ECOSYSTEMS IN BRITISH COLUMBIA AT RISK

Coastal Sand Dune Ecosystems in British Columbia

Most coastal dune ecosystems occupy only a few hectares each

BRITISH COLUMBIA | Ministry of Environment

What are Coastal Sand Dune Ecosystems?

Occupying areas of open sand bounded by the ocean and the forest, these sparsely vegetated ecosystems struggle for existence. Both the front and rear boundaries of sand dune ecosystems are determined by the sea: no vegetation can grow within reach of the salty waves, and tree growth is only possible away from the burning salt spray.

Dunes bear the full brunt of coastal winds, which move the loose sand, burying plants or exposing their roots. Fully exposed to the sun, the sand surface can get up to 50 or 60°C on a cloudless summer day. Between this heat and the sand's low capacity to hold water, the surface layers quickly dry out after a rain. Any available nutrients – from sea spray, windblown seaweed, seabird droppings, or decomposing plant material – are also quickly leached out by the rain.

This harsh dune environment changes from front to back, creating a variety of unique habitats. On the exposed, high-energy west coast of British Columbia, sand movement is high and the dunes are extensive, with distinct vegetation in each zone. On the upper beach you'll see hardy annuals, like beach pea and coastal strawberry, which are very tolerant to sand burial and salt spray. Immediately behind the upper beach rises a ridge of sand, called the foredune ridge, occupied by dune perennial grasses such as dune wildrye. Behind the foredune ridge you sometimes find a damp trough or *slack* that is scoured out by the wind as it sweeps down the back of the foredune. The wind removes the dry surface sand and leaves the heavy, damp, sub-surface sand in the slack, providing a safe "nursery" for dune plants to germinate and establish.

Rolling plains of loose sand with very sparse vegetation, including large-headed sedge and dune bluegrass, occur further back in the dunes. Then the sand rises up in a great ridge crowned by inland plant species that are tolerant of some salt spray and sand movement, such as mat-forming kinnikinnick and hardy salal. Mosses and lichens are also able to colonize the stabilized sand and form an important though fragile part of the ground cover. Dominated by salt-tolerant Sitka spruce, the forest begins behind this ridge.

Caught in the ever-changing contact zone between the ocean and the continental land mass, sand dune ecosystems have a dynamic history.

Along the inner coasts of the Strait of Georgia, the dune environment is milder, and in many places the forest begins immediately behind the foredune. Spits make up a significant part of the sand dune environment on the inner coasts, with species like silver burweed, large-headed sedge, and sea rocket growing alongside the ever-present dune wildrye.

In a few areas the dunes are more developed. Here, the foredunes are dominated by dune wild-rye and/or large-headed sedge, and in the damp *slack* areas you can find black knotweed and yellow sand-verbena, both species at risk in British Columbia.

One at-risk dune ecosystem, known only from Savary and Sandy islands, is dominated by two sand-binding species, northern wormwood (a relative of the more aromatic sage) and a delicate native red fescue. These species are accompanied by a variety of early spring wildflowers such as blue-eyed Mary, seablush, seashore lupine, nodding onion, redstem spring beauty, and the rare, minute, contorted evening-primrose.

What is their history?

Caught in the ever-changing contact zone between the ocean and the continental land mass, sand dune ecosystems have a dynamic history.

In the last million years, several ice ages have affected British Columbia. Globally, glacial ice tied up enough frozen water to result in a lower sea level while the weight of the ice depressed the continental landmass causing lower land levels. During deglaciation, the rise in sea level is faster than the rebound of the depressed continent and in the most recent deglaciation this resulted in a relative sea level up to 200 metres higher than present day sea level. Thus, sediments that were originally deposited under water are exposed and available for erosion and redeposition.

Also during this last glaciation, ice over a kilometre thick flowed out of the mountains into the sea. It scoured and eroded the landscape and carried with it massive amounts of sediment. As a result, British Columbia's coastline has been carved into rocky, steep-walled fjords with a few areas of gentle shoreline topography constructed of thick deposits of sand and gravel.

