MacKerricher State Park

Photo: 2002–2012 Kenneth & Gabrielle Adelman – Adelman@Adelman.com

Dunes Formation

Features:
Coastal geomorphology, and geobotany

Sand supply, shore topography, climate, and vegetation determine the location and features of sand dunes. Each of these variables is sensitive to climate change and sea-level fluctuations. Along the California coast up to four major phases of dune formation have occurred since the middle of the Ice Ages (mid-Pleistocene—roughly one million years ago), continuing to about 4,500 to 7,000 years ago and coinciding with a climate period known as the mid-Holocene warm period and its aftermath. More recent phases of dune activity have partially concealed or obliterated earlier dune formations.

In MacKerricher State Park, the mid-Pleistocene and mid-Holocene phases have been recognized. Subsequent periods of dune formation occurred approximately 500 to 550 years ago, 936 years ago, during what is known as the Medieval Climatic Anomaly, and about 1,550 years ago. Modern dune processes continue to modify the ancient dunes.

Coastal dunes generally form downwind of major river mouths and against the northwest face of westward extensions of the rugged coastline that block the wind and sand. Coastal streams supply the sediments that are deposited in their deltas.

What you can see: Dune fields extend from the mouth of Ten Mile River four and a half miles southward to Lake Cleone. Streams that have been able to maintain flow to the ocean through the dunes divide the dunes into three lobes, producing unique peripheral wetland habitats such as Sandhill Lake and Inglenook Fen.

The sediments are moved from beneath the water and onto land in two primary ways. Waves and currents, especially in the summer, push the sand ashore onto beaches where the wind then blows and moves finer grains. To the north of the park, sand from the mouth of the Ten Mile River is washed ashore and feeds the dunes.

On a vastly different timescale, relative drops in sea level during glacial periods and sporadic coastal uplift periodically exposed parts of the continental shelf and deltas to wind erosion. The flat, broad coastal terraces of the ecological staircase at Jug Handle State Park beautifully show how dramatically relative sea level and land elevations have changed over the past millennia. Subsequent rises in sea level further propelled the sand landward.

Windborne sand is initially deposited around obstacles such as rocks, kelp, debris, and annual plants. As the wind velocity slows around these objects, it drops its load of sand. The initial dune formation begins with small transitory tongues of sand that form on the beach. Sometimes these usually temporary tongues can continue to accumulate sand around plants and form “embryonic dunes” located beyond the upper limits of wave action. As the dunes accumulate sand, the moderate onshore summer winds dry the sand and transport the lightest grains inland. Winds move the sand particles by blowing them up and over the windward (facing the wind) dune slopes. The sand grains are then deposited on opposite (leeward) dune slopes where they are sheltered from the wind. The wind blows the dunes into a series of wave-like dunes. Dunes migrate downwind until stabilized by moisture and vegetation or blocked by obstacles such as forests or steep slopes. Changes in vegetation or climate can remobilize dunes. Streamflow in Inglenook Creek—which forms the fen—adequately flushes advancing dune sand and maintains the drainage to the ocean.

Why it's important:
MacKerricher State Park and the Ten Mile Dunes complex contain a unique, relatively pristine native dune and wetland ecosystem.

The effects of climate change over the past several thousand years have been recorded by sediment deposits along the coast. Recurrent periods of dune formation and sea level oscillation have been associated with the Ice Ages and more recent climatic events. These shifting sands of time produced enclosed areas of water ponding that became vegetative microclimates such as Inglenook Fen and Sandhill Lake. The difference between a fen and a bog is that a fen has through-going drainage while a bog does not. Inglenook Fen contains an assortment of plants and insects that are otherwise found to the north from Oregon to British Columbia. The fen is a piece of the puzzle of how climate change induces habitat fragmentation—a key evolutionary concept.

This equilibrium is delicate, and minor changes in climate and stream flow can disrupt the precarious balance.

Fen Formation

Over the past millennia, natural depressions have formed between the active dunes. The depressions collect water that drains from adjacent uplands. Vegetation establishes in these nascent wetlands receiving nutrients from both runoff and groundwater and over time the wetlands can mature into bogs and fens. A fen is a nutrient-rich wetland which is fed by groundwater.

There are two pathways along which these wetlands mature. One is the progression of an aquatic community to a dryland community. Silt and organic matter accumulate around aquatic plants and create a suitable medium for the growth of fen vegetation. In areas where the water is well-oxygenated and contains a high level of nutrients, the fen vegetation vigorously builds up the soil, which eventually supports a wooded swamp of small tree species, such as willow and alder.

The other pathway to maturity involves the accumulation of organic material that effectively raises the bottom of the bog. This impedes drainage, causes water levels

to rise, and allows the bog to expand laterally. Slack water stagnates, becoming oxygen-depleted and acidic enough to be nearly sterile. The accumulating organic matter does not rot due to the general lack of decomposing bacteria and oxygen. Instead the organic matter (known as “sphagnum moss” or “peat moss”) compresses under its own weight to become “peat”, a juvenile fossil fuel.

Inglenook Fen

Inglenook Fen is the only known coastal fen in California. It provides habitat for numerous listed species—Menzies’ wallflower (*Erysimum menziesii spp. menziesii)*, Howell’s spineflower (*Chorizanthe howellii*), and numerous other special status plants. Howell’s spineflower is found nowhere else on earth.

Photo: Mike Fuller

To explain the unusual presence of plants of more northern affinities in the fen, some have postulated that the fen has provided a microclimatic refuge for its assortment of plants since the last Ice Age (over 11,000 years ago). But preliminary radiometric dates of peat samples taken from near the bottom of the fen suggest formation at 1,000 to 2,000 years ago, and thus do not support the refugia notion. In the park, the oldest discovered peat deposits were found at Lake Cleone and formed approximately 7,000 years ago. Whether the shifting dunes cover even older wetland deposits is unknown. So the mystery remains.

Final Thoughts

Often geological processes such as dune formation create the topography where organisms eventually find suitable habitat. The fen provides an excellent example of a reverse process where life creates its own environment and becomes a geological force.

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Prepared by California Geological Survey, Department of Conservation | www.conservation.ca.gov/cgs
for California State Parks | www.parks.ca.gov

Geological Gems of California State Parks, Special Report 230 – Fuller, M., Brown, S., Wills, C. and Short, W., editors, 2015 Geological Gems of California, California Geological Survey under Interagency Agreement C01718011 with California State Parks.