



SAN ANDREAS FAULT

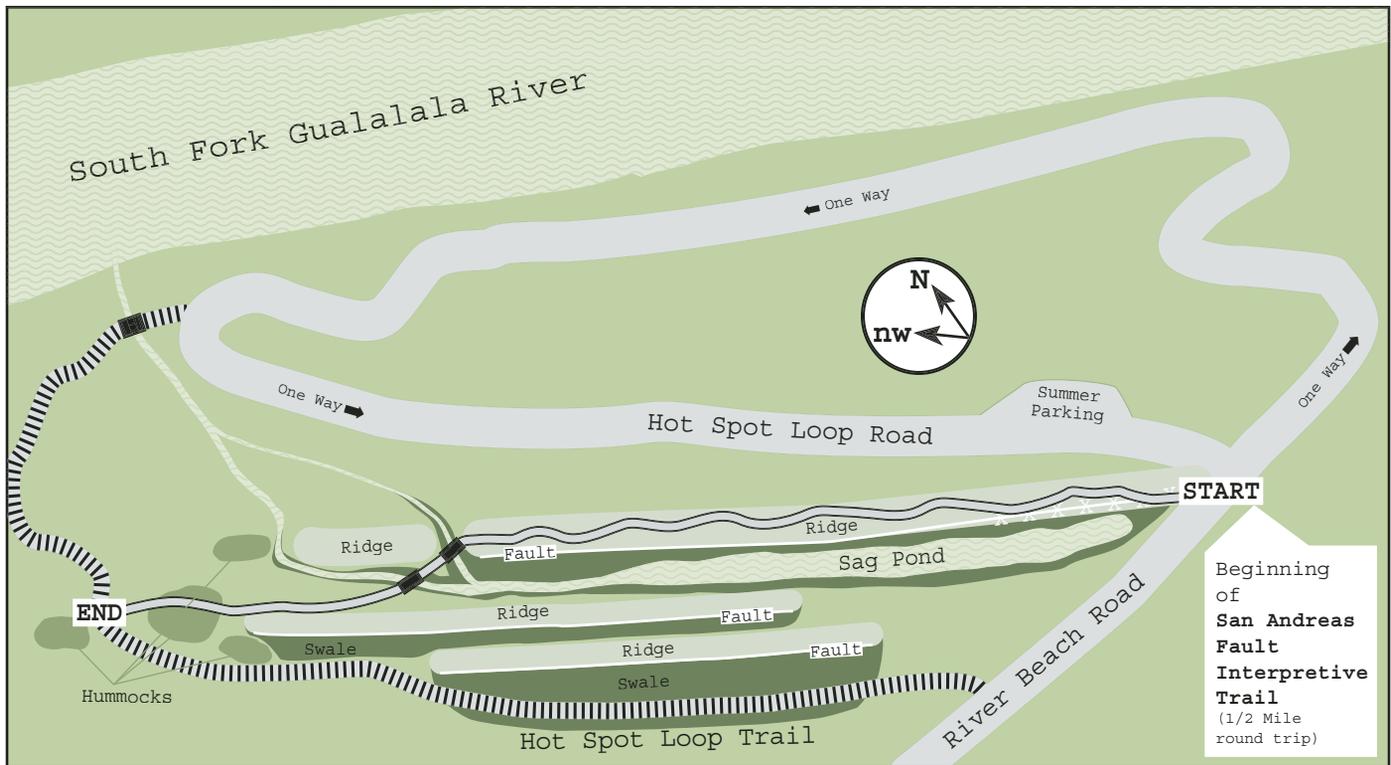
Interpretive Trail Guide

You are standing on one of several faults of the San Andreas Fault Zone. The 1906 magnitude 7.8 San Francisco quake was caused by lateral movement along more than three hundred miles of this fault zone, from San Juan Bautista to Shelter Cove. Minor shakes felt here since then have been from several parallel faults about two miles offshore and from the Mendocino Fault Zone.