Survival is the first order of business for dune plants

In the period of de-glaciation, outwash plains existed where melting

ice and melt-water streams deposited thick layers of sands and gravels along the coastline and in the Strait of Georgia. These glacial deposits, located both above and below sea level, are the most recent sediment source from which our coastal sand dunes and beaches are formed.

Sandy seaside cliffs are gradually eroded by waves and weather, and this material, along with the underwater deposits, is moved around by ocean currents and waves. Whether and where these deposits end up on shore depends upon the direction, intensity and size of ocean winds, waves, currents, and tides. The balance of these forces changes over time, leading to long periods of active beach-building alternating with periods of stability and erosion. Prevailing winds pick up and transport exposed shoreward sediments and redeposit them inland. This leads to the dynamic formation and migration of sand dunes.

Currently, beaches on Vancouver Island's west coast are accumulating sand and growing seaward by 25 centimetres a year, while Savary Island sand cliffs are eroding at a rate of 25-45 centimetres per year.

How do they function?

Survival is the first order of business for dune plants as the harsh, dynamic dune environment eliminates all but the hardiest coastal species. Dune plants use a variety of survival mechanisms from dormancy, to outrunning sand burial by growing up and out, to growing hairy or waxy leaves that reflect burning sunlight, or deep roots that access moister, cooler layers of sand. Some plants swell up with water to dilute effects of harmful salt spray or have special membranes to prevent absorption of salts into their cells.

A walk inland from the water through the dunes and into the forest is actually a walk back in time

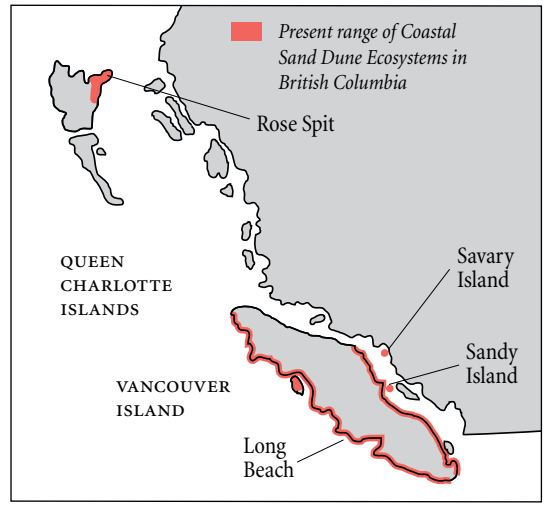
Dune plants survive the hot, dry summer by completing their flowering in the spring, and spending the summer in seed form. They germinate only in damp slacks in the fall, behind the protective foredune, and grow in the wet, cool fall and winter. To cope with a lack of nutrients in the soil, some plants form symbiotic relationships with nitrogen-fixing soil bacteria or with mycorrhizal fungi to obtain nutrients. Other plants focus energy resources on seed production rather than vegetative production, ensuring survival of the species in the unforgiving enviroment.

Dunes are a great place to observe the interactions between species and their environment. Dune plants affect the dune environment by creating the vertical topography of the dunes. Because sand accumulates on any obstacles such as plants and washed-up seaweed on the upper beach, the resulting network of old buried roots, stems, and leaves stabilizes the sand to form the foredune ridge, with an accompanying trough behind it. This ridge and trough system may be stationary or "migrate" inland as sand gets blown off the front of the dune and on to the rear slope of the ridge.The ridge may break up, with parts moving inland or eroding, and others staying where they are, creating a complex mosaic of sandy hills, valleys, and plains.

Because beaches and dunes are built from the shoreline inward, a walk inland from the water through the dunes and into the forest is actually a walk back in time. As dune plants grow and die, and their remains accumulate in the soil, both the nutrients and the water-holding capacity of the sand increase. The further back you go in the dunes, the better the soil gets. The change is relatively small but it makes it possible for somewhat less salt-hardy but more competitive species to establish in the area.

Over time, as dune migration or seaward dune growth creates distance from the salt spray, the dunes are eventually colonized by inland mosses

plants, and shrubs, and finally the coastal forest takes over. But the remnants of dune dynamics are still apparent in the parallel ridges and troughs that you can sometimes find in the forest behind the dunes. Examples of ancient stabilized dunes that are now forested are the Sitka spruce forests at Naikoon Park and the ridge top western hemlock and lodgepole pine forests found on Savary Island.



