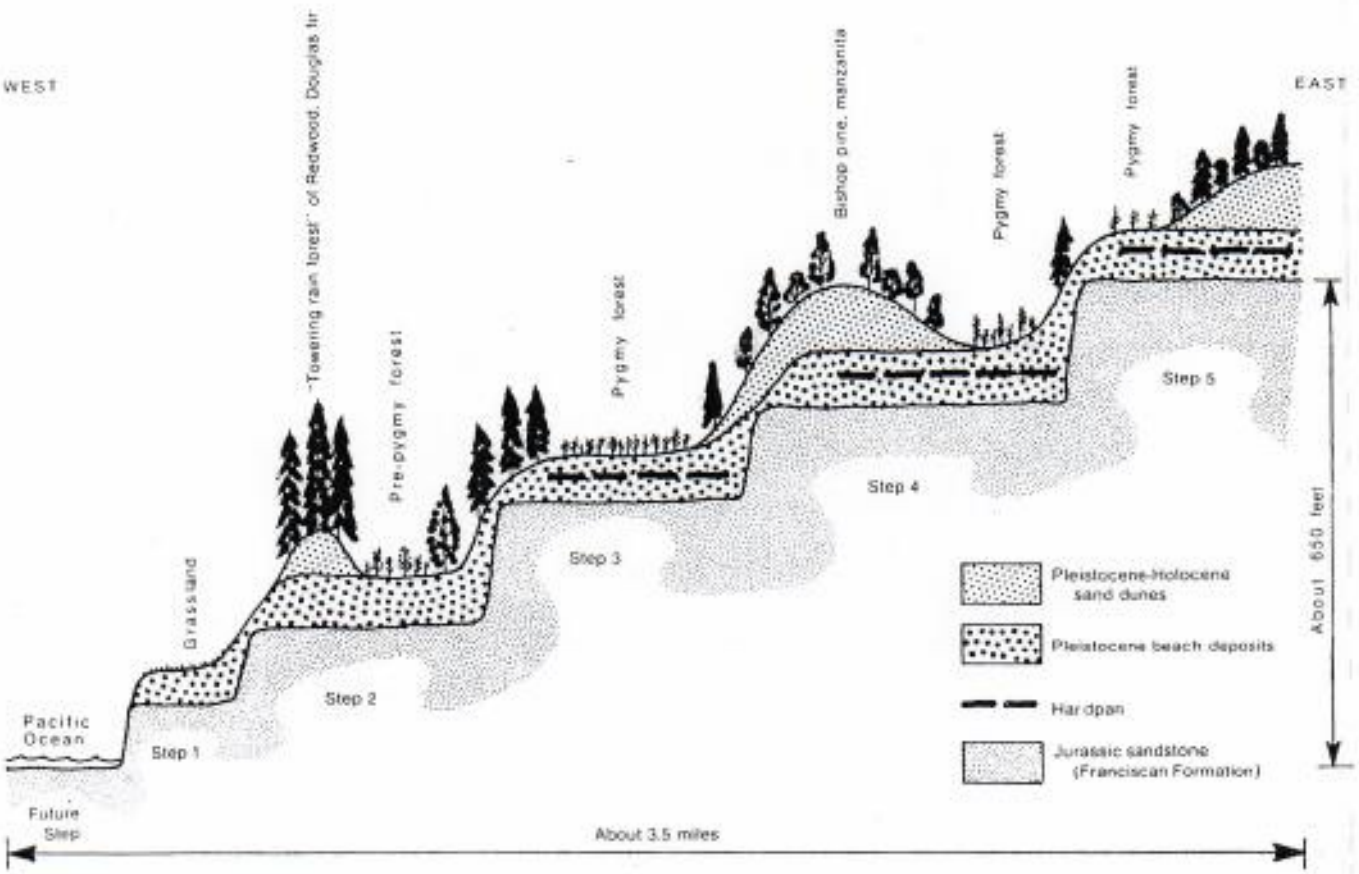
CGEOA 29(1) 1-24(1976)

Single copy 25¢

CALIFORNIA GEOLOGY

January 1976



PYGMY FOREST:

AN ECOLOGIC STAIRCASE

A PUBLICATION OF THE CALIFORNIA DIVISION OF MINES AND GEOLOGY

CALIFORNIA GEOLOGY

California Geology, the monthly publication of the California Division of Mines and Geology, reports on the progress of earth sciences, especially as California, and informs the public of discoveries of interest and concern to their lives and livelihood in geology, mining, seismology, paleontology, volcanology, and allied earth sciences. Correspondence to the editors should be addressed to California Geology, 1416 Ninth Street, Room 1341, Sacramento 95814.

