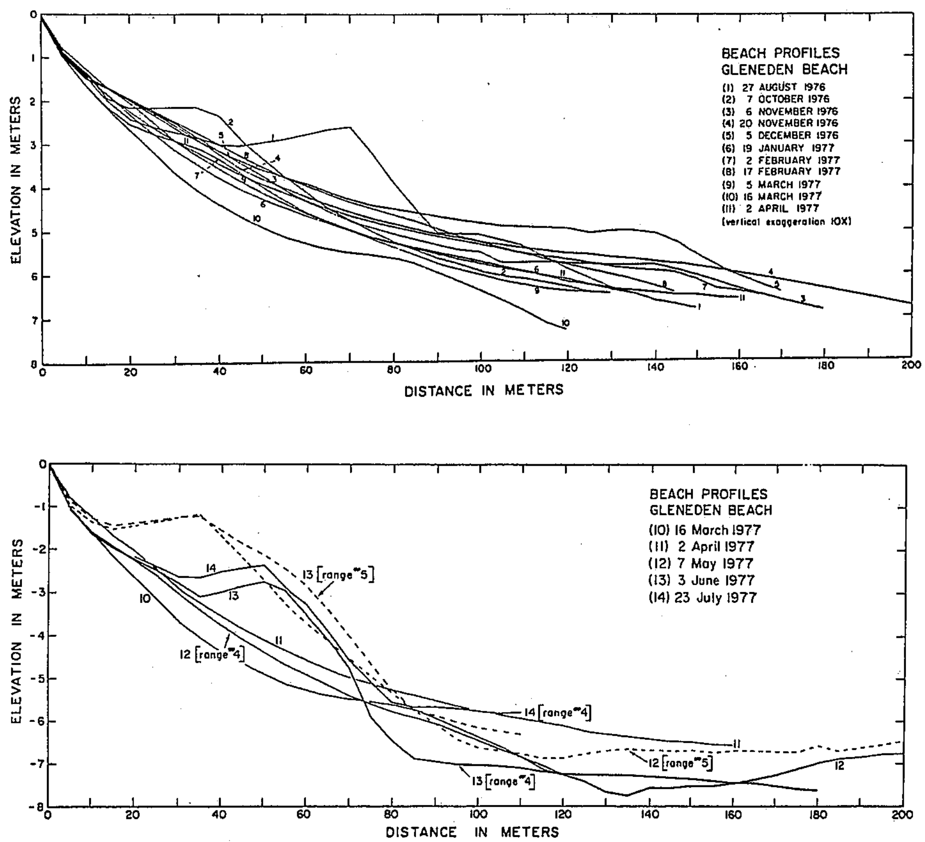


Figure 11. Profile changes measured at Gleneden Beach from August 1976 to July 1977 showing the winter erosion of the exposed portion of the beach followed by deposition as the spring and summer months of lower waves return. The profiles do not extend far enough offshore to show the offshore bars (from Aguilar and Komar, 1978).

shift offshore before attacking coastal property. Sand mining reduces the beach's ability to act as a buffer between the land and the erosive ocean waves.

G. Nearshore Currents and Sand Transport

Waves reaching the coast generate currents in the nearshore zone that are important to sand movements on the beach and to beach erosion. These currents are independent of the normal ocean currents that prevail further offshore, being negligible on the beaches (except for the tidal currents which are important to beach processes in some cases).

When waves break at an angle to the shoreline they generate a current that flows parallel to the shoreline (Komar, 1976, Chapt. 7). This current, together with the waves, produces a transport of sand along the beach known as littoral drift. On Oregon beaches the waves tend to arrive from the southwest during the winter months and from the northwest during the summer (corresponding to the changes in wind directions). As a result, there appears to be a seasonal reversal in the direction of littoral drift; north in the winter, south during the summer. The difference between the two, the net littoral drift, appears to be nearly zero, at least when averaged over a number of years.

That the net littoral drift is essentially zero is demonstrated by the absence of continuous accumulations of sand on one side of jetties or rocky headlands, with erosion on what would be the downdrift side. Instead, sand tends to accumulate and/or erode symmetrically around newly constructed jetties. The major rocky headlands appear to protrude sufficiently far out into the sea that the sands forming the beaches cannot pass around them. Thus, they would also block any net littoral drift if it did exist. Instead, the beaches of Oregon are essentially pocket beaches, isolated from one another by the headlands, with zero net littoral drift prevailing in each pocket. For this reason, when one develops a budget of littoral sand for a particular beach the analysis should include the entire length of the pocket beach between two major headlands (as was done in Figure 5). Only the beach of the Clatsop Plain north of Seaside does not fit into this concept of being a pocket beach, this exception being due to the presence of the Columbia River.

Most of the time the waves approaching the Oregon beaches are nearly parallel to the shoreline trend. Under such circumstances the nearshore currents form a cell circulation, the most prominant part of which are the rip currents (Figure 12), narrow currents flowing offshore away from the beach. The rip currents are fed by longshore currents flowing roughly parallel to shore, but for only a short stretch of beach, unlike the longshore currents which are generated by waves breaking at an angle to the shoreline. The cell circulation pattern illustrated in Figure 12 rearranges the sand on the beach, the feeder longshore currents following troughs in the beach profile shoreward of the offshore bars, and the rip currents bisecting the bars. Of special importance to beach erosion, the rip currents often carry sand offshore, hollowing out embayments into the beach as illustrated in Figure 12. At times these embayments can extend across the entire width of the beach and begin to erode into foredunes or sea cliffs. Such patterns have been important to erosion on Siletz Spit.

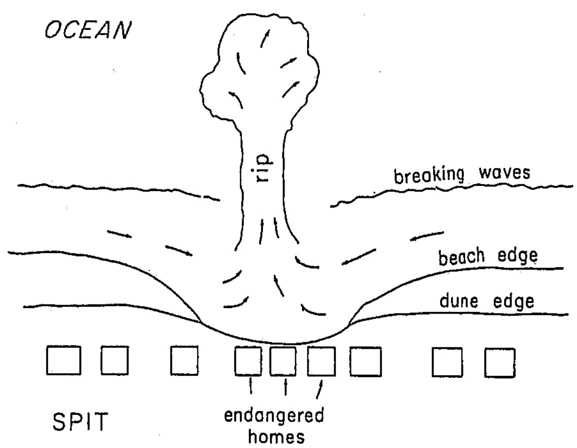


Figure 12. A rip current flowing outward across the beach hollowing out an embayment into the beach and eventually into the foredunes causing property losses.

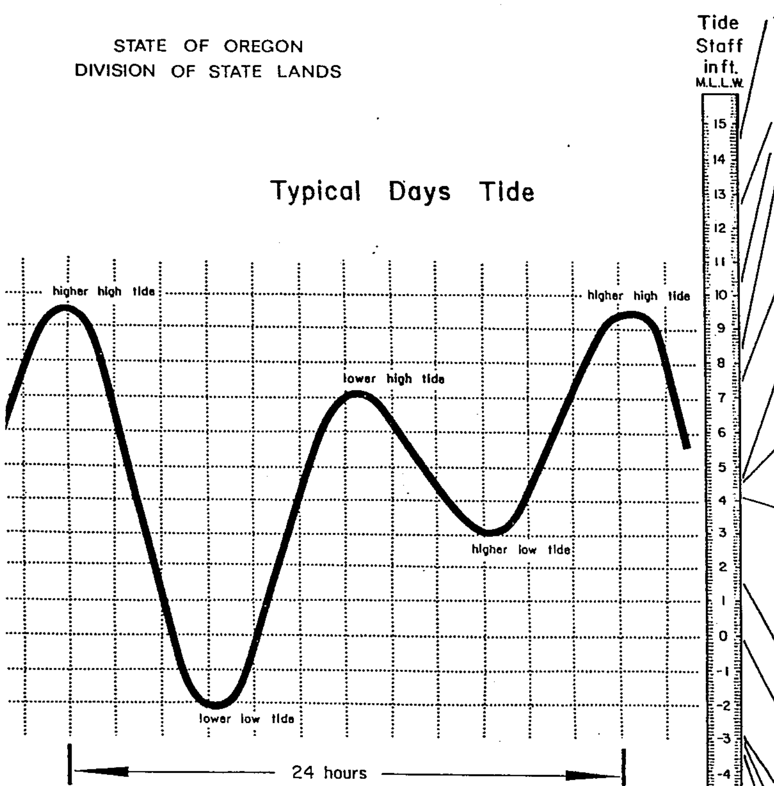
H. Tides

Tides on the Oregon coast are moderate with a maximum spring tide range of about 13 feet and an average range of about 6 feet. There are two highs and two lows each day, with the two highs and two lows usually of markedly different levels (Figure 13).

TIDAL ELEVATIONS ON THE OREGON COAST

STATE OF OREGON
DIVISION OF STATE LANDS

Typical Days Tide



Note: Specific elevations are based on six years of tide observations at the Oregon State University Marine Science Center Dock on Yaquina Bay. Values have been reduced by the National Ocean Survey (formerly the Coast and Geodetic Survey). The elevations differ from estuary to estuary and from different points within an estuary. The exception is MLLW which is zero by definition.

14.5 Extreme High Tide – The highest projected tide that can occur. It is the sum of the highest predicted tide and the highest recorded storm surge. Such an event would be expected to have a very long recurrence interval. In some locations, the effect of a rain induced freshet must also be taken under consideration. The extreme high tide level is used by engineers for the design of harbor structures.

12.63 Highest Measured Tide – The higest tide actually observed on the tide staff.

10.3 Highest Predicted Tide – Highest tide predicted by the Tide Tables.

8.38 Mean Higher High Water – The average height of the higher high tides observed over a specific time interval. The intervals are related to the moon's many cycles which range from 28 days to 18.6 years. The time length chosen depends upon the refinement required. The datum plane of MHHW is used on National Ocean Survey charts to reference rocks awash and navigational clearances.

7.62 Mean High Water – The average of all observed high tides. The average is of both the higher high and of the lower high tide recorded each day over a specific time period. The datum of MHW is the boundary between upland and tideland. It is used on navigational charts to reference topographical features.

4.58 Mean Tide Level – Also called half-tide level. A level midway between mean high water and mean low water. The difference between mean tide level and local mean sea level reflects the asymmetry between local high and low tides.

4.51 Local Mean Sea Level – The average height of the water surface for all stages of the tide at a particular observation point. The level is usually determined from hourly height readings.

4.11 Mean Sea Level – A datum based upon observations taken over a number of years at various tide stations along the west coast of the United States and Canada. It is officially known as the Sea Level Datum of 1929, 1947 adj. and is the most common datum used by engineers. MSL is the reference for elevations on U.S. Geological Survey Quandrangles. The difference between MSL and Local MSL reflects numerous factors ranging from the location of the tide staff within an estuary to global weather patterns.

1.54 Mean Low Water – The average of all observed low tides. The average is of both the lower low and of the higher low tides recorded each day over a specific time period. The datum of MLW is the boundary between tideland and submerged land.

0.00 Mean Lower Low Water – The average height of the lower low tides observed over a specific time interval. The datum plane is used on Pacific coast nautical charts to reference soundings.

–2.9 Lowest Predicted Tide – The lowest tide predicted by the Tide Tables.

–3.14 Lowest Measured Tide – The lowest tide actually observed on the tide staff.

–3.5 Extreme Low Tide – The lowest estimated tide that can occur. Used by navigational and harbor interests.

Figure 13. Tidal elevations as measured in Yaquina Bay (from Hamilton, 1973).

Tides are an important factor in coastal erosion in that they govern the hour by hour level of the sea and hence the position of the shoreline and the zone where ocean waves expend their energy. In particular, spring tides may bring water levels high up on sea cliffs and foredunes so that the waves attack the coastal properties directly. Such high spring tides have been shown to aid in the erosion of Siletz Spit and to have had an important part in causing the 1978 breaching of Nestucca Spit. Tides are also significant to the currents which occur in estuaries, especially in the inlets of bays and estuaries.

I. Tsunami

Tsunami are large waves generated on the ocean surface, usually by an earthquake producing a displacement of the sea floor. The most common source of significant tsunami reaching the Oregon coast come from earthquakes in and around Alaska. Two have struck the Oregon coast in recent years--28 March 1964 and 16 May 1968. Their impact on the coast is described in Schatz, et al. (1964), Schatz (1965) and Wilson and Torum (1968).

Figure 14 shows the heights of tsunami waves arriving at various Oregon coast sites during the 1964 episode. It is seen that at each location there is a series of waves, the first wave not always being the largest in the series. In that episode, the maximum wave heights were approximately 10 feet. About the same heights were recorded in the 1968 tsunami.

Maximum destruction from the tsunami occurred along the shorelines of bays and estuaries rather than on the open ocean coastline. This is because at least initially the heights of the tsunami waves increase as they are wedged into the constricting confines of the estuaries. For example, the 1964 tsunami damaged bridges and dwellings along the shores of the Necanicum and Neawanna Rivers (Figure 15), the damage being estimated at $276,000. Other hard hit areas were Cannon Beach ($230,000), the Waldport-Alsea area ($160,000), Florence ($50,000) and Coos Bay ($20,000).

There are few reports of tsunami wave destruction along the ocean shorelines. During the 1964 tsunami four children were drowned as their family slept on the beach at Beverly Beach State Park. This low-lying campground was evacuated twice in 1965 as a result of tsunami warnings (Stembridge, 1975, p. 103). There may be more destruction from future tsunami as many dwellings have been recently constructed in vulnerable areas close to the beach. In addition to low-lying areas that have little or no elevation above the beach, foredune areas can in general also be expected to be vulnerable to tsunami runup. This is because the foredunes commonly have a general oceanward slope that permits the tsunami runup to continue with no direct obstacles. In contrast, areas with sea cliffs should not be endangered as the cliff will reflect most of the energy of the tsunami waves.

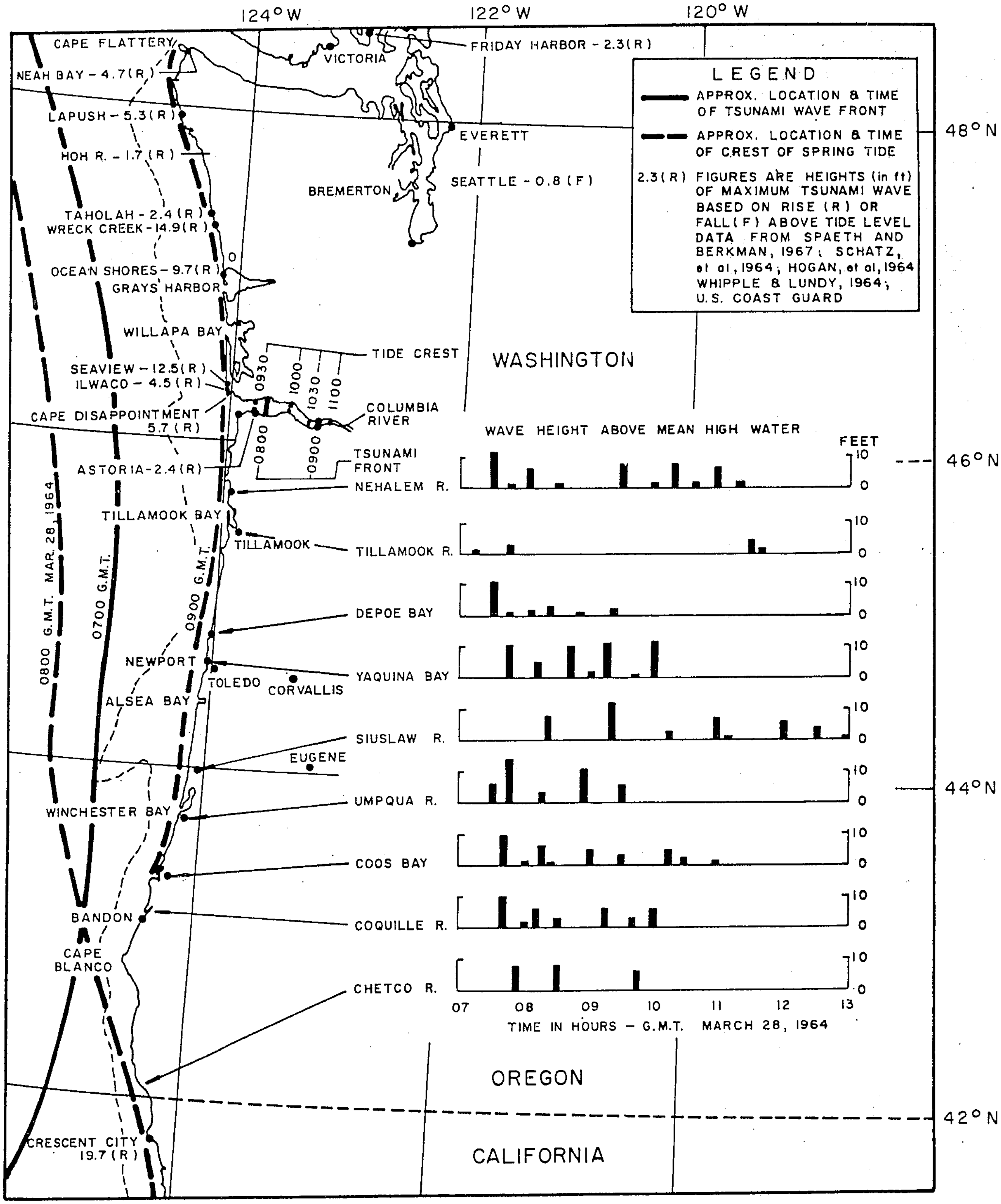


Figure 14. Maximum heights of tsunami waves recorded at tide stations or by observations along the Washington-Oregon coast (from Wilson and Torum, 1968).

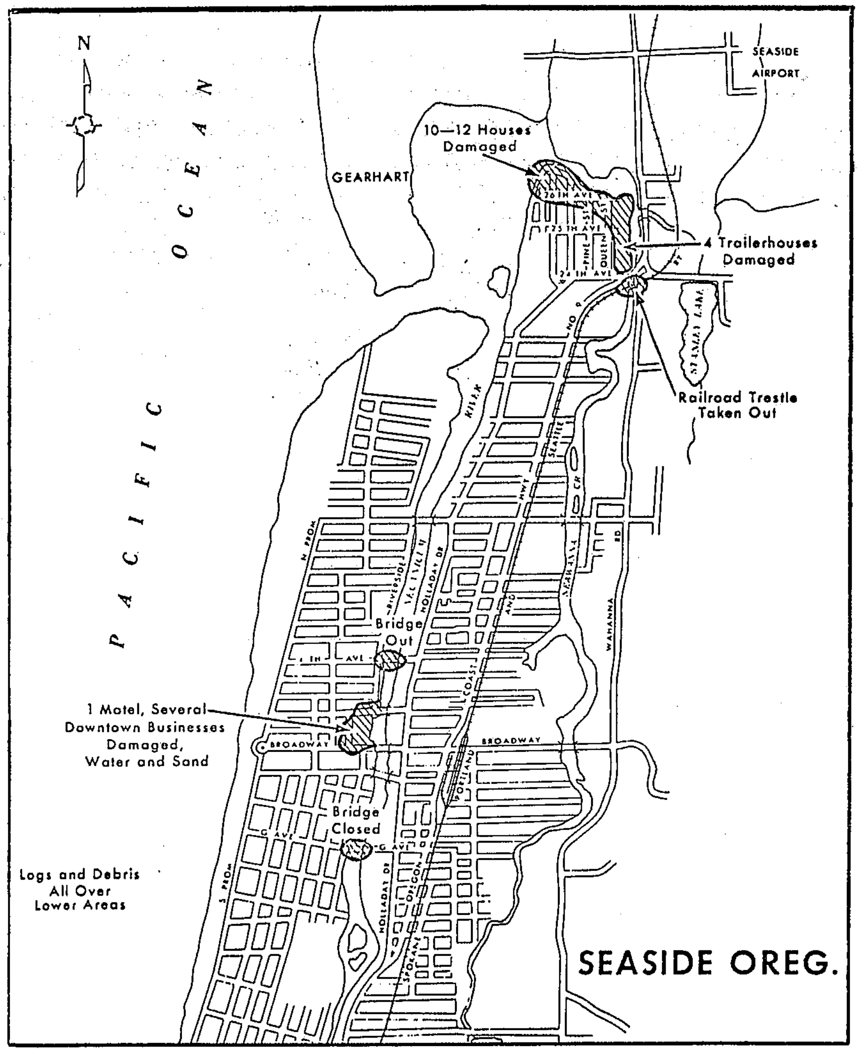


Figure 15. Destruction at Seaside from the March 1964 tsunami (from Wilson and Torum, 1968).

The occurrence of tsunami along the Oregon coast is very sporadic and unpredictable. However, there is a strong probability that another will occur within the next 10 to 20 years. In addition to the estuary areas, almost any foredune or low-lying area can be a potential site for destruction. Unfortunately, with our present understanding of tsunami it is difficult to predict their expected runup for a specific area. Studies following the occurrence of a tsunami show a great deal of variability in the amount of runup along the coastline and the amount of resulting destruction, a variability which at present is poorly understood and cannot be predicted. For this reason, at the present time it is best to be cautious when building on foredunes and in low-lying areas susceptible to tsunami runup.

J. Sea Level Changes

Changes in sea level with respect to the land have important consequences to coastal erosion. With the melting of the Pleistocene ice sheets, which most recently began about 30,000 years ago, water was returned to the oceans causing a rise in sea level. At first this sea level rise was rapid, but about 7,000 years ago it slowed down appreciably (Komar, 1976, p. 154-7). For the past 34 years there appears to be at most a 1.5 mm (0.005 ft.) per year rise in sea level (Hicks, 1972). Hicks determined this rate from long-term tide gauge records obtained on all coasts of the United States. If one averages the recordings of a tide gauge for the entire year, an average water level for that year is obtained. Over the years this level can change, indicating an apparent long-term change in the sea level. The result obtained at a particular coastal site will depend on whether the land there is stable, rising or lowering, as well as on any actual sea level change. For example, on the east coast of the United States the land is sinking so that the apparent sea level rise is still larger than the 1.5 mm/year value (Figure 16). As a consequence, in the long term (tens of years to centuries) the shoreline there tends to migrate landward, resulting in shoreline erosion and endangering dwellings constructed too close to the beach. In contrast, much of Alaska is rising at a geologically rapid rate, much greater than 1.5 mm/year. This results in the land emerging from the sea with the shorelines receeding (Figure 16). If sea level is presently rising at the rate of

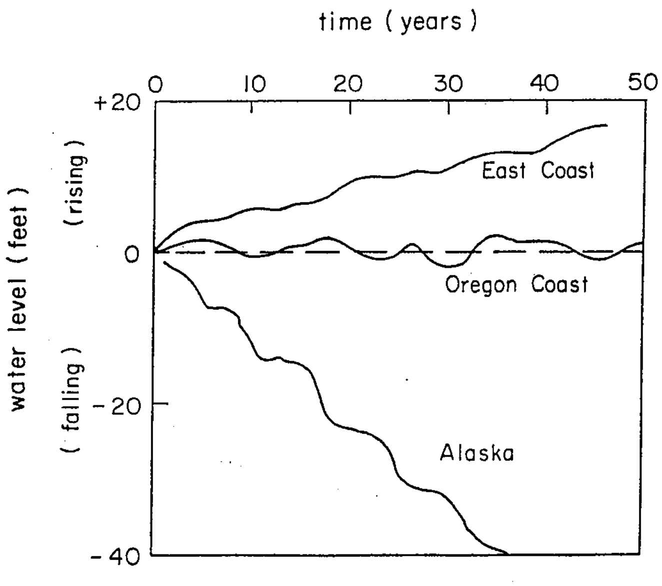


Figure 16. Schematic of water level changes on the Oregon coast as compared to the East coast and the coast of Alaska, based on the data of Hicks (1972).

1.5 mm/year, then the Oregon coast must be rising at about the same rate as the tide-gauge records at Astoria, Crescent City (California), and Friday Harbor (Washington), analyzed by Hicks (1972), all show no apparent sea-level changes over the years (Figure 16). Excepting the yearly fluctuations which have many causes, the long-term trends show a nearly unchanging sea level. In contrast to the east coast, the apparent lack of a rising water level with respect to the land along the Oregon coast should act as a deterrent to coastal erosion. However, as recently as 7,000 years ago the sea was probably transgressing rapidly over the Oregon coastal zone, producing erosion. Insufficient time has passed since then for the coast to come to equilibrium with the present sea level, so that the general erosion of the rocky headlands and terraces is more a response to that past rise in sea level than due to any present-day rise.

III. EROSION DUE TO JETTY CONSTRUCTION

The earliest erosion problems on the Oregon coast were associated with the construction of jetties at the entrances to bays and estuaries. Most of these were installed early in the century, but subsequently have been repaired and in some cases lengthened. Of interest are the causes of the erosion resulting from jetty construction or extension. An examination of these problems also provides information about the littoral drift of sand along Oregon's coastal beaches.

The most dramatic and famous case of erosion due to jetty construction on the Oregon coast is that which occurred on Bayocean Spit opposite Tillamook Bay. Following the installation of a single north jetty, sand accumulated to the north side of that jetty, resulting in sand deposition to the north (Figure 17). At the same time, erosion occurred along most of the length of Bayocean Spit and south past the community of Cape Meares. Somewhat earlier the resort community of Bayocean Park had been developed on the spit; its homes and buildings were progressively undermined by the erosion and lost (Figure 18), so that eventually the entire town disappeared. Erosion to the spit culminated in November 1952 when storm waves combined with high tides to break through the spit at its narrow mid-section, the northern half of the spit becoming an island. The newly breached area became the main inlet to the bay; the former inlet with the jetty began to close. For this reason, in 1956 the U.S. Army Corps of Engineers built a dike across the new inlet, closing it, and the inlet with the jetty opened once again. The story of the development of Bayocean Spit and its subsequent erosion is documented at length in Terich (1973) and in Terich and Komar (1974).

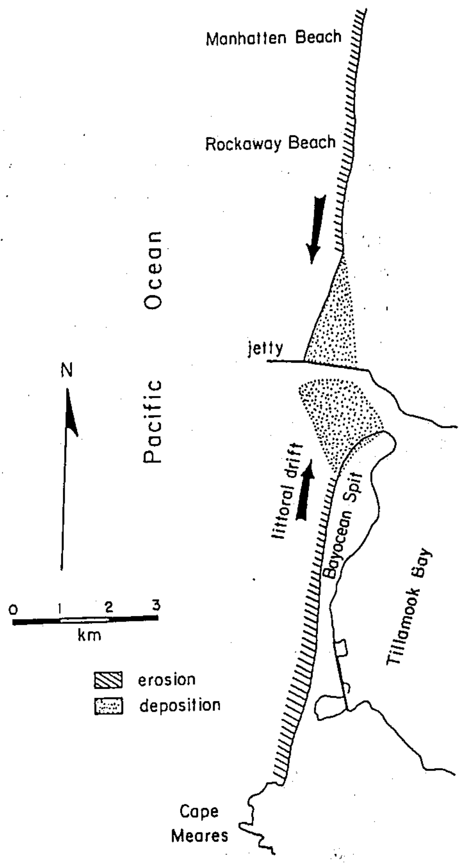


Figure 17. Patterns of beach deposition and erosion resulting from construction of the north jetty at the entrance to Tillamook Bay (from Terich and Komar, 1974).

The sand accumulation to the north of the Tillamook jetty together with erosion along the spit to the south (Figure 17) led early studies to conclude that the jetty construction had blocked a large net littoral drift of sand toward the south. Such patterns of erosion and deposition (beach sand accumulation) are typical of the blockage of a net littoral drift, diagramed schematically in Figure 19A, such as has commonly occurred on the east coast of the United States and in southern California. As previously mentioned it is now believed that this and other beach areas of the Oregon coast have essentially zero net littoral drifts (Figure 19). If a very large net littoral drift did occur in the Bayocean Spit area, then Cape Meares to the south (Figure 17) should have acted similar to a jetty, blocking the drift with a large accumulation of sand on its north side; there is none.

The erosion of Bayocean Spit has to be understood in terms of having occurred under conditions of a zero net littoral drift. Even with a zero net drift there can be local rearrangements of beach sand produced by the jetty construction. Such changes are best seen where two jetties are constructed rather than a single jetty as at the Tillamook Bay entrance.

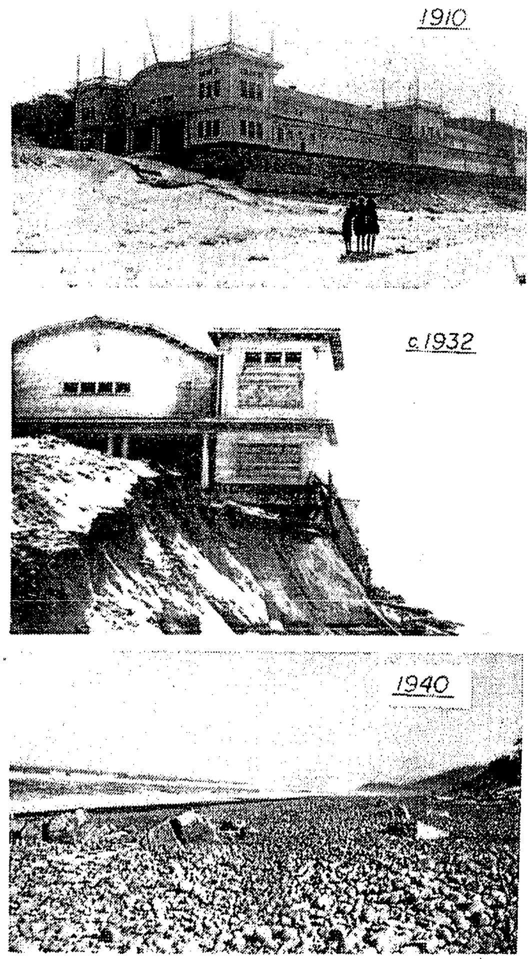


Figure 18. Erosion on Bayocean Spit leading to the loss of the natatorium with an indoor swimming pool (from Terich and Komar, 1974).

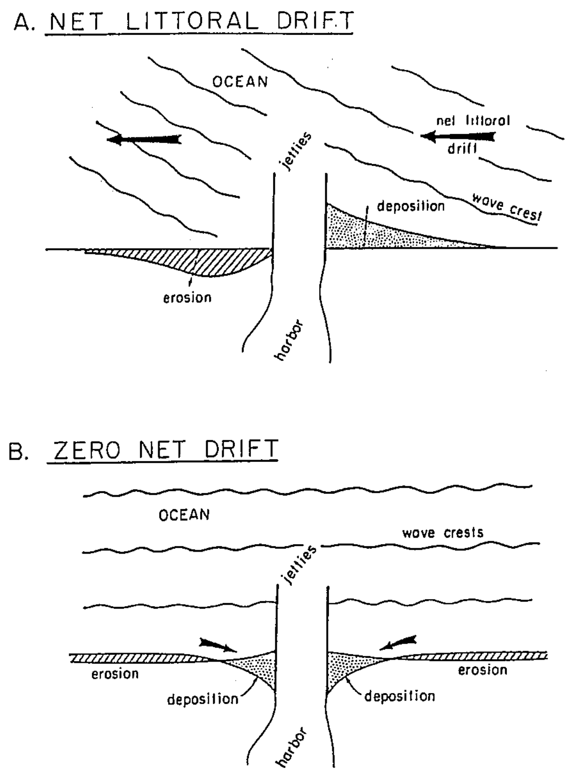


Figure 19. Schematic of shoreline changes (deposition and erosion) produced by jetty construction in areas experiencing a net littoral drift versus an area such as the Oregon coast where there is a zero net littoral drift.

Large shoreline changes also occurred following construction of a pair of jetties at the entrance to the Siuslaw River near Florence (Figure 20). It is seen that where two jetties are constructed, there is beach sand accumulation both to the north and south, immediately adjacent to the jetties. This deposition and shoreline advance occurs because an embayment is formed between the newly constructed jetty and the pre-jetty shoreline. Before jetty construction, the shoreline curved inward toward the inlet and was in equilibrium with both the ocean waves and with the currents coming in and out of the inlet. Jetty construction eliminated the inlet currents acting on that curved portion of shoreline, leaving only the waves. The waves broke at angles to the curved shoreline and so moved sand into the embayment until it completely filled with sand (Figure 21). Once the embayment filled and there was a smooth and nearly straight shoreline parallel to the dominant waves, then a zero net littoral drift once again prevailed. After that stage is reached there are no additional large-scale adjustments of the shoreline due to the presence of the jetties. Therefore a new equilibrium is achieved, and shoreline changes do not continue indefinitely. In the case of the blockage of a net littoral drift (Figure 19A), the only equilibrium that could occur following jetty construction is if the sand accumulated on the updrift side of the jetties until it is able to pass around the jetties to the downdrift side.