Where do they occur?

There are three major concentrations of coastal dune ecosystems in British Columbia. The west coast of Vancouver Island has a number of significant beach and dune systems scattered up and down its exposed coast. Most notable among these is the 16-kilometre Long Beach between Tofino and Ucluelet. At the northern end of Vancouver Island, there is another extensive beach and dune system, appropriately called "Sand Neck," which joins Cape Scott (formerly an island) to Vancouver Island.

The second concentration of dune ecosystems is the southeast coast of Vancouver Island and adjacent islands in the Strait of Georgia. Among the most important dune habitats in this area are the sandy spits, such as Sidney Spit, beaches such as Island View Beach, and a few unusual islands formed from ancient sand deposits such as Savary Island.

The third and most spectacular concentration of dune ecosystems is on Graham Island in the Queen Charlotte Islands. The northeast quarter of the island is made up of deep glacial deposits that provide ample raw materials for beaches and dunes. The ocean currents erode sand from seaside cliffs and move it northward along the east coast of the island, eventually forming the 20-kilometre Rose Spit. From there the currents move sand west toward Masset, forming more beaches and dunes. Altogether there are about 85 kilometres of almost continuous beaches and dunes wrapped around the northeast tip of Graham Island.

What makes them special?

Ecosystems at risk often contain concentrations of species that are at risk, and sand dunes are no exception. Though our dune ecosystems typically have few plant species compared to other ecosystem types, a much higher proportion of dune plants are listed as at risk in British Columbia. As well as those at-risk plants already mentioned, pink sand verbena, beach groundsel, grey beach peavine, beach bindweed, dune bentgrass, seashore lupine, and sand-dune sedge occur on our coastal dunes.

A much higher proportion of dune plants are listed as at risk in British Columbia

Our dunes also provide an interesting example of a rare animal that is dependent on a rare plant that is dependent on a rare ecosystem. The rare plant species, yellow sand-verbena, is the host for a rare species of cutworm moth, or sand verbena moth. This moth lays its eggs on yellow sand-verbena, and the larvae, or caterpillars, feed exclusively on the plant. Since the larvae emerge at the height of summer, they must burrow into the sand during the day to avoid the heat, feeding only at night. They bury themselves for the winter while their food is not available. When they are ready to mature, they construct a cocoon out of sand particles stuck together, and finally emerge as adult moths in early summer, ready to repeat the life cycle.

Sand dune ecosystems are special to humans for their open spaces and scenic views of the adjacent sea and forest. It should be no surprise that about a million people a year travel from all over the world to visit the dunes and beaches of Pacific Rim National Park Reserve. The other accessible beach and dune ecosystems in British Columbia parks are also very popular with visitors, with seaside campsites being reserved months in advance. The benefits to the tourism industry are significant, as are the less tangible benefits to the millions of visitors of fresh air, exercise, and the enjoyment of the beauty of nature.

Why are they at risk?

The most obvious threat to our dunes is outright destruction. Due to their desirable location, some dune areas have been lost to development, especially on the southeast coast of Vancouver Island and adjacent smaller islands.

A more widespread and gradually harmful threat is the disruption of the sand supply. Roads, buildings, shoreline armouring, breakwaters,

sand stabilization, and even drift logs can interrupt the flow of sand that maintains sand dune ecosystems.

Other culprits of dune disruption are invasive non-native (alien) plants. European beachgrass was deliberately introduced to North America in the early 1900s to stabilize dunes that were threatening to engulf waterfront property and infrastructure. This plant builds up tall and stable foredune ridges that cut off the landward movement of sand, while at the same time crowding out native dune grasses. The low, relatively unstable foredune ridges formed by native dune wildrye are disappearing, not only in British Columbia but along the entire Pacific coast from Alaska to Mexico.

