Redwood | *Sequoia sempervirens*

Redwoods might just be the grandest plant in the plant world, from top to bottom, everything about them screams domination. The tallest redwood is 115+ meters tall and one of the most massive redwoods is a *mere* 97m tall but has a basal diameter of nearly 8m—those are some big #@?* trees! All of the tallest and most massive redwoods grow in northwest California where they prefer mountain slopes and valleys facing the sea and situated in the summer fog belt. In their chosen placement across the landscape other species are outcompeted when soil, water and exposure are optimal. Those that do associate with redwoods are one of a handful of conifers able to eke out an existence either in the shade of, or just outside the habitat of, these giants.

Compared to the former range of the species what forests are left are remnants of a once great dynasty. The history of the redwood goes back some 245 million years. As members of the former Taxodiaceae family (now incorporated into Cupressaceae) redwoods were once widespread across western North America. Diversification of this family came about in the Cretaceous, about 150 million years ago (Ma), where they became the most dominant of all conifers—across what would become both North and South America (though fewer species were in the south.) In the Tertiary, forests were vast and often dominated by as many as six species of redwoods. Plants evolved with *sempervirens*-like characteristics around 65 Ma. The two species that survive today in North America (*Sequoia* and *Sequoiadendron*) separated into these two genera about 36 Ma. *Sequoia* enjoyed mid-latitude growth in a climate similar to what it enjoys today—where it was the most widely distributed taxodiaceous conifer of the entire Cenozoic (Noss, 2000). About thirty million years ago, as the climate shifted and became drier and the redwood forests shifted too. Ultimately, the remaining relicts became restricted to the western Sierra (*Sequoiadendron*) and the Pacific coast (*Sequoia*).

Locations of redwood forests have continued to shift, particularly near the southern limit of the range. 40,000 years ago the species could be found near the site of present-day Santa Barbara (Noss, 2000). But today one must travel 100 miles north from that location to see the southernmost stand in a creek canyon microsite near the San Louis Obispo and Monterey County line. A grove of trees flourishes in this canyon and just one canyon south—no more redwoods. These forests span 1000 km from central California to southern Oregon. John Sawyer (2006) offers that while redwoods are relicts, the forests we see today are a recent phenomenon because only in the late Holocene, about 4,000 years ago, can one really begin to talk about redwood forests resembling anything like those we know today. If a redwood is on average 500 years old and these forests evolved into what they are like today 4,000 years ago what we witness while walking, say, on northern California's coast are only eight generations old! Now that is a dynamic forest.

The modern-day redwood groves encompass three forest regions described by Sawyer. In the southern part of its range, redwoods are restricted to specific microsites in cool coastal canyons often on the north aspects. The environmental gradients are steep and forests abut chaparral—the juxtaposition is quite a sight to see along the Big Sur coast. From Monterey Bay north to San Francisco the forests become more extensive. In the central part of the range, extending from San Francisco north to around Humboldt Redwood State Park, the climate is cooler and redwoods associate with Douglas-firs and various hardwoods including California bay, Pacific madrone, and tan oak. In the northern most part of the range, redwoods comprise pure coniferous forests that, in a sense, are similar to the Pacific Northwest rainforests of Alaska, British Columbia, and western Washington. In these unparalleled wonderlands, redwoods associate with Douglas-fir, grand fir, Port Orford-cedar, Sitka spruce, western hemlock, and western redcedar. All but the Port Orford-cedar and redwood are common in the temperate coniferous rainforests further north.

The northern most redwood forests growing along the Chetco River in Oregon and define a vegetation type one would expect to see between San Francisco and Eureka even though this region experiences an average annual precipitation which is higher than anywhere else in the range of the species. This is due in part to the fact that these trees are along an inland river valley. But why, with sufficient rain, do redwoods not grow further north into Oregon?

If the southern-most groves are apparently shifting northward, should the northern most groves be moving north? The answer will not be discovered in our life time, but my guess is probably not. Redwoods north of Crescent City are the only ones that grow within the Klamath Mountain Province. Because of steep topography and varied soil type in the Klamath Mountains, northward expansion would be inhibited for redwoods north from the Chetco—there is a stark band of serpentine that runs east to west from the mountains to the coast that provides an edaphic barrier for northward movement. Nutrient rich soils are a necessity for redwood success and Klamath Mountain serpentines offer a nutrient poor substrate—it appears redwoods are stuck where they are.

Redwood forests have been shaped by three important factors: fire, wind and floods. Fire in the foggy rainforest is not something one might consider likely. However, studies show that north coastal groves experience fire about every 250 years, and the drier groves—either farther south or inland—can experience fire as often as every 25 years. Fire events lead to quick propagation from "destroyed" stumps. Redwoods are one of the few conifers that have the ability to sprout vigorously—within months of cutting or burning. The root structure of the redwood has also evolved in response to wind and flood events. First, they lack deep taproots; with most roots close to the surface. This is beneficial in groves of trees along riverbeds, because a major flood might deposit ten feet of alluvium at the base of a tree. They are quick to send out roots below the new surface, simply shifting the root system upward. Second, roots of neighboring trees interlock. During windstorms each tree holds others in place, effecting mutual support.