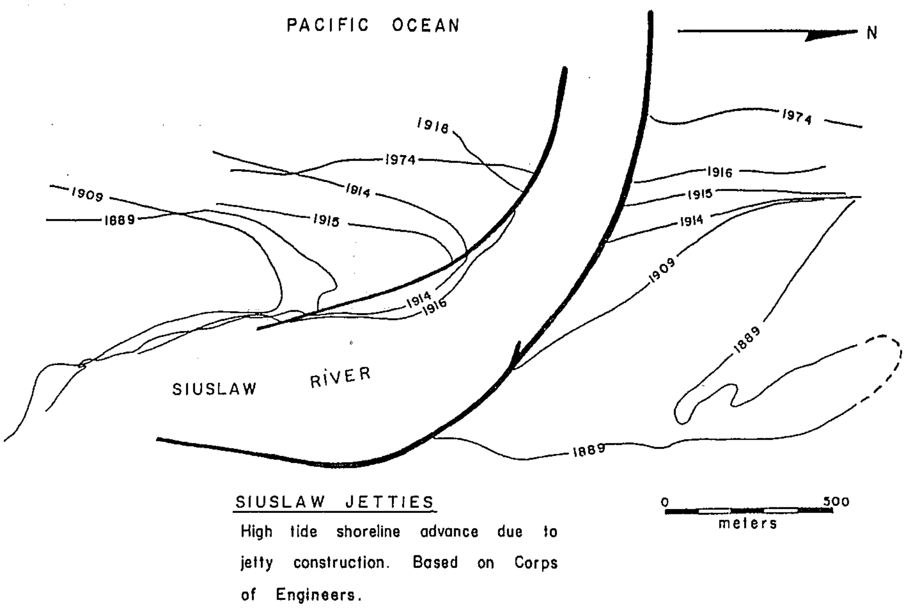


Figure 20. Compilation of shoreline changes resulting from jetty construction at the mouth of the Siuslaw River, based on old ground surveys and aerial photographs. The 1889 shoreline predates jetty construction (from Komar, et al., 1976a).

The sand that fills the shoreline embayments produced by jetty construction must come from somewhere, and most of it comes from shoreline erosion at greater distances from the jetties (Figure 19B). Thus a symmetrical pattern of erosion and deposition results with beach sand accumulation immediately adjacent to the jetties, both to the north and south, and with erosion at greater distances from the jetties (Figure 19B). This contrasts with the asymmetrical pattern where the jetties block a net littoral drift, the shoreline advancing seaward on the updrift side and erosion occurring on the downdrift side (Figure 19A). As in the case for jetty construction on the Siuslaw River (Figure 20), the patterns of erosion and deposition may not be perfectly symmetrical due to the different sizes of embayments created on the two sides of the

jetty construction was filled and the shoreline straightened. There was probably some erosion further to the north, but the length of beach there is long so that there was only a small amount of erosion per unit shoreline length. Sand also accumulated at the northern tip of Bayocean Spit even though a true embayment was not formed by jetty construction. This accumulation was in the form of a large shoal which developed seaward of the south side of the inlet (Figure 17). That sand apparently came from the erosion of Bayocean Spit, so there was something of a symmetrical pattern of deposition and erosion (Figure 17), similar to that of the Siuslaw jetties. The erosion of Bayocean Spit was large because the eroded sand came from a short length of beach, Cape Meares being to the immediate south. In 1976 a south jetty was constructed at the inlet, forming a true embayment with the pre-jetty shoreline. As at the Siuslaw inlet and other Oregon-coast inlets, the embayment filled until the shoreline was straight with the shoreline along the remaining length of Bayocean Spit. That filling required some additional sand, again derived from further erosion of the spit. However, since that time, erosion of the spit and the Cape Meares area has been small since a new equilibrium exists in which no further sand is required for deposition next to the south jetty.

On the Oregon coast and other areas of zero net littoral drift, once jetties are constructed and sand has filled the embayments to either side, the jetties can subsequently be extended without producing additional major shoreline readjustments and erosion. This is especially true if the jetties are perpendicular to the coastline trend, extending straight out to sea. For example, the jetties on the Siuslaw River inlet (Figure 20) could be extended without causing renewed erosion problems, and the proposed extension of the south jetty at Tillamook Bay will not cause significant additional erosion on Bayocean Spit. However, where jetties are oblique to the shoreline trend, as at the Yaquina Bay entrance (Figure 22), jetty extension produces some additional sheltering from the waves to the enclosed side and results in further sand accumulation next to the jetty and some further erosion at greater distances from the jetty; this was the case with the extension of the Yaquina Bay jetties in 1971.

The filled embayment areas to either side of inlet jetties are dependent upon the presence of the jetties. If the jetties are allowed to degrade then there may be some erosion to these filled areas. A possible example of this may be the recent erosion at Nedonna to the immediate south of the jetties on the Nehalem River. As at the other inlets, following the construction on the Nehalem in 1917, the embayments to either side filled and the shoreline there advanced seaward. No further work has been done on these jetties, however, and they have deteriorated to the point that they are covered with water at high tide. The shoreline again curves back inward into the inlet, but not as much as prior to jetty construction so that further erosion might be expected. The community of Nedonna Beach was developed on the south embayment fill, in an area that was underwater before jetty construction.

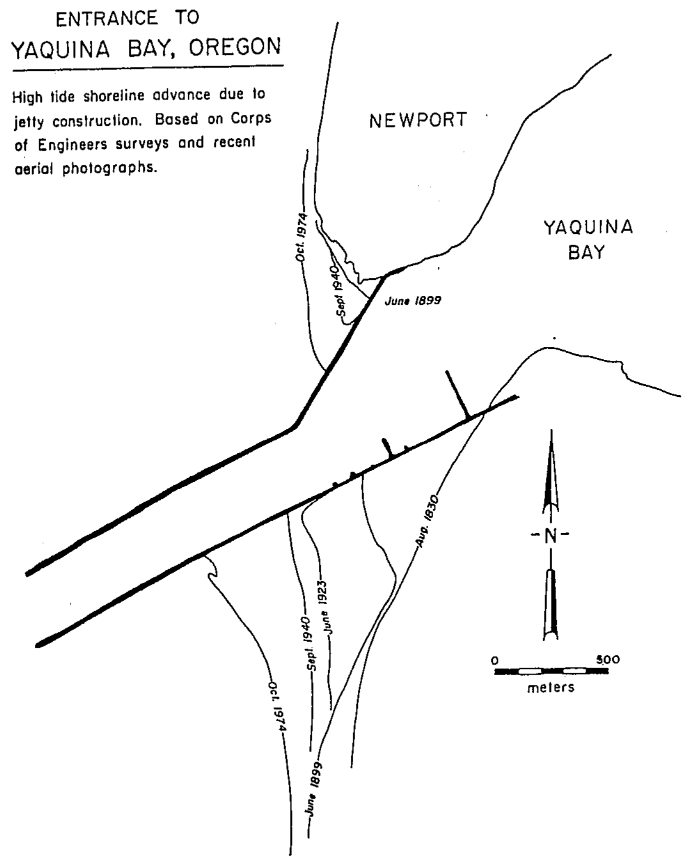


Figure 22. Compilation of shoreline changes resulting from jetty construction and then later extension at Yaquina Bay. The 1830 shoreline predates the jetty construction. The south jetty extension occurred between 1940 and 1974 and is seen to have produced some shoreline advance due to the additional protection caused by the jetty extension (from Komar, et al., 1976a).

All of the jetty systems on the Oregon coast, with the exception of the Columbia River jetties, were studied by Komar, et al. (1976a) to determine patterns of erosion and deposition. All were shown to conform to the pattern of deposition adjacent to the jetties with erosion at greater distances. This provides strong evidence that there is indeed a zero net littoral drift prevailing along the coast of Oregon as discussed earlier.

IV. SAND SPIT AND FOREDUNE EROSION (SILETZ SPIT)

Bayocean Spit eroded due to jetty construction. But other spits, such as Siletz and Nestucca Spits, have also suffered episodes of erosion without the presence of jetties. Their storm wave erosion problems are therefore attributable mainly to natural causes, man playing a minor role in the processes. This section will deal with such natural erosion to the fragile sand spits, especially that which has occurred on Siletz Spit as the problems there have been extensively studied (Rea, 1975; Rea and Komar, 1975; Komar and Rea, 1976b; McKinney, 1977; Komar and McKinney, 1977).

Prior to 1960, Siletz Spit appeared much as it had for hundreds of years; over most of its length there were low hummocky dunes, active or sparsely covered with dune grasses. Development of the spit began in the early 1960's. A road was cut along its length and artificial lagoons were carved into the bay-side of the spit. A scatter of houses appeared.

Following spit development, beach erosion first appeared during January 1971 when a series of storms cut into the foredunes upon which homes had been built. Several homes were in the path of the erosion, but riprap placement halted the erosion advance before they were seriously threatened.

Erosion returned in the winter of 1972-73. A major storm occurred over the North Pacific in late December 1972 (Figure 8), generating wave breakers up to 23 feet in height (Figure 9). The waves cut into the foredunes, quickly threatening several homes. A house still under construction was left unprotected and so was undermined by the retreating dune bluff and collapsed onto the beach (Figure 23). Riprapping began on Christmas Eve to protect the other homes. However, these houses were initially defended only on their seaward sides, empty lots to either side being left unprotected. Foredune erosion and retreat continued in these empty lots, flanking the riprap fronting the homes, necessitating the placement of rocks along their sides as well as fronts (Figure 24). The result was groups of homes situated on promentories extending out onto the beach, supported by riprap on three sides.

Erosion has returned in varying degrees in subsequent winters. It was particularly severe during the winter of 1975-76 and again in 1977-78 when a storm generated breaking waves about 23 feet high, and at a time of high Spring tides. The combination of large waves plus high tides nearly breached the spit (Figure 25). This same storm did breach Nestucca Spit, (see Section V).

In each instance foredune erosion did not occur over the entire length of the spit. Instead, it was limited to two or three zones, each some 200 feet of spit length. This localization of dune erosion was governed by the positions of rip currents as previously discussed (Section II). The seaward flowing rip currents transport sand offshore, hollowing out embayments into the beach berm. At times these embayments reach across the entire beach and begin to cut into the foredunes on Siletz Spit, setting the stage for severe erosion. The major erosion itself occurs during a severe winter storm which produces high wave conditions along the coast. The large waves are able to move ashore over the deep water of the embayments with little loss of energy, swashing directly against the base of the foredunes, cutting them back. Such embayments are seen in Figure 26 at the time of the December 1972 erosion; major foredune erosion occurred shoreward of the most pronounced embayment.

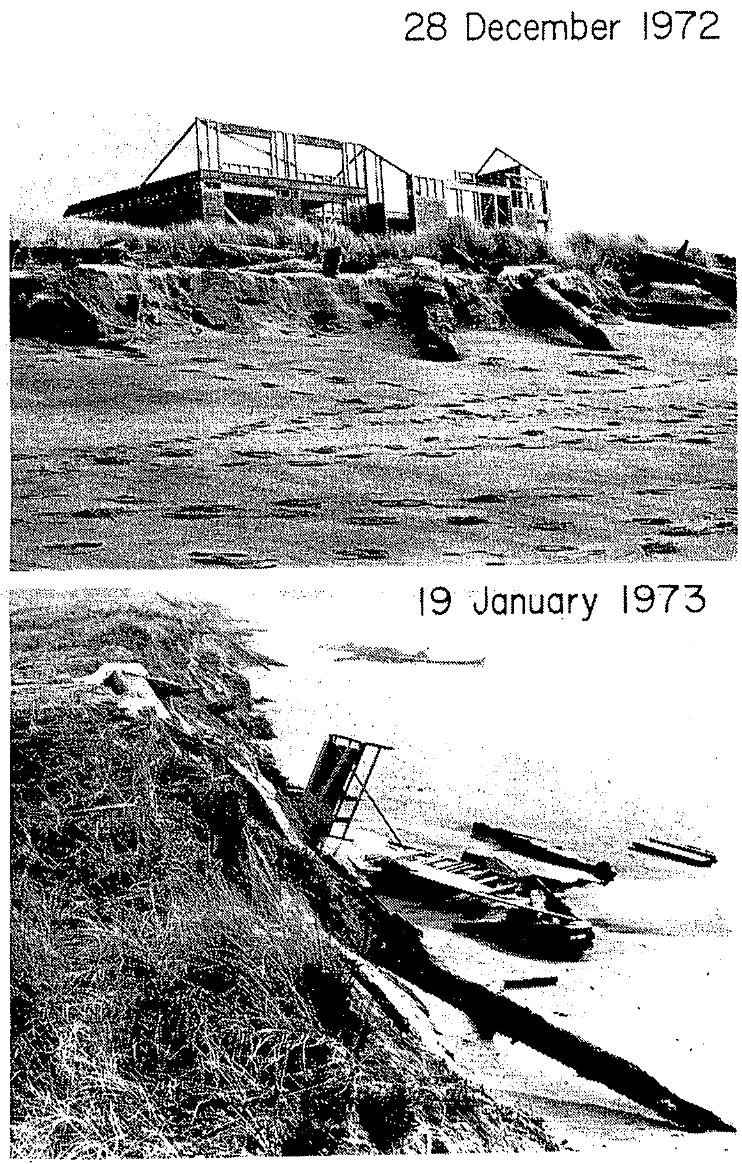


Figure 23. Destruction of house under construction on Siletz Spit due to the rapid wave erosion of the foredunes upon which the house was being built (from Komar and Rea, 1976).

Figure 24. House left on a promentory of riprap on Siletz Spit as adjacent unprotected empty lots continued to erode (Photo by P. D. Komar, 23 January 1973).

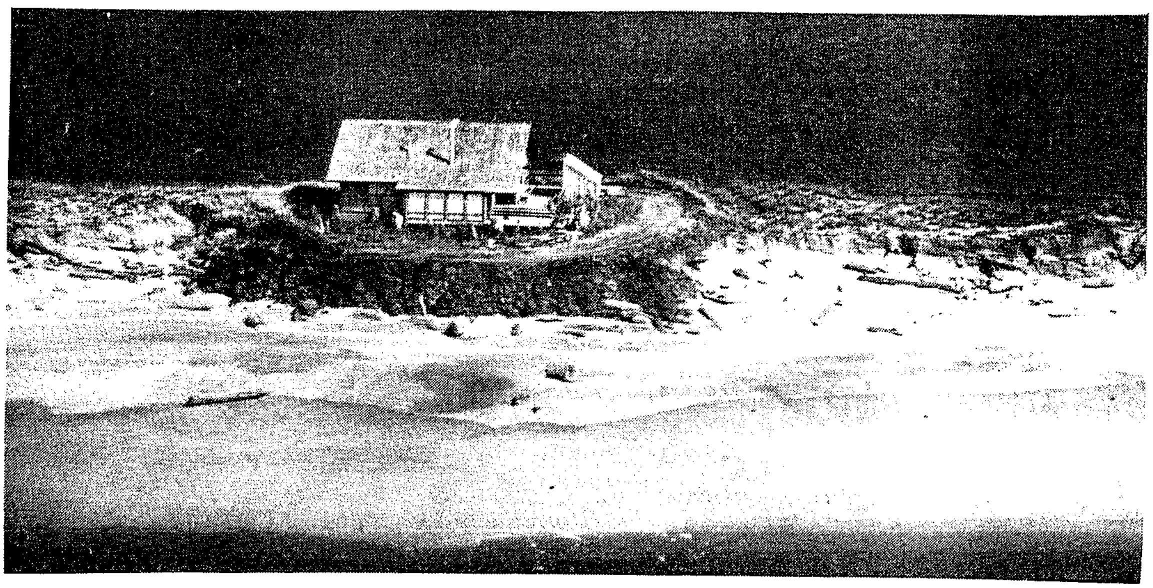


Figure 25. Erosion during the winter of 1977-78 along the narrowest portion of Siletz Spit, nearly leading to its breaching (Photo by P. D. Komar).

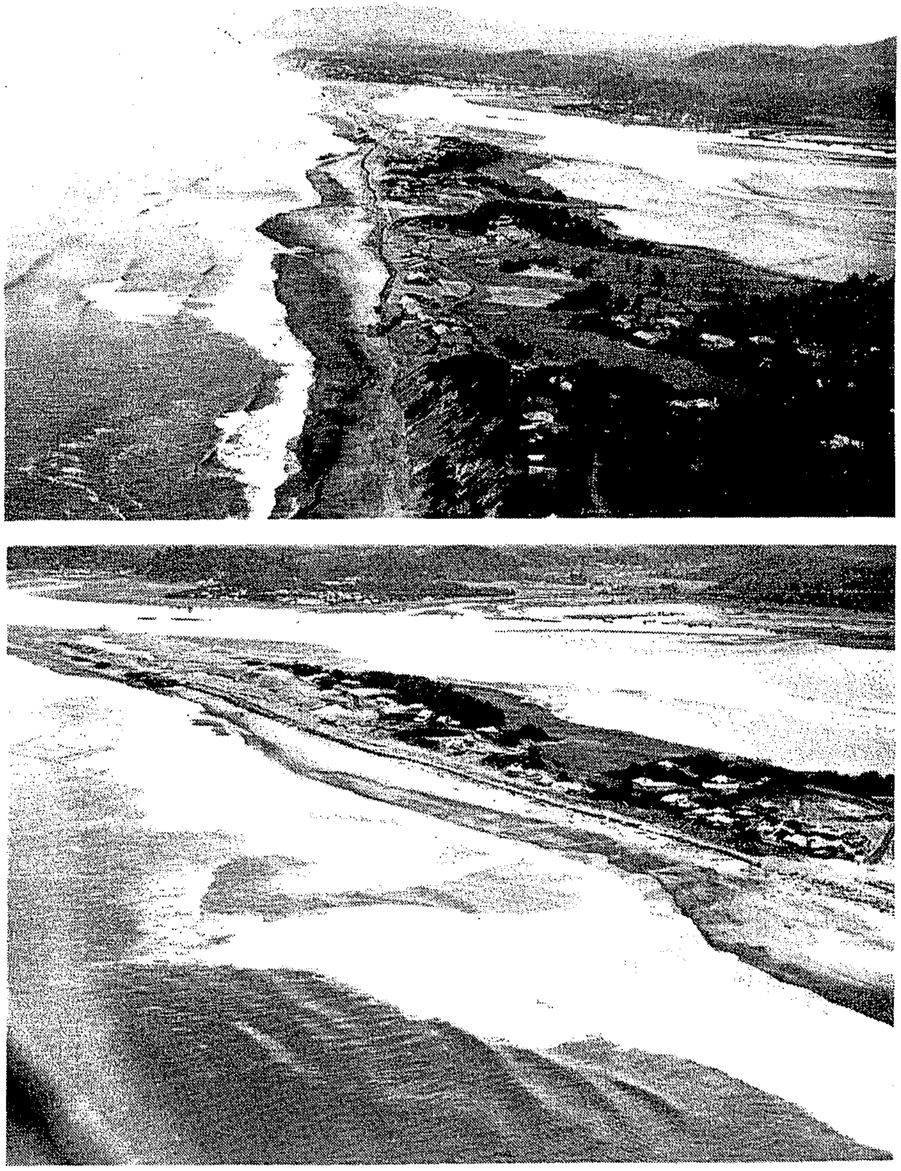


Figure 26. Embayments cut out of the beach and into the foredunes on Siletz Spit leading to property losses during December 1972 and January 1973, produced by seaward flowing rip currents (from Komar and Rea, 1976).

Thus the positioning of the rip currents during the winter governs the locations of maximum beach and foredune erosion. This usually changes from one winter to the next so the areas of erosion are not always the same. At present we are unable to predict where the rip currents will form. But once it is seen where they are positioned we can anticipate that these could be potential erosion sites. During some winters they remain relatively fixed in position and so are able to hollow out large embayments; such conditions are most conducive to major erosion. During other winters the rip currents migrate somewhat north-south, probably when waves arrive obliquely to the coastline, and do not form as large embayments; consequently the potential for erosion is smaller.

During severe episodes of erosion on Siletz Spit, the foredunes were cut back some 100 feet around the lengths of ocean-facing lots. Studies of aerial photographs dating as early as 1939 show that such erosion has occurred repeatedly in the past, but that following the erosion, beach sand is washed and blown into the eroded zone eventually rebuilding the foredunes (Rea, 1975; Rea and Komar, 1975; Komar and Rea, 1976b). The following sequence of events is revealed by aerial photographs and is typical of many cycles of erosion and accretion of the foredunes: (1) high storm waves erode an embayment or vertical scarp into the foredunes; (2) subsequent high tides deposit drift logs in the eroded embayment; (3) lower energy waves during the summer build a wide beach; (4) the logs behind the beach trap sand that is either blown off the beach or washed there by the waves at high tides; (5) wind-blown sand continues to accumulate around the logs, sometimes aided by dune grasses, until the foredunes are re-established; (6) erosion again occurs to repeat the cycle. If uninterrupted, one complete cycle can take from ten to fifteen years. Figure 27 illustrates the process of dune reformation (steps 4 and 5) in a small embayment cut into the foredunes. The criss-crossing matrix of logs is seen to be effective in trapping sand to re-establish the foredunes. Drift logs can therefore be an important agent in the reformation of foredunes.

Such cycles of erosion and foredune accretion have occurred repeatedly in the past, shown by the sequence of aerial photos of the Siletz Spit. It is also indicated by the presence of sawed drift logs buried within the foredunes, revealed by the erosion. Many homes built on Siletz Spit were constructed on foredune areas that had previously been eroded away and then reformed as described above--erosion which occurred as recently as the 1950's and early 1960's, just before spit development.

In summary, erosion of foredune areas can be very rapid, removing some 100 feet of property in two or three weeks. The erosion is mainly centered in the lee of rip currents which hollow out embayments into the beach. Maximum erosion occurs under large storm waves, and is also aided by the high water levels of Spring tides. Following erosion the foredunes may be re-established by beach sand washing and blowing into the eroded zone; drift logs aid in dune reformation by trapping the wind-blown sands.

Figure 27. Drift logs washed into an embayment cut by a rip current on Siletz Spit, now actively trapping wind-blown sands and beginning to reform the foredunes (from Rea and Komar, 1975).

It would have been preferable if development on Siletz Spit had been prohibited in the approximately 100 feet zone where foredunes are susceptible to rapid wave undercutting and erosion. Then the natural cycle of erosion followed by dune rebuilding could have continued. Instead, the presence of the homes necessitated the placement of huge quantities of riprap to the detriment of the spit's appearance (Figure 28). Much of this riprap was placed on an emergency basis, without the benefit of correct engineering procedures. As a result this riprap is being progressively washed away (Figure 29) and will have to be replaced at additional cost to the homeowners.

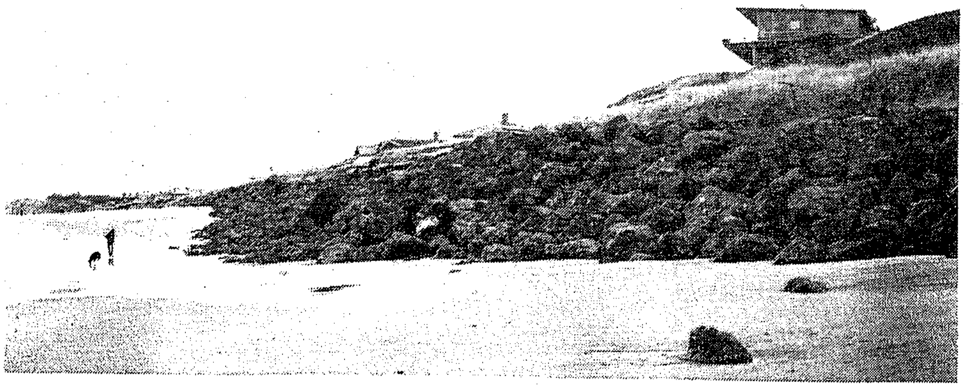


Figure 28. Large piles of riprap employed on Siletz Spit to protect the homes built on the foredunes.

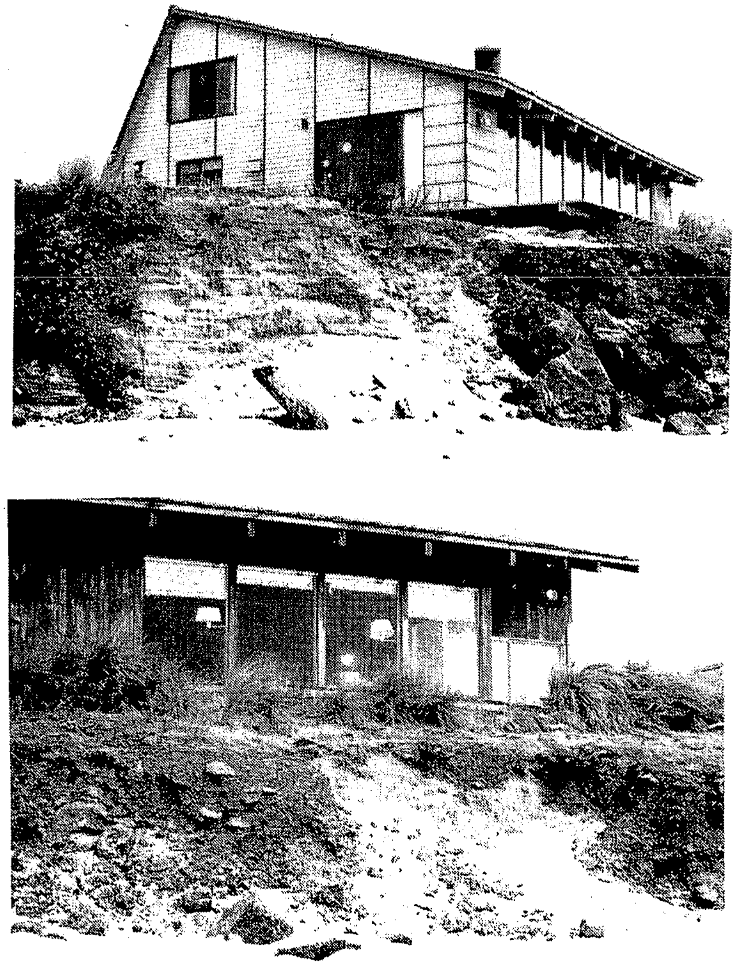


Figure 29. Erosion of riprap on Siletz Spit by a series of storms, exposing the dune sands to wave attack (from Rea and Komar, 1975).

V. OTHER AREAS OF FOREDUNE EROSION OR POTENTIAL EROSION

Other sand spits and foredune areas have suffered erosion on the Oregon coast in addition to that which has occurred on Siletz Spit. Even though erosion may not have been noted in the recent past, all foredune areas have the potential for rapid wave erosion due to their negligible resistance to wave attack. This section will discuss other sand spit and foredune areas that have eroded or have the potential for future erosion.

A. Nestucca Spit Erosion

The erosion of Nestucca Spit, Figure 30, is comparable in extent and in processes to the erosion on Siletz Spit, already discussed (Komar, 1978). The erosion has threatened a number of homes at the Kiwanda Shores development to the south of Cape Kiwanda, necessitating the placement of large quantities of riprap even before house construction was complete (Figure 31). Maximum erosion occurred during the winter of 1977-78; under the onslaught of 23-foot high breakers at a

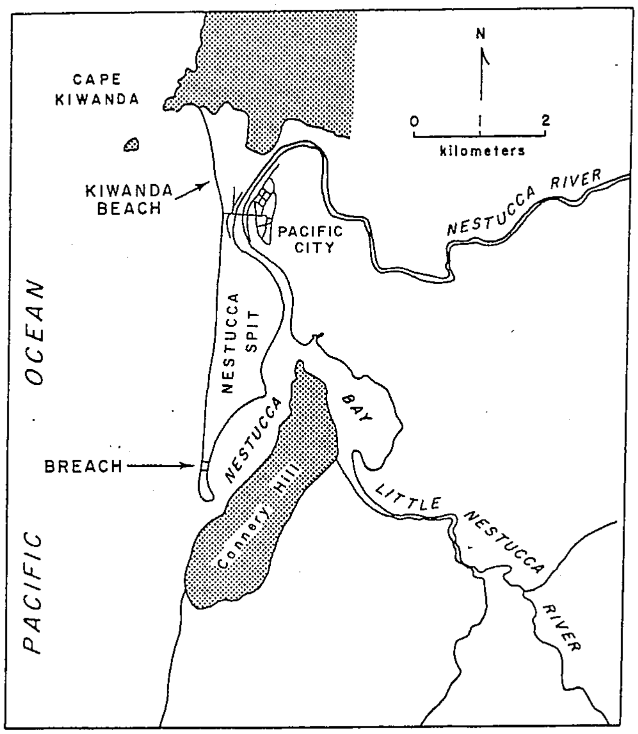
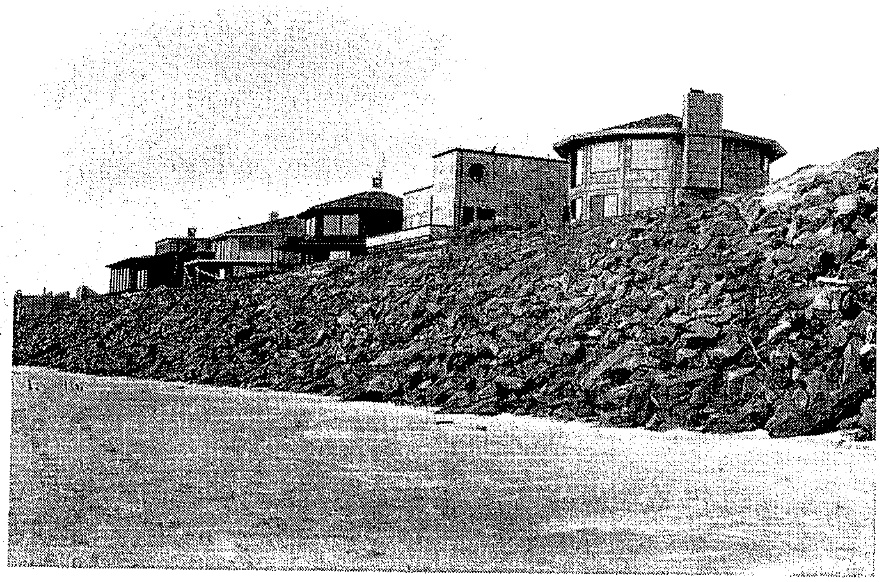


Figure 30. Nestucca Spit, showing the areas of foredune erosion and breaching during February 1978 (from Komar, 1978).



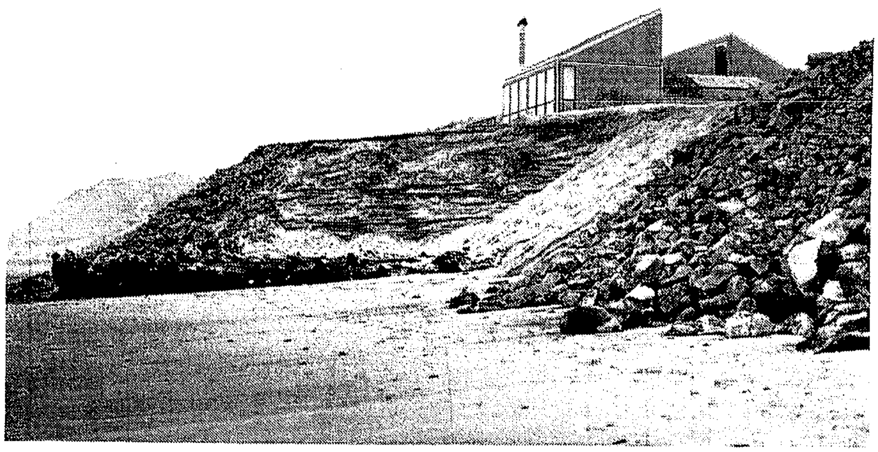


Figure 31. Homes to the south of Cape Kiwanda protected by riprap placed due to the erosion of the foredunes upon which they were being constructed (from Komar, 1978).

time of high Spring tides on 5 February 1978, the resulting erosion broke through the spit near its southern end (Figure 32). This is the only known occurrence of the natural breaching of a sand spit on the west coast of the United States (the breaching of Bayocean Spit, discussed above, was not natural in that the ultimate cause was the construction of jetties). Fortunately, the breached site at Nestucca Spit was well away from any developments and so threatened no dwellings. However, it did demonstrate the fragile nature of sand spits and their general unsuitability for development.