In addition to features of the Fault Zone such as ridges, hummocks, swales, and a sag pond, this trail demonstrates:

- Other earthquake clues
- Forest ecology
- Impacts from logging in the 1890s

(Do not disturb or collect anything. Please stay on the trail as the very thick layer of decaying material is deceptively deep and you may fall through.)



1. **RIDGES & HUMMOCKS** have been formed over tens of thousands of years by small vertical movements accompanying the much greater horizontal slippage. During the 1906 earthquake, this area had about twelve feet of lateral, and about ten inches of vertical movement, adding even more height to this remarkable feature. Walk up this fault's *scarp* (ridge face) to post #2 and continue northwest along the top of this ridge.

2. **DWARF OREGON GRAPE**, rare at The Sea Ranch, has shiny evergreen holly-like leaflets and grape like clusters of blue fruits. The *forest understory* is predominantly Sword Fern. *Ground cover* is mostly mosses and Redwood Oxalis (Redwood sorrel), which colonizes

rapidly by rhizomes. It looks like clover but is in a different family. Stump islands are unique man-made habitats, colonized by species from the ground cover or the understory or both.

3. **SAG PONDS & SWALES.** A sag pond may develop in the swale formed as a ridge is pushed up, because rocks there have been pulverized to impermeable clay. Rain and ground water from the upslope cannot drain but instead accumulate and may last through to the next rainy season. Unlike most sag ponds, this one also has a large culvert, installed in 1965 as River Beach Road was constructed, draining into it. It also differs in having a drainage stream as the topography slopes northwest along the scarp, as well as down to the river.

4. **BURNING** was a common part of logging operations in the late 1800s and early 1900s. By cutting when the sap was running under the bark, a “peeler” debarked the logs using a pointed bar. Debris of bark, branches and brush greatly slowed skidding of logs to the river, so loggers set fire around the stumps to burn everything which might be in the way.

5. **ANNUAL RINGS** like these are very useful as a written record of the past. They are visible because of the very dark line of contrast between small, thick-walled wood cells formed in late summer growth with the following spring’s much larger, thinner-walled and therefore paler, wood cells. Cell differences within a year’s growth are too gradual to be apparent. Counting rings near the base of the tree can indicate its age. Patterns of wide/narrow rings are used to date past environmental conditions such as earthquake damage, climatological variations and such other factors as changing competition for sun, water, and minerals. (See small laminated sheet on cut surface.)

6. **SPLIT TRUNKS & DOUBLE TRUNKS** show damage from the 1906 severe shaking. The *fir tree on the right* shows a split of the main trunk. The conspicuous vertical scar indicates a crack in the wood from earthquake damage. Wood, unlike bones, cannot knit together again so wood and bark development is changed and a fork results.

The *fir on the left* of the trail, high up, had its leader snapped off. Two horizontal branches curved up, replacing that vertical orientation, forming a double trunk. Note that there is no split trunk scar. (See if you can find other examples as you walk along the trail.)

7. **CALIFORNIA TORREYA** (California Nutmeg), quite rare at The Sea Ranch, is related to the Yew, not to the nutmeg spice, although the seeds look superficially similar. The two sexes are borne on separate trees. The very heavy 1.5-inch long seeds are spread only by gravity, which insures proximity of sexes. The 1906 earthquake damage resulted in five trunks from this *Torreya*’s originally large base.

Sit on a log here overlooking the pond so you can enjoy the ambiance, sounds, and aromas of this redwood forest, as you read the Overview from pages 3-4 of this guide, which provides the essential perspective for understanding or “reading” the landscape.

8. **DIFFERENTIAL WEATHERING** greatly accentuates the contrasting properties of wood cells on this very old, split and weathered remnant of a large redwood

tree. Thin-walled, horizontally formed vascular ray tissue is paler and softer, thus more rapidly and deeply eroded than thicker-walled, darker, harder wood. On the snag the harder remnants stand out as darker raised horizontal bands, alternating with the paler, deeper bands. Annual rings appear as vertical lines in this longitudinal view.

9. **TORREYA SAPLINGS** are easily distinguished from the Redwood, Grand Fir, and Douglas Fir of this *tree canopy* by the very sharply pointed needles. Just feel those points to be convinced and remember!