Walking through a redwood forest in a winter storm—as trees sway with intertwined roots absorbing nourishing water from swelling streams—is a transcending experience. However, experiencing the forest floor is only part of the story offered by redwoods. Steve Sillett, of Humboldt State University, began pioneering research in the crowns of redwood trees in 1996. He discovered that there are literally forests within forests—often over 80m in the air! As the leaders die back in old-growth redwoods, at around 150 feet above the ground, new leaders begin to grow from the tops of the older trees. These "trees within the trees" begin to form their own forest floors as needles fall and collect in the crowns, are composted, and soil is created. These soils support the same understory as can be found on the forest floor with plants like huckleberries, salal, and hemlock. In one enigmatic tree named Atlas, Sillett and his coworkers found that soil was one meter deep in the nooks created by the reiterations (trees within trees) in the canopy—over 200 feet in the air!

Compared to other forests in northwest California, there is less biodiversity in redwood forests. This is probably due to the ephemeral nature of the redwood forests themselves and the fact that redwoods are such dominating trees—casting deep shade. It is difficult for plant to grow on the redwood forest floor and, while some plants are successful, these include only a handful of specifically derived species. Diversity is one aspect but the sheer biomass within these forests—in tons of plant material per hectare—is unparalleled. The redwood forest contains more above ground biomass (living and dead organic material) than any other forest on Earth.

Because the redwood invests heavily in the maintenance of heartwood, they have few natural enemies—like insects or fungus—that might weaken the tree. However, because of the monetary value of this biomass, a new living enemy has come to play. In the past 100 years, humans nearly devastated these cathedrals. Less than 5% of the old-growth forests that existed immediately before European arrival remains. Thankfully, because of the redwoods' adaptation to fire, old cut stumps often sprout vigorously. In logged areas this unique adaptation has saved the species. The forethought of others has established preserves throughout the range for visitors to revel in both old and new growth redwoods.

There are legends of ancient trees felled in the Humboldt Bay region that were larger than the largest giant sequoias of today—currently the largest of all living things. On such unfathomable tree, named the Maple Creek Tree, was reported to have been nearly 10m in diameter and 94m in height. If true, the volume would have been almost 1,800 m^3 (Noss, 2000). The volume of General Sherman in Sequoia National Park, considered the largest living thing, is 1,500 m^3. With only 5% old growth left to measure it is feasible that 120 m (400 foot) tall trees may have once existed.

Range* map for: giant sequioa (***Sequoiadendron giganteum***) redwood (***Sequioa sempervirens***)

** based on Griffin and Critchfield (1976) and Van Pelt (2001)*

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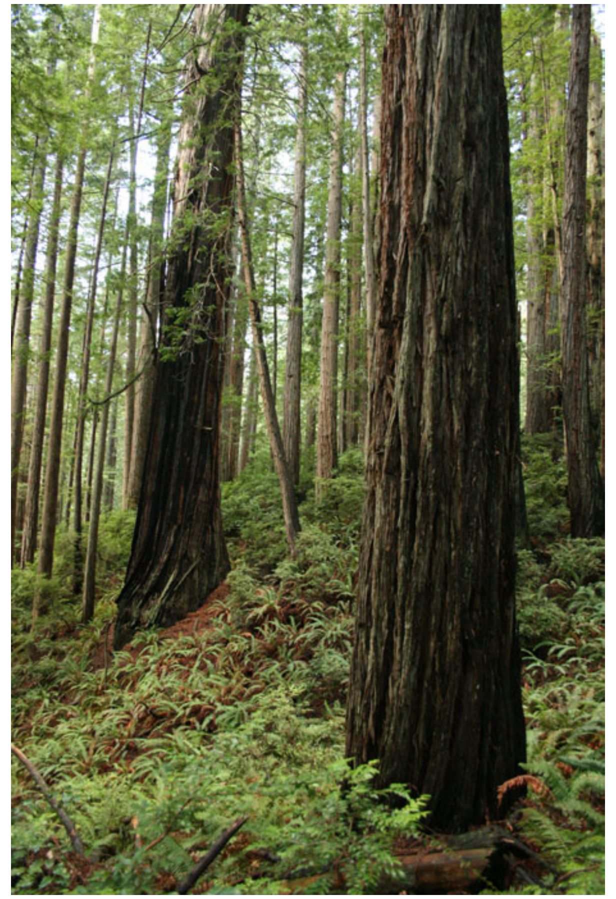
ABOVE: these needles and cones are common closer to the top of the tree

ABOVE: needles that are longer and broader are common closer to the ground.



RIGHT: typical North Coast old-growth redwood forest with sword fern in understory

Bark: Red when young to gray with age, long linear strips becoming deeply furrowed and highly variable with age, but distinct in all forms **Needles**: variable from top to bottom of tree; lower branches are straight, short, flat (max of 1 inch), tips are pointed, stomatal bloom is in two rows only on underside, upper needles are short, rounded and pointed. **Cones**: small (1.25 inches), barrel-shaped, brown, with scales that broaden from the base **Habitat:** cool, coastal, fog belt, 0-2000 ft **Range**: Southern Oregon south to just north of San Luis Obispo county line, generally live within 1 to 30 miles of the coast.