

MASS IRRUPTION OF CEANOTHUS AFTER THE 2020 CZU FIRE PROVIDES A LESSON FOR REDWOOD FOREST MANAGEMENT

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ABSTRACT

Observations were made in Big Basin State Park of the response of understory vegetation to the 2020 CZU Lightning Complex Fire for five years immediately after the fire. The fire triggered a massive synchronous pulse of Ceanothus thyrsiflorus from a soil seedbank in the redwood stands. A literature review of the life history and population ecology of Ceanothus revealed that the pulse was driven by a evolutionary adaptation of Ceanothus to a climate-driven fire regime. A re-examination of tree fire scar studies done in the Santa Cruz Mountains, claimed by many to support a fuel-limited fire regime, were also compatible with a climate-driven fire regime. Recommendations are given for appropriate management measures to mitigate fire severity in old-growth redwood stands.

INTRODUCTION

No one expected the massive irruption of Blue Blossom Ceanothus (*Ceanothus thyrsiflorus*) that appeared in Big Basin State Park and elsewhere after the 2020 CZU Lightning Complex fire. Soon after the fire there were more than 40,000 Ceanothus seedlings present per acre (Keeley and Pausas 2025). Five years after the fire they covered nearly 100% of the forest floor beneath redwoods (with a small number of tan oak and redwood sprouts mixed in) and formed a dense thicket that was 15 – 20 feet high (personal observation) (Note: See photos of the Ceanothus irruption Appendix 4).

Park staff, researchers, and visitors were all taken by surprise. Park records, going back to 1902, and early-day park floras made no mention of a similar event (Meadows 1950, Taylor 1912). Why did Ceanothus emerge unexpectedly after the fire? Why in such high numbers, and why hadn't it happened before? Most importantly, what does it mean about future wildfire risk and what possible mitigation practices would be effective.

This article attempts to answer those questions and explores the implications for old-growth redwood forest management. In the Appendices can be definitions of technical terms used in the text, photos showing the extensive *Ceanothus* “invasion” of the park, and a flow chart showing the population “life cycle” of *Ceanothus thyrsiflorus* which is also discussed below.

LIFE CYCLE STAGES OF CEANOTHUS THYRSIFLORUS IN THE REDWOOD FOREST

1. After a severe crown fire *Ceanothus* plants appear in mass and cover the forest floor. *Ceanothus* does not sprout after a fire and its only means of reproduction is by seed. Seed remains viable in the soil for over 100 years.
2. *Ceanothus* plants die at about age 40 after producing seed every year. A large number of seed must be produced in order to make up for large losses to predation.
3. Much time passes until the next severe crown fire occurs. During that interval soil organisms and rain water percolation move the seed deeper into the soil to a depth where it is will not be killed by low intensity surface fires.
4. *Ceanothus* seeds need high heat from a severe crown fire to germinate. In order to grow well the seedlings need ground free from established plants that would compete for nutrients and water, and need lots of sunlight. Only a severe crown fire will reduce canopy shading enough.
5. This cycle is dependent on a long-interval fire regime. If fires occurred every 10-15 years, *Ceanothus* would have been extirpated from the park by now. The reason is that fires this frequent, even low intensity fires, would kill the adult plants (when present) before they had time to produce enough seed, and would kill much of the existing soil seed since it would still be near the ground surface.

-See the Appendix for a flow chart showing the life cycle-

STUDY AREA

This study was undertaken in Big Basin Redwoods State Park in the Santa Cruz Mountains of California. The park is located approximately 40 miles south of San Francisco. It extends from the coast to approximately 7 miles inland, and contains a mix of different vegetation types, but is best known for its old-growth redwood forest. The park contains the largest old-growth stand remaining in the Santa Cruz Mountains – approximately 4400 acres (1800 ha) (Halbert and Singer 2017, Singer 2003) which was erroneously reported as 10,800 ha by Cowman and Russell (2021).

The CZU Lightning Complex fire started on August 16, 2020 from several different lightning strikes north of the park. They merged and burned south through the park, being pushed by high winds, with flame heights of 300 feet. The fire front passed through the park overnight on August 18 and 19, when the entire park burned in just 12 hours (Spohrer, pers. comm., Halbert, pers. comm.) Most of the park burned at high or extreme intensity (Singer and Rinkert 2025). Using 2020 Landsat satellite imagery, Potter (2023) reported that all tree live canopy coverage was lost in 77 percent of the park.

The study area is approximately 2600 acres in size and is located in the eastern half of the park (see map in Appendix 1). It contains the majority of the park's remaining old-growth coast redwood – Douglas-fir forest but also contains lesser amounts of young-growth redwoods, mixed evergreen forest, and chaparral. Hereinafter the study area will be referred to as “Big Basin”. The terms, “Big Basin State Park” or “park” will refer to the entire area within the park boundary.