Figure 32. The breach in Nestucca Spit produced by a combination of unusually high storm waves and high Spring tides in early February 1978 (State of Oregon, Highway Department photo).

The erosion processes on Nestucca Spit are very similar to those on Siletz Spit. Rip current embayments again played a role in determining the centers of maximum erosion. However, the beach sand on Nestucca Spit is finer than on Siletz and therefore the beach slope is somewhat less (see Section II). This causes the rip current embayments on Nestucca Spit to be wide and shallower than on Siletz, and they do not cut as far back into the foredunes. The result is that foredune erosion on Nestucca Spit tends to cover a longer length of coastline, but does not reach as far inland. During the time of maximum erosion and breaching, sawed drift logs were observed within the eroding foredune scarp. As at Siletz, this indicates that these foredune areas have eroded before, since logging began in the coastal watersheds about the turn of the century.

B. Netarts Spit

Netarts Spit has a total length of about 5 miles, and is wide to the north but very narrow in its middle section. The spit is covered with dunes, the highest reaching nearly 50 feet high. To the south the dunes are apparently old as they are covered with Sitka spruce. Elsewhere the dunes are vegetated only with low pines or sparse dune grasses.

Erosion of Netarts Spit by wave attack was apparently a threat to the southern portion prior to 1940. Dicken (1961, p. 57) suggests that there is evidence that the spit may have broken through early in the century in its narrow portion. In 1940 the State of Oregon developed Cape Lookout State Park at the spit's southern end. The State constructed a wood piling bulkhead backed by riprap along 600 feet of the park where erosion had apparently been occurring (Figure 33). On the basis of aerial photographs, Stembridge (1975, p. 80) estimates that erosion has amounted to only 10 to 15 feet since 1939.

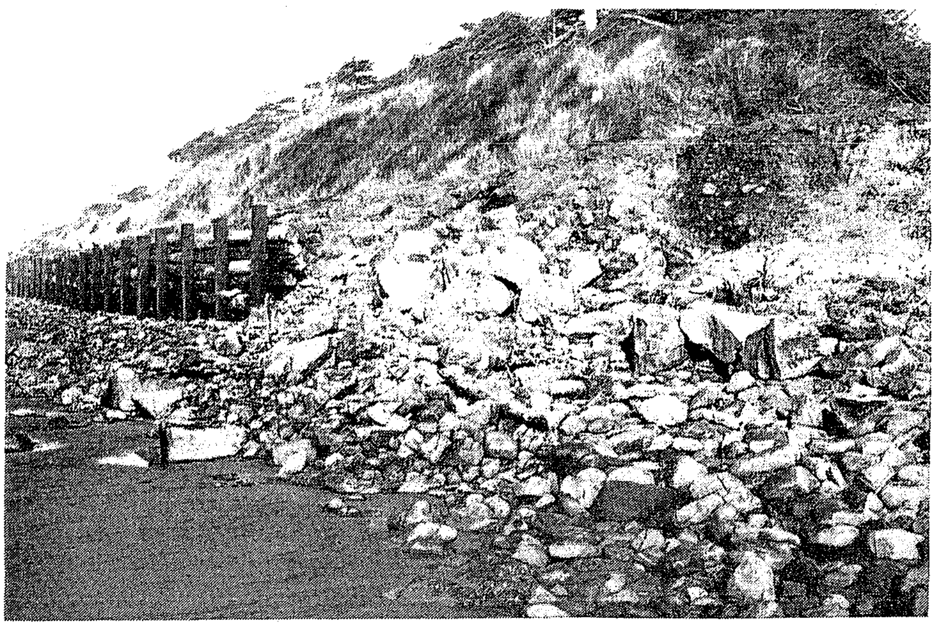


Figure 33. The wood piling bulkhead built on Netarts Spit to stop wave attack of the dunes.

The dune bluff facing the ocean is vegetated and also testifies to the fact that little or no erosion has occurred in recent years. At times the waves do reach the base of the slope, making a slight notch into the dunes, but this has been minor. It would probably take a very unusual combination of storm waves, high tides and a storm surge to cause appreciable erosion on the spit. At present, the chief problem is due to visitors cutting paths through the dune vegetation (Figure 34) which may lead to wind erosion of the dunes.

Figure 34. Degradation of the dunes on Netarts Spit due to visitors cutting a path from the beach to the state park.

The sand on Netarts Spit is fine and the beach slope very low. As a result, the rip current embayments are extremely broad and shallow, so much so that they do not appear to play any significant role in beach erosion as was the case on Siletz and Nestucca Spits. This may be a major factor in the general lack of erosion problems on Netarts Spit.

C. Nehalem Spit

Nehalem Spit is an area of low dunes that have been conditionally stabilized by European beach grass, there having been a dramatic growth of the grass in the area since 1939 (Stembridge, 1975, Figure 31). On the basis of aerial photographs, Dicken (1961, p. 66) estimated that the spit has eroded 5 to 10 feet over a 21 year period (0.25 to 0.5 feet per year). As discussed earlier (Section III), there was shoreline progradation adjacent to the Nehalem inlet jetties following their construction in 1910-19. But subsequently that area has also been eroding due to the progressive deterioration of the jetties.

The bluff in the Manzanita area cut by this long-term erosion is now nearing many homes (Figure 35) built a number of years ago. The erosion is progressive, rather than periodic and rapid as at Siletz Spit, so these homes are probably not in any immediate danger. Further south, on Nehalem Spit itself, a number of new homes have been recently constructed on the foredunes close to the beach (Figure 36). There are signs of wave erosion of the foredunes in this area so there may be some potential danger to these houses. Sands are also being actively moved by the winds, which may also lead to problems. Unfortunately, no one has made a detailed study of this area.

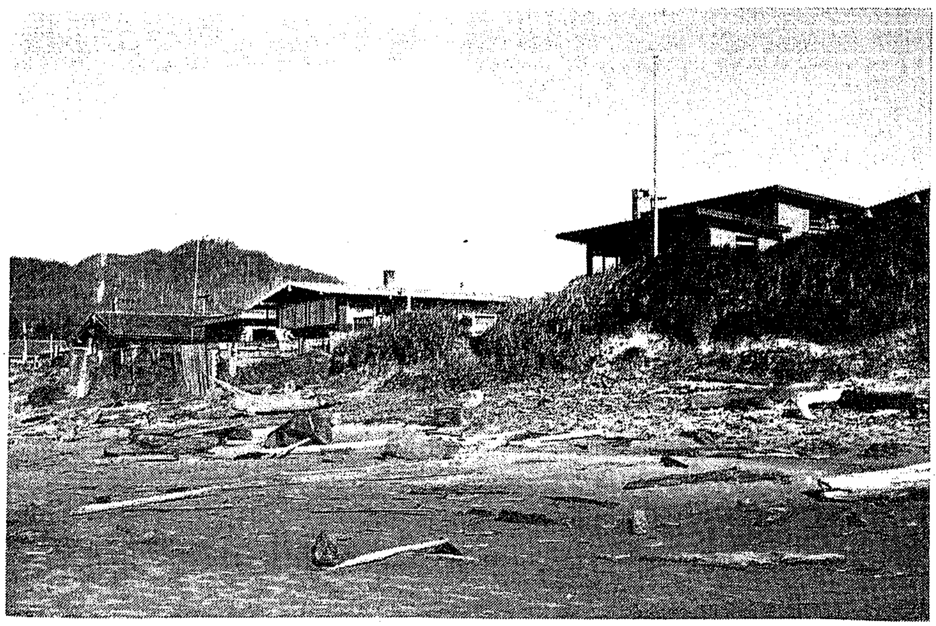


Figure 35. Long-term progressive erosion in Manzanita, now nearing some of the homes.

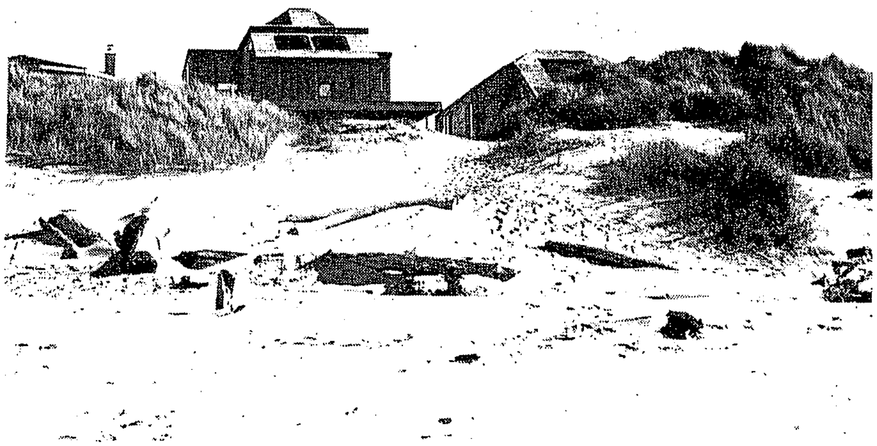


Figure 36. Homes built on Nehalem Spit in an area of active foredunes susceptible both to ocean wave attack and wind erosion.

D. Alsea Spit

Alsea Spit may be the one spit on the Oregon coast that is accreting rather than undergoing long-term erosion. This is to be hoped for as the spit is presently undergoing intensive development over its entire area.

Stembridge (1975, p. 115-120) compared aerial photographs of 1939 and 1974 of the area and found that the south tip of the spit has shown maximum accretion, an average of 10 feet per year. The accretion progressively decreases in amount northward along the length of the spit, until at about 1.6 miles north of the inlet it becomes zero with erosion occurring still further to the north. Erosion rates of up to 2 feet per year have been occurring along the bay side of the spit.

This accretion of Alsea Spit may be related to high sediment yields from the Alsea River as suggested by Stembridge (1975, p. 120). Because the accretion is maximum at the south tip of the spit, it may instead have resulted from a southward migration of the inlet itself, such migrations being common for inlets without jetties. If this is the case, then at some future date the inlet migration could reverse and move back to the north. This would cause erosion on the spit, especially at its south tip, so it would be best not to develop that area.

E. Seaside - The Necanicum River Inlet

An example where foredunes have been eroded by inlet migrations is provided by the Necanicum River inlet at the north edge of Seaside. In past decades the position of this inlet has alternately migrated north and south over a distance of about 4,000 feet. In 1948, for example, it moved well to the south to the very edge of the Seaside community, endangering the sewage treatment plant there. It then moved back to the north causing erosion of the foredunes south of Gearhart.

Seaside and the Necanicum inlet area are at the southern portion of the Clatsop Plains and thus have an abundance of sand. Because of this, whenever the Necanicum inlet migrates away from an area, sand rapidly accumulates to form a foredune. At present, such an active foredune is found north of the inlet at the south edge of Gearhart. However, such foredunes adjacent to the inlet are very susceptible to erosion by renewed inlet migration.

In 1967 the inlet migrated to the north and a spit of foredunes began to develop to the south as a continuation of Seaside. A developer quickly placed riprap over that foredune area so the inlet would not migrate back and reclaim the area. The intention was to construct dwellings on the newly accreted area, but the riprap was placed without a permit and so has been under litigation ever since. The inlet has periodically been attempting to migrate back to the south and has been progressively eroding and undermining the riprap at its northern tip. In the meantime, foredunes have accumulated in the area on top of the riprap. In 1978 these active dunes were bulldozed flat, covered with sludge from the sewage treatment plant and seeded with grass.

Due to their natural migrations, such inlet areas without jetties are particularly dangerous to develop. The strong currents in the inlets can undermine the riprap unless done with jetty-scale material. The deep-water of the inlet also allows ocean waves to reach the shoreline with little loss of energy so that inlet areas can also suffer from wave attack. They are also particularly susceptible to overwash by tsunami waves (Section II). In the particular case of the Necanicum inlet, there will be continuing problems with wind-blown sands due to the particular abundance of sand there.

The Necanicum inlet also provides an example of foredunes and bay-shore properties being eroded by currents within the estuary itself. The Neawanna Creek enters the Necanicum estuary on its north side to the east of Gearhart. In the past few years, the flow of the Neawanna has been eroding the bay-side of Gearhart, necessitating the placement of riprap to protect homes there. It strikes the bay side of the foredunes south of Gearhart and is actively eroding them (Figure 37).

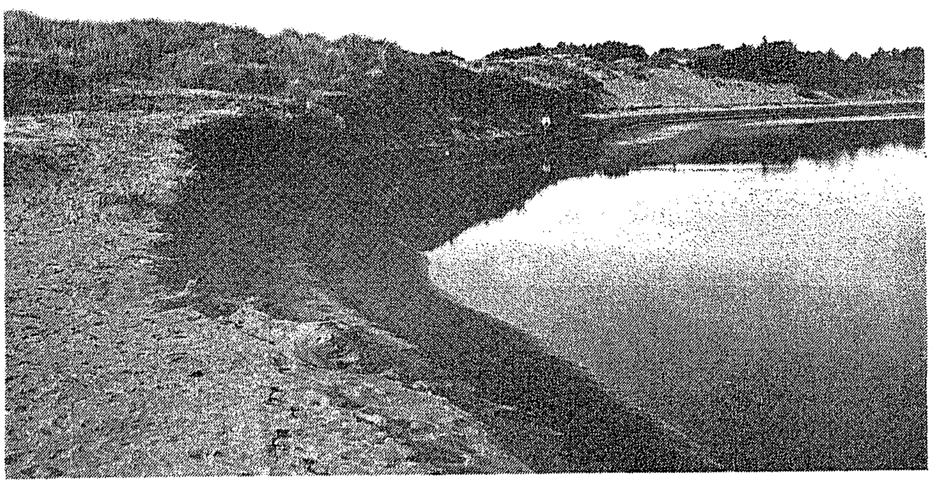


Figure 37. Bay-shore erosion at Gearhart, caused by the flow of the Neawanna Creek against the property.

Such bay-side erosion could also pose a threat to any dwellings placed in the area. Bay-side erosion has similarly occurred on Siletz Spit where the flow of the Siletz River impinges on the spit after flowing across the bay (Figure 38). The erosion there has been aggravated by the placement of the Siletz Keys landfill. Prior to the landfill, river flood waters were able to spill into the south part of the bay (open arrows of Figure 38), but after the landfill blocked these channels

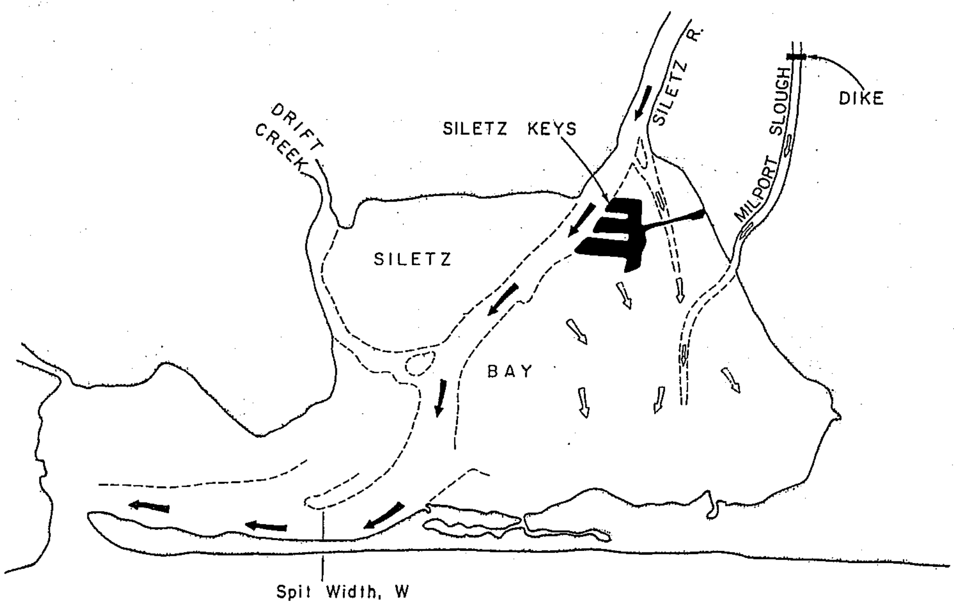


Figure 38. Bay-shore erosion on Siletz Spit where the Siletz River strikes the backside of the spit. The erosion has been aggravated by the placement of landfills such as Siletz Keys which prevents flood-waters from spilling into the south portion of the bay (from Rea and Komar, 1975).

all of the flood waters were jetted against the spit (Rea, 1975; Komar and Rea, 1976b). This bay-side erosion has progressively narrowed the spit, and together with the ocean-side erosion (Section IV), may cause a breaching of the spit (see Figure 25). Old, well-vegetated dunes may also be eroded by bay or estuary currents; an example is the north shore of the Siuslaw River.

F. Cannon Beach (Breakers Point)

Not all foredune areas are located on sand spits are associated with inlets. There are examples where foredunes have formed fronting sea cliffs or older well-vegetated dunes. One example is found in the Cannon Beach area to the north of Elk Creek (Figure 39), a portion of which is presently undergoing development. There are clear signs that the formation of this foredune is quite recent, probably less than 100 years old. At times storm waves cut into the foredunes, much as on Siletz Spit, removing as much as 30 feet during a single storm (Rosenfeld, 1979). This erosion has exposed sawed drift logs, again much as observed on Siletz Spit (Section IV), indicating dune accumulation since logging began in the area. Backing the northern portions of this foredune are higher, older dunes covered with trees. A clear erosion scarp, now covered with grass, has been cut into the seaward-facing side of these older dunes (Figure 39). This indicates that not too long ago erosion proceeded all the way up to the older dunes, entirely removing the foredunes. That erosion must have been an unusual combination of extreme storm waves, high Spring tides and a storm surge, producing an event analogous to the 100 to 200 year flood in a river. Since that event the foredune sands have been accumulating with the exception of the 30 feet or so that is periodically eroded by more common winter storms. Like the river floodplain which is covered by the 100-year flood, this foredune area and others like it are not desirable locations for permanent dwellings.

Figure 39. Foredunes at Breakers Point, Cannon Beach, backed by older, well-vegetated dunes into which waves at some time cut a near-vertical scarp.

VI. SEA CLIFF EROSION

Although not as dramatic as the rapid erosion of foredunes, the long-term, progressive erosion of sedimentary sea cliffs along the Oregon coast remains an important problem for the coastal planner and resident. Certainly on a coast-wide basis, more homes are threatened by sea cliff erosion than by eroding foredunes. This is because many of our coastal communities (Cannon Beach, Lincoln City, Newport, Waldport, Bandon, Brookings, and numerous others) are located in areas of eroding sea cliffs. Most of these are built on the flat areas of marine terraces, consisting of Pleistocene marine sandstones overlying mudstones of older ages. These rocks are susceptible to wave attack to form the familiar sea cliffs (Figure 40) seen along much of the Oregon coast.

This section will examine the processes of sea cliff erosion (including landslides), what is known about their recession rates, and what attempts have been made to protect them from wave attack and the success or lack of success of such attempts. Examples of problems with eroding sea cliffs on the Oregon coast are cited.

A. Processes of Erosion

Erosion of sea cliffs is often viewed as a process of wave attack undermining the cliff followed by landsliding. This view is somewhat oversimplified as other processes are also involved including groundwater sapping and direct erosion by rainwash (especially important in Oregon). The Pleistocene terrace sandstones that form a primary component of the Oregon sea cliffs are only weakly cemented and so are easily eroded away by rainwash and groundwater. The sand so washed away, or that which has dropped from the cliff as a minor landslide, tends to accumulate at the base of the cliff as a tallus pile, sloping toward the sea (Figure 40). Most often the waves are more important in periodically removing this tallus accumulation than in directly attacking the sea cliff itself. The amount of tallus found at the cliff base can give some idea as to the frequency of wave attack in a particular area (Figure 41). A large accumulation, especially one with vegetation growing upon it, indicates that a long period has elapsed since storm waves were able to reach the sea cliffs. This was the case at Taft until the winter of 1977-78 at which time unusually severe winter storms removed the extensive tallus accumulations (Figure 42). A large quantity of drift logs had been removed from the beach fronting Taft, and this too may have played a role in the renewed erosion of the sea cliff.

The absence of any tallus accumulation at the base of the sea cliff indicates a very recent episode of water erosion. Where the fronting beach is narrow, such erosion may occur nearly every winter so only minor tallus accumulations may be found during the summer months. Such areas are generally those that show the maximum rates of overall sea cliff recession. At other areas, Taft being an example, wave attack occurs infrequently and the tallus may accumulate over several years before again being eroded away; such areas generally show smaller rates of cliff recession.

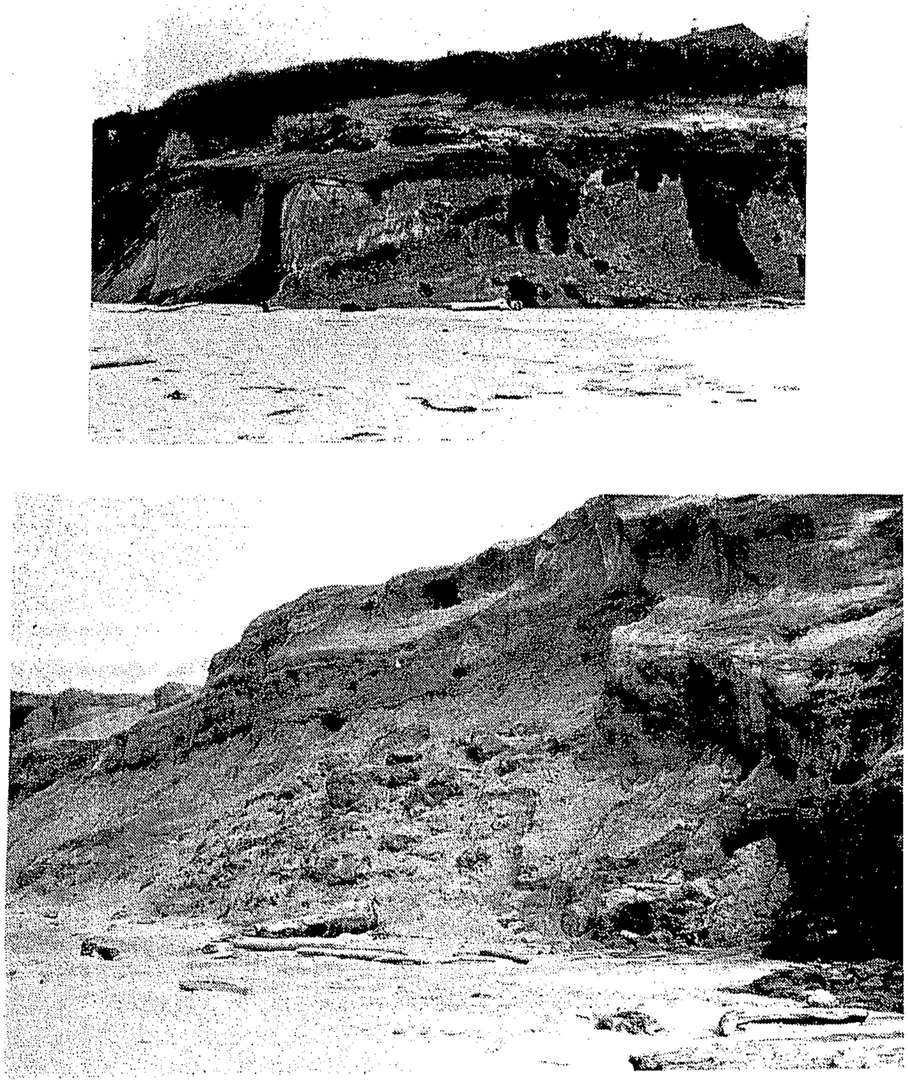


Figure 40. Typical sea cliffs of the Oregon coast formed by erosion of marine terraces. The upper photo shows a thin layer of Pleistocene terrace sands overlying older Tertiary mudstones with an apparent dip to the left. The lower photo, from the Lincoln City area, is a sea cliff composed entirely of terrace sandstones, and is seen to be more susceptible to erosion processes.

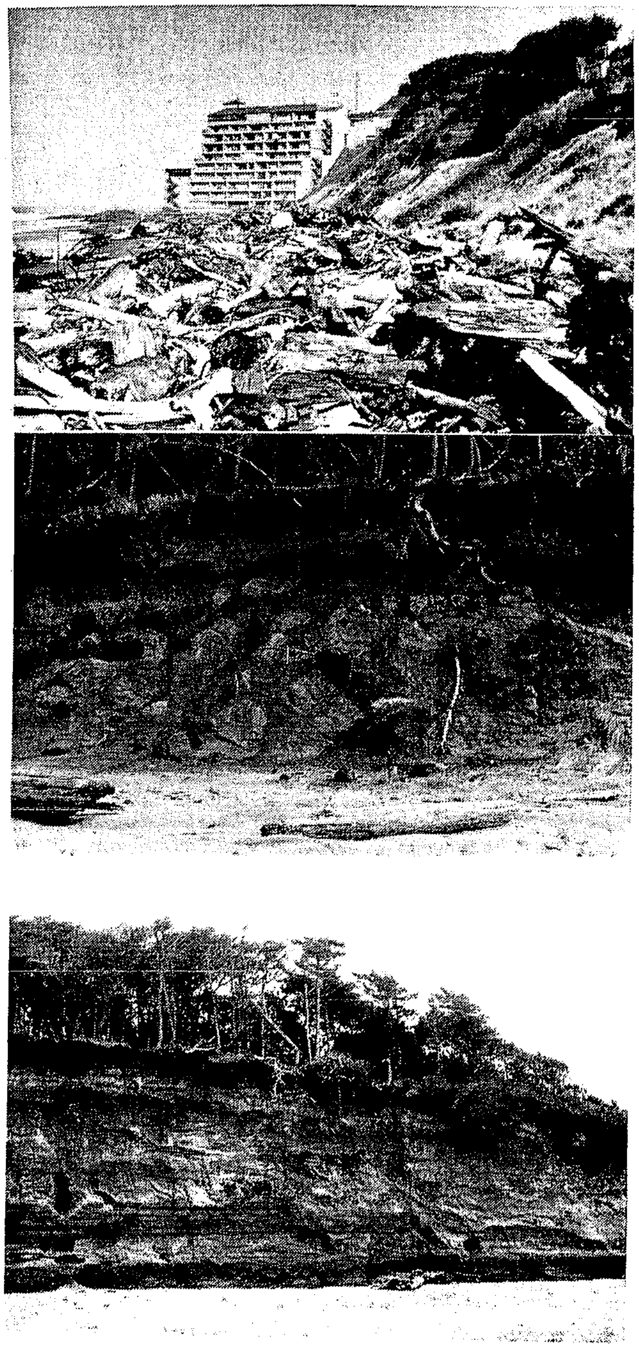


Figure 41. The extent of tallus accumulation at the base of the sea cliff can give some indication of the frequency or recency of wave attack. The upper photo from Taft shows a considerable accumulation with the development of vegetation, indicating an extended period of time since wave erosion, in this case the logs possibly offering some protection (compare with Figure 42 of the same area after erosion during the winter of 1977-78). The middle photo from Gleneden Beach shows a sea cliff with a large tallus accumulation but no vegetation, indicating no wave attack for perhaps 5 to 10 years. The lower photo is from the same area, the severe storms of the winter of 1977-78 having washed away all of the tallus accumulation.

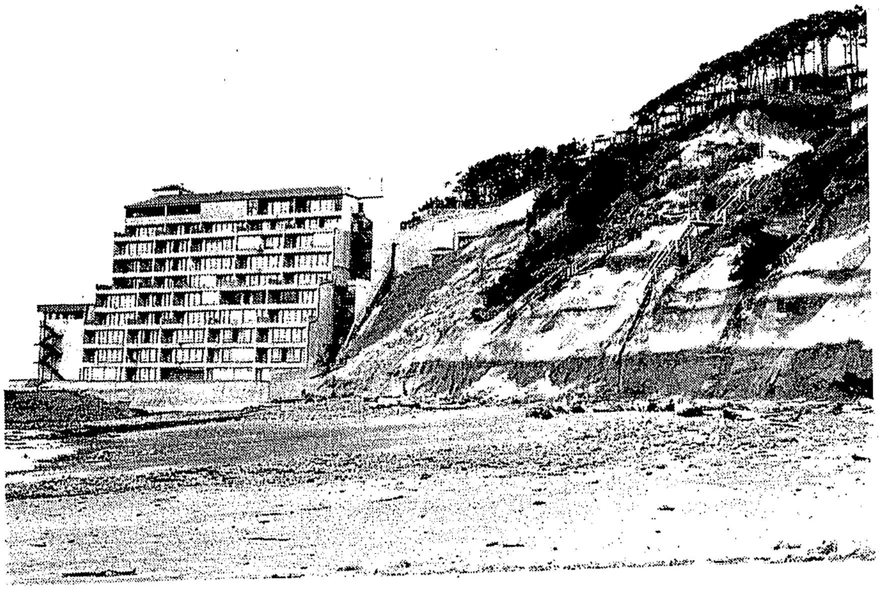
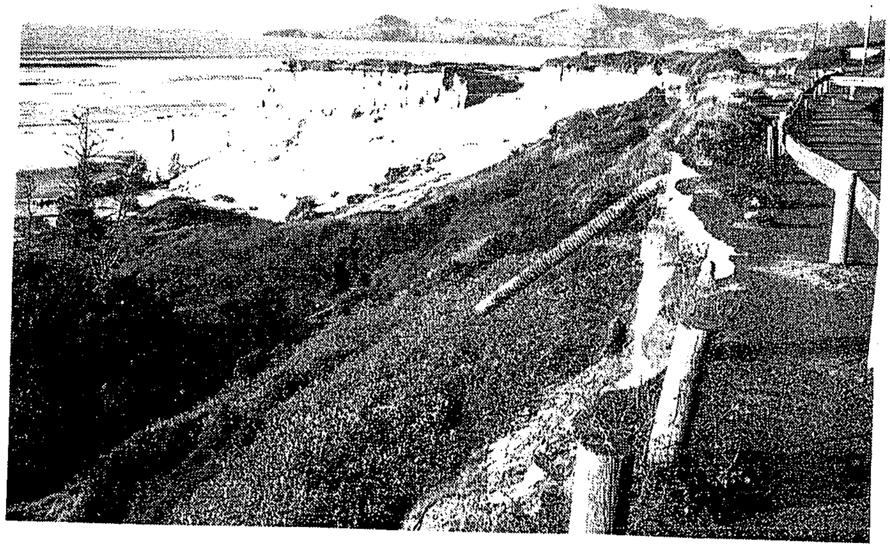


Figure 42. Sea cliff erosion at Taft during the winter of 1977-78. Compare with the first photo of Figure 41 of the same area, noting the loss of logs on the beach and the loss of the vegetated tallus slope.

The presence of the tallus slope offers some support to the sea cliff. Once it is removed landsliding usually quickly follows, responding more to this loss of support than from actual wave undercutting of the cliff. In most areas the landsliding consists of only small sections of the cliff dropping down onto the beach (Figure 43). This minor slumping, together with rainwash and groundwater sapping, produces a slow to moderate progressive retreat of the sea cliff and loss of property.

Figure 43. Small landslides are an important process to sea cliff erosion, especially where the cliff is composed of terrace sandstones.