The Division also publishes Bulletins, Special Reports, County Reports, the Geologic Map of California, the Mineral Resource Map of California, and other maps and information. A list of the Division's available publications will be sent free upon request. All orders for California Division of Mines and Geology publications, changes of address and subscriptions to California Geology should be addressed to the Division at P.O. Box 2980, Sacramento 95812. The subscription price for California Geology January through December is $2.00.

SECOND CLASS POSTAGE PAID AT SACRAMENTO, CALIFORNIA. RETURN POSTAGE GUARANTEED.

January 1976 / Volume 29 / Number 1

IN THIS ISSUE

COVERS

Front cover

Diagrammatic cross section of the pygmy forest ecologic staircase, Mendocino County, California. The unique ecosystem on Pleistocene marine terraces was created by the combined processes of tectonic uplift, climatic change, erosion, weathering, and soil development. The staircase has developed over the last 500,000 years and each step has formed over a time interval of approximately 100,000 years. The pygmy trees growing in the ecosystem that are 50 years old may be less than 4 feet high. The vertical scale of the diagram is approximately 28 times the horizontal scale. *Adapted from Gardner (1967).*

Back cover

Diagrammatic sketch of seismic refraction survey equipment and energy wave path through the ground. The waves are refracted upward from a more dense medium. Refracted waves are sensed by the geophones and converted into an electric current which is recorded on light-sensitive paper. Waves encountering the vertically displaced fault block will be delayed in being refracted and thus a time jump will be evidenced on the record. If this time jump is also recorded when the weight is dropped at the other end of the spread of geophones, then this time anomaly may indicate a vertical offset of the basement rock.

SOCIETY OF MINING ENGINEERS

"World Mining and Metals Technology" will be the focus of the 1976 Society of Mining Engineers Fall Meeting and Exhibit, 1 to 3 September 1976 at Currigan Hall, Denver, Colorado.

Leading mining and minerals engineers will be discussing the position of the mining industry in the world and relating recent technical advances.

Adding further international tones to the meeting will be the Third Mining and Metallurgical Institute of Japan (MMIJ) and American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) Joint Meeting.

General chairman of the SME Fall Meeting, which will feature a total of 33 technical sessions, is P.A. Meyer, manager of mineral commodity evaluation for the Rocky Mountain Energy Co., Denver, Colorado.

Of the 33 technical sessions spanning the three-day meeting, 15 are joint with the Japanese. The joint sessions will include papers by both Japanese and U.S. authors.

Japanese and U.S. companies alike have received information inviting them to exhibit at SME's 1976 Fall Meeting. As of this date, 15 percent of the Denver exhibit booths have been reserved.

For further information on programming or reserving exhibit space, contact Ruth Orologio, SME Meetings Manager, P.O. Box 8800, Salt Lake City, UT 84108 or call (801) 582-2744.

MINERAL AND SOIL RELATIONSHIP ON THE STAIRCASE

In the pygmy forest sector of the Mendocino coast the mass of Franciscan Formation graywacke sandstone which forms bedrock, has a ratio of about 18 feldspar granules to every 100 quartz granules. Fresh, unweathered sand derived from this graywacke sandstone will have this same proportion. Thus, on the ecologic staircase, quartz, which has no nutrients useful to plant growth, provides physical support, and feldspar provides plants with calcium, sodium, and potassium, all necessary nutrients for their growth.