SAND-BINDING NORTHERN WORMWOOD AND NATIVE RED FESCUE DOMINATE A RARE DUNE ECOSYSTEM ON SAVARY ISLAND. *L. Webster photo*

Destabilization of dunes is also a serious threat. Destabilization is caused by damage to the vegetation and the stabilizing network of underground roots and rhizomes. All-terrain vehicles are still being used on the dunes of Graham Island, though efforts are now being made to reduce their impact on the vegetation.

A less obvious but more common destabilizer is the many feet that walk on our dunes. One stroll through a dune may not cause much damage, but when multiplied by millions of visitors every year, the resulting damage can be significant, and recovery can take a long time in the harsh dune environment.

What is their conservation status?

The relatively few gentle coastline areas explain the natural rarity of coastal sand dune ecosystems. We do not know the exact area of coastal sand dune ecosystems in British Columbia, but according to a recent study, the significant dune ecosystems on the west coast of Vancouver Island cover an area of only 104 hectares (a quarter of the size of Vancouver's Stanley Park). We estimate that most coastal dune ecosystems occupy only a few hectares each throughout the province, and many are at risk.

The dynamic nature of dune ecosystems makes protecting them a challenge

Fortunately, governments have recognized the benefits of keeping beach and dune ecosystems public, so many dune ecosystems have been preserved in parks, especially on the outer coast of Vancouver Island and on Graham Island. Nearly all sand dune ecosystems in these regions still exist. The situation is different for some dune ecosystems along the Strait of Georgia. Only a few areas have been protected and many have been lost to development or continue to be threatened by ongoing development, overuse, and invasive alien plants.

How can we protect them?

Over a dozen national, provincial, and local parks currently provide some protection of sand dune ecosystems throughout British Columbia. However, there are ecosystems, primarily along the southeast coast of Vancouver Island and in the Gulf Islands, that are still not protected. Although these dune sites occupy a small area, they make up a significant proportion of the sand dune ecosytems in British Columbia and are representative of unique dune vegetation types. Wherever possible dunes should be preserved to ensure their future survival, including preservation of nearby sand sources such as eroding cliffs.

Once protected, dune ecosystems require careful stewardship to compensate for unnatural disturbances caused by recreational use. If you are a visitor, take care to avoid treading on the sensitive dune vegetation and respect fenced-off areas that may be especially vulnerable or need time to recover from past use. If you are a land manager, support research on dune dynamics. More research into the way dunes change and develop will help dune stewardship to be as dynamic and responsive as dune ecosystems are themselves.

A much more difficult stewardship problem is controlling invasive alien plants. Removing these plants is very labour-intensive and requires continued diligence. You can help by preventing the spread of alien species onto sensitive dunes, by participating in organized invasive plant-removal parties and by joining community groups dedicated to stewardship of local parks.

RESTORATION SITE OF PINK SAND VERBENA AT PACIFIC RIM NATIONAL PARK. *D. Meidinger photo*

SAND NECK DUNES AT CAPE SCOTT PROVINCIAL PARK. *BC Parks photo*

SAND-VERBENA MOTH
N.A. Page photo

DIMINUTIVE CONTORTED EVENING PRIMROSE ON SAVARY ISLAND.
L. Webster photo

VEHICLE TRACKS THROUGH DUNE VEGETATION.
Sensitive Ecosystems Inventory: East Vancouver and Gulf Islands, MELP, CWS photo

SAND-VERBENA MOTH LARVAE FEEDING ON RARE YELLOW SAND-VERBENA.
N.A. Page photo

If you are a private land owner with dunes on your property, avoid activities that will damage dune vegetation or impede the flow of sand. In particular, locate roads and buildings outside the dune zone to avoid creating a situation where artificial stabilization of the sand is required to protect your property, and remove existing artificial barriers to sand flow.

The dynamic nature of dune ecosystems makes protecting them a challenge. Dune ecology is based on a fine balance between sand stabilization and sand movement. Because long-term changes in sea level, weather, and currents will continue to change dune ecosystems as they have in the past, the goal of dune stewardship is not to preserve dunes exactly as they are now, but to maintain the natural processes and native species that form these irreplaceable ecosystems.

FOR MORE INFORMATION ON SPECIES AND ECOSYSTEMS AT RISK, CONTACT:

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