At times, however, large landslides can occur that suddenly remove several acres of land. Important to their generation is the geometry of the sea cliff, including its height and the orientation of the geologic strata forming the cliff. Large landslides are likely to occur in areas where the older rocks underlying the Pleistocene terrace sands slope in the seaward direction as the sliding of the rock mass can occur along this bedding. Byrne (1964) has estimated that such stratigraphically seaward-dipping terrace deposits are present along more than half of the coastline north of Waldport. One such area is Newport where in 1943 an area of about six acres progressively slid seaward, dropping down 20 feet in the process (Figure 44). More than a dozen homes and other structures were lost, some of which originally had been well back from the cliff edge (North and Byrne, 1965; Stembridge, 1975). Figure 45 summarizes the sea cliff retreat over the years in the Newport area, a retreat brought about mainly by landsliding.



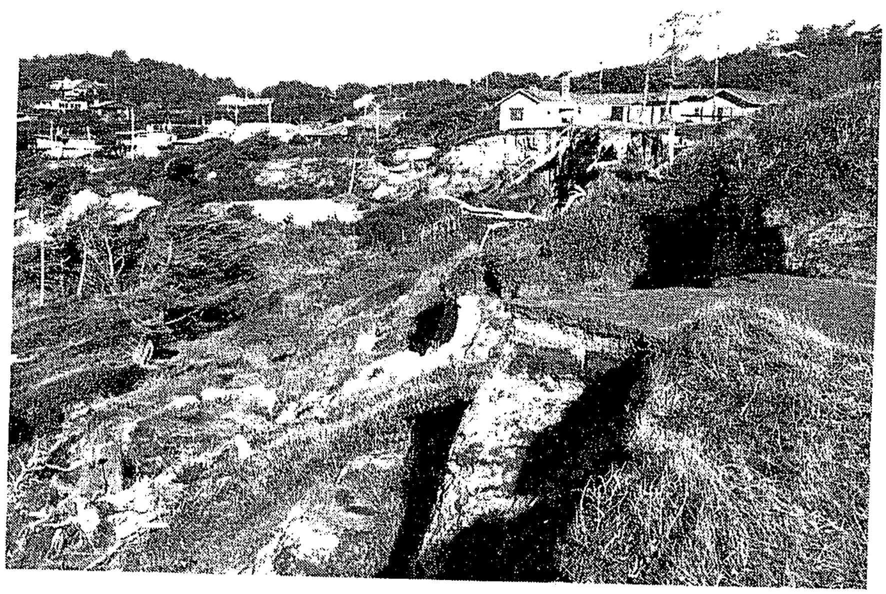


Figure 44. Large landslides in the Jumpoff Joe area of Newport.

Another factor important to the generation of large landslides is the presence of groundwater which lubricates the slide, increases the weight of the material, and may also produce a pore-water pressure. Compiling the occurrences of major landslides as reported in coastal

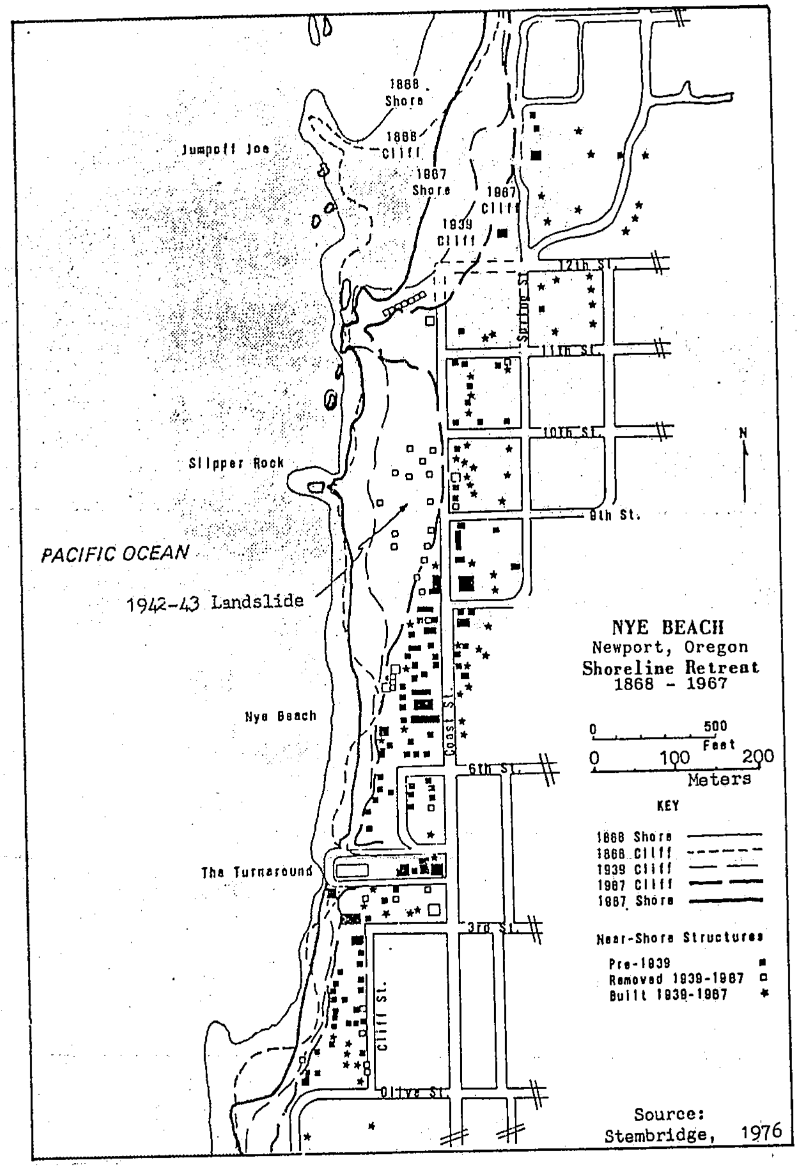


Figure 45. The sea cliff retreat in the Jumpoff Joe area of Newport as documented by Stembridge (1975) from aerial photographs. The property losses here are due almost entirely to large landslides.

newspapers, Byrne (1963) showed that they occur almost exclusively during the months of October through April (Figure 46). Although wave attack may play some role in the winter increase in landsliding, the increased precipitation appears to be more important in that most of the newspaper accounts indicated that sliding occurred during or immediately after extended periods of torrential rains. In more recent years, large landslides appear to have increased in frequency during the summer months rather than being restricted to the winter, probably due to the increased usage of septic tanks which contribute to the ground water at all times of the year.

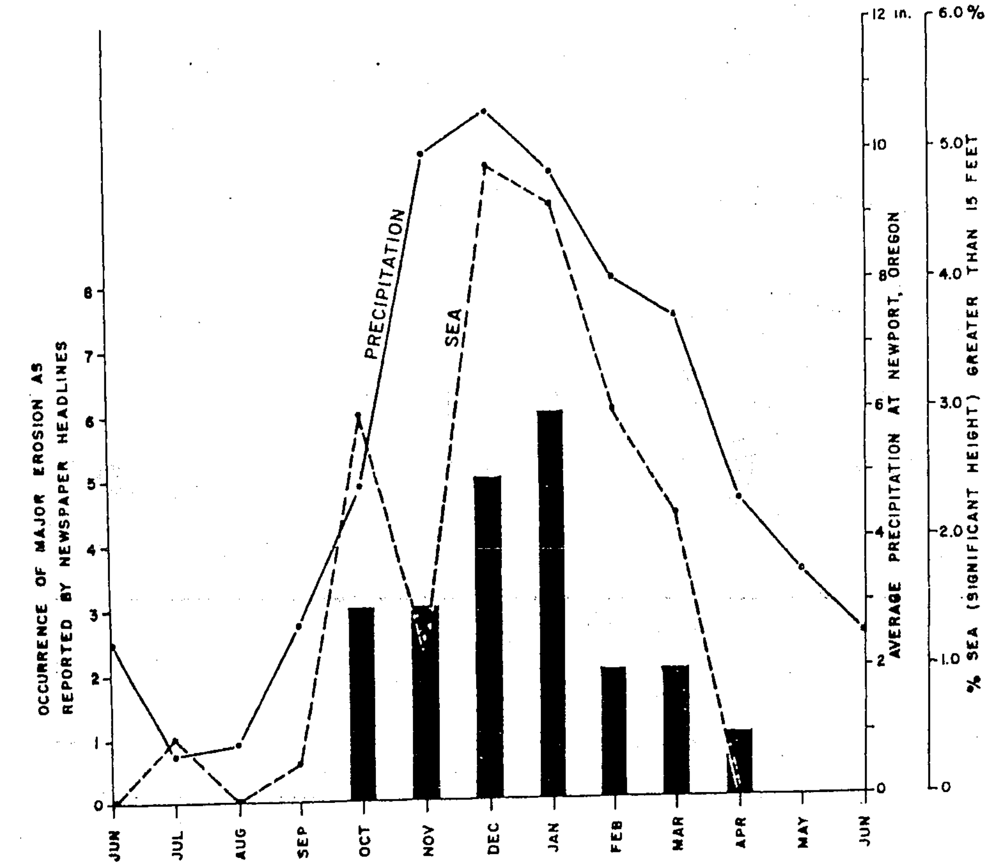


Figure 46. The compilation of landslide occurrences on the Oregon coast from newspaper reports, showing their development during the winter months at times of high precipitation and wave action (from Byrne, 1963).

Large landslides are also important in the headland areas due to the high slopes. The landslides occurring in Ecola State Park are good examples (Schlicker, et al., 1961). Large landslides are particularly common on the flanks of the headlands due to the combination of steep slopes and the presence of loose rock and soil derived from the headland. These areas pose a special problem in that they are often prime sites for housing developments.

Landslides on the Oregon coast have received considerable attention. Byrne (1963), North (1964) and North and Byrne (1965) document landsliding on the northern coast from Florence to the Columbia River. The various reports of the Oregon Department of Geology and Mineral Industries, discuss the hazards from coastal landsliding (for example, Schlicker, et al., 1973). Schlicker (1956) reviews landsliding in general, and Prestedge (1977) discusses the mechanics of landsliding with specific reference to the Oregon coast and the engineering techniques of stabilization.

One additional factor is important to sea cliff erosion--the human factor. Figure 47 illustrates how people can have an impact on the erosion rate by carving graffiti and in some cases even cutting tunnels into the sea cliffs. Considering that natural sea cliff recession rates often amount to only a few inches per year, this human factor cannot be viewed as negligible.

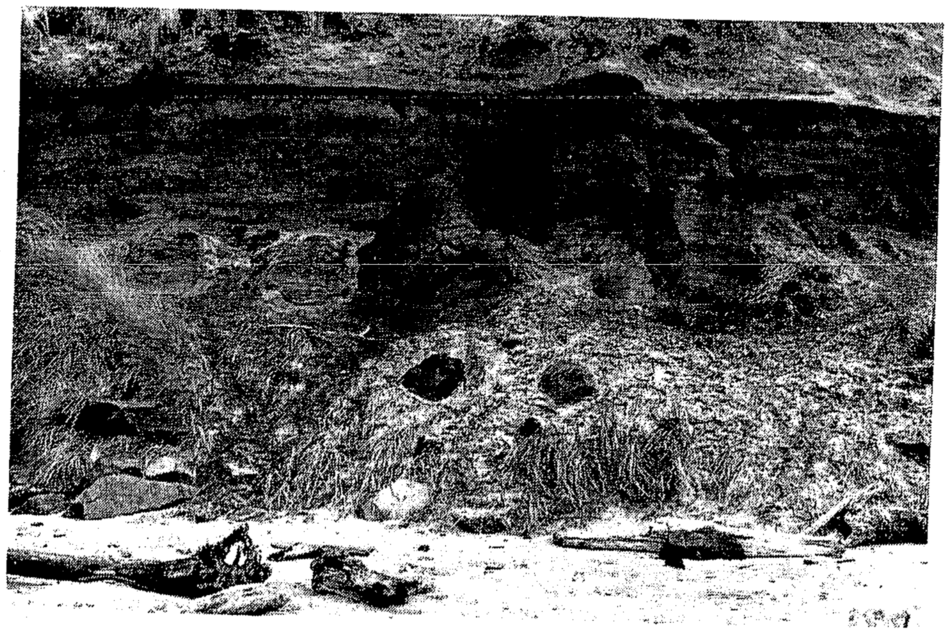


Figure 47. Graffitti carved into a sea cliff at Lincoln City, having a significant effect on the long-term cliff retreat rate.

B. Rates of Sea Cliff Erosion

Of relevance to planning is the long-term recession rate of sea cliffs and the potential for landslides removing large blocks of property in a short time. Landslides have already been discussed, and in most cases their presence or potential is reasonably clear. The progressive recession of sea cliffs is important for determining what distances homes or other structures should be set back from the eroding sea cliff so that they are not destroyed before their anticipated life time of use.

A standard procedure for determining long-term cliff recession rates is through the use of sequences of aerial photographs. There are many difficulties and inherent uncertainties in this procedure so that the amount of erosion measured has to be large if the measured rates are to exceed the uncertainties. This means that the procedure gives best results in areas that have high rates of cliff recession or if there is a very long period of time represented by the available aerial photographs so that even though the rate may be small the total amount of erosion over that period of time is large enough to measure.

The earliest aerial photogaph coverage of substantial stretches of the Oregon coast dates back to 1939. The areas covered by those 1939 photos are diagramed by Stembridge (1975, p. 193). Coverage in the 1940's is scarce, but in the 1950's to the present many more flights were carried out. This forty years of coverage is adequate so long as the cliff recession rates are moderate to high, but if low (less than 2 to 4 inches per year) then the total amount of erosion that has occurred can barely be measured with any certainty by aerial photo techniques.

Stembridge (1975) gives a coast-long summary of the cliff recession rates, based upon the 1939 and 1967 aerial photos and upon field inspections. Table 2 summarizes his estimated erosion rates for backshores of various compositions. The terrace deposits are seen to have a wide range of recession rates, from less than 1 foot per year to greater than 20 feet per year. The large recession rates are found in areas susceptible to landsliding, such as the Jumpoff Joe area of Newport, already discussed. The largest recession rates are for areas of recent sand deposits, the rapid erosion of Bayocean Spit being the primary example (see Section III). Stembridge (1975) does discuss the erosion rates he found for a number of areas along the Oregon coast, as well as presenting the overall summary of Table 2.

Smith (1978) has determined coastal changes for Lincoln County, again using aerial photographs (1939, 1959 and 1973). Erosion rates for that 34-year period range from amounts too low to measure to a maximum of about 240 feet in the Jumpoff Joe area of Newport. The mean amount of erosion was about 20 feet, giving a mean rate of 7.1 inches per year for that 34-year period. Included in that average are some basalt headlands with very low rates of erosion. Excluding those areas from the county-wide average leaves an average of 9.2 inches per year, an average for the coast consisting of sedimentary terraces or unconsolidated materials (the sand spits). Smith found a great deal of variability in recession rates along the Lincoln County coast, so that these averages should not be applied to estimate the recession rate of sea cliffs in some particular area. It would be wise for each county to conduct a study similar to that of Smith (1975) in Lincoln County.

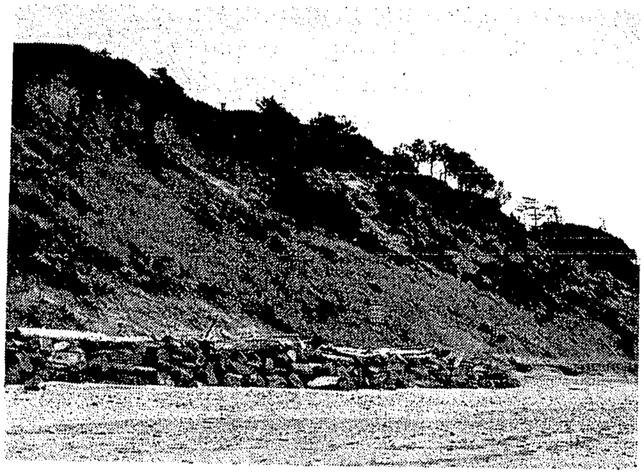
Table 2. Ranges of maximum backshore erosion rates (after Stembridge, 1975)

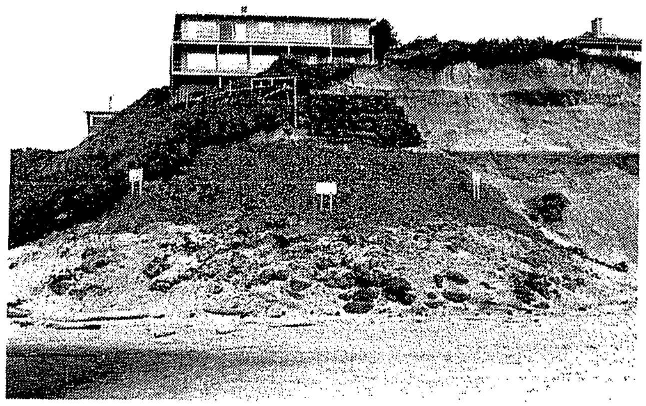
Backshore Composition	Range of Maximum Erosion (in feet per year)	Examples
Igneous (basalt)	< 0.1 to > 0.3	Cape Foulweather, Heceta Head
Metamorphic	< 0.1 to > 1.0	
Sedimentary	< 0.5 to > 2.0	Cape Kiwanda, Cape Arago
Terrace Deposits	< 1.0 to > 20.0	Lincoln City, Jumpoff Joe
Recent Sand Deposits	< 10.0 to > 100.0	Bayocean Spit

C. Methods of Sea Cliff Protection

Several methods have been employed on the Oregon coast in attempt to prevent or slow the erosion of sea cliffs. Those most commonly used are riprap and a variety of sea walls. The sea walls may be constructed of concrete or logs; drift logs taken from the adjacent beach are sometimes employed. Groins that project out across the beach to trap part of the littoral sand drift have not been used on Oregon beaches, and probably would not be effective due to the lack of a littoral drift.

All of the protective devices must act to defend the sea cliff from wave attack. In many cases this defense is against only the wave swash rather than the full force of breaking waves. In such cases, a low wall of logs fixed in place at the base of the sea cliff or just in front of the tallus slope is adequate. Great masses of riprap are really needed only where there is severe and direct wave attack. The weight of the riprap does have the added advantage of helping to prevent landsliding as it weights the toe of the cliff. Solid concrete walls have the same effect, but have the disadvantage that they can reflect the wave energy which induces erosion of the beach adjacent to them. This can lead to the undermining of the sea wall and its failure and collapse onto the beach. Log walls and riprap may be partially destroyed by wave attack, but seldom completely fail like a concrete wall.





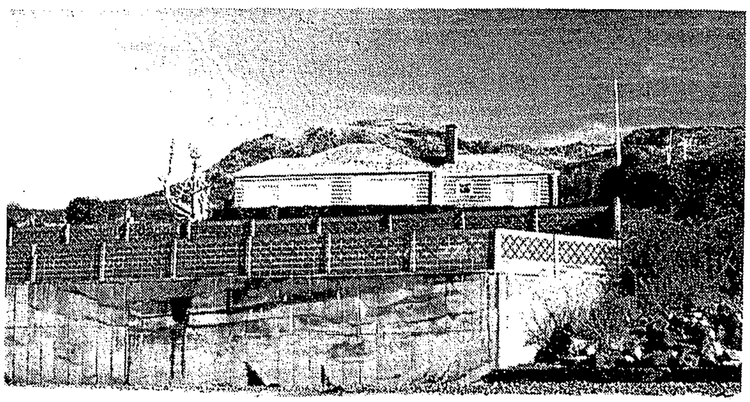


Figure 48. A variety of sea cliff protection approaches have been employed on the Oregon coast, mainly involving log sea walls, concrete sea walls and riprap.

None of these protective schemes completely halt the sea cliff recession unless they extend to the full height of the cliff. If they cover only the base of the cliff, the bare upper portion will continue to suffer some erosion by rain wash and groundwater sapping. This retreat of the top of the cliff will continue until the overall slope of the cliff is decreased, at which time it may become vegetated. But before that stage is reached, the top of the cliff could retreat by several feet, but at a lower rate than before protection was provided to the lower portion of the cliff.

There are arguments against any form of sea cliff protection. First, they can be expensive and would be unnecessary if dwellings were set back an adequate distance from the cliff edge. As discussed in Section II, the erosion of sea cliffs in most cases provides the principal source of sand to the Oregon beaches; cutting off this source by extensive protection will lead to the long-term diminishment of our beaches. And finally, the huge piles of riprap or concrete sea walls can be unsightly, destroying the aesthetic value of the coast that originally attracted people there.

VII. THE COASTAL DUNE SHEETS

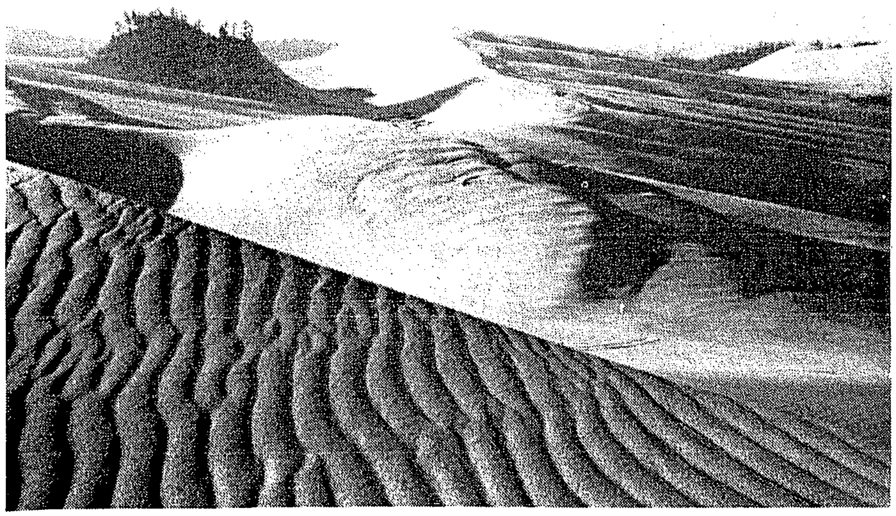
Sections IV and V of this report dealt largely with foredune erosion, whether the foredunes are located on sand spits such as Siletz and Nestucca, or fronting sea cliffs and older dunes as at Cannon Beach (Breakers Point). This section will concentrate instead on the older dunes generally found more inland. It was pointed out in Section II that such dunes, active or vegetated, cover about 45 percent of Oregon's 310 miles of coastline. The best known and most intensely studied is the sheet of active dunes extending for a distance of 55 miles between Coos Bay on the south to Heceta Head near Florence. These dunes and others on the Oregon and Washington coasts were investigated by Cooper (1958), and most of our information on Oregon dunes comes from that source. Later contributions have been made especially by Lund (1973) and various chapters in Dicken (1961). This section will summarize what is known about the physical processes important to dune sand movements on the Oregon coast, the effects of vegetation, and the problems relevant to the management of these areas.

A. Active Dune Types

In his study of the active dunes of the Oregon coast, Cooper (1958) identified two principal types, the transverse-ridge pattern and oblique-ridge pattern (Figure 49). These dune types are somewhat different from those commonly found in deserts and other coastal dune areas.

The transverse-ridge pattern of dunes originally occurred in nearly all the major dune localities on the Oregon coast, but since the introduction of European beachgrass its form has been restricted to the Coos

Bay dune sheet. They are asymmetric in cross-section with windward slopes of 3 to 12 degrees and lee slip faces averaging about 33 degrees, the steepest possible slope for sliding sand. They vary greatly in length; a single ridge may be more than half a mile long. They are not uniform in height, the ridge crest forming a succession of highs and lows.



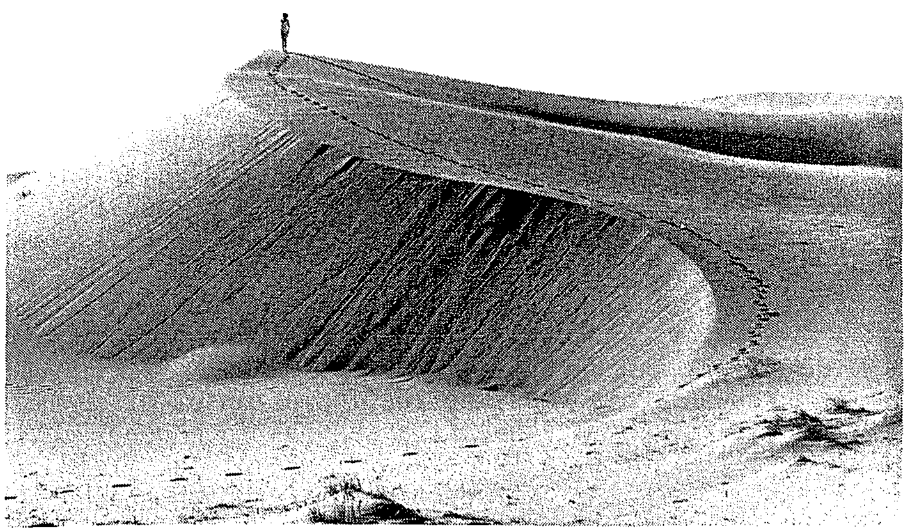


Figure 49. The two active dune types found on the Oregon coast, the transverse-ridge pattern and the oblique-ridge pattern, both now largely confined to the Coos Bay dune sheet. (Lower photo courtesy of Oregon Department of Transportation.)

Cooper has shown (1958, p. 31-33) that the Oregon transverse-ridge dunes are not precisely perpendicular to the controlling northwest summer winds, although they are nearly so. Instead, he found that the transverse-ridges form angles of 11 to 23 degrees to what should be the perpendicular to the wind, facing more to the landward (Figure 50). Presumably the dunes also migrate by this same 11-23 degrees to the left of the wind direction, although Cooper did not demonstrate this to be the case.

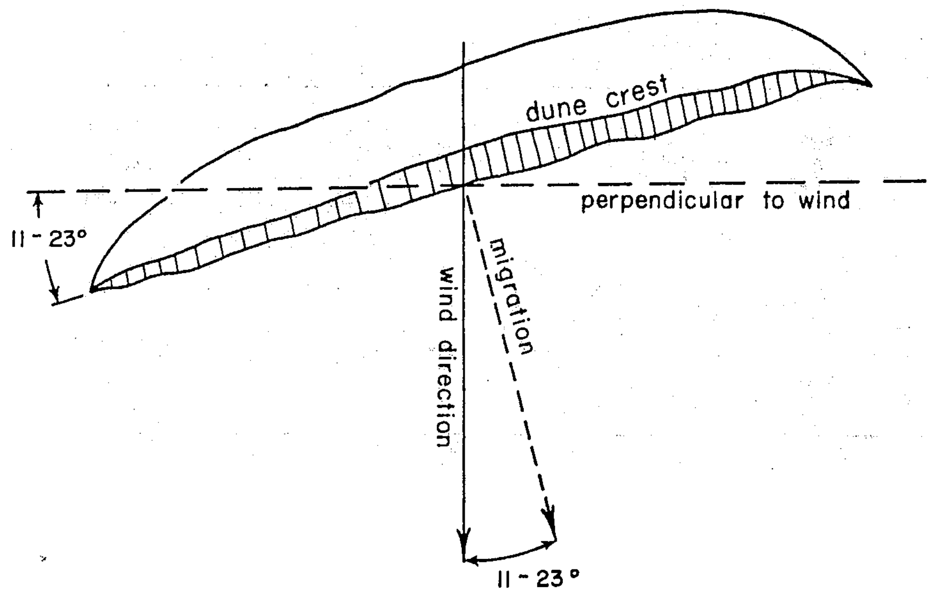


Figure 50. Cooper (1958) has shown that the transverse-ridge dunes do not align exactly perpendicular to the wind direction, instead forming an angle of about 11 to 23 degrees, the dune facing (and migrating) more landward.

Transverse-ridge dunes occupy a strip adjoining the beach or separated from it by foredunes parallel to the shore. Prior to the introduction of European beachgrass and the formation of grass-covered foredunes backing the beaches, transverse-ridge dunes covered the entire area from the beach to the seaward edge of the field of oblique-ridge dunes. Since the introduction of European beachgrass their area has been greatly reduced and continues to shrink. On their inland edge they merge with the field of larger oblique-ridge dunes, the transverse-ridges sometimes climbing up and over the seaward ends of the oblique-ridges. They tend to be smallest near the shore and largest at their inland edge. Average crest to crest distances in fields of transverse-ridge dunes range from 60 to 160 feet.

Cooper (1958) made a few measurements of migration rates of transverse-ridge dunes on the Coos Bay sheet. Measurements were obtained for four dunes with slipfaces over a period of six years. The average rate of advance was 5.2 feet per year, varying from 2.3 to 9.2 feet per year. As expected, most of this advance takes place during the dry summer months of April through August. Also for this reason, the migrations tend to be toward the south to southeast under the north to northwest winds prevailing during those months. Cooper also found that the closer the dunes are to the shore the higher their rates of advance, resulting from the greater wind speeds closer to shore than further inland. He found no correlation between dune height and its rate of advance.

A knowledge of dune migration rates is important in planning measures of dune control or in keeping structures out of the path of an advancing dune. As pointed out by Cooper, his few measurements over a period of six years have to be viewed as the maximum for long-term over-all advance as there may be periods of temporary stabilization with no advancement. Additional study needs to be made of migration rates of these transverse-ridge dunes on the Oregon coast.

The oblique-ridge pattern of dune formation identified by Cooper (1958) occurs only on the Coos Bay dune sheet. They are much larger than the transverse-ridge pattern, forming a series of ridges 4,000 to 5,500 feet in length, aligned with their lengths roughly in an east-west (onshore-offshore) direction (Figure 49). They are highest at a point somewhat shoreward of their landward ends, both in absolute altitude and in height above the immediate base. Cooper measured an average height of 185 feet for ten major dunes. The ridges are spaced rather evenly, particularly at their seaward parts, where the average inter-crest distance ranges between 500 to 650 feet.

On their landward ends the oblique-ridges blend with a ridge of sand that connects them together, the resulting pattern being described by Cooper as a rake, the oblique-ridges forming the teeth of the rake. The connecting ridge is part of the precipitation ridge that has a landward-facing slipface, slowly moving inland and progressively burying the forests that usually lie in the path (Figure 51). This inland advance always appears to be slow (Cooper gives no measurements, however), tending to be somewhat more rapid where the ridge is low.

The oblique-ridge dunes are oriented such that their crests are oblique to both the summer north-northwest winds and to the southwest winds of winter. Most important, they do not migrate, but instead remain fixed in position except for minor shifts with no consistent trend. In cross section the steepest side is usually on the north. During the summer the eroding northern slope is smooth-faced and the south side has a prominant slipface below which is a gentler slope leading to the floor of the adjacent corridor. In most places the windward slope is almost as steep as the slipface. During the summer the oblique-ridge behaves much as a giant transverse-ridge and sand is moved to the southeast. During the winter a slipface of sorts forms on the north side, which is subject to frequent mass slumping, so that even during the winter there is a northward sand transport in the midst of the rain.

Figure 51. A precipitation ridge of the Coos Bay dune sheet migrating slowly landward, burying trees in its path. (Photo courtesy of Oregon Department of Geology and Mineral Industries.)

B. Vegetation Effects

The native flora of the Oregon coast did not provide species capable of building substantial foredunes. Thus prior to the 1940's extensive active dune fields existed, sands blowing inland from the beaches to provide a plentiful supply of sand. In about 1910 European beachgrass (Ammophilia arenaria (L.)) was first brought into the Coos Bay region. European beachgrass took a firm hold and has subsequently spread along the coast producing in many places a prominant foredune where none existed before. These developing foredunes have largely cut off the sand supply from the inland dunes.

The most noticeable effect has been the shrinking of areas covered by transverse-ridge dunes. With the sand supply cut off, the winds erode the dune sands down to the summer groundwater level so that vegetation can quickly take hold. Areas formerly covered by active transverse-ridge dunes have been converted into deflation plains since the 1940's. Comparisons of aerial photos of that period with more recent photos reveal dramatic changes (Figure 52). In places, the areas of open active sand have narrowed by nearly half in 30 years (Lund, 1973).