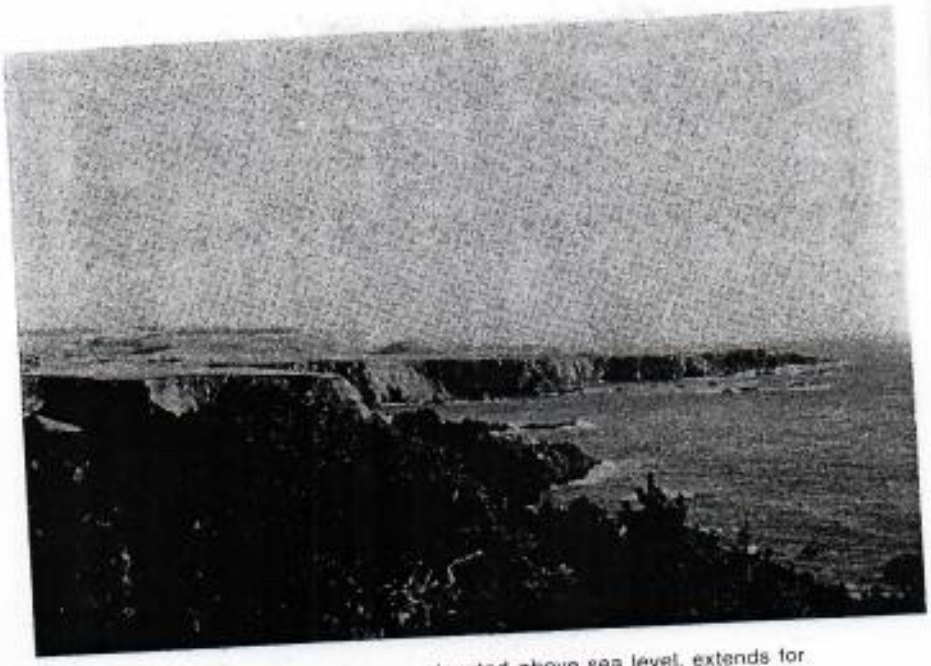


Photo 2. The first terrace, elevated above sea level, extends for many miles along the Mendocino County coast. Trees visible on the horizon (left center) occupy the second terrace. *Photo courtesy of Hans Jenny.*

The First Step

The "riser" of the first step in this staircase ecosystem is the sea cliff where the sandstone is exposed. The "tread" is the broad flat terrace that generally lies along the coastal bluff (photo 2). Where the exposure is fresh and unweathered, the black soil crowning the cliff contrasts with the lighter colored rock underneath. In the language of the soil scientist this black soil is known as prairie soil, like the classic soil on the prairies half a continent away. This prairie soil has the richness imparted by organic matter from the decay of roots, leaves, and stems of lupine, poppy, grass, and other perennial plants, which have renewed themselves annually over the centuries.

It has been suggested that the first terrace is grass-covered because Indians burned the trees off, or the early loggers cut the trees closest to the shore for easy shipping. The latter idea is disproved by photos from the 1860s showing the growth of grass and flowers and neither trees nor stumps. Black prairie soil develops over a long period of time—perhaps longer than the Indians have been around—and does not develop at all under coniferous tree cover.

Tree growth is not encouraged by the lashing salt spray that on-shore breezes bring to the first stair step. Redwoods and Douglas firs are found dotting the eastern edge of the terrace, where soil and wind contain the least amount of salt, and these trees grow up the riser onto the tread of the next step above.

All along the ocean front, real estate developers rate the first terrace as choice for gracious living. The green carpeting, dotted with blue, pink, and orange blossoms of wild flowers, leads the eye to the white surf and far out over the blue sea beyond. As an ecosystem, however, the first terrace of rich black soil is in a state of alteration and is a thing of the moment that would change before the eyes if one could watch it intently through a hundred millenia.

The Second Step

On the second step, about 200 feet above sea level and nearly 1 mile back from the cliffs, the salty wind no longer determines which plants will survive. Forests dominate this zone, and the soils reflect their presence. Conversely, changes in the soil are beginning to have their influence upon the welfare of the forest. The term "towering rain forest" is better applied here than on any other terrace.

This second step has distinct remains of sand dunes on its seaward edge—distinct in configuration, at least, although internal change has taken place. In the hundreds of thousands of years that the step has been forming, the high rainfall (40 to 60 inches per year) and the constant shower of needles and leaves from the stately redwoods, firs, and hemlocks have masked the sand that blew in long ago.

Weathering has darkened the sand and altered some of the feldspar to clay, changing the ratio of 18 parts feldspar to 100 parts quartz. Decay of the needle-and-leaf compost has made a humus zone on the ground surface that slowly imparts nutrients and a moderately acid reaction to the soil body. The dune has become a favorable site for timber, because of the influence of the rainfall and the cover of the awesome giant redwoods, themselves.

The midsection of the second terrace is duneless. The soil is developing directly in the beach deposits that rode the step from the beginning of its ascent. The rim of dunes along the edge has cut off surface drainage from this central area and has even enhanced its wetness by releasing internal moisture onto it through seepage of springs. The result is a prolonged season of soaking until the short summer arrives and everything becomes so parched that one wonders how plants accustomed to moisture could have adjusted.

All of the events that have formed more completely in the midsections of the third, fourth, and fifth steps have begun at the position of the second step. Cypress clumps and bishop pines are present here, but are less obvious than the sphagnum bogs and pygmy forests on the higher steps.

the association along with Labrador tea, salal, rhododendron, and huckleberry. All are small, and most of the plant population show further effects of poor nutrition in die-back symptoms, infestations of dwarf mistletoe, and fist-sized orange-colored growths of pine-gall rust.

Here and there among the pygmies is a rarity of bishop pine that has sunk a tap root through a crack in the hardpan and grown to overshadow all else. Without such phenomenal luck the others are rooted only in the top half-foot of soil where they find little sustenance.