10. **THE OLD LOGGING ROAD** across the way appears to have used the sag pond depression, which probably dried up in summer in those pre-culvert days. Note nearby, a fine example of a double-trunked fir. It shows that more than two adjacent branches may curve up, but in the competition for light, three are left stunted so we see just two co-dominant trunks.

11. **NOTCHES** on this large stump were cut for springboards to support lumberjacks above the basal swell of the tree. Old growth redwoods here were being harvested during the 1890s. We determined this date by annual ring counts of crown sprouts from stumps of the 1998 logging south of the Hot Spot.



Lumberjacks
on
Springboards

12. **ANOTHER EARTHQUAKE-FORMED RIDGE**, from a parallel break, can be seen if you look upslope from this trail. Both ridges extend to the southeast, across Annapolis Road, where they are evidenced by two successive dips in the road just downhill from the Sea Ranch Association office.

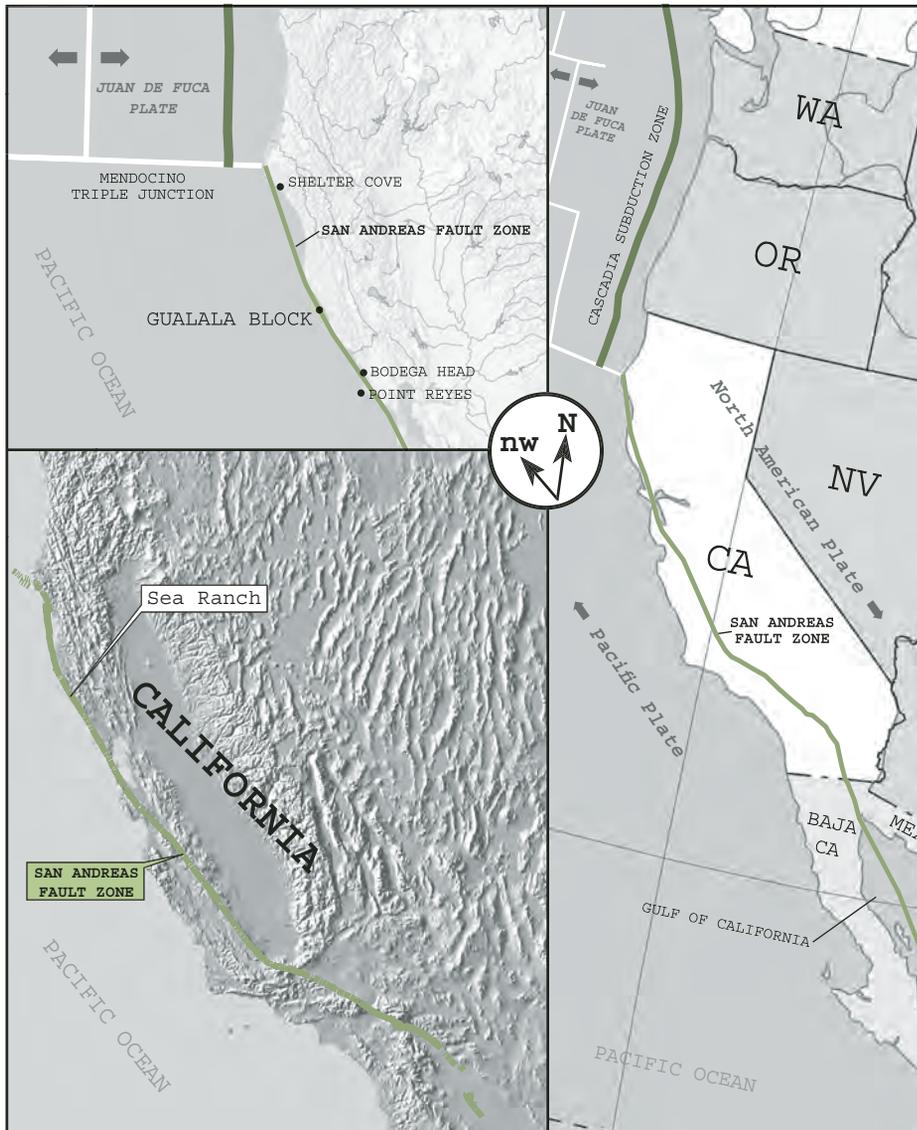
13. **A CIRCLE OF ROOT CROWN SPROUTS** results when a redwood tree is cut and regenerative tissue at the base is activated. These compete for light so that some become stunted and eventually die. Adjacent re-sprouts, rubbing together, may graft through their cambia (lateral growth tissues) to form one trunk with a graft line. Do not confuse a graft line with a split-trunk scar.