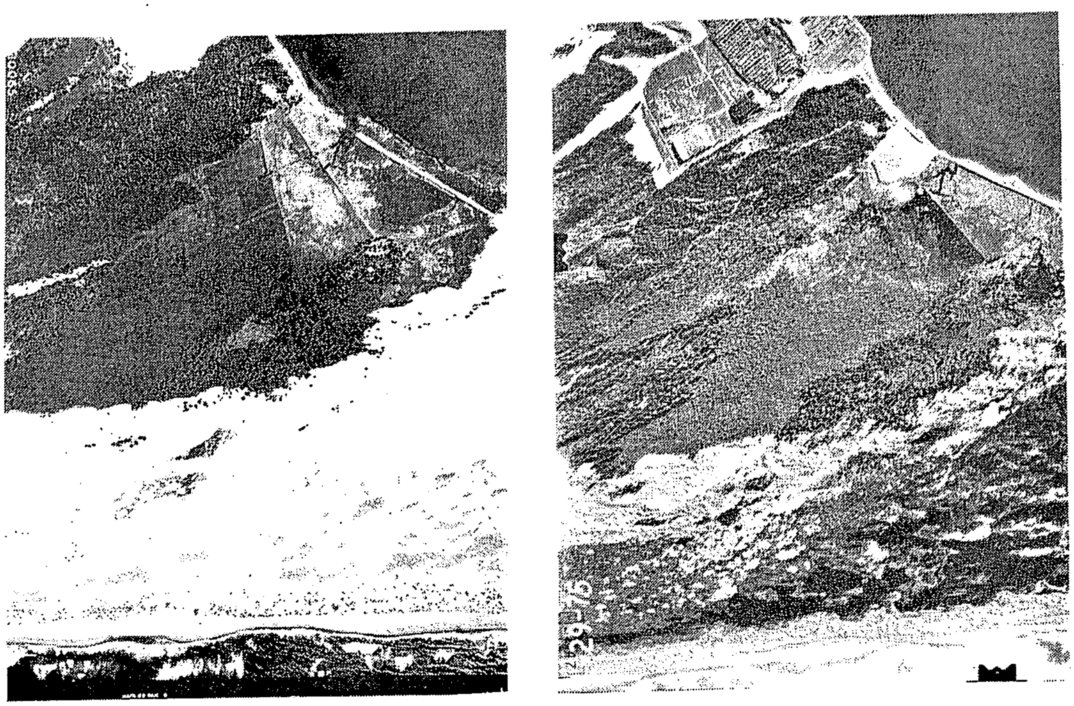


Figure 52. An example of the effects of the introduction of European beachgrass to the Oregon coast at Coos Bay, diminishing the extent of active dune sands and encouraging the formation of foredunes and deflation plains (left - 1939, right - 1975). (Photos courtesy of U.S. Army Corps of Engineers, Portland District.)

C. Older Vegetated Dunes

The active dune fields found on the Oregon coast achieved their present development during the last few thousands of years as the sea rose to its present level. Cooper (1958) discusses the abundant evidence that a similar history of dune development occurred earlier during the Pleistocene, also at times of submergence (times of glacial melting). There appears to have been at least two such episodes of dune formation on the Oregon coast. The dune fields formed during these earlier episodes are now generally well vegetated with forests of pine and spruce and with at least some soil development. They vary considerably in the amount of cementation of the old dune sands beneath the soil cover. Although vegetated forms of transverse-ridge and oblique-ridge dunes cannot be recognized, vegetated precipitation ridges provide good evidence for the landward extent of the old dune fields.

Most of these older dune fields are adjacent to important bodies of modern dunes, indicating that in the earlier cycles, dune development followed processes similar to those of the present fields. Particularly large areas exist to the east of the active Coos Bay dune sheet, especially to the north of Florence and to the immediate north of Coos Bay. Portions of these old forested dunes are also found on sand spits such as Bayocean and Netarts, and in terrace areas such as around Newport. Cooper (1958) provides a series of maps showing the aerial extent of the old vegetated dune fields.

Where these old dune sands are uncemented, removal of the vegetation cover can result in their rejuvenation. Natural examples of this are commonly found adjacent to the beaches where wave erosion cleared some of the dunes of vegetation. This leads to a blowout, removing dune sands from the exposed portion. If the effective wind is unidirectional, then the blowout can develop into a parabola dune, a trough blowout of major size with large terminal and lateral walls. Parabola dunes grow progressively in length in the direction of effective wind, and more slowly in width. According to Cooper (1958, p. 75), most have developed in areas protected from the summer winds and are hence mainly under the influence of the winter's southwest winds. For this reason, most develop northward to northeast. In addition to originating near the beach, a number of parabola dunes have also formed along the margin of the Coos Bay dune sheet. The extensive field of active dune sands to the north of Sand Lake is basically a large parabola dune, the largest on the Oregon coast (Cooper, 1958, p. 75). Although these examples of parabola dunes were formed naturally, man's removal of the vegetation covering the older dunes can similarly bring about rejuvenation and the development of a blowout or parabola dune.

The Clatsop Plain extends from the Columbia River south to Tillamook Head, and is largely covered by a series of vegetated dune ridges. These dune ridges are long linear features extending approximately north-south, roughly parallel to the modern-day beach. Long linear lakes, marshes and creeks occupy the lows between the dune ridges. The vegetation cover of the Clatsop Plain has undergone extensive changes in the last 100-150 years; these changes are documented by Hanneson (1961, p. 85).

Although vegetated, the dunes of the Clatsop Plain are not as old as the other vegetated dunes discussed in this section. They were formed during the last several thousand years as the sea neared its present level. Following sea level rise, the beach built out and the dune ridges developed on the accreting land, formed by the abundant sand supplied by the Columbia River. Cooper (1958, p. 123-6) recognizes three stages of progradation on the basis of three groups of ridges. Shoreline advance appears to be continuing, although the picture has been somewhat complicated by the construction of the jetties at the mouth of the Columbia. Dicken (1961, p. 73) calculated, for example, that the maximum growth of the beach between 1944 and 1960 was about 500 feet, some 30 feet per year. As discussed in Section V, the excess of sand at Seaside has resulted in problems with blowing sand, and several hundred thousand cubic yards of sand have been removed from the Seaside beach since 1960 (Stembridge, 1975, p. 45).

Beneath their vegetative cover, the dune sands of the Clatsop Plain are loose. As already discussed for the older dunes of the Oregon coast, removal of the vegetation cover can lead to blowouts and dune rejuvenation.

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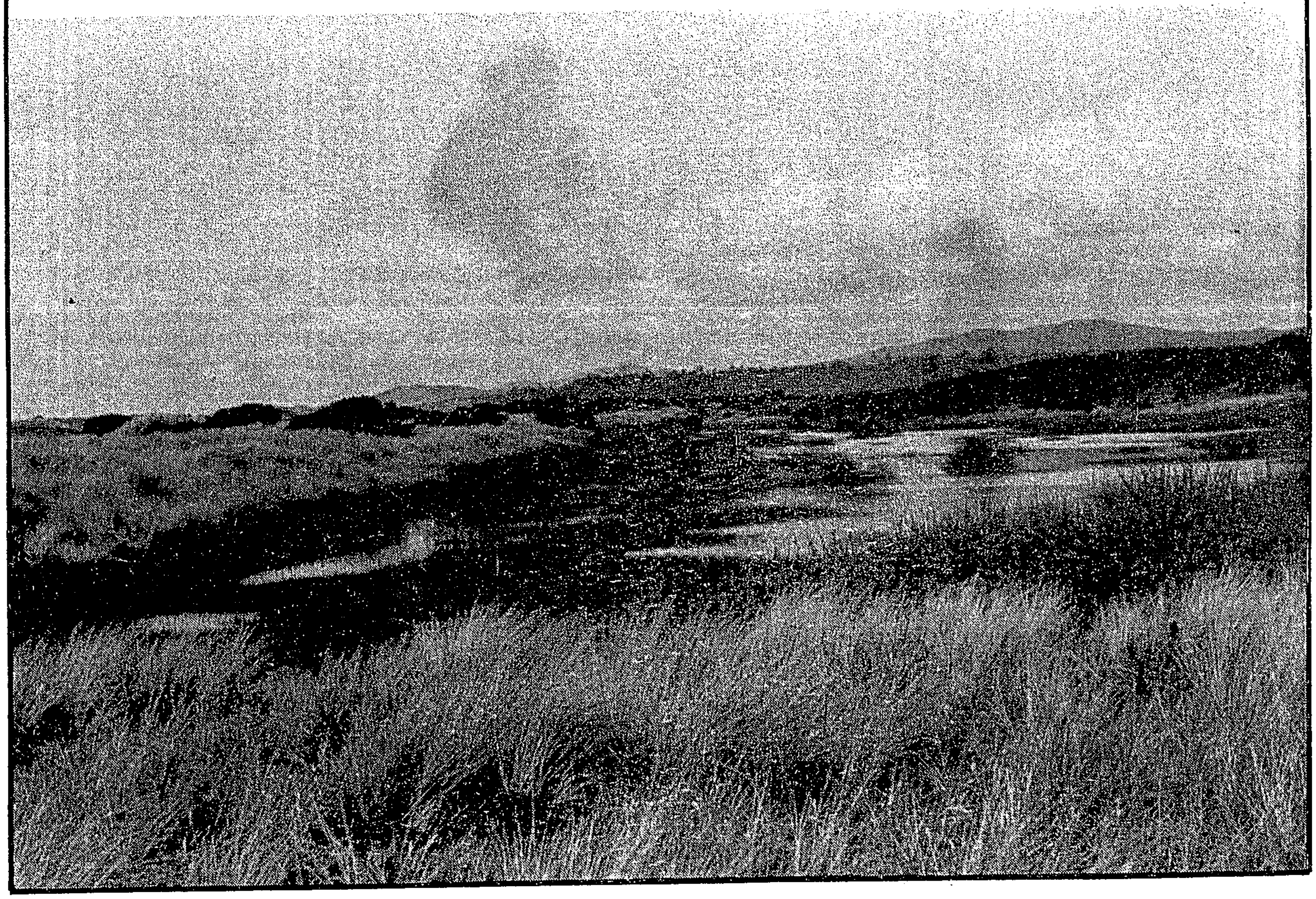
Dune Groundwater

Planning & Management Considerations

For The Oregon Coast



Oregon Coastal Zone Management Association, Inc.

This report was prepared as part of a larger document addressing various beach and dune planning and management considerations and techniques. Other segments of the document and additional materials are:

I. BACKGROUND ON BEACH AND DUNE PLANNING:

Background of the Study

An Introduction to Beach and Dune Physical and Biological Processes

Beach and Dune Planning and Management on the Oregon Coast: A Summary of the State-of-the-Arts

II. BEACH AND DUNE IDENTIFICATION:

A System of Classifying and Identifying Oregon's Coastal Beaches and Dunes

III. PHYSICAL AND BIOLOGICAL CONSIDERATIONS:

Physical Processes and Geologic Hazards on the Oregon Coast

Critical Species and Habitats of Oregon's Coastal Beaches and Dunes

IV. MANAGEMENT CONSIDERATIONS:

Dune Groundwater Planning and Management Considerations for the Oregon Coast

Off-road Vehicle Planning and Management on the Oregon Coast

Sand Removal Planning and Management Considerations for the Oregon Coast

Oregon's Coastal Beaches and Dunes: Uses, Impacts and Management Considerations

Dune Stabilization and Restoration: Methods and Criteria

V. IMPLEMENTATION TECHNIQUES:

Beach and Dune Implementation Techniques: Findings-of-Fact

Beach and Dune Implementation Techniques: Site Investigation Reports

*Beach and Dune Implementation Techniques: Model Ordinances**

VI. ANNOTATED BIBLIOGRAPHY:

Beach and Dune Planning and Management: An Annotated Bibliography

VII. EDUCATIONAL MATERIALS:

Slide show: *Managing Oregon's Beaches and Dunes*

Brochure: *Planning and Managing Oregon's Coastal Beaches and Dunes*

*Prepared under separate contract between Oregon Department of Land Conservation and Development and the Bureau of Governmental Research, Eugene.

Cover photo by Christianna Crook, Newport, Oregon.

DUNE GROUNDWATER PLANNING AND MANAGEMENT CONSIDERATIONS FOR THE OREGON COAST

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PREFACE

The following report presents the results of an overview of groundwater planning and management considerations necesssary in beach and dune areas as conducted by the Oregon Coastal Zone Management Association, Inc. This report constitutes one element of an overall analysis of planning for, and managing, coastal beaches and dunes as required by Oregon's Beaches and Dunes Goal.

This report was prepared by Christianna Crook, OCZMA Beaches and Dunes Study Team Research Associate, with assistance from other Study Team members composed of Carl Lindberg, Project Director, Wilbur Ternyik, Project Coordinator, Arlys Bernard, Project Secretary and Kathy Fitzpatrick, Project Administrator.

In addition, valuable review and comments were made by the Beaches and Dunes Steering Committee composed of:

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Steve Stevens, U.S. Army Corps of Engineers
Sam Allison, Oregon Department of Water Resources
Peter Bond and John Phillips, Oregon Department of Transporation, Parks and Recreation Division
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I. SAND DUNE GROUNDWATER CHARACTERISTICS

Groundwater is that water beneath the earth's surface which is contained in pore spaces within the soil and rock. It is critical to acquire an adequate picture of groundwater characteristics before developing areas underlain by immense quantities of sand such as those which exist along the Oregon coast. Sand deposits are comparatively porous and thus downward percolation is quite rapid. Because of that potential, hazards associated with the development of this region include, for example, drawdown, saltwater intrusion and surface and groundwater pollution.

Groundwater exists as a large coherent body of water (or aquifer) which underlies dune sands. The boundaries of the groundwater are formed by underlying bedrock and relatively impervious terrace deposits, bedrock margins exposed at the surface (i.e. the basal western slopes of the Coast Range), and the ocean to the west, (see Figure 1). Impermeable silt and clay lenses are found within the deeper parts of the sand deposits which oftentimes restrict the vertical movement of water.

The top surface of the zone of groundwater is the water table. The general shape of the water table is a subdued replica of the land surface. It is farthest from the surface under the larger oblique-ridge dunes and closest at topographic lows. Most surface water (lakes, streams and marshes) is a surface expression of this water table occurring where the land surface dips to intersect the water table. Locally, "perched" water tables may exist. These are created by discontinuous bodies of impermeable materials located beneath the land surface but higher than the main water table. This impermeable layer catches and holds the water reaching it from above. On the western margin of the aquifer, the position of the freshwater/saltwater margin is not clearly understood but it most commonly appears to extend somewhat seaward of the beach.

The water table reflects a seasonal variation, being higher in the winter recharge months and lower in the summer. Recharge of dune aquifers occurs primarily from infiltrating precipitation. It is estimated that fully 75 to 80 percent of the 50 to 70 inches of annual precipitation received on the Oregon coast reaches the groundwater. The remainder is lost through surface runoff in streams, evaporation and plant use. Most of the groundwater eventually seeps directly into the ocean under the beach. Locally, lesser amounts enter lakes and streams especially during recharge months. Throughout the year the interaction between the lakes, streams and the water table appears to be one of mutual dependence. During summer months the water table may be lowered from three to ten feet, at which time it appears that lakes may discharge water back to the water table.

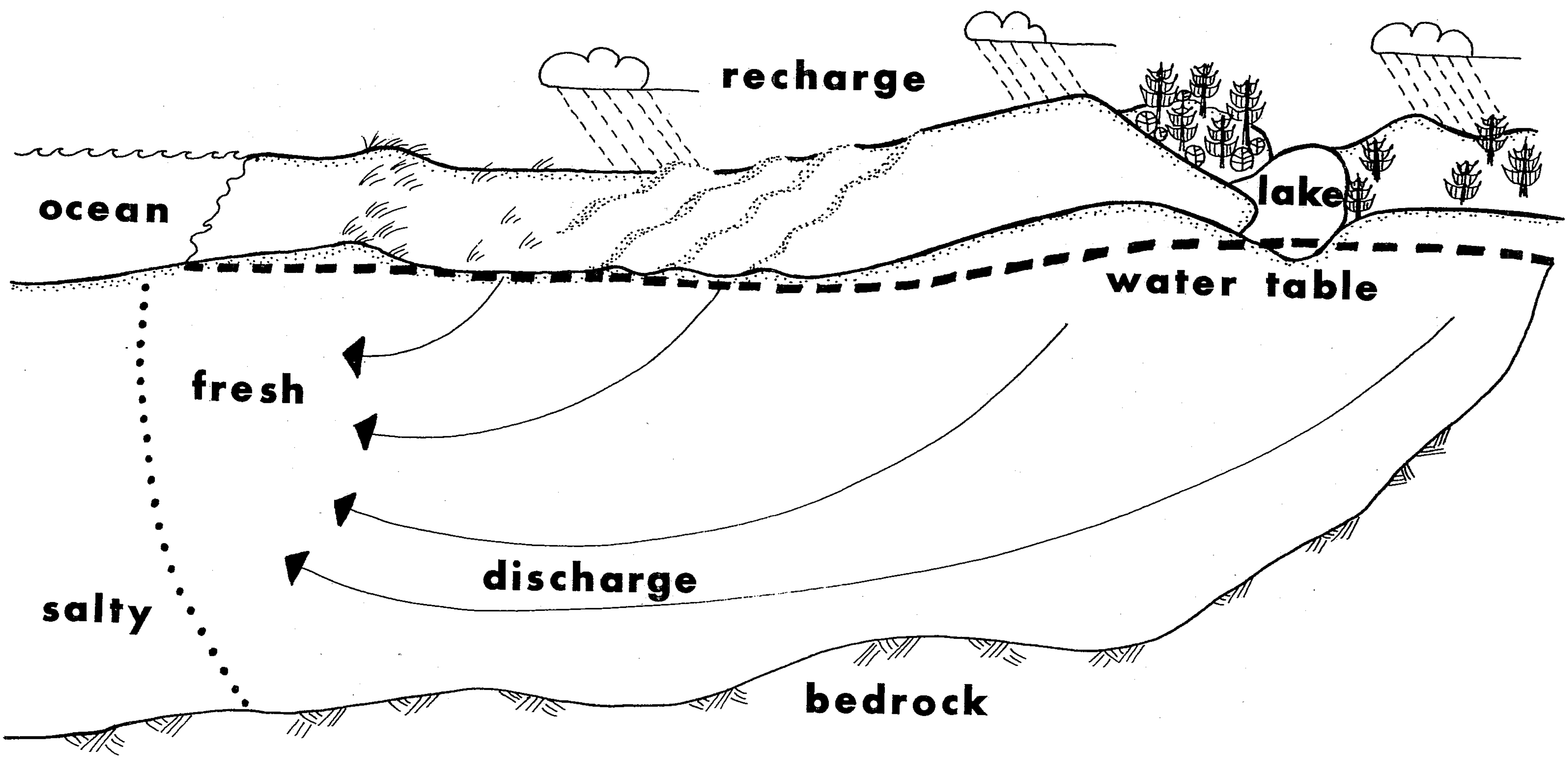

Figure 1. Schematic illustration of groundwater interactions common to coastal beach and dune areas indicates the cycle of discharge and recharge and the confines of groundwater between bedrock and the surface (source: U.S.G.S. unpublished materials).

Three larger dune areas, the Clatsop Plains and the Florence and Coos Bay dune sheets, appear to possess complete groundwater flow systems. That is the groundwater flow operates as an exclusive unit within the sand deposit and has little or no interaction with groundwater outside its own boundaries. A system may contain more than one subbasin. Groundwater moves relatively slowly both down gradient and from recharge to discharge zones. Rate of flow varies from site to site but is estimated to be five to seventeen feet per day in the Clatsop dune aquifer (Sweet, 1977, p. 11).

The chemical quality of the groundwater is generally good except for local problems with acidity. At a number of sites, high levels of dissolved iron and nitrate-nitrogen concentrations exist. These result naturally from chemical activities associated with the decomposition of vegetation in bog and marsh areas (Sweet, p. 16 and 18; Luzier, 1978).

II. GROUNDWATER HAZARD TYPES

Hazards and problems associated with the dune groundwater include high water table, ponding, saltwater intrusion, water table drawdown and pollution. It should be pointed out that hazards exist only in relation to man's use of a site. Any sites suspected of exhibiting hazard characteristics should be further investigated in light of the projected use for the area.

A. High Water Table

A high water table technically occurs at any surface intersection of the groundwater such as a lake, stream or marsh. However, those high groundwater areas associated with hazard are most commonly sites of extremely flat topography or depressions which contain water only part of the year. These sites exhibit standing water anywhere from a few weeks to eight months or more. They may be recognized in the drier summer months by the presence of such features as marshy ground, reeds, marsh grasses, soil with a high organic content and a black to gray or blue-gray color, sometimes accompanied by a strong organic aroma.

1. Potential sites

Those sand dune landforms most susceptible to the incidence of high water table problems include:

a. All deflation plains

This includes both the presently "active" forms which are situated on the lee side of the foredune and the historically active forms which are now found considerably inland from the present foredune area. These exhibit a flat surface topography, are usually forested and the water table is at or near the surface most of the year.

b. The border zone between the deflation plain and interior dunes

Both interior hummock dunes and transverse-ridge dunes irregularly interface with the deflation plain on their western border. These sites would be susceptible to high water table problems in their basal portions. They can often be recognized by the presence of marsh vegetation or surface water between dunes.

c. The fringes of mostly permanent waterbodies

The areas surrounding intersections of the groundwater table are likely to possess high water table levels themselves. This is because: (1) the water table follows the general slope of the land, (2) it fluctuates during the year and (3) because the area may be subject to flooding.

d. Occasionally wet interdune area

This includes topographic lows between dunes of any form but primarily the larger oblique-ridge and the commonly forested surface-stabilized and older stable dunes. These may exhibit mottled gray-blue soils and/or marsh vegetation.

2. Potential impacts and management techniques

Developmental activities in areas of seasonally high groundwater can incur such impacts as the flooding of surface and subsurface facilities, flotation and failure of buoyant buried structures such as pipelines and septic tanks, differential settlement of larger structures, construction and excavation difficulties, surface and groundwater contamination, destruction of valuable fish and wildlife habitat, and heightened earthquake impact.

In order to avoid such problems, certain development criteria should be adhered to. Developments should be restricted to those forms of land use which are either compatable with the characteristics of the site or which can be built to provide adequate safety and minimize impacts on the water resources. Structures, roads and sewage disposal systems should be set well above the winter high water table and well back from any water bodies. The alteration of wetlands by dredging or filling should be avoided where possible in order that the system's unique productivity and water retention capabilities will not be diminished.

Engineering studies should be undertaken particularly for any linear developments, such as pipelines and roads, which must span high water table areas. The use of pilings and drainage tiles and culverts are commonly recommended in such areas.

B. Ponding

Ponding occurs in low, poorly drained sites where excess precipitation or flood waters accumulate. Topographic restrictions and/or poor soil and bedrock permeability disallow runoff or infiltration at these sites. The result is standing water which is not necessarily associated with the local groundwater table. Ponding can be identified by the local accumulation of rain or flood waters. It can be differentiated from high water table because no lag time is involved between precipitation and accumulation and because other sites susceptible to normal high water table may not possess standing water. Although water commonly moves fairly rapidly through sand, local soil development, surface or subsurface impermeable lenses (clays or bogs), or extremely high water table could reduce infiltration. These sites may contain marsh grasses and blue-gray mottled soils.

1. Potential sites

a. Foredune/deflation plain

Some special ponding problems may occur here which involve some degree of interaction between these two landforms. Many deflation plains contain valuable freshwater marshes. Any breaching of the foredune, whether natural or man induced, may allow flooding from ocean storms to reach the marsh. The addition of saltwater could have damaging effects on the freshwater habitat particularly if the breaching allows for frequent flooding. Furthermore, particularly severe ponding in the deflation plain may cause breaching of the foredune from the inland side. Breaching from the landward side may be caused by saturation, from hydrostatic pressure, or overflow at a lowspot in the foredune. This can lead to further erosion and limit the protective capacities of the foredune.

b. Interdune and other low lying sites

Any low lying site commonly susceptible to high groundwater may develop ponding problems when the water table is too high to allow infiltration of excess water. Also those interdune areas which possess soils, particularly marsh or bog soils which may contain clays and other relatively impervious materials, could develop ponding conditions.

c. Surface stable dune and older stable dune

These dunes are susceptible to the effects of ponding because they are often underlain by relatively impermeable iron bands or older buried soils. In addition to other ponding impacts, slope failure can occur in this landform particularly when saturated strata have been bisected.

2. Potential impacts and management techniques

In addition to many of the impacts resulting from a high water table, ponding can lead to serious flooding of surface structures and habitats. Damage to subdivisions in low-lying areas, airport runway safety hazards, slope failure and possible habitat degradation could result from ponding. Those activities which would dam waterways, alter drainage routes, compact the soil surface or otherwise significantly reduce infiltration rates (i.e. blacktopping) can increase the ponding hazard.

Proper design, engineering and building techniques can avoid many problems here. Large scale developments which could have wide ranging impacts, particularly if proposed for flat or low-lying areas, merit special attention. Landfills, septic tanks or other subsurface structures should not be permitted without a thorough engineering review. There is a high possiblity of contamination of surface and groundwaters from septic tank failure resulting from ponding. The use of dikes and levees to prevent flooding along riverways should be considered carefully as these devices can prevent the natural runoff of rain and floodwaters. The use of ditches, drain tiles, floodgates and building on pilings may improve the potential for development in such sites.

C. Saltwater Intrusion

The intrusion of saltwater into the groundwater occurs when the hydrostatic pressure (head) from fresh groundwater sources is insufficient to keep the marine water at bay. As already mentioned the position of the saltwater/freshwater interface is not known for all sites along the coast. Where it has been investigated under the larger dune sheets, the interface most commonly extends slightly seaward of the beach (Sweet, p. 12; U.S. Forest Service, 1972, p. 14; USGS, unpublished). It also appears to maintain a fairly vertical slope to some depth as even those exploratory wells behind the foredune have drawn no saltwater (U.S. Forest Service, p. 14).

Areas which do not capture enough precipitation to maintain sufficient head against the marine water may be underlain by saltwater. Because freshwater is less dense than saltwater, it may form a lens which overlies the saltwater in such sites. Sand spits, because they possess so little recharge area and are nearly surrounded by marine and brackish waters, may be potential sites for this groundwater pattern.

1. Potential sites

The sites most susceptible to saltwater intrusion are sand spits and the thinner beach and dune strips which possess more marginal water supplies. Although those spits underlain by sand to a considerable depth usually contain good groundwater supplies, the lack of recharge in the summer months when water is most in demand by summer residents could be potentially hazardous. The deeper, westernmost wells would be the first to experience saltwater intrusion. With overdevelopment of groundwater resources, saltwater could intrude some distance even into the dune sheet regions.

2. Potential impacts and management techniques

Overdevelopment of the groundwater resources could lead to encroachment of saltwater into this resource. The impacts of saltwater intrusion can result in permanent or temporary pollution of the freshwater supply, loss of freshwater dependent vegetation and habitat, corrosion of pumping facilities and the added cost of providing new water supplies to developed areas.

All dune areas for which groundwater withdrawal is being considered should have adequate hydrological studies conducted to determine the amount of groundwater required to provide protection against saltwater intrusion and any secondary effects. Some surveys have been produced for the major sandsheet areas along the Oregon coast and others are currently underway (see Appendix A).

Monitoring of the groundwater head and water quality at shoreline sites could provide prompt information on any changes in the freshwater/saltwater interface.

D. Drawdown

Drawdown is the resultant lowering of the water table level from well pumping. Given homogenous materials, the water table will drawdown in a cone shape surrounding the well or wells (see Figure 2). Extended development and pumping in an area can result in general lowering of the regional water table. The pattern of groundwater reduction is complicated in the deeper sands of the dune sheets because they are commonly interspersed with less permeable lenses of clay and silty materials. Groundwater at depth tends to flow seaward laterally through these lenses (see Figure 3). Thus pumping here may not lower the water table in the immediate vicinity but rather in an adjacent region up gradient.

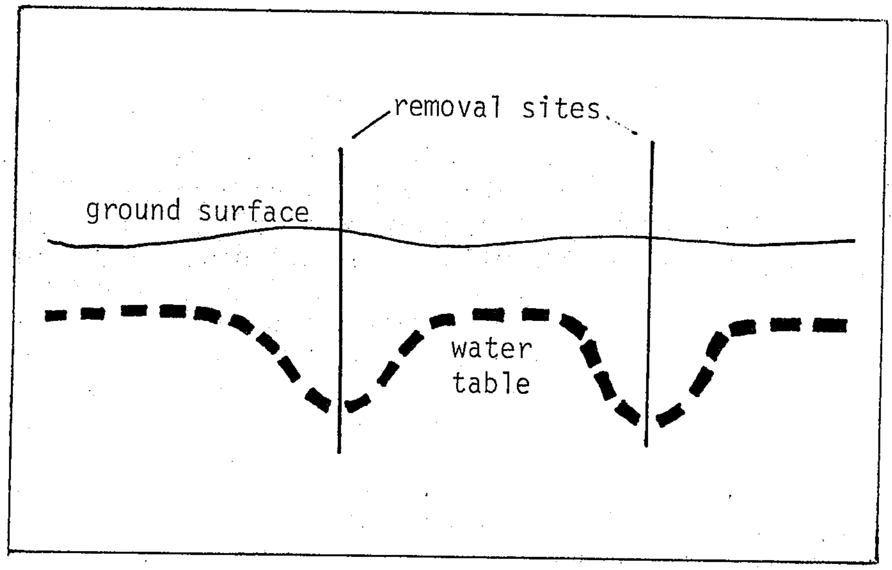

Figure 2. Generally, water withdrawn from the groundwater supply will result in cone-shaped depressions surrounding the removal site.

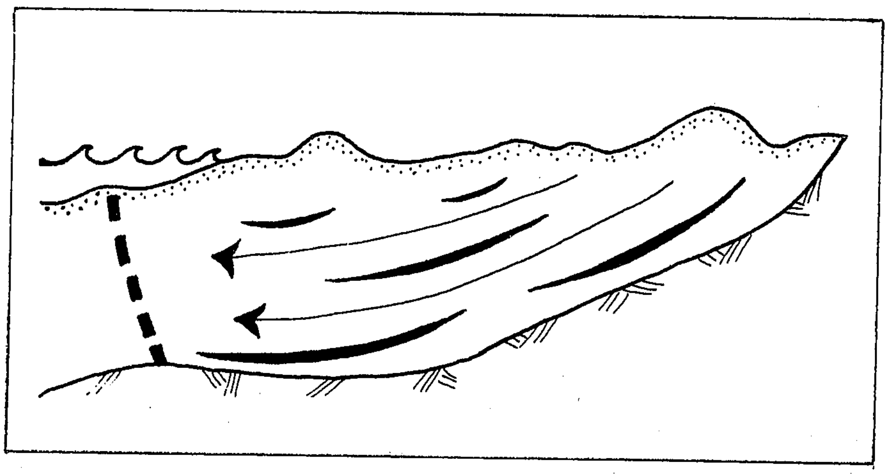

Figure 3. Impermeable lenses of clay and silty materials may direct the seaward flow of groundwater laterally.

1. Potential sites

Naturally all areas are potentially subject to drawdown. Critical areas would include recreational lakes, areas of stabilizing vegetation and those with little recharge.

2. Potential impacts and management techniques

The hydrological characteristics vary considerably from one site to another and therefore the potential impacts of a lowered water table also vary. Some potential impacts include the lowering of the water table below the depth of local wells, reduction of lake levels, draining of wetlands, loss of vegetation, seawater intrusion and intrusion of water of poor quality from underlying bedrock.

With advance planning most of these problems can be readily avoided. The proper spacing of wells to avoid overlap and regional lowering of the groundwater table can be calculated by hydrological studies. Wells should not be placed near those lakes most affected by lowering of the water table. Some dune lakes interact intimately with groundwater because this and direct precipitation are their only recharge sources and because they have highly permeable sand beds. Beale Lake and Sandpoint Lake in Coos County are examples of lakes underlain by less permeable sediments which slow down the rate of recharge from the lake back to the groundwater in the summer. Coffenbury Lake in Clatsop County and perhaps to a lesser extent Clear, Saunders and Butterfield Lakes in Coos County fit this category (Robison, 1973; Frank, 1970). These lakes may be partially fed by surface streams and runoff from hard rock areas bordering the sand dunes. Hyrological studies will provide critical background information for the safe and beneficial development of these areas.

E. Pollution

The pollution of groundwater involves the introduction of unwholesome or undesirable elements rendering the water unfit for use or environmentally degraded. Because sand dune aquifers experience particularly high infiltration rates, they are especially susceptible to pollution. Many fluid pollutants travel significant distances quickly in this sand medium.