Commonly, the pygmy pine that has reached the century mark will lift its tip to a height of 5 to 10 feet on a trunk with a 2.5 inch diameter. A 50-year old cypress may be less than 4 feet high and less than 1 inch in diameter, anchored by a root system with a breadth of 1 foot (photo 4).

With branch growth measured at 1 inch per year, or even less, the Bolander pine barely paces the 1000-year-old bristlecone pine—the pygmy of the desert mountains (see p. 180, December 1974 CALIFORNIA GEOLOGY). No pygmy Bolander pine is known to be older than 300 years.

The wonder is that so many have lived so long on so little. Pygmy forests sog in winter, sear in summer. They subsist with chronic malnutrition and endure their diseases and infestations in the world's sourest soil. The one thing they are not is crowded.

Dr. Jenny describes the extreme pygmy forest condition on the staircase as species-poor and space-unsaturated with 1/4 of the ground area bare or covered with lichens. He sums up its significance by saying that the little forest and its podzol (soil) come as close to a terminal steady-state ecosystem as can be found in nature.

SOME UNANSWERED QUESTIONS

The pygmy forest anomaly has brought scientists from far places and the opportunity to see, learn, marvel, and teach has attracted over 2000 visitors per year. But the complete story is not known and many questions are still unanswered.

Photo 4. Waist-high pygmy trees may be older than the man. *Photo courtesy of Hans Jenny.*

Why are the podzols of the pygmy forest developed to such an extreme degree, compared to their European counterparts?

How did *Pinus bolanderi* accomplish the change in genes that took place while the soil material was becoming a podzol?

How can the towering redwoods and the dwarfed pines with their differing environmental demands exist as such close neighbors?

The questions yet to be answered will continue to intrigue ecologists, and the attraction will grow as long as the pygmy forests continue to ride the escalator intact.

PRESERVATION

The pygmy forest area is currently designated as a "Registered National Landmark", and the California Institute for Man in Nature, along with Dr. Jenny, advocates that a 900-acre Jug Handle Creek National Monument be created to give more protection to the ecologic staircase than the "Registered National Landmark" designation offers. In 1974 passage of a recreation bond issue gave hope that the area will be incorporated into the State Park System.

SELECTED REFERENCES

California Department of Natural Resources, 1950, Vegetation-soil (maps), Mendocino County.

Clark, B., 1970, Plant-soil relationships in the pygmy forest of the Mendocino coast: Unpublished report and M.A. thesis, University of California, Berkeley.

Critchfield, W.B., 1957, Geographic variation in *Pinus contorta*: Publication of Maria Moors Cabot Foundation Botanical Research, No. 3.

Gardner, R.A., 1967, Sequence of podsolic soils along the coast of northern California: Ph.D thesis, University of California, Berkeley, 226 p.

Gardner, R.A., and Bradshaw, K.E., 1954, Characteristics and vegetation relationships of some podsolic soils near the coast of northern California: Soil Science Society of America Proceedings 18, p. 320-325.

Jenny, H. 1960, Podsols and pygmies: a special need for preservation: Sierra Club Bulletin 8-9, April-May.

Jenny, H., Arkley, R.J., and Schultz, A.M., 1969, The pygmy forest-podsol ecosystem and its dune associates of the Mendocino coast: Madroño, v. 20, p. 60-74.

Mason, H.L., 1934, Pleistocene flora of the Tomales Formation: Publication 415, Carnegie Institute of Washington, p. 81-180.

Matthews, R.A., 1972, Mendocino's pygmy forest, a priceless and unique portion of California's ecology *in* Geologic guide to the northern Coast Ranges, Lake, Sonoma, and Mendocino Counties, California, Annual field trip guidebook of the Geological Society of Sacramento, p. 57-70.

McMillan, C., 1956, The edaphic restriction of Cupressus and Pinus in the Coast Ranges of central California: Ecology Monograph 26, p. 177-212.

McMillan, C., 1964, Survival of transplanted Cupressus and Pinus after thirteen years in Mendocino County, California: Madroño, v. 17: p. 250-253.

O'Day, M. and Kramer, J.C., 1972, The "coastal belt" of the northern California Coast Ranges *in* Geologic guide to the northern Coast Ranges, Lake, Sonoma, and Mendocino Counties, California, p. 51-56.

Rigg, G.B., 1933, Notes on a sphagnum bog at Fort Bragg, California: Science, v. 77, p. 535-536.

Westman, W.E., 1971, Production, nutrient circulation, and vegetation-soil relations of the pygmy forest region of northern California: Ph.D. thesis, Cornell University, 411 p.