- 14. THE SOUTH FORK OF THE GUALALA RIVER** is visible far below. Our Fault Zone extends from east of the riverbed, up this steep eastern slope of the Gualala Block almost to Timber Ridge Road on the west. Old skid trails like the one below, lined perpendicularly with logs and kept wet to facilitate “skidding”, were used to skid logs down to the river. A “sniper” rounded one end of each log to prevent digging in as it was dragged.
- 15. LINEAR STAND OF “TREES”** When a tree falls but the roof system is not fully torn out, some horizontal branches, responding to gravity, may grow vertically. They form a linear stand whose “trees” have no roots of their own, as this *Torreya* so clearly demonstrates. The green vertical growth nourishes the original root system, way off to the right, which provides water and the essential minerals. A California Bay linear stand is also developing just beyond here. Its curved trunk probably resulted from a heavy branch falling on it and tip finally rotting away.
- 16. SAG POND DRAINAGE** responds to gravity as well as blockage by fallen trees and branches as it carves its channel. That stream gradually eroded a broad gap here as the originally much lower ridge was only occasionally and very slowly being upheaved. One of the ancient earthquakes *laterally offset* the channel enough to the northwest that this broad one was abandoned; the stream we cross at the bridge ahead had to cut a new channel running toward the ravine along the Hot Spot Trail. In 1965 a culvert was installed when River Beach Road was constructed. Subsequent erosion, augmented by the culvert drainage, *partially recaptured* this old channel, carving a newer, deeper v-cleft to the river.
- 17. REDWOOD HEART-ROT** was the most common reason for loggers to discard a large redwood that had been cut. Only the harder heartwood was wanted. Walk to the other end of this hollow log. The fungus enters either through a small fire scar, later healed over, or a broken top, as from earthquake shaking. It digests away the dead heartwood but the tree continues to grow ever larger, because only the outer, newer sapwood is functional. Return to the trail to continue down the scarp, across the bridge, and up adjacent parallel ridge formed by a parallel fault.
- 18. THE CURVED TREES** you see as you look around and ahead are the result of “soil creep”. Creep is caused by the very slow downhill movement of particles in the top few meters of a steep surface. As they are rearranged by expansion and contraction of soil during wetting and drying cycles, the soil moves down slope under the influence of gravity. Since the top of the soil layer moves faster than the soil beneath, young trees grow in a curve in response to progressive leaning. As the enlarging root system stabilizes the soil, creep is greatly diminished and the trees from then on can grow straight.
- 19. CHANNEL ABANDONMENT/RECAPTURE** Look downslope here to see that, as a result of further horizontal earthquake movement, our stream, which was running to the left into the ravine along the Hot Spot Trail, has eroded enough to recapture an earlier deep channel, which plunges more directly to the river. Some slope drainage in the abandoned path to the ravine may reverse to flow into the recaptured channel, depending upon how much detritus and fern growth blocks that reversed flow.
- 20. A HUMMOCK** such as the trail ascends ahead is a small quake-upheaved mound, in contrast to an upheaved ridge, which is elongate.
- 21. A SWALE**, a depression formed along another adjacent fault break and ridge, makes an easy wide trail back to River Beach Road. To reach it, continue to the Hot Spot Trail just ahead, and turn left. The “Swale” probably was flattened as it was utilized as an early logging road.