1. Potential sites

Because the sand is highly porous and does not filter some types of harmful elements, all sand dune areas "downstream" from emission points of harmful substances should be considered potentially pollutable.

Those areas which should receive special consideration because of particular locational or high water table problems are:

a. All deflation plains and deflation plain fringes

This includes both the presently "active" deflation plain forms which are situated on the lee side of the foredune and historically active forms which are now found considerably inland from the present foredune area. These exhibit a flat surface topography, are usually forested and the water table is at or near the surface most of the year.

b. Lakes, streams and marshes

These bodies of water can be surface expressions of polluted groundwater. Conversely, polluted lakes, streams and marshes may affect local groundwater quality.

c. Near-beach sites

These areas may be occuped by temporary or permanent settlements and are major emptying points for the sand dune aquifer. Any non-filtered hazardous substances may appear here.

2. Potential impacts and management techniques

Bacteria have been shown to travel a maximum distance of only about 100 feet through similar sand aquifers (California Water Pollution Control Board, 1954, p. 99). However, sand is incapable of removing chemical contaminants. This includes those chemicals used in most household detergents which can render water unfit for domestic purposes. Some such contaminants not only produce a potential health hazard but may also threaten stabilizing vegetation.

Sand aquifers also appear incapable of filtering out viruses (Frank, p. 34). Outbreaks of hepatitis in some counties may be linked to septic tank problems in areas of high water table or ponding (Schlicker, 1974, p. 57).

Besides the naturally occurring sources of nitrate-nitrogen (NO_3-N) present in some areas of the sand dune groundwater, there also exist additional induced sources. Septic tank emissions and fertilizer used on pasture and croplands are significant sources in some areas (Sweet, p. 18). There are indications that excessive nitrate ingestion may cause methemoglobinemia (blue babies). The U.S. Public Health Service prohibits the use of water for drinking purposes if NO_3-N concentration is greater than 10 mg/liter (Sweet, 1977, p. 17). Furthermore, the U.S. Department of Environmental Quality has set a limit of 5 mg/liter in at least some sand aquifer areas on the Oregon coast (Berg, 1979). This is apparently due to seasonal population peaks and associated septic tank discharges (summer), natural seasonal peaks in the release of NO_3-N to the groundwater (winter), and high NO_3-N concentrations in some local organic soils (Sweet, p. 24).

There are a number of areas which use septic tanks and other private sewage-disposal systems which discharge into the sand. Some of these reportedly are sources of pollution to the area and others could become so (Frank, 1970, p. 34). The seriousness of the problem would depend on allowed density of development and the position of the waste discharges in relation to overall groundwater flow within the aquifer. Some experts feel that those operations which involve waste discharge, such as septic tanks and industrial lagoons, are not appropriate for sand areas under most conditions (Beaulieu, 1974, p. 30).

Local decision-makers and home owners alike will benefit from a better understanding of the potential benefits and hazards of the local groundwater regiem. Several studies have been conducted concerning water supply, quality, recharge and flow characteristics. A number of other studies are presently underway (Appendix A). Those state and federal agencies or local offices which may be contacted for further information include:

U.S.D.A., Soil Conservation Service
U.S.G.S., Water Resources Division
Oregon Department of Environmental Quality
County Sanitarian

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Smith (1962)

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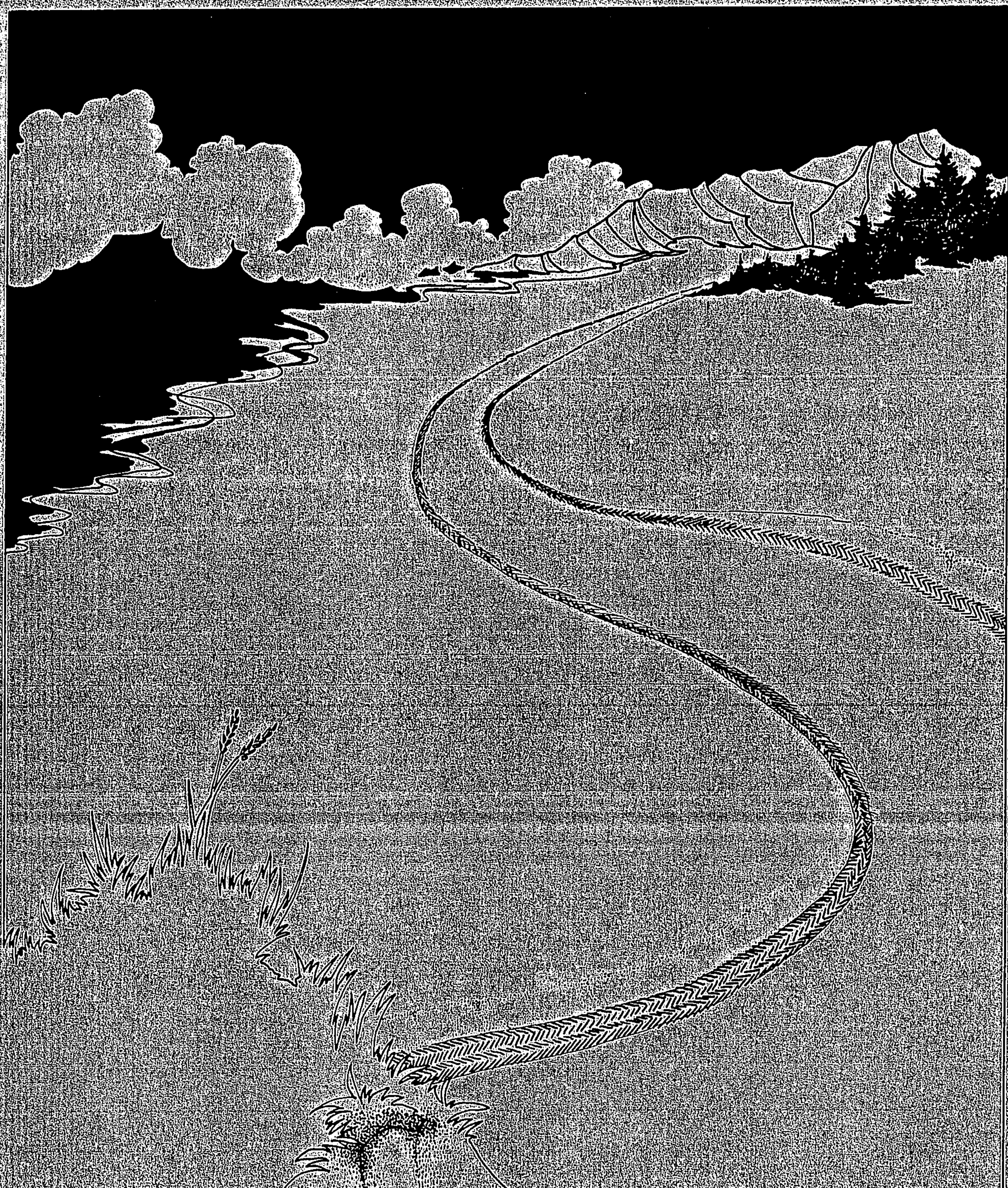
APPENDIX A

Water Resource
Studies In Progress

WATER RESOURCE STUDIES IN PROGRESS

COUNTY	AGENCY	PURPOSE	STATUS
Clatsop	Clatsop County Planning Dept. and Oregon Dept. of Env. Quality (208 Water Quality-EPA)	A continuation of the Carrying Capacity of the Clatsop Plains Sand-Dune Aquifer (Sweet, 1977). Study will allow more in-depth research on the quality and quantity of the groundwater supply.	Approval recently granted
Lane	Lane County Environmental Health Division (Lane County Coastal Domestic Water Supply Report)	Study by Charles Strong (1979) identified available surface and groundwater supplies along coastal Lane County; focused on developed and developing areas.	To be released
Lane	Lane County Division of Environmental Health--North Florence Dunal Aquifer Study	Grew out of finding in Lane County Coastal Domestic Water Supply Report which identified potential groundwater problems in this rapidly developing area. Report will consider water supply, quality and potential groundwater hazards.	In progress
Douglas	U.S.G.S., Water Resources Division (LCDC)	Tests conducted at four wells in the deflation plain at about eighty feet deep. Both water quality and quantity are being researched.	In progress
Coos	Coos Bay Water Board/ (U.S.G.S. - WRD)	1. Dissolved Iron--study being conducted to determine the distribution of dissolved iron in the dunal aquifer. Series of test wells between Jordan Cove and Ten-mile Creek to aquifer bottom. Test samples to determine changes which take place in the location and concentration of dissolved iron and other chemicals as well as pumped.	In progress
		2. Extraction System--following the above study, when the best water sources have been identified, a groundwater extraction system will be designed which will allow water removal with the best possible benefits to users and the environment.	Planning stages
		3. Spit Water Supply Investigation--Research presently underway to determine the best possible way to develop the Coos Bay Spit's water supply to serve an industrial park system.	Planning stages



Off-Road Vehicle Planning & Management On The Oregon Coast

Oregon Coastal Zone Management Association, Inc.

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OFF-ROAD VEHICLE PLANNING AND MANAGEMENT ON THE OREGON COAST

by

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Western Interstate Commission for Higher Education

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December, 1978

ABSTRACT

A framework to plan and manage off-road vehicle (ORV) use on the Oregon coast is developed. Federal and state ORV policies are compared and contrasted. Regulations applying to coastal ORV use are presented, which cover primarily equipment and noise limits. ORV environmental impacts are divided into inherent and behavioral types. Inherent impact is the minimum baseline level of impact for a recreational form, and behavioral impact is the impact, in addition to the baseline level, caused by human action. ORV inherent impact on natural terrain is greater than pedestrian impact. ORV behavioral impact is usually more significant than a pedestrian's. Coastal ORV use is divided into three activity designations for planning/management purposes: competitive events, vehicle play, and access corridors. Beach and dune areas are divided into ORV management units based on their identification and sensitivity to ORV impacts. A management unit's sensitivity is matched with an activity designation's impact to determine what type of ORV use may be suitable. Specific environmental impacts on sand, vegetation, and wildlife should be considered in planning an ORV area. They are outlined and discussed. Site criteria are provided for the activity designations. Management considerations are discussed, including posting, law enforcement, safety, user compatibility, environmental monitoring, and special permits. The Sand Lake ORV area is provided as a case study in planning and managing ORVs. Specific recommendations are offered to make ORV use at Sand Lake compatible. Also, policy recommendations are provided. Coastal areas of ORV use and potential suitability are mapped. Final recommendations are offered regarding the Oregon Dunes National Recreation Area, the north spit of the Coos River, and comprehensive State legislation.

PREFACE

The following report presents the results of an in-depth analysis of off-road vehicle use on Oregon's coastal beaches and dunes conducted by the Oregon Coastal Zone Management Association, Inc. This report constitutes one element of an overall analysis of planning for coastal beaches and dunes as required by Oregon's Beaches and Dunes Goal.

Funding for this study was provided by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, under Section 306 of the Coastal Zone Management Act through the Oregon Department of Land Conservation and Development. Preparation of this report was made possible through the cooperation of the Western Interstate Commission for Higher Education, Boulder, Colorado.

This report was prepared by Timms Fowler, WICHE Intern, under the direction of Kathy Fitzpatrick, Project Administrator, with assistance from OCZMA's Beaches and Dunes Study Team composed of Carl Lindberg, Project Director, Christianna Crook, Project Associate, Wilbur Ternyik, Project Coordinator, Dr. Paul Komar, coastal geologist under contract, Bill Burley, coastal biologist under contract, and Ruby Edwards, secretary.

In addition, valuable review and comments were made by the Beaches and Dunes Steering Committee composed of:

R.A. Corthell, U.S. Soil Conservation Service
Steve Stevens, U.S. Army Corps of Engineers
Sam Allison, Oregon Department of Water Resources
Peter Bond and John Phillips, Oregon Department of Transportation, Parks and Recreation Division
Bob Cortwright, Oregon Department of Land Conservation and Development
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Anne Squire, Oregon Land Conservation and Development Commission
Jim Stembridge, Oregon Department of Soil and Water Conservation
Steve Felkins, Port of Coos Bay
Rainmar Bartl, Clatsop-Tillamook Intergovernmental Council
Gary Darnielle, Lane Council of Governments
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Steve Goeckritz, Tillamook County Planning Department
Oscar Granger, Lincoln County Planning Department
Curt Schneider, Clatsop County Planning Department

Throughout this endeavor, the OCZMA has received tremendous response and assistance from private individuals and groups, as well as local and state agencies. The Association deeply appreciates their enthusiasm and cooperation and would especially like to acknowledge the following individuals:

U.S. Forest Service: Robert Shrenk, John Czermerys, Ed Oram, and especially Wayne Gale and Dwight Johnson, Oregon Department of Transportation, Parks and Recreation Division: Peter Bond,

Tillamook County Planning Department: Lori Dull

Thanks are also due to the many thoughtful and energetic people involved in the ORV clubs. Specifically they are:

South Coast Beach and Dune Recrecationalists: Andy Adams and Rex Bales,

Pacific Northwest Four-wheel Drive Association: Cliff Bales and Gerry Brown,

Northwest Trail and Dune Association: Gene Noble and Duke Witney,

Northwest Trail and Dune Association: John Critzer.

Special thanks is due to Timms Fowler, WICHE Intern, who invested considerable time and effort in fastediously researching the ORV literature and conducted innumerable interviews towards the preparation of this report. This report, the culmination of three months work, is a tribute to Mr. Fowler's energetic manner and professional abilities.

Cover design by Denise A. Goulett, Toledo, Oregon.

Illustration (Figure 1) prepared by Lorraine Morgan, Newport, Oregon

This report was prepared as part of a larger document. If read singularly, the cross references to the critical habitat section should be disregarded.

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I. INTRODUCTION

A. Growth

The national growth of off-road vehicles (ORVs) and their use has been explosive in recent years (Stupay, 1971, pp. 14-18). Most ORV studies' introductions are laiden with statistics on growth; two statistics on vehicle use are provided here. The Motorcycle Industry Council (1978, p. 32) offers statistics for off-road motorcycle use in 1977. Thirty-five per cent or 4.5 billion miles of the total motorcycle mileage was off-highway use. In 1977, of the 142,700 motorcycles in Oregon, 105,700 were used off-highway at some time (p. 30). Oregon's coastal beaches and dunes are no exception to the growth and popularity of ORV recreation, however, ORV user counts are unavailable.

B. National Response

Initially, national planning and management of ORV recreation failed to keep pace with the rapid evolution of this sport; thus, its potential problems have become real problems. Gradually, since the early seventies research has helped identify the problems (McCool and Roggenbuck, 1974) and provided information on ORV user behavior, environmental impacts, and management techniques.

Baldwin and Stoddard (1973) summarize the concerns about ORV recreation, while Bury, Wendling, and McCool (1976) provide a literature review. Lodico (1973) reviews the early environmental effects of ORVs, and Rasor (1978) provides examples of viable ORV programs in five states. The State of Washington (1976) and California (1978) have well developed programs including legislation, registration, and a self-supporting funding system.

C. Federal Policy

Federal policy and planning for ORV use was initiated by Executive Order 11644 (Nixon, 1972) which requires that federal agencies develop plans to administer ORV use (Appendix A). Later it was modified by Executive Order 11989 (Carter, 1977) which enables federal land managers to close areas open to ORV use if such use is causing or will cause adverse environmental effects (Appendix A). Thus, federal agencies have developed or are developing their respective plans pursuant to the Executive Orders. The proposed Bureau of Land Management regulations provide an example and a background of national policy evolution (Appendix B).

The Forest Service policy and regulations are given in the Code of Federal Regulations 36CFR 295 -- Use of Off-Road Vehicles (Appendix C). A portion of those regulations (295.6 - 295.8) were revoked February 15, 1977, pending probable revision and are included for informative purposes (Appendix C). Finally, under the Code of Federal Regulations 36CFR 261.13 (prohibitions) certain rules apply to ORV use (Appendix C).

D. The Oregon Situation

1. Federal involvement

The United States Forest Service (Siuslaw National Forest) plays an active role in management of ORVs at Sand Lake, in Tillamook County, and at the Oregon Dunes National Recreation Area (NRA). The regulations adopted pursuant to Executive Order 11644 form the basis of their management plan (U.S. Department of Agriculture, 1976). Different areas can have differing regulations so an ORV recreationalist should check to make sure all regulations are understood. Oregon Department of Environmental Quality noise standards are enforced at the NRA and Sand Lake. The state ORV equipment requirements are only enforced at the NRA (Oregon Revised Statute (ORS) 483.833 - 483.847) (Appendix D); however, the Hebo Unit presently is working to resolve this inconsistency.

2. State involvement

Oregon, despite several legislative attempts, does not have a comprehensive plan to accomodate and manage ORV recreation. House Bill 2764 is a good example; it was rewritten three times during the 1975 Regular Session and at the session's close was left in committee. The basic issues considered were: registration, limitation of use to specified areas on public land, area development, application of the snowmobile law, a funding system, and an advisory council. Lacking sufficient political support, a comprehensive ORV program for Oregon, presently, does not exist.

Several state statutes apply to ORVs, which are defined as: "...any motorized vehicle designed or capable of cross-country travel on or immediately over land, water, sand, snow, ice, marsh, swampland or other natural terrain." (ORS 483.333) (Appendix D). The most extensive body of law deals with snowmobiles. It covers operator certification, operator conduct, accident reporting, law enforcement, and local provisions (ORS 473.710 - 483.755) (Appendix D). Cities and counties can regulate snowmobiles on public lands, waters, and other properties under its jurisdiction if such regulations are consistent with state law (ORS 483.755).

Another state statute establishes equipment requirements for ORVs operating only in the Oregon Dunes National Recreation Area and the ocean shore open to vehicular traffic within the NRA (ORS 483.833 - 483.847) (Appendix D).

Two noise standards for ORVs exist at the state level (Department of Environmental Quality (DEQ)). First, ORVs must meet in-use noise limits (decible limits) (ORS 467.030, Oregon Administrative Rule (OAR) 340-35-030(1)(b)) (Appendix E). Also, ORVs must not cause surrounding (ambient) noise levels to exceed standards near houses or other noise sensitive property. The vehicle operator and/or the property owner on which the vehicle is operated may be responsibile (ORS 467.030, OAR 340-35-030(1)(d)). Noise considerations are covered in the DEQ Handbook for Environmental Quality Elements of Oregon Local Comprehensive Land Use Plans (1978). Further information and assistance is available from DEQ. Enforcement of the noise standards by DEQ is on a complaint basis and is not an adequate management program for ORV areas. Apparently local law enforcement officers have the authority to enforce ORV noise standards but lack the equipment and direction to do so.

Other state involvement includes regulations of motor vehicles in certain zones on the ocean shore. The Oregon Department of Transportation may establish zones where vehicle use is restricted or prohibited through a specified procedure including public hearings and consultation with local government as provided for in ORS 390.688 (Appendix F). These zones are enforced by the Oregon State Police and local law enforcement agencies.

The ocean shore is defined by ORS 390.605 (Appendix F) as the area between extreme low tide and a survey line, based on the Oregon Coordinate System called the "vegetation line". It is not really the vegetation line but is a survey line defined by a series of points along the coast as described by ORS 390.770 (Appendix F). This line is often referred to as the "zone line". Also most of the wet sand area (the area between ordinary high tide and extreme low tide) is a state recreation area (ORS 390.615) (Appendix F). Many of the motor vehicle laws apply to the ocean shore except such areas within the Oregon Dunes National Recreation Area, which are addressed by the State ORV requirements.

3. ORV planning

Pertinent planning goals and guidelines administered by the Oregon Department of Land Conservation and Development are: (1) Beaches and Dunes: (2) Recreation; (3) Coastal Shorelands; (4) Estuarine Resources; (5) Open Spaces, Scenic and Historic Areas, and Natural Resources; and (6) Areas Subject to Natural Disasters and Hazards. Coordination between related goals is significant because of ORV use in beach areas as well as in upland areas. Sand Lake is a good example where the Estuarine, Coastal Shorelands, Beaches and Dunes, and Recreation Goals must be dovetailed.

The Recreation Goal does not specifically mention ORV use while in the beach and dunes guidelines, ORV recreational use is mentioned by name. One must assume ORV activities would be classified as: "...active or passive games and activities" in the Recreation Goal. Its guidelines (paragraph five) suggest that the State Comprehensive Outdoor Recreation Plan (SCORP) be used as a planning guide when developing recreation facilities. SCORP (1977) specifically considers ORV use, providing standards to determine state and local needs, and should be used directly by the planners when providing for ORV recreation.

E. ORV Policy: Comparisons and Contrasts

The federal government recognizes ORV use as a legitimate recreational form, planning and managing it, while the State of Oregon only tactily recognizes ORV use without a plan or management scheme. The Department of Transportation's vehicle zones, SCORP (1977), and the Beach and Dune Guidelines are the only recognition of ORV use. ORV recreation is not mentioned by name in the Recreation Goal.

Many of the motor vehicle laws apply to vehicles operating on the beaches except within the NRA, where only the ORV equipment standards are required (ORS 483.837). Also, the Forest Service has no jurisdiction over the beaches, and the state or county cannot enforce federal regulations on federal land except through special agreements (under Public Law 92-82).

II. UNDERSTANDING ORV ENVIRONMENTAL IMPACT

A. Introduction

Plainly, whether a given impact[1] is "good" or "bad" is value dependent. When impacts are variable in degree, it becomes more difficult for people to agree on what is an acceptable level of impact for a given activity because of different personal values and different interpretations of the "facts".

To place ORV use in perspective with other types of recreation, it is useful to make a distinction between two types of environmental impacts. Specifically, it can be divided into two types: (1) inherent impact and (2) behavioral impact. The distinction is based on how much the impact's size can vary and the factors that determine the impact's size. Inherent impact is fixed in size while behavioral impact varies.

B. Inherent Impact

Inherent impact is the minimal impact on the environment for a given type of recreational activity. It is the least impact possible

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[1]Whether written in the singular or plural form, impact shall be considered as the sum total of the effects for a given activity. One action rarely has a single effect on the environment.

(determined by common sense and scientific research) provided that a specific activity does, in fact, take place in a given environmental setting. Thus, it forms a baseline.

The inherent impact is determined by the nature of the activity and where the activity takes place. Specifically, ORV recreation is motorized and for the purposes of this study, takes place on the beach and dune areas of the coast. Thus, the inherent impact would be less than that for ORV activity in a desert or alpine tundra area. Typically, ORV inherent impact is greater than that for non-motorized recreational forms.

C. Behavioral Impact

Behavioral impact is the impact that exceeds the minimal baseline effects (inherent impact) as a result of human action(s). It can vary greatly in size depending on one's behavior, regardless of whether it is intentional or unintentional. Specifically, ORVs (primarily motorcycles and four-wheel drive vehicles) can be tools of destruction if used thoughtlessly; their power and weight are no match for soil, vegetation, and wildlife.

D. Illustration of Inherent and Behavioral Impacts

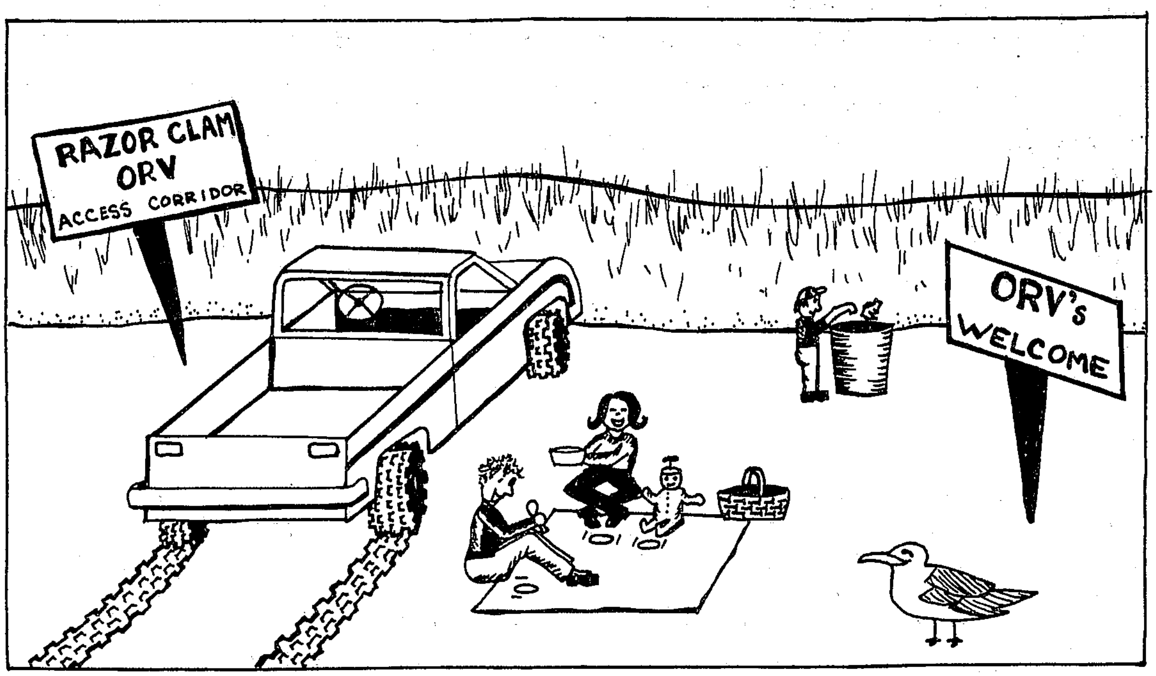
A simple example is the difference between a person driving a vehicle down a beach to go clamming and another person going clamming but deciding to play "hill climber" on the foredune (breaching it) and "trailblazer" through the deflation plain (destroying its vegetation). Clearly, going from one place to another for access and sightseeing has a minimal impact (inherent impact), while active vehicle play in unsuitable areas caused impact far beyond the baseline level. Vehicle play is acceptable only in specific areas; outside of those areas it is inappropriate and results in large behavioral impacts. Behavioral impact is important in ORV planning, management, and the recreation itself (see Figure 1).

E. Inherent and Behavioral Impacts: ORV Recreation Relative to Pedestrian Recreation

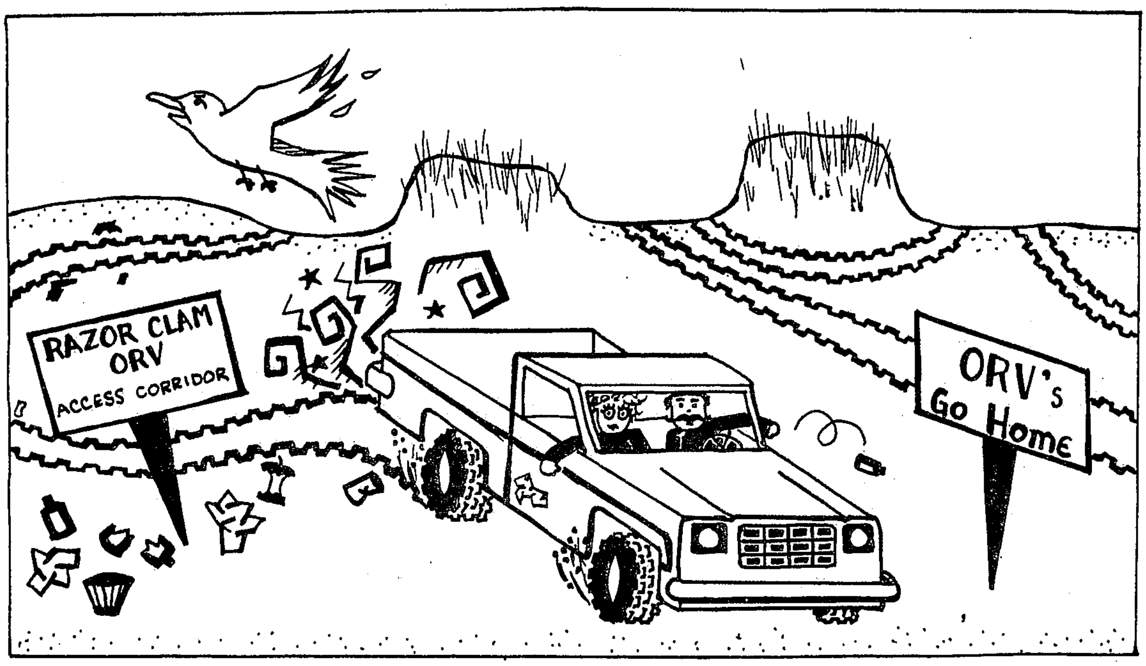
1. Motorization is the difference

The fundamental difference between ORV recreation and other recreational activities (particularly pedestrian) is the use of a motor vehicle to traverse areas typically unsuitable for a normal vehicle. This difference is the largely unique, attractive aspect of the recreation, but paradoxically, also is potentially a detriment to this recreational form. The problems with this motorized sport, as well as the

USE IT



BUT DON'T ABUSE IT



OR YOU'LL LOSE IT

Figure 1. Behavioral impacts are important to consider when planning for and managing ORV areas. Caption is based on a phrase from the BLM'S Operation ORVAC, 1970.

positive aspects, must be recognized and understood by both participant and non-participant.

2. Inherent impact

The inherent impact is greater for ORV recreation than it is for pedestrian types on natural terrain. An analysis follows comparing a trail bike and a pedestrian which illustrates how motorization and degree of impact relate. Although ORV recreation also includes dune buggying, four-wheel driving and special events such as sand drag-races, they all take place on the Oregon coast and share the common motorized character.

ORV impact is larger because it is motorized. Three specific areas can be identifed showing how the motorization increases the inherent impact's size: (1) the specific area contacted by the recreationalist or the recreationalist's ORV (interface between the recreationalist and the environment), (2) the range or area covered by a recreationalist in a given amount of time (total area contacted or total interface area), and (3) the area of recognition based on sight or sound (area of recognition).

First, at the area of immediate contact between the recreationalist and the environment, the interface, the inherent impact is greater for the ORV (recreationalist) because its greater mass and power production is translated proportionally into environmental impact. "Generally, the greater the torque applied at the machine/environment interface, the greater the potential for impact." (Bury et al., 1976, p.41). Also Muntz, Deglow and Campbell comment generally, not quantitatively, on the relative erosional effects between a trail biker and a hiker (1972, p. 9):

> For example, in the case of trail bikes, erosion should be considered. It seems that the trail bike must be worse than the hiker since the trail bike and rider represent something like three times the mass of a hiker. In addition, feet intelligently guided are rather more efficient at gaining firm holds than wheels, thus allowing a hiker to gain or lose altitude and generally to accelerate or decelerate per unit mass with less displacement of trail surface material than a trail bike.

The behavior described above as "feet intelligently guided" is indicative of pedestrian behavior with minimal environmental impact, and suggests that even the most consciencious trail biker's inherent impact would be greater than that of the hiker, due merely to the use of a motorized vehicle.

Second, comparing the range or contact area covered in a given amount of time (total interface) for the ORV user versus the pedestrian a tool of destruction far exceeding the potential harm done by a lone individual exhibiting such depreciative behavior. The mechanical advantage makes the operator's behavior the crucial determinant in controlling environmental impact (see Figures 2 and 3).

Second, the great range and ability to venture into remote areas with ORVs may be a positive attribute of ORV recreation. On the other hand, if ORVs serve as a vehicle to carry depreciative behavior into back country areas they are ruinous. ORVs remove many of the functional barriers (distance, elevation, etc.) that have limited access in the past.

Thus, when irresponsible behavior takes place involving an ORV, the damage is extraordinarily large and the ORV can serve to transport that damage to areas previously protected by limited access.

Bury *et al*. summarized these points (p. 20):

> While the proportion of individuals assuming depreciative behavior forms may be no larger than in other recreation activity groups (although research is needed to determine the proportion), the potential for impacts of this behavior may be considerably larger because of the mechanized nature of the activity. Mechanization not only allows individuals to cover more terrain than most other recreational pursuits, ... Stated perhaps more succinctly, the geography of depreciative behavior among ORV operators will be more dispersed than that caused by other recreational participants.

Due to the possibly large, negative behavioral impact and its wide geographical distribution, management becomes very difficult and expensive. Perhaps an effective means to deal with depreciative behavior is through peer influence. An ORV participant may respond more favorably to regulations by observing others' respect for them and following their encouragement to do likewise for the benefit of all ORV recreationalists. This can be promoted by user education programs. Also, planning can greatly reduce many user conflicts and management requirements regarding environmental impacts.

