Jug Handle State Natural Reserve and Van Damme State Park

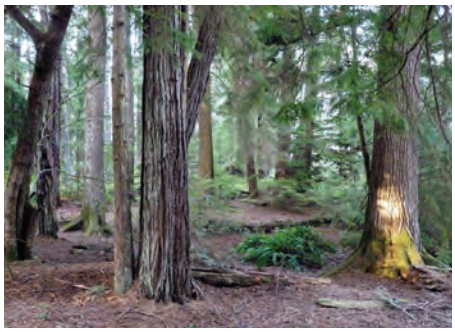
Photo: 2002–2012 Kenneth & Gabrielle Adelman – Adelman@Adelman.com

Plate Tectonics

Features/Process:
Coastal geomorphology, and geobotany

At the edge of the continent, Jug Handle State Natural Reserve and Van Damme State Park occupy the boundary zone between the North American and Pacific tectonic plates. At first, the North American plate overrode the oceanic crust of the Pacific plate, then shifted motion to a lateral grinding that continues to push up the bedrock. The bedrock exposed was scraped, bent, buried, exhumed, and eventually mashed against the North American continent. Bedrock in this region, known as the Franciscan Complex, consists mainly of greywacke (sandstone composed of quartz and feldspar grains incased in a clayey matrix that has been slightly cooked and squeezed).

This segment of coastline has risen for about 500,000 years at an average rate of two to three centimeters per century. Movement within the San Andreas Fault zone, which lies about 3.5 miles offshore, contributes to the tectonic uplift.

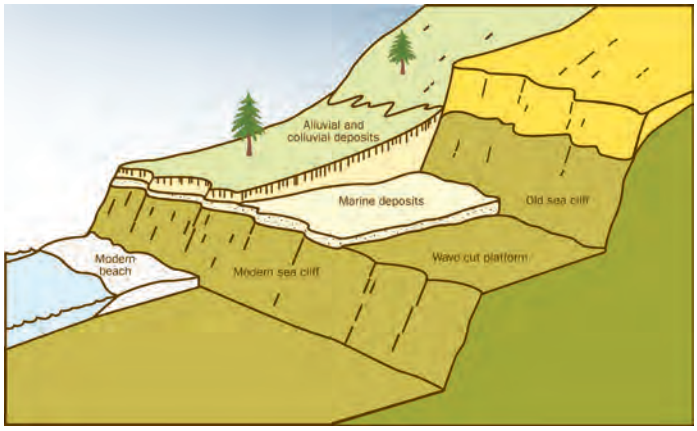


What you can see:

Jug Handle State Natural Reserve and Van Damme State Park host a "staircase" of five wave-cut marine terraces formed as a result of tectonic uplift and sea level fluctuations associated with glacial and interglacial periods over the last 500,000 years. Each terrace or "step" contains different ecological communities. The higher steps in the staircase contain "pygmy" forests of miniature bonsia-like trees.

Marine Terraces Formation

Ocean waves eat away and abrade bedrock surfaces at sea level, gradually creating a gently sloped underwater platform. Steep sea cliffs mark the junction of ocean waves and land. The dynamics between tectonic uplift and sea-level fluctuations created multiple marine platforms (terraces) carved into the Franciscan bedrock.



Marine terraces consist of a wave-cut bedrock platform (bench) with a thin, discontinuous blanket of marine and younger non-marine deposits. The origins of the terraces are tied to changes in climate and associated fluctuations in eustatic (worldwide) sea level during the Pleistocene epoch 11,000–1.1 million years ago. Modified from Weber and Alwardt, 2001.

The terraces record the interaction of the slowly rising land with comparatively rapidly fluctuating sea levels. Sea level reacted to the major advance and retreat of glaciers worldwide during the Ice Ages. Sea levels rose during glacial retreats and cut terraces into the coast which were slowly uplifted to their current elevations. With time, sediment from the surrounding uplands spread across on each terrace and its overlying marine sediments creating an additional top layer. The highest terrace in this area is 650 feet above sea level and rising.

Why it's important: Some lands are preserved for their scenic beauty or wilderness qualities, but others, such as the pygmy forest, are protected because they are ecologically unique. The sequence of terraces provides a 500,000-year-long timeline of soil and plant community development that demonstrates the interplay of biology and geology like nowhere else.

The terraces support prairies, coastal scrub, bishop pine forest, north coast mixed forest, and pygmy forest. The age of each of the five terraces increases with elevation. Very old soils mantle the uppermost oldest terraces. Soils on these terraces have been leached of minerals (such as calcium, magnesium, potassium and sodium) over hundreds of thousands of years and have formed a hardpan layer cemented with iron oxide impermeable to roots and water. The nutrient-starved plants that do grow are stunted.

Ecological Staircase

Each "step" (terrace level) of the "staircase" supports a different ecological community depending on the distance from the ocean and the soil type and age. The lowest step in the staircase is the submerged terrace which is still being formed. Kelp, fish, and intertidal communities populate the overlying shallow water.

The second step is the first, elevated terrace (on land). It is the broad, flat bluff overlooking the Pacific Ocean. Rich black, organic soil tops the terrace and supports lupine, poppy, grass and other perennial shrub species. Tree growth is retarded by the salt spray brought by onshore breezes. Redwoods and Douglas-fir dot the eastern edge of the terrace, where salt conditions are tolerable. These trees grow well on the slopes that rise to the next terrace above.

Upper Terraces

On the upper steps (second, third, fourth, and fifth subaerial terraces), salt spray is not a limiting factor. Over the centuries, strong coastal winds have picked up beach sand and built dunes against the "riser" of each step. Forest vegetation eventually took hold in the dunes through a cyclical process of plant growth, decay, leaching and soil formation. High rainfall (currently 40 to 60 inches per year) percolated through the gradually accumulating organic litter (needles and leaves) and sandy substrate to make a slightly acidic layer of decomposed material called humus. As humic acid leaches nutrients from the humus, it fortifies the underlying sandy soils that nourish the conifer forest.

The midsections of steps consist of beach deposits but lack dunes. The dunes along the back edge impede drainage from the central area resulting in prolonged ponding and, in extreme cases, development of acidic bogs. Sphagnum moss grows in the stagnant bogs which become so low in oxygen and bacteria that dead moss does not decay; instead, it is compressed beneath new growth and becomes peat (a juvenile fossil fuel).

Outside of the bogs and dune areas, strange pygmy forests occur due to the unique soil conditions that stunt growth. Due to the poor drainage and prolonged leaching, the acidified surface soils are depleted of nutrients, while a nearly impermeable mineral hardpan forms beneath. The acidic and nutrient-poor conditions, coupled with shallow hardpan formation contribute to the stunted, sparse growth of the “pygmy” forest.

Final Thoughts

The ecological staircase and its story of soil development are famous among soil scientists and plant ecologists. Preeminent soil scientist Hans Jenny insisted that places like this should be granted status on a par with art museums and universities. Here, the long ago and far away advances and retreats of glaciers at higher latitudes caused sea level changes which along with tectonic forces formed the terraced topography upon which soil processes and life forces operate to create this unique geological and ecological gem.

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Photos: Mike Fuller (except where noted)

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