GLOBAL, REGIONAL, AND LOCAL OVERVIEW

GLOBAL: The earth’s crust is in constant very slow motion, which is called Plate Tectonics. Escaping heat from the Earth’s core melts rocks about 60 miles below us to a viscous mass upon which seven large (and a dozen smaller) crustal Plates drift with the convection currents. They also are pushed apart as new crust constantly wells up as magma at “Spreading Centers”.

The San Andreas Fault is the longest and most active fault in the world. It runs northwest, about 800 miles from the evolving Gulf of California (Sea of Cortez), through most of California, and exits to the ocean north of Pt. Arena at Alder Creek. It continues just offshore and cuts through Shelter Cove east of the airport. Thence it turns west and becomes part of the Mendocino Triple Junction where the Pacific, North American, and Juan de Fuca Plates join. To the north is the 700-mile long Cascadia Subduction Zone. The latter is the most active seismic zone in the continental U.S. and has in historic time caused very large subduction earthquakes and tsunamis in Washington, Western Oregon, and California. The Spreading Center in the Gulf of California, the San Andreas Fault and the Cascadia Subduction Zone illustrate the three different types of



boundaries that are possible between tectonic plates. The Spreading Center marks the zone of extension where new oceanic crust is being formed. The “Subduction Zone” is a region of compression where the Juan de Fuca plate is colliding with the North American Plate and is being subducted back into the earth’s interior. The Spreading Center and Subduction Zone are joined by the San Andreas Fault, which marks a zone of horizontal movement where, for the last approximately thirty million years, the Pacific Plate has been sliding northwest past the North American plate. This creates a one half mile wide chaotic fault zone of mixed rocks from both, and many, more or less parallel, fault breaks. An earthquake is the result of sudden release with elastic rebound, of the large amount of energy accumulating for years from unrelieved stress of friction-locked edges.

REGIONAL: In northern California the San Andreas Fault has cut off four slivers (islands) of the Pacific Plate: (See maps above.)

- Pt. Reyes - with its large Inverness Ridge and Olema Valley
- Bodega Head
- A 43 mile “Gualala Block”, including TSR, from just south of Ft. Ross to Alder Creek
- Shelter Cove

These 4 slivers can be considered “Islands in Time” since successive movement along both the San Andreas and San Gregorio Faults to the south has moved the “Gualala Block” about 140 miles northward over approximately sixty million years from its original location west of the Santa Cruz Mountains to our present position.

The South Fork of the Gualala River follows the line of least resistance, fault pulverized rocks at the eastern base of the Gualala Block. It has carved a deep, 30-mile long canyon, parallel to the coast, until it turns west to the ocean, near Gualala.

LOCAL: The Northwest Trend of all the features of the San Andreas Fault Zone can be clearly seen with our small ridges, sag ponds, and swales. Our eight sag ponds are visual evidence of the relatively recent slippage and severe shaking in the San Andreas Fault Zone. Those ponds, including the two on the Sag Pond Trail, are mostly along the top of our section of the Gualala Block, an uplifted ridge running from northeast of Ft. Ross to east of Pt. Arena. Along the top of the Gualala Block severe shaking cracked the ground, making depressions, which funnel rainwater, and may form sag ponds if subtended by an impermeable clay substrate.

Paleoseismologists locate and analyze evidence of earlier seismic activity. By determining dates and magnitudes of each event they can more accurately calculate probabilities for the next big one. Techniques used include:

1. LIDAR scans to map fault zones, as described below,
2. Deep trenches to compare earlier ground movements, and
3. Microscopic tree ring analysis of ancient trees such as our large redwoods, which grew on a fault where movement stressed their growth for years after each earthquake.

LIDAR (Light Determination and Ranging) uses light waves from a laser, mounted in an airplane, to scan systematically through trees producing a 3D topographic map with accuracy in inches. GPS (Global Positioning System based on about 21 satellites) continuously records the concurrent 3D location of the aircraft.

For California daily quake activity go to:
<http://quake.usgs.gov/recenteqs/latest.htm>
<http://www.data.scec.org/recenteqs/>