III. OFF-ROAD VEHICLE ACTIVITY DESIGNATIONS

A. User Types

ORV recreationalists are a diverse group of people and utilize various types of vehicles in different ways. However, three groups can be identified (Peine, 1973, pp. 9-10; State of California, pp. 9-10): (1) vehicle oriented, (2) activity oriented, and (3) land oriented. The first group see the vehicle as an end in itself enjoying the performance, skill of operation and maintenance. This group would include the most

avid riders and competitors. The second group, activity oriented, are using their ORVs as a means to another end, transportation to areas in which to hunt, fish, clam, camp, etc. The last group, land oriented, seek to be out of doors and enjoy remote scenery and points of interest. These groups are useful in distinquishing some of the different user motivations but are limited in their application to planning and management because their respective impacts are not considered.

B. Activity Designations

As previously discussed, different activities have different impacts, so based on their functional differences and related potential impacts, three ORV activity management designations can be made: competitive events, vehicle play, and access corridor.

1. Competitive events

Organized competition can be planned in detail, managed and monitored very closely through special permits issued to an individual or a club that assumes the responsibility for the event. Thus, impacts and problems can be dealt with in advance. Events like sand drags, because of their organized structure, are quite manageable (see Table 1).

Table 1. The relative potential impacts and manageabilities for the three vehicle activity designations

Activity Designation	Impacts		Manageability
	Inherent	Behavioral	
Competitive Events	High	High	High
Vehicle Play	High	High	Low
Access Corridor	Low	High	Low

Thus, their potentially large impacts (inherent and behavioral) can be mitigated, raising their compatibilities with adjacent lands.

2. Vehicle play

The distinction between vehicle play and vehicle access is dependent on the ORV users' behavior since their machines, especially in the case of four-wheel drive vehicles and motorcycles, have the dual capacity for play and access.

Vehicle play includes the active testing of one's machine and skill to negotiate steep hills, rough terrain, etc. Generally, it can consist of a mixture of activities such as touring an area, hill climbing, and informal racing with a friend. Vehicle play is basically vehicle oriented. Perhaps, it is best described as an activity resulting from the use of a powerized vehicle to freely traverse a variety of terrain (large dune bowls, small dunes, open sand straight-aways) at a variety of speeds.

Both the inherent and potential behavioral impacts are great because of the motorized, free, and relatively wide-open nature of the activity. Management must be sufficient to deal with these problems. However, management is difficult due to the range and mobility of an ORV. An overly enthusiastic driver may venture into areas not appropriate for such use; simple rules become difficult to enforce. Vehicle play is much harder to administer than competitive events and therefore, may be less compatible with adjacent areas (residential areas, important habitat areas, stabilized vegetation areas) (see Table 1).

3. Access corridor

Vehicle access, in theory, would include transit from one point to another on a single path or corridor, the vehicle serving as a means of transportation whether it be for fishing, clamming, or sightseeing. Thus, it functionally includes the activity and land oriented ORV user groups. Assuming normal driving habits (shortest distance routes, low speeds, etc.) and no thrill-seeking behavior, the inherent impact for an access corridor would be significantly smaller than that for vehicle play. This would likely increase the compatibility of this activity, facilitating its provision since it could be permitted in or near more areas. However, if individuals ranged over inappropriate terrain, outside the access areas as if it were a vehicle play area, this would constitute depreciative behavior and result in unacceptable behavioral impacts. Clearly, the ORV user's behavior in beach and dune areas determines, in reality, whether an access area can exist or not. The inherent impact would be less than that for vehicle play, but the potential for behavioral impact would still be large (see Table 1). This should be kept in mind while planning and working with the ORV groups.

IV. COASTAL ORV MANAGEMENT UNITS AND THEIR SUITABLE ACTIVITY DESIGNATIONS

A. Management Area

The management area is the largest land division having identifiable boundaries, natural (headlands, rivers, etc.) or man-made (highways, etc.). It includes all planning elements (house construction, recreational areas, wildlife habitats, etc.), stressing the interactions between all the elements. The aim of such a division is to promote the consideration of an activity's impact on the adjacent land or land uses both immediate and distant.

B. ORV Management Units

Subdivisions within the management area are management units. Specifically, ORV management units are readily identifiable contiguous landforms and/or plant communities sharing in part a common sensitivity to ORV traffic. The ORV management unit's sensitivity determines which activity designations are suitable. Within each ORV management unit, the significance of ORV impacts can vary and so the exact location of an ORV activity should be situated accordingly. Suitability of a given activity designation is not an absolute policy statement. Other factors must be considered, and suitability can change over the period of a year or more.

The environmental impacts of ORVs in coastal settings such as beaches, dunes, salt marshes, and tidal flats were studied at Cape Cod National Seashore between 1974 and 1977. The results are summarized by Godfrey, Leatherman, and Buckley in Coastal Zone '78 (1978, pp. 581-600). These studies conducted by the University of Massachusetts National Park Service Cooperative Research Unit, are used extensively in the following explanations of ORV impacts on habitat types.[1] The following ORV management units are defined by their sensitivity to ORV traffic and their easy identification.

1. Protected intertidal

The protected intertidal ORV management unit includes salt marshes, sand flats, and estuarine areas generally protected from direct ocean wave action. The sand flats within river outlets are not really protected and may be more appropriately considered in the beach foredune management unit as an intertidal "beach".

Of the areas studied, the protected intertidal unit is the most sensitive to vehicle traffic. "These are the salt marshes and sand flats which harbor a variety of marine and coastal organisms, as well as supply-

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[1]The author gratefully acknowledges the Unit's comprehensive research.

ing primary productivity to the estuarine and nearshore marine food webs," (Godfrey et al., p. 590). In salt marshes, very low levels of vehicle traffic can maintain bare areas indefinitely. In open intertidal sand flats, vehicle traffic may stop the natural development of marsh vegetation and may affect the survival of marine life such as worms, clams, and other mollusks (Godfrey et al., p. 592).

Typically, the protected intertidal ORV management unit is not suitable for any ORV activity designation. This is consistent with the estuarine and other related goals. However, in the case of emergencies, salvage operations, and special management needs, an access corridor might be a necessity.

2. Beach foredune

The beach foredune ORV management unit consists of the beach and the entire foredune and makes a naturally identifiable unit with regard to ORV use.

Within the beach foredune area, impact sensitivity varies. The intertidal beach (wet sand area between high and low tide) is probably the area most resistant to ORV impact, since it is so naturally variable (sand transport during tidal cycles and storm cycles, etc.). The natural changes are much greater than any vehicular effects. However, the high beach (berm) where only the highest tides reach can be heavily impacted. In this area, birds nest and drift accumulates. Where vehicles pass only a few times on driftlines, organic deposits can be broken up along with the destruction of pioneering plants and reduced bacterial counts (Godfrey et al., p. 586).

Although foredune vegetation is highly susceptable to destruction by ORVs, it is also an area of vigorous growth and recovery. (Note: there are special erosion hazards associated with destabilized foredunes, which are considered in the specific impacts section.)

Overall, the ORV impacts on the beach foredune unit are significantly less than in the protected intertidal areas. In light of the foredune sensitivity and associated wildlife habitat, an access corridor is the only suitable designation for the beach foredune management unit. User compatibility and other management factors should be considered in making such a designation (refer to those sections).

3. Vegetated dune

Vegetated dunes are susceptable to removal of their stabilizing vegetation causing erosion hazards and esthetic impacts. Access corridors are the only suitable designation for this ORV management unit. Some dune areas that were stabilized at public expense have been damaged by ORV use. Does recreation justify this destruction?

4. Vegetated deflation plain

Vegetated deflation plains are similar to vegetated dunes in that the vegetation can be destroyed by vehicles. The impact is significant regarding wildlife habitat and its associated flora. Vegetated deflation plains constitute an ORV management unit that is potentially suitable only for a carefully planned and monitored ORV access corridor designation.

5. Open sand

Open sand areas and open sand dunes constitute ORV management units which apparently are ideal for all ORV activities. Clearly, open sand areas (excluding beach areas) are most suitable for ORV use with little lasting inherent impact. Wildlife distrubance is probably minimal, however, open sand deflation plains can serve as resting areas for migrating birds. During those periods, such areas are not suitable for any ORV activity. Also where dunes are encroaching on valuable land, ORV activity is inappropriate because it might accelerate dune migration (through down slope sand transport and wind transport).

V. SPECIFIC ENVIRONMENTAL IMPACT CONSIDERATIONS

Consider the inherent ORV impacts on sand, vegetation, and wildlife. Some impacts on these resources are certain to occur and require special attention. The general topics concerning ORV impacts for each subject are listed. Only those pertinent and previously documented in the literature are reviewed. Some management recommendations are offered to reduce the impacts, however, a more complete analysis of management techniques is discussed in Chapter VII.

In the planning process, the ultimate determination is whether the probable ORV recreational impact is consistent with LCDC's land use goals and a community's values (recreational and environmental). Regarding environmental impacts, goal number five concerning natural resources is the most applicable: to conserve open space and protect natural and scenic resources which would include fish and wildlife areas and habitat, as well as ecologically and scientifically significant natural areas.

A. ORV Effects on Sand

1. Downslope sand transport and compaction (geomorphological effects)
2. Wind erosion (wind transport)
3. Water erosion (beach, creeks)

Niedoroda studied the effects of ORVs on the beaches and dunes of Cape Cod (1974). Although the Oregon oblique dunes are very different from other dune forms (Cooper, 1958), the process of sand transport, compaction, etc., due to vehicles, would be similar in nature.

1. Sand transport and compaction

Niedoroda's work indicates sand transport downslope was a significant effect, changing the dune relief locally. This appeared not to threaten the overall relief of the dunes given the level of ORV use. The major factors in sand transport were the slope of the hill and tire pressure; compaction was minimal (pp. 76-78).

The study raises the question of whether ORV activity on the oblique dunes of Oregon have significant effects on their relief. Apparently these effects depend on the natural process of sand movement. If the natural sand transport (dune building) is greater than the effects of sand movement from ORVs, then there is probably no observable net effect. Conversely, if the ORV activity moves more sand than the opposing natural processes, the dunes' relief may be changed.

Any quantitative answer is impossible to provide, although general observation may be useful. It appears the oblique dunes are much larger than those studied by Niedoroda. Therefore, the ORV impact might be less significant. However, this question should be considered further.

2. Wind erosion

Regarding wind erosion in open sand, Niedoroda's work indicated ORV disturbance of the sand surface had no effect (pp. 84-85). However, this is not definitive. On some dune ridges, tracks accelerate wind transport. Tracks either increase or retard wind erosion depending on their orientation to the prevailing wind. (The winter wind from the southwest is the most significant wind.) If the tracks parallel the wind direction, erosion is accelerated; tracks oriented at some angle to the wind direction retard erosion, (Ternyik, 1978).

3. Water erosion

Water erosion appears to be pertinent only in regard to ORV activity on the beach. Here, Niedoroda indicates that for eroding beaches, the natural sand loss exceeds any possible effects from ORVs (p. 39). However, on accreting beach areas ORV activity has a detrimental effect on the newly forming (thinly vegetated) dunes. A local example of such an area would be the prograding area of South Beach in Lincoln County.

B. ORV Effects on Vegetation

1. Loss of vegetation and wind erosion
2. Loss of vegetation and water erosion
3. Fire hazards during dry periods
4. Destruction of rare species (cross reference to critical habitat section)

The open sand areas have no vegetation so there is no opportunity for mechanical destruction. It is highly suitable for ORV activity.

However, ORVs are often not restricted merely to open sand areas; when this occurs the vegetation damage is significant and can have potentially disastrous effects on nearby land uses and habitat.

1. Vegetation loss and wind erosion

Unfortunately, the likelihood of vegetation damage from ORVs is high, since few vehicle passes are needed to remove beach and dune vegetation. Once removed, other ORV users feel the open area is a "legitimate" trail, and vegetation removal progresses.

Wind erosion resulting from the destruction of stabilizing vegetation is of vital concern. Removal of European beachgrass (Ammophila arenaria) and other species that help bind the sand and reduce wind speeds (causing deposition), allow the sand to blow and possibly inundate adjacent areas. Careful site investigations must be conducted before such destabilization occurs to protect nearby land uses (homes, recreational facilities, etc.) and natural resources (habitat). Liability is an important issue here.

Generally, areas sensitive to wind erosion after ORVs remove the stabilizing vegetation include any temporarily stabilized dune area that has, at most, a thin soil layer underlain by loose sand. The degree of vegetation loss which would result in wind erosion varies depending on factors such as orientation to the prevailing wind, sand consolidation, adjacent land forms, water table depth, etc.

The effects of ORVs were studied on American beachgrass (Ammophila breviligulata), and reported by Godfrey et al. (pp. 587-590). Different areas showed somewhat different impacts. On the seaward edge of the foredune, where the beach grass advances, less than one hundred vehicle passes reduced the vegetation to low levels. Recovery of the beachgrass was dependent on its location relative to a new sand source (high in nutrients). Given three growing seasons without ORV use, the affected areas almost recovered to the pre-impact levels. However, in back dune areas, further away from the sand source, recovery was much slower. Thus, the ORV impact lasts longer in areas receiving less new sand. These observations are applicable to the Pacific oast (Ternyik, 1978). The general impact process and idea of a carrying capacity is discussed (Godfrey et al., p. 587):

> The first 175 vehicle passes over beach grass inflict maximum damage; after that, incremental damage is less because most of the harm is already done. A "minimum number" or a "carrying capacity" of dune vegetation for vehicles is really quite low, since any track can require several years to return to pre-impact conditions.

Generally, more dynamic (storms, wind, salt spray, etc.) areas have more resistant vegetation relative to stable areas, although it varies for different plant species and habitats (p. 589).

The ORV impacts on American beachgrass and European beachgrass are similar although the recovery rate of European beachgrass would be faster since it is a heartier species (Ternyik, 1978). ORV activity unquestionably removes significant amounts of beachgrass as evidenced by the Godfrey et al. study and casual observations at Sand Lake in Tillamook County. The problems with vegetation loss and wind erosion can be avoided by operating ORVs strictly on open sand, or allowing ORVs to remove vegetation only where increased wind erosion would not threaten valuable adjacent land.

2. Vegetation loss and water erosion

Water erosion of foredunes may be increased by ORV related vegetation loss. Foredunes serve as protection during winter storms. If there is destruction of the stabilizing vegetation, the foredune is more susceptible to winter storm-wave erosion (Ternyik, 1978). This means the foredune will suffer more damage and provide less protection until it redevelops. Breaching the foredune can also result in a blowout, leading to wave intrusion and salt deposition.

These considerations are important where protection from winter storms is needed. For example, houses immediately behind the foredune would need such protection. Typically, foredunes should not be designated as vehicle play areas and access should be provided to the appropriate beach areas on specified access corridors which minimize destabilization and erosion. ORV access corridors should be located in areas where protection is not vital.

3. Fire hazards

During periods when the fire hazard is high, ORV activity may need to be temporarily curtailed. Actual vehicle fires and emission sparks constitute the likely ignition sources from the vehicles. Careless campfire use would be a behavioral impact source (from any recreationalist). Generally, carrying a fire extinquisher as required in the NRA would reduce the hazard. Also, fire resistant plant species could be planted.

4. Rare plant species

There are relatively few plant species in the beach and dune areas as a whole, and only a few of those are considered rare. Thus, implementation of the natural resources goal and its guidelines would not be difficult. Reference should be made to the critical habitat section and at the time of planning or site investigation, the Oregon Natural Heritage Program or other programs monitoring the state's flora and fauna should be contacted. ORV participants have an interest in such protection, thus demonstrating their legitimacy and compatibility as a recreational form on the Oregon Coast.

C. ORV Effects on Wildlife

The evidence with regard to ORV impact on wildlife is far from complete. Basic concerns about negative effects from ORV disturbance are widespread, but there is little scientific evidence available to indicate definitely what the effects are.

Obviously, chasing or harassing game will have an adverse effect on them, but less intense disturbance is a different problem. Bury et al. state (p. 43): "Changes in daily routine plus additional stress are probably the major effects of ORVs, rather than direct mortality."

Research has focused primarily on snowmobiles, but the problems of noise and visual disturbance probably have some application to ORVs in general. The literature reviewed by Bury et al. indicates whitetail deer are not as disturbed by snowmobiles as resource managers suspected. Elk may be more sensitive. Impact from snowmobiles, on medium sized mammals is not generally clear (pp. 43-46). Thus, some evidence indicates snowmobile activity may not be as negative as at first thought, however, this is neither conclusive nor directly applicable to all ORVs.

While planning and managing any of the ORV activity designations, special attention must be paid to the following considerations for birds, mammals, marine life, and their sustaining environments:

1. Birds

a. Rare species (cross reference to critical habitat section)
b. Nesting areas
c. Resting areas for migratory species
d. General disturbance

The most visable forms of wildlife within beach and dune areas are birds. Many different species are seen providing recreation and amusement for people.

In regard to rare species, it appears there is only one in the beach and dune areas; it is the snowy plover (Charadius alexandrinus nivosus). When planning and managing ORV areas, the critical habitat section of this report should be reviewed and the Oregon Natural Heritage Program contacted.

A full background on the snowy plover may be obtained by reading the critical habitat section.[1] Only the points relevant to ORV recreation

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[1]This is a significant issue regarding ORV activity since a relatively complete knowledge of the situation may promote ORV recreation compatibility.

are considered here. The snowy plover nests along the foredune areas, often, but not exclusively, in the driftwood areas. Occasionally, they nest on open sand areas and into the foredune area for some distance. The nesting period is the most critical time of year for the plover and ranges from April into June. Snowy plovers' nest selection seems to vary in geography. During the nesting period, pedestrian and ORV disturbance could result in negative effects on snowy plover nesting success. Although in a study on Least Terns (Sterna albifrons), that was not the case (Blodget, 1978, p. 60). Any direct application of the Blodget study would not be reasonable, but it is a consideration. A low and declining population within Oregon justifies a conservative approach to protecting the snowy plover, which is consistent with goal number five.

It is significant that the disturbance can result from pedestrians as well as ORVs. In the case of the Least Terns, this was certainly true (Blodget, p. 61). Dogs are also a threat to them. In remote beach areas (where access points are widely dispersed), the only likely disturbance is from ORV recreationalists (and their dogs) due to their extensive range relative to pedestrians.

In addition to the plover, other shorebirds forage on the beaches and the effects of general disturbance are not specifically known. Resting or wintering areas for migratory species should not be areas of ORV activity.

To specifically reduce nesting disruption of the snowy plover, land managing agencies should implement a short closure period in the more remote (few access points) beach areas during April through June. Also research on the effects of vehicle and pedestrian traffic on plover nesting success is needed.

2. Mammals

a. Rare species (cross reference to the critical habitat section)
b. Breeding areas
c. Calving areas
d. General disturbance

Generally, ORV effects on mammals are unclear. ORV noise may have detrimental effects on mammals, however, research is needed to confirm this. The points listed above should be considered, especially as more data becomes available.

Within beach and dune areas, probably the most immediate consideration is the occurrence of a rare species, the white footed vole

(*Phenacomys albipes*). Details are noted in the section on critical habitat. The Oregon Natural Heritage Program should be contacted for any new data. Typically, areas of importance for rare species should not be designated for any vehicle activity. In instances where an important species has been identified a buffer or other appropriate management techniques should be employed for protection.

3. Fish

Siltation of streams from either direct stream crossings or erosion can be avoided if vehicles remain in open sand areas away from lakes and streams.

4. Marine life

ORV activity may have a significant effect on clams and other marine life (Godfrey *et al*., p. 592). The degree of impact is related to the characteristics of a given species so it is advisable to consult marine biologists prior to making ORV designations in estuarine or beach areas.

VI. SITE CRITERIA

A. User Interests

1. Vehicle play

Most vehicle play participants seek a variety of challenging terrain. The large oblique dunes (e.g. Umpqua Lighthouse State Park) and associated bowls are favorite areas. These areas offer steep hills for climbing and wide, open land to traverse freely. The parabola dune at Sand Lake is a good hill climb area, while transverse dunes are less suitable being small and rough, and sometimes quicksand occurs between them in the winter. Despite some shifts in use due to closures, concentrated ORV use generally helps to identify the favored areas. The most reliable and effective way to determine specific needs and areas for site designation is to work with the ORV recreationalists -- organized clubs provide a readily identifiable group. Selecting an ORV site in concert with the potential users ensures it will be a positive experience for them and reduces management concerns.

2. Access corridor

Regarding vehicle access corridors, the same approach is applicable.

3. Competitive events

The specific club or individuals sponsoring an event will probably have an idea where they would like to locate it. The location should be jointly worked out between the sponsors, the land holding party, and the adjacent land owners.

B. Size

1. Vehicle play

The sizes of general use ORV areas vary for minibikes, motorcycles, four-wheel drive vehicles, and dune buggies or a mixture of such vehicles, on a local level from ten acres (State of California, 1978, p. 92) to several thousand acres on the state level (p. 60). Pismo Dunes State Vehicular Recreation Area was 810 acres and was expanded to 2,000 acres (State of California, 1975, p. 7; State of California, 1978, p. 60). Turkey Bay ORV area (located in Kentucky and Tennessee) is 2,350 acres in size (McEwen, 1978, p. V). The size determination of an open sand vehicle play area is dependent on the prefered topography, management strategy, and available land. It is difficult to provide a figure for the minimal size of a vehicle play area because its viability is linked with an overall management strategy (total area open coastwide to ORVs, potentially different areas for different vehicle types, management compatibilities, etc.).

A rough estimate to guide a major development for multi-vehicle (motorcycles, dune buggies, four-wheel drive) play areas might be 500-1,000 acres. Smaller sizes may be feasible. The only practical solution is to work with the ORV recreationalists within the constraints of land availability.

2. Access corridor

The length depends on the location of the point of interest relative to a conventional access point (parking lot, pull out for cars, etc.).

3. Competitive events

The sponsors will, or should, have clear specifications as to the area needed for the event itself, parking, spectators, concessions, buffer zones, etc. The planning and actual size determination must be determined well in advance with technical assistance when necessary (e.g. noise buffers).

C. Access Control

1. Vehicle play

There must be access to vehicle play areas, however, it must be controllable. This point cannot be over emphasized. In dune areas lacking abundant natural barriers, the mobility and range of ORVs are important considerations.

First, the number of roads that provide conventional access to an area should be small to facilitate complete control. Any more than one or two access points make management extremely difficult. In the planning of Turkey Bay, access control was very important, and it was limited to one road (McEwen, p. 6). Also, the implementation of temporary contact stations (check booths on access routes) at Pismo Beach helped reduce management problems such as uncontrolled over-crowding and law enforcement (State of California, 1975, p. 48). In area selection, access must be controllable although it may only have to be monitored at certain peak-use periods.

Second, the freedom to traverse a given area is what many ORV recreationalists seek and should be provided for. In beach and dune areas with few functional barriers, this is done best by providing areas rather than trail systems. However, vehicle play should be strictly contained in specified vehicle play areas to limit environmental impacts and incompatibility (regarding noise and esthetics).

The level of management (law enforcement) necessary to patrol a trail system's perimeter as a means of containment is extremely high compared to that for a designated play area. Regarding a vehicle play designation, keeping people on a set of trails is difficult. Thus, the area used for recreational play should be maximized and the management boundary minimized (the area to boundary ratio should be large). This will reduce the management responsibilities and still provide the ORV experience people seek (McEwen, p. 6).

Using natural boundaries that are easily recognized and that functionally limit access further reduce management responsibilities. The ideal boundary is a creek like Ten Mile within the NRA, while the type of boundary to be avoided is a posted line through open sand like the Coos-Douglas County line. In selection of an ORV play area, viable boundaries should be used in conjunction with controlled road access to greatly reduce management responsibilities.

The capacity to control access is important to (1) limit the total number of people into an area at peak-use periods for reasons of safety, public health, resource damage, and law enforcement (i.e. if needed, implement an optimum carrying capacity), (2) obtain accurate user counts, and (3) facilitate distribution of important information (rules, maps, etc.).

2. Access corridor

An access corridor, in reality, constitutes a trail system within beach and dune areas, and thus constitutes a large management boundary that is difficult to maintain. The behavior of the users is critical to keep an access corridor from becoming a play area.

The impact of only a few vehicles disobeying the designation can be great. Thus management may need to be intensive to eliminate depreciative behavior. Vehicle play areas provide for free-sport driving, while access corridors should provide for transportation resulting in minimal environmental impact.

3. Competitive events

Access control is very important at these events to manage crowds in a safe and orderly manner. A clear plan of crowd and access control in an events area is necessary and should be worked out prior to approval of such an event.

D. Staging Area

1. Vehicle play

For a vehicle play area, a simple staging area is necessary. A parking area for conventional two-wheel drive vehicles with ORV trailers is needed, along with adequate litter barrels, a bulletin board to post all needed information (maps, rules, etc.), drinking water and perhaps sanitary facilities. Other facilities such as camping areas are often enjoyed along with the use of an ORV and could be developed as funds permit. Campsites are usually near the staging areas, since they are a natural focal point of activity. Backcountry ORV camping requires policing and maintenance of designated sites, and limitations on the number of campers to avoid land use conflicts (State of California, 1975, p. 53).

2. Access corridor

The only requirements would probably be adequate litter barrels and a bulletin board to post necessary information.

3. Competitive events

Staging areas for a competitive event would refer to the pit area, but the entire layout should be planned with parking, spectator areas, crowd control, etc.

E. Jurisdictional Considerations

The selection of an area for any of the three ORV designations should include analysis of the political and legal responsibilities of the land holding party or parties. In general, fewer agencies simplify management and planning, however, through the management area concept a joint management plan may be developed. Since various agencies have different legal authorities and skills, they may serve to compliment each other, particularly regarding law enforcement and environmental concerns. (For an example see Appendix G). Due to the large impact of ORVs and their potentially damaging effects, management must be in proportion to these problems. Regardless of the number of land holding parties involved, at least one must have the managerial capacity to post, regulate, monitor impacts, and render aid within the area.

F. Adjacent Land Compatibility

Compatibility of all three designations (vehicle play, access, and competition) to adjacent lands must be considered while planning. Practical concerns are wind and water erosion hazards to nearby land uses or valuable habitat. Perhaps a more common problem is the compatibility of ORV noise to adjacent noise sensitive areas, primarily private residences. Use of ORVs in de facto vehicle play areas results in complaints that affect the public's attitude toward ORV use. Some sand dunes on the coast are privately owned and should be respected. DEQ ambient noise standards for residential areas (noise sensitive property) would apply here (see Appendix E), as would the in-use noise emission standards.

The technical determination of buffer type and size to adequately limit noise from disturbing other areas depends on the topography and on other factors. Therefore, in the planning of any ORV designation, especially a vehicular play area and a competitive events area, DEQ should be consulted for specific technical assistance to ensure that a proper buffer zone is established.

To provide a rough estimate of how far ORV noise can be heard, the following is taken from Harrison's "Off-Road Vehicle Noise Measurements and Effects" (In Chubb, 1973, p. 138). The measurements were made at fifty feet with the vehicle accelerating, using practices proposed or established by the Society of Automotive Engineers (SAE).

> The range of sound levels measured at 50 feet was from 74 dbA [decibles on the A scale] for the quietest all-terrain vehicle (ATV) to 100 dbA for the loudest dune buggy. The real question here, however, is how far will these vehicles be audible above a normal forest background. Using the method developed by Fidel, Piersons, and Bennett of Bolt, Beranek & Newman, we determined that the quietest ATV can be heard from 1,500 feet, while the noisiest dune buggy will be audible for 21,000 feet.
>
> Table I embodies many assumptions, one of which is that the background is approximately 45 dbA. Background levels as low as 11dbA have been measured near Lolo Pass, Montana, a popular snowmobiling area. Low backgrounds, downwind propagation, absence of intervening mountains and trees, etc., all could considerably expand the distances shown. Calculating the detectability distance of a vehicle under forest conditions is very difficult, and involves making assumptions which are justified only some of the time. However, these numbers are generally conservative, and probably represent distances which would not be exceeded in more than 25% of the cases.

TABLE I

	Detectability Distance, ft.		
	Quiet	Average	Loud
Dune buggy	3,200	12,000	21,000
ATV	1,500	4,600	6,200
Snowmobile	4,000	8,000	15,200
Motorcycle	4,000	7,000	11,500

The differences in distance show how important noise standards (mufflers) can be in increasing an ORV's compatibility with adjacent areas. How the ratings: quiet, average, and loud relate to the DEQ standards is not easily determined because different tests are used. DEQ uses the twenty-inch test and Harrison used the fifty-foot test. Assuming DEQ standards are not any quieter than the "quiet" rating, a minimum buffer distance might be, roughly, one mile. To determine buffer size, many factors must be considered; the only reliable way is to seek technical assistance.

VII. MANAGEMENT CONSIDERATIONS

A. User Education

User education is both an immediate and long term solution to most of the problems regarding ORV recreation. An informed user should understand the rules, why they exist, how they relate to the individual, and their costs and their benefits to the individual and to ORV recreation as a whole. Special programs could be developed to promote this understanding and responsible ORV use.

B. Posting ORV Designations

If management plans are to succeed they must be understood by the people they affect. All rules and ORV designations must be readily available in written form, posted, and publicized (this is not directly applicable to competitive events areas). Posting should take place on all key access routes to designated ORV areas (play and access), and within the ORV area as well. At an ORV play area posting should take place at the staging areas or other appropriate focal points. At vehicle access corridors, posting should occur where the corridor begins and at various locations along the way.

The distributed written information should include:

1. The type of area one is entering (ORV play area, ORV access corridor, ORV competitive area).
   a. An explanation of what the designation means and what is expected from the ORV recreationalist in such an area.
   b. Why there is such a designation.
2. A simple map indicating where the designated area is and its boundaries.
3. A list of regulations that apply to the area.
   a. Equipment
   b. Conduct
4. Who enforces the regulations and that violators will be subject to prosecution.

Uniform graphic signs should be used to mark each ORV designation and all boundaries. These should be developed with the users and all agencies managing ORVs on the Oregon coast (state and national uniformity in this regard would be very useful).

1. Vehicle play

Regarding the nature of a vehicle play area the following must be understood by all recreationalists:

1. This area has been specifically designated as an ORV PLAY AREA for vehicular recreation.
2. An ORV PLAY AREA is a place where you are free to ride anywhere you wish as long as you stay within the area's boundaries and off any vegetation.
3. This area is provided for hill climbs and other active vehicle uses.
4. In some vehicle play areas, pedestrian use may be prohibited; violators could be prosecuted.

2. Access corridor

Regarding an ORV access corridor the following must be understood:

1. This area has been specifically designated as an ORV ACCESS CORRIDOR.
2. An ORV ACCESS CORRIDOR is a designated path through or to areas of interest (to relax, fish, clam, walk, etc.). Vehicle traffic of any kind is allowed only on specifically identified routes.

   These routes must be indicated on a map and be identifiable in the field. The path would not be an official road since in time it would return to a natural state (revegetate). Vehicles would be restricted only to the predetermined and identified routes; no traffic would be allowed on other routes.

3. Any vehicle off a designed route would be subject to a boundary violation and prosecution.

3. Competitive events

Competitive events areas can be managed according to the event and location. Posting should reflect the sponsors plans and regulations.

C. Law Enforcement

Along with education and posting, an active law enforcement program is necessary to make the management plan work. Safety and resource protection are promoted by some regulations and they must be enforced. Management and enforcement should be in proportion to the real and potential problems of a recreational type; enforcement of ORV regulations should be thorough.

Law enforcement would likely come from a federal agency if on federal land or a sheriff's deputy as support, under Public Law 92-82 (see Appendix G). On county or state land the sheriff and state police would have jurisdiction. The beach is state land and no federal agencies have law enforcement jurisdiction over it, thus, the sheriff or state patrol will need to be included in the law enforcement plan. Basically, the enforcement program would include:

1. Boundary violations
2. Equipment violations
3. Noise violations
4. Operator violations
5. Criminal acts

Law enforcement is expensive but essential in ORV management, because of its extraordinary impact, potential damage of adjacent land, and incompatibility with noise sensitive areas. Planning can effectively reduce the level of management needed but it cannot replace it. Patrolling ORV area boundaries is a big job; self-policing by organized clubs may fulfill a large part of the management requirements.

Self-policing is not law enforcement, but would serve as a monitoring system over ORV activities. ORV clubs could plan and schedule interested people to monitor specific areas on weekends or other peak-use periods. Their function would be, primarily, one of observation and communication. They could encourage compliance with regulations and watch for and report boundary violations. No actual law enforcement would be necessary, but they could serve as a witness and testify as to the violation. Self-policing procedures could be developed and implemented. For example, the volunteer patrols could be linked to sheriff's deputies through citizen band (CB) communications, and if actual enforcement or help of any kind was needed, they could quickly contact the appropriate authorities. This capacity has been demonstrated by ORV recreationalists in search and rescue missions within the dunes. Many of the "rigs" have CB's. Potentially, such volunteer patrols could work in coordination with law enforcement personnel directly or indirectly providing observations and communications. The experience may be positive for the individuals involved, as well as for ORV recreation in general. Since management is necessary and costly, this may provide a substantial part of that management at minimal cost allowing more areas to be open for ORV designation. In special cases, ORV clubs could provide joint assistance in protecting critical habitat areas too. They have the potential to play an active, positive role in recreation management. Their efforts in picking up litter from the back dune areas is a good example.

D. Safety

1. Equipment

To promote public safety, uniform ORV equipment requirements should be adopted and uniformly enforced on all public lands throughout Oregon (better still, nationally). At present, there are state equipment requirements for ORVs only in the NRA (ORS 483.837-483-847) (Appendix D). Those requirements serve as a basis for the following suggestions and specifications:

a. Muffler

A muffler should be required which meets in-use noise emission standards (decible limits) and visual inspection standards. There are already DEQ standards for ORVs in the State (see Appendix E).

Enforcement of DEQ standards will reduce the potential for operator hearing loss. There is considerable literature demonstrating how noise can have an effect on hearing. Evidence indicates hearing loss can result from the operation of an ORV (snowmobile) (Bess, 1973, p. 147). Vehicles participating in competition are usually exempt from noise restrictions, but the spectators should be aware of a potential hazard from long exposure to noise. Noise limits may also help increase the compatibility of an ORV area to adjacent land.

b. Flags

All vehicles operating in vehicle play designations should have a flag, especially small vehicles such as three wheelers and motorcycles. This is to increase visibility around blind corners that are everywhere in the dunes. Increased visibility should reduce the likelihood of collisions in heavily used areas. These blind corners and hills are dangerous even when extreme caution is used. The flag must be red and at least eight inches wide on one side and twelve inches long to the other. It should be displayed at least nine feet from the ground level.

c. Brakes

Brakes must be hydraulic, except for motorcycles, and must effectively control at least two rear wheels on three or four wheeled vehicles, and the rear wheel of a two wheeled vehicle. Motorcycle brakes may be mechanical or hydraulic.

d. Seat Belts

All vehicles, except motorcycles, must be equipped with seat belts for each occupant. Seat belts must be of the quick release type and must be securely fastened to a frame member.

e. Roll bar

All vehicles, except motorcycles, must have installed a roll bar or other enclosure that will support the vehicle's weight, and must protect the occupant's head when the vehicle is resting on the roll bar or enclosure.

f. Lights

Every vehicle operating from one-half hour after sunset to one-half hour before sunrise shall be equipped with and display headlights and taillights. Definite specifications should be adopted.

g. Seats

All seats must be securely mounted.

h. Fire extinquisher

All vehicles, except motorcycles, must be equipped with a functional, dry chemical-type fire extinquisher of at least two pounds. Fire extinquishers must be approved by Underwriters Laboratories or another acceptable testing agency.

i. Chain guide

Any vehicle equipped with a chain shall have a guard designed so that in the event of failure, the chain will remain under the vehicle.

j. Floor pan

All vehicles, except motorcycles, must be equipped with floor pans. Motorcycles must be equipped with foot pegs or the equivalent. Floor pans and foot pegs must be designed so they will keep the driver's and any passenger's feet within the frame or from beneath the vehicle.

k. Fuel tank

All fuel tanks shall be securely mounted and connections kept secure and tight.

l. Windshield wipers

Any vehicle, except motorcycles, equipped with a windshield must have a windshield wiper.

2. Rules of operation

In addition to equipment requirements, operating restrictions should be developed and enforced:

a. Prohibit the operation of an ORV while under the influence of any drugs and include an open container law.
b. Prohibit the harassment of any wildlife or livestock with an ORV.
c. Prohibit boundary violations.
d. In access corridors, establish a maximum speed limit of 15 mph whenever a pedestrian is present and 25 mph when they are not present; the speeds should be lower if the conditions warrant it. This is consistent with the concept of an access corridor and will provide vehicle access, greater compatibility, and safety for all recreationalists. This is especially important on beaches where both vehicles and pedestrians are allowed.
3. A junior operator's education and certification program could be developed similar to the hunter safety program and snowmobile program.

3. ORV designation

Understanding the ORV designation system should promote safety. Both pedestrians and vehicle operators should know what to expect while in a given area.

Typically in planning ORV play areas, high pedestrian use areas should be avoided. However, if an ORV play area experiences high levels of use and overlaps with a pedestrian area, pedestrian use should be prohibited and the pedestrian closure enforced.

Generally if pedestrians enter an ORV play area they should be aware vehicles will be present, and it is potentially hazardous. However, ORV operators should always proceed carefully over dunes because either a pedestrian or a vehicle could be hidden on the other side.

In access corridors, pedestrians and ORV users should expect to encounter each other. People should not camp in access corridors such as beaches. If everyone knows where vehicles will be operating accidents will be prevented.

E. Compatibility

1. Adjacent land uses

The compatibility with adjacent land uses is primarily a concern in the planning of an ORV designation (ensuring critical habitats were avoided, erosion hazards were considered, noise buffers were established, etc.). Thus, management can only be an extension of the overall plan ensuring ORVs stay in the appropriate areas. Enforcement of the boundaries and noise limits are the most practical follow-ups to ensure an ORV designation is compatible.

2. User compatibility

The compatibility of different user groups, primarily motorized and non-motorized, is a concern. Differences in esthetic values and the types of recreational experiences sought result in what is often called user conflict. The only practical solution to this problem is to provide some areas that meet specific recreational needs. Heavy use in ORV play areas functionally exclude other types of recreation. Sand Lake in Tillamook County is an example. The area's heavy traffic, high speeds, and noise make it primarily suitable for ORV activities. Specific play areas should be designated and maintained for such recreation. On the other hand, areas without any ORVs should be established to offer an environment free from the noise and the reminders of machines. Thus, separation and clear posting of the designations will inform people what to expect in a given area. This will reduce disappointment for those who seek specific recreational experiences.

If people wish to test their vehicles and drive actively, then they should go to a designated ORV play area. Likewise, if people seek a quiet natural setting free from machines, then they should go to such an area. Separation will work, but what proportions will be allotted to various groups? Allottment may be based on: (1) the area needed for the given recreational experience, (2) the relative numbers of individuals seeking the given recreational experience, (3) the overall environmental impact of the activity, and (4) the availability of land (which is finite).

Also, some unique recreation areas probably cannot be divided so specific interests may have to give way to more general interests. For instance, an ORV play area would be typically unsuitable for an area used for many other activities, while an access corridor may be suitable. However, multiple use of all land is not feasible since it does not provide the specific experiences sought by motorized and non-motorized recreationalists.

F. Environmental Monitoring Plan

Since ORV recreation is mechanized, it must be carefully monitored to determine what environmental impacts are taking place. This could be done in detail with scientific studies starting with baseline data from a thorough inventory or perhaps a simple and less expensive approach could be used.

The most basic concerns would be shifts in wildlife populations and changes in vegetation. True baseline data for areas already ORV impacted are difficult to obtain, but data from present inventories and academic research should be of some use. Monitoring census statistics and distribution is a big job but an effective effort must be made.

To monitor changes in vegetation destruction and dune migration, yearly comparisons of aerial photographs would be easy and effective. It would illustrate major changes in vegetation patterns and the resulting erosion. This would also show if boundaries were being observed, particularly in access corridors. Sources of aerial photos could include the Oregon Department of Transportation and the Environmental Remote Sensing Applications Laboratory (ERSAL) at Oregon State University.

Based on aerial photos and field observations effective changes in management strategy and boundaries could be made, as well as an overall assessment of management effectiveness. Development of such a monitoring program is necessary prior to the designation of an ORV area. In this regard, a joint management plan could prove useful to obtain biological expertise from one of the agencies involved. By Executive Order (Nixon, 1972) all federal agencies, including the U.S. Forest Service, must monitor the effects of ORVs on lands within their jurisdiction.

G. Special Events Permits

Special events permits for organized ORV events such as sand drag-races on public property usually address the issues of liability, performance, and planning. This discussion only suggests what some permits include--legal counsel and persons knowledgeable about insurance should be contacted if a permit is to be issued. (See Appendix G for an example).

1. Liability

The land holding party should be indemnified against all damages (to property and life). This could include naming the land holding party as a co-insured party. The land holding party should require sufficient insurance be held by the event's sponsor to cover any damages resulting from the event.

2. Performance

A performance guarantee should be obtained from the event's sponsor perhaps as a bond or security deposit. If the sponsor fails to carry out the tasks agreed to, then the land holding party would use the deposit to carry out the tasks neglected. Trash removal, restoration of stabilizing vegetation, etc., can be expensive.

3. Adjacent land

If an event is to occur, the adjacent land uses should be given consideration. Specifically, private land and residences must be protected from trespass and nuisance acts.

4. Events plan

A complete plan for the event should be required. It should describe in detail provisions for access control, parking, crowd control, sanitation, security, cleanup, distribution of regulations and other information, fire prevention, and a mapped site plan.

5. Requirement deadlines

Planning should be done well in advance, prior to the granting of formal approval. The land holding party should allow ample time to review the sponsor's plan and suggest additions or deletions to it.

VIII. SAND LAKE

A. Background and Analysis

Sand Lake is a small undeveloped estuary twelve miles southwest of Tillamook, Oregon. There exists an open sand area of roughly 1.5 square miles and most of it is heavily used as an ORV play area. The use has grown rapidly in the past few years, however, user counts are not available from the Unites States Forest Service. The Forest Service administers the campground and adjoining federal land.

Numerous problems have developed which reach crisis proportions on major three-day weekends. How these problems relate to the comprehensive planning process and to ORV management in general make Sand Lake an excellent example on which to focus.

Sand Lake exhibits the classic problems: (1) extreme over use, (2) significant environmental impact, (3) multi-jurisdictional area, (4) incompatibility with adjacent lands, and (5) requirements to comply with LCDC's goals. These problems can be categorized as either a management problem or a legal policy problem, although the two are related.

The management problem consists of the first four topics listed above. However, the most fundamental issue is simply -- severe over use. User demand far exceeds the limited open sand area because of Sand Lake's proximity to Portland and other major urban centers. It is the only recognized ORV area on the northern half of the coast, so use in this region is focused at Sand Lake.

In such over-crowded conditions, impact can be expected to be extraordinarily great. Vehicles are not limited to the truly open sand areas. ORV use has destroyed large areas of vegetation and cut deeply in the foredune and dune hummocks, reducing the latter to small barren sand mounds that will erode leaving just sand (see Figures 4 and 5). Perhaps the two bowls and other open sand areas are insufficient in size and topography to satisfy the users. A balance must be reached when demand reaches the limit of the resource or when user satisfaction declines. Satisfaction for some users has declined at Sand Lake as evidenced by ORV club members speaking of it as a "no man's land" filled with the "crazies" on three-day weekends.

If it is a no man's land, where are the land agencies and an enforcement program? They are outnumbered and doing what is possible within the limits of human safety to enforce the regulations. Typically, this is Forest Service personnel supported by the Tillamook County Sheriff's Department under a special agreement (see Appendix G).

There are really two sets of jurisdictions at Sand Lake--the land holding agencies and the users. The land holding agencies are the Forest Service, the State of Oregon and Tillamook County (see Figure 6). The county land lies between the State beach on the west and the Forest Service's campground on the east and extends north across Galloway Road for some distance. ORVs freely traverse all three lands.

Regarding the users, there is the public using the general facilities and there is the Northwest Trail and Dune Association. The Association is highly organized and has a special use license to hold up to seven drag races (sand drags) between April 1 and October 15 through 1983. The agreement was entered into by the Commissioners of Tillamook County in March of 1978 (see Appendix H).

In addition there are private residences along the eastern perimeter that report trespass and various types of abuse from some ORV users (see Appendix I) and feel the vegetation destruction is a threat to their property. Much of the stabilizing vegetation in the

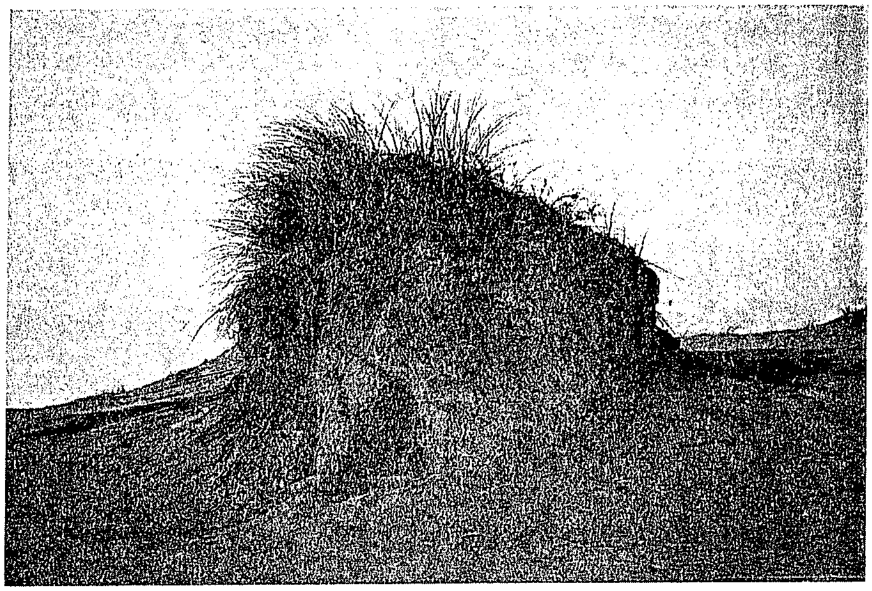

Figure 4. Dune hummock cut on all sides by ORVs at Sand Lake, Tillamook County, Oregon.

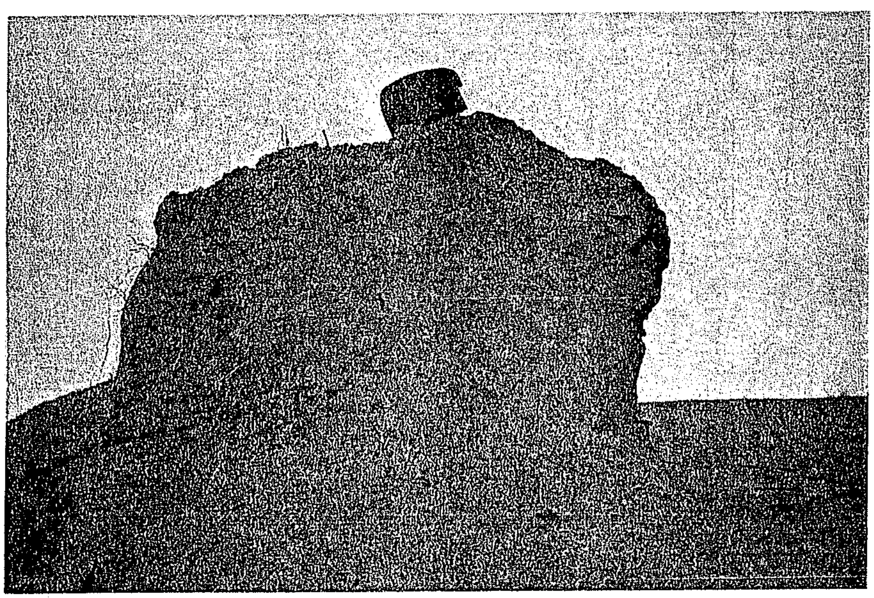

Figure 5. A barren sand mound cut by ORVs at Sand Lake. The black object is a 135 mm camera case.

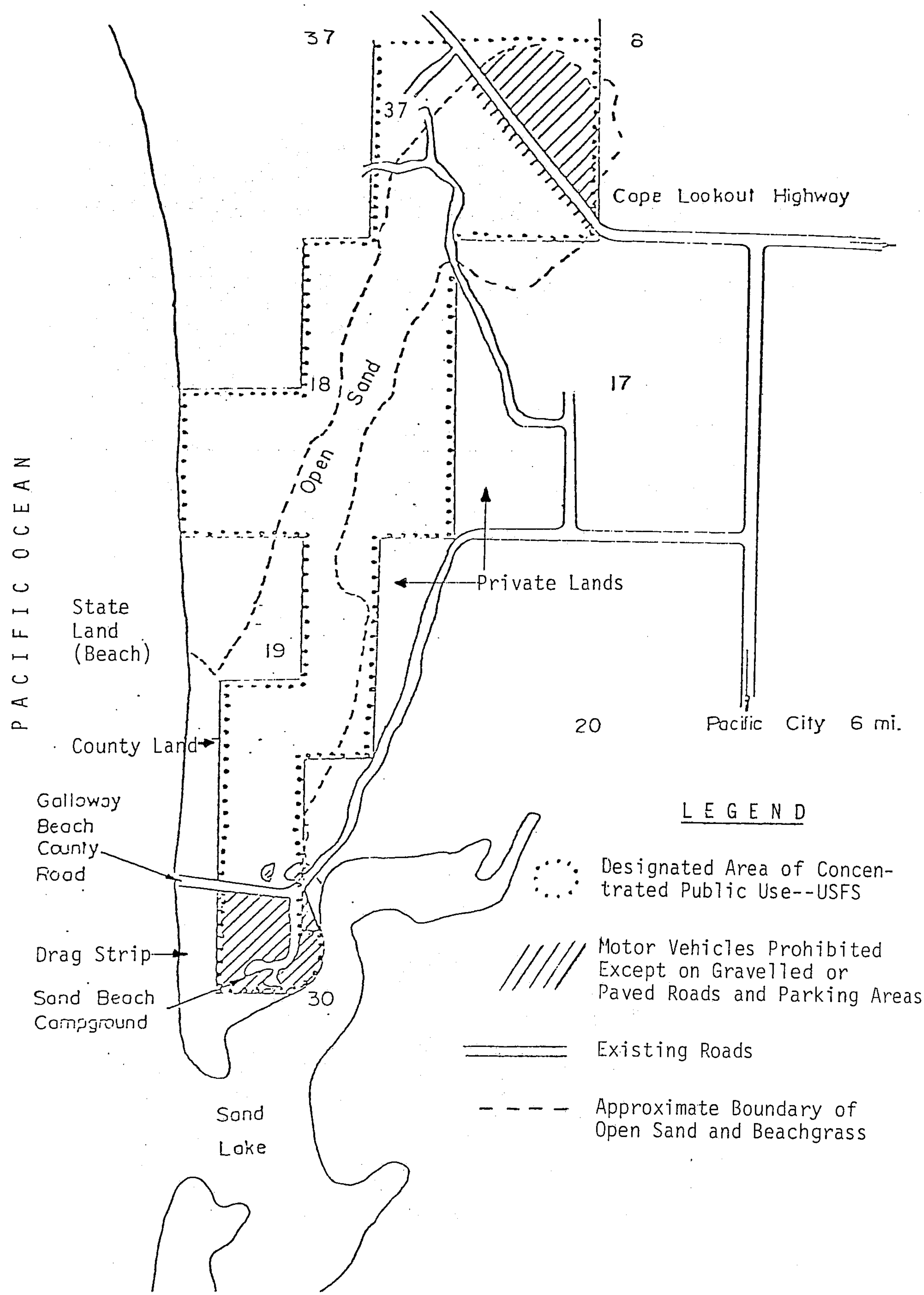

Figure 6. A map of the Sand Lake Dunes Area illustrating areas of concentrated public use, and areas of regulated cross country motor vehicle travel. Map also illustrates the various land holding agencies in the Dunes Area--U. S. Forest Service, the State of Oregon, Tillamook County and private land owners.
Source - U.S. Forest Service

area, planted at considerable public expense during the 1930's, has been allowed to be destroyed by sanctioned ORV use (Ternyik, 1978). Fire associated with ORV dune camping and vehicle operation is a potential threat to the security of these private lands.

Also, there is a question of dune migration onto these private lands. A soils report by the Forest Service (Bush, 1976) indicates vegetation will continue to take over the open sand, and the effect of ORVs is merely to alter the vegetation's appearance, not significantly changing its rate of encroachment. The active sand migration is not mentioned as a threat to the nearby private land. Ternyik (1978) indicates sand migration may be a threat to these lands.

In addition to all the parties involved (federal, state, county, private land owners, a private club, and the general public) is the issue of compliance with LCDC's land use goals. The Beaches and Dunes, Estuarine, Coastal Shorelands, and Recreation Goals directly apply. They must be dovetailed to produce a viable plan.

Sand Lake is classified as a natural estuary by LCDC; it is one of five in the state. Such a classification determines what activities will be allowed within the estuary. Since it is classified as a natural estuary, only natural management units can be established within it. In establishing these natural management units, the following must be considered: (1) adjacent upland characteristics and existing land uses, and (2) compatibility with adjacent uses, according to the Estuarine Goal. Therefore, an assessment of the upland ORV activities' compatibilities relative to the estuary is necessary.

The uses of a natural estuary are very specific (Administrative Rule Classifying Oregon Estuaries):

> Natural estuaries shall only be used for undeveloped, low intensity, water-dependent recreation; and navigation aids such as beacons and buoys; protection of habitat, nutrient, fish and wildlife and aesthetic resources;

In light of these considerations, the compatibility of the ORV use should be determined. To analyze this problem, two separate criteria may be used: (1) the impact of ORV activities on the ecological processes of the estuary, and (2) the impacts on the natural esthetic resources of the estuary and upland area. It is reasonable to consider only the ecological impacts actually on the estuary which would include upland impacts if they affect the estuary. The ORV impact on the upland area would be a separate issue if it does not directly affect the estuary. The esthetic consideration must be broader including the upland area, since the esthetic perception is impacted by what is seen and heard in the entire area.

ORV activity at Sand Lake is not a single phenomenon. In a compatibility assessment it may be separated into two activities: the club's drag strip, and the general public's ORV use. The estuarine compatibilities of both are conditional with regard to the ecological impacts, and subjective with regard to the esthetic impacts.

First, consider the drag strip activity and its facilities. The drag strip is located close to the estuary's edge (estimated less than 1,000 feet). There are permanent structures erected--two steel guard rails and a tower. The strip was leveled removing the vegetation and a gravel parking area established. The boundary along Galloway Road has a log barrier built by the club. Many thousands of dollars are invested in the facility. Their races are nationally sanctioned "drags". When the drag strip is not in use, its ecological compatibility is high since there is probably minimal impact on the estuary. The drift log barrier serves to limit ORV access south of Galloway Road toward the estuary. However, the beach provides access onto the foredune, north spit area, and estuary.

On race-weekends the drag strip area is filled with several thousand people. Control of the crowd and their vehicle activities is the condition of compatibility. If ORVs are not operated in or on the shore of the estuary, then there will probably be little direct impact on the estuary. The unrestricted noise and heavy general disturbance of the area would likely add to the disruption of the adjacent nesting snowy plover located on the north spit area during the months of April through June.

Esthetic compatibility on non-event weekends is low due to the presence of the permanent structures and the conspicuous man-made open sand area. The tower is colored with earth-tones making it less conspicuous.

On the race wekends, the esthetic compatibility is extremely low relative to the natural esthetic resources criterion. A drag strip with its hundreds of vehicles and noise are not consistent with a natural setting.

In summary, if the drag races are strictly controlled and occur only at certain times of the year, it may be compatible ecologically but esthetically it is incompatible.

Similar to the club's compatibility is that for the general ORV use. The direct effects on the estuary are potentially less because most of the vehicle activity appears to be north of Galloway Road. However, there is significant ORV use on the foredune south of Galloway Road, on the north spit (may effect the nesting plovers), and sometimes in the estuary. Again, the compatibility is conditional on the restricted use of ORVs in or immediately adjacent to the estuary, which at present is low.

Vehicles, their tracks, and their noise diminish the natural esthetics of the estuary. Also, the upland use of ORVs has resulted in the highly visable vegetation damage and background noise which are not compatible esthetically.

In conclusion, the drag strip is more compatible than the general ORV area because it better meets the condition of use (no operation of ORVs in or immediately adjacent to the estuary). Presently, the general ORV activity is not a compatible upland use ecologically. During the plover nesting period, both activities are incompatible with the natural estuarine classification which specifically protects all wildlife. Esthetically, both the drag strip and general ORV use are not compatible adjacent land uses.

B. Policy Recommendations: Goal Compliance

To meet the criterion for ecological compatibility, no estuarine impacts should result from ORV use, regardless of the location. It appears this condition can be met if ORV use is limited to the area north of Galloway Road. The drag strip is located on the south side of the road but may be ecologically compatible provided no vehicles (competitive or recreational) operate near the estuary, the crowd is controlled, and no races are held April through June. These suggestions are probably viable means to make each activity ecologically compatible with adjacent land uses.

Esthetically a compatible land use should reflect the same natural esthetic resources of the estuary itself. Both ORV activities fail to do this and are not compatible adjacent land uses.

The intent of the Recreation Goal and the Beaches and Dune Guidelines is to provide for ORV recreation in an "appropriate" location. Sand Lake, in light of the estuarine designation, its implications, and the other problems discussed, is not the best location. However, on the northern half of the coast it provides the only open sand area for ORV recreation. Thus, Sand Lake, in spite of its multitude of problems, is fulfilling a recreational need.

Sand Lake provides a regionally unique recreational and ecological experience within Oregon. If the ORV area is brought into compliance as a compatible adjacent land use ecologically and no permanent land committment is made to ORV recreation, Sand Lake should remain open as a designated ORV area (including the appropriate vehicle play areas and access corridors) for an interim period of several years. This does not reconcile the non-compliance on the basis of esthetic compatibility. The value ecologically and esthetically of Sand Lake will increase dramatically as the number of natural areas diminish in the future. Therefore, over the interim period, an alternate site for a major ORV park should be developed near the major metropolitan areas. Ultimately, ORV use at Sand Lake should be phased out.

Regarding the Northwest Trail and Dune Association's drag strip, it is in reality a regular drag strip and is sanctioned as one. A specialized use on unique public land which is inconsistent esthetically with a specific land use goal may be inappropriate. The Association has a very good reputation for managing its events and this should be given consideration. However, the nature of the event cannot be changed. It appears reasonable during the interim period to seek a location more suitable for a drag strip nearer a large metropolitan area.

C. Management Recommendations

1. Develop a joint management plan

Develop a joint management plan for the entire area giving consideration to the estuary, federal land, state land (the beaches), county land, and private land. The ORV activities affect all these lands in some way and so the planning and management should encompass the entire area affected. The parties involved in such planning should include the Forest Service, the State, the County, the Northwest Trail and Dune Association, and the local residents. Formation of an advisory council may promote communication and help to provide information during the planning stage.

2. Control all access

Access control during peak-use periods can be used to limit the total number of people in the management area. This will reduce health, safety, environmental impact, compatibility, and law enforcement problems. Derrick Road should be closed as an access route for recreation and the road off the Cape Lookout highway should be closed or at least controlled.

3. Establish a total capacity for the area

Set a total capacity for the management area including federal, state, and county land. A special use permit system could be used to implement it. Permits for peak-use periods would be obtained in advance to secure entry into the area. A fee may or may not be needed. Distribution of permits and other details should be jointly worked out and well publicized in advance.

A set capacity for the general use area and the drag strip area would have to be determined respectively, and their sum would be the total capacity for the area at a given time. If races were not held on major weekends, then the drag strip's capacity could be larger and the total capacity would not be exceeded.

4. County responsibility

The county should be responsible for the provision of water and trash removal for activities it sanctions.

5. Back dune camping restrictions

The number and location of campers should be restricted to prevent damage to vegetation, trespass on adjacent private land, and other problems. Camping should be allowed only in designated areas. It could be located in the "county strip" along the deflation plain and should not be anywhere on the north and east sides of the open sand areas near private land. Such restrictions will provide for camping and reduce trash and resource damage problems. Another alternative would be to close the area to overnight camping altogether.

6. Law enforcement

A law enforcement plan should be an integral part of the overall management plan. All lands should be covered through a joint enforcement plan and patrol. The beach and estuary are areas requiring special attention. To manage the resource effectively, a high level of enforcement is necessary. This would include a high enforcement profile on the part of the Forest Service.

7. Beach status

The short stretch of beach from Galloway Road south to the estuary outlet should be closed year around to ORVs and enforced. This will provide a beach area for pedestrian recreationalists to enjoy without vehicles passing immediately by them. The majority of the Sand Lake area is open to ORVs so a small closure for another recreational pursuit seems reasonable. It may promote safety and reduce user conflict.

This closure would protect the estuary from ORV traffic which is a necessary condition for upland ORV use. Regarding erosion, it is advisable to keep vehicles away from the outlet area (Komar, 1978). Also, the snowy plover nests on the spit area and should be protected from disturbance during that period (April through June). Pedestrian disturbance should be discouraged by posting it as a nesting area.

It is a viable closure since the area is readily identifiable (where Galloway Road intersects the beach south to the outlet). It could be posted and enforced. Also, the adjacent foredune should be enforced as a closure forming a viable buffer between the general ORV activity and the estuary.

The protection of the estuary and its wildlife, public safety, and increased user compatibility all warrant this closure. Simply, if this buffer is not established and enforced, ORV activities will continue in and around the estuary which is a violation of the Estuarine Goal.

8. Residential protection

On peak-use weekends a peace officer with the power of arrest should be assigned solely to patrol Galloway and Derrick Roads offering protection to private property against trespass and harassment.

9. ORV practice area

An ORV practice area for children or others learning to operate an ORV should be established. The deflation plain and the small dunes nearby (north Galloway Road and between the foredune and gravel parking area) may be suitable. It is relatively flat, but offers some small dunes to learn on and is close to the campground so parents can check on their children. This concept is to promote fun for the children, peace of mind for the parents and relative quiet in the campground. Few people enjoy hearing someone drive endlessly through a campground.

10. Environmental monitoring program

A program should be developed that monitors changes in vegetation and sand movement. Aerial photography may be a useful technique. Also the snowy plovers status could be monitored.

IX. COASTAL ORV AREAS

The vast majority of ORV use on the Oregon coast occurs on or within the Oregon Dunes National Recreation Area, Sand Lake in Tillamook County, the north spit of the Coos River and the beaches open to vehicles. The areas described and mapped (by county) are typically those of heavy use and large size. Small, lightly used areas are not generally included, however, they may be significant in regard to erosion (see Maps 1-25).

The areas mapped were identified by one or more methods: aerial photography (from ODOT and ERSAL), a flight from Newport to Brookings, field observations (from vehicles and on foot), and interviews with various ORV clubs.

The topographic maps indicate <u>generally</u> the locations of areas used by ORVs, not necessarily the actual boundaries of such use. The various beach zones are <u>not</u> indicated on the topographic maps. To determine the vehicle status of a beach area refer to the Oregon State Highway Commission's maps. If a beach is open, one can assume it will be used by ORVs to some degree.

Finally, identification of areas suitable for ORV use should be done carefully on a case by case basis including coastal and statewide coordination to balance regional supply with demand. Coastal ORV use should not be totally separated from that of the rest of the state. Presently, there seems to be a need for a major non-coastal ORV area near the large metropolitan areas (Portland area).

Coastal areas that are <u>potentially</u> suitable for an ORV designation, are crosshatched on the topographic maps. The areas identified are already in use with one exception. The mapped areas are <u>not</u> the only open sand areas potentially suitable for an ORV designation. The mapping and determination of ORV access corridors should be done on an individual basis so they are not mapped. The final determinations of ORV designations require careful planning and management decisions locally and regionally that are beyond the scope of this work.