METHODS

This study was an observational study combined with a targeted literature review of *Ceanothus thyrsiflorus* and *Ceanothus* spp. fire ecology and tree fire scar chronologies done in the Santa Cruz Mountains. After the fire, observations of the recovery of Big Basin vegetation were made during 25 visits between October 20, 2020 and October 23, 2025.

A literature review was undertaken to learn the population “life cycle” of *Ceanothus thyrsiflorus*, hereinafter referred to as CETH, its associated fire regime, and the implications of that for forest management. Relatively few studies have been undertaken on the life history and ecology of this species. However, numerous studies have addressed *Ceanothus* as a genus or have addressed related species of *Ceanothus* that also occur in California. When necessary, these studies were used to fill in the life history gaps for CETH.

OBSERVATIONS AND DISCUSSION

CETH plants didn’t dominate the forest floor until the third spring after the fire. Rainfall during the first post-fire winter was well below average (17.4 inches as measured at Boulder Creek) compared to normal of 46.05 inches (San Lorenzo Valley Water District 2025). That spring vegetation cover on the ground was sparse and there was probably not enough water to germinate the CETH seed. In addition to basal sprouts from redwood and tanoak there were, in widely scattered small patches, native redwood herbaceous flora, such as Redwood Sorrel (*Oxalis oregana*), Modesty (*Whipplea modesta*), Star Flower (*Lysimachia latifolia*), and Redwood Violet (*Viola sempervirens*). Grasses and non-native weeds like Bull Thistle (*Cirsium vulgare*), were also present in modest numbers. Mahdizadeh and Russell (2025) also reported that CETH was absent that first spring.

In the second post-fire spring, rainfall was 34.61 inches and dense stands of Horseweed (*Erigeron canadensis*) covered much of the study area with smaller numbers of redwood and tan oak (*Notholithocarpus densiflorus*) sprouts mixed in. There were occasional small openings in the vegetation cover, and in those spots a few small solitary CETH plants were present. Although not conspicuous, underneath the dominant Horseweed plants there must have been CETH plants growing because by the third post-fire spring (2023), after a winter with abundant rainfall (71.02 inches), CETH dominated the forest floor with plants being approximately four feet tall. By the fourth spring (2024) CETH plants had formed dense impenetrable thickets with individuals 12 feet to 15 feet tall, and in some cases nearly 20 feet tall (pers. obs.).

The mature CETH plants now densely covering the forest floor have produced seed every year since at least 2025, and possibly earlier since profuse flowering was seen as early as 2023 (pers. obs.) Because seed predation rates are high (Calif. Native Plant Society 1995) CETH plants need to continue to produce seed for their entire 40-year lifespan (Ford and Hayes 2007) in order to replenish the soil seed bank (Warzecha and Parker 2014, Backus et al. 2023). CETH plant stems and foliage are highly flammable (Ford and Hayes 2007). As time goes by, rain, the movement of soil organisms and the wetting and drying cycles that occur in the soil gradually work the seed deeper (Parker 2015, O'Neill and Parker 2005). If a surface fire were to occur during that period of seed replenishment, before the seed had settled deeper into the soil (for a degree of insulation), the seed would be incinerated by the fire and the species would not be able to re-appear after the next intense fire (Rundel et al. 2018, Knapp et al. 2012, Keeley and Fotheringham 2000).

Ceanothus seed is small and has a hard seedcoat that needs to be broken before germination can occur (Zomer et al. 2022, Keeley and Fotheringham 2000). High heat, such as from an intense combination surface /crown fire, will crack open the seed coat and allow germination to occur (Knapp et al. 2012, Calif. Native Plant Society 1995). Abrasion from scraping or grading of the ground, such as would occur in a logging operation, can also open the seed coat. Otherwise, the seed stays dormant and can remain so for well over 100 years (Keeley et al. 2024, Pausas and Lamont 2022). A related species that also occurs as a forest understory shrub, *Ceanothus velutinous*, has seeds that can remain viable for over 500 years (Zavitkowski and Newton 1968).

Seed dormancy is a trait that, in this case, adapts seed coats to open only after high intensity fires (Moreno and Oechel 1991) which occur very infrequently in the coast redwood forest (Keeley et al. 2012). Only a high intensity fire can guarantee that the seedlings will have no competition for growing space and that there will be plenty of sunlight available (Zomer 2022, Angevin and Chabot 1979). As a consequence, this species could not persist in an ecosystem with a fuel-limited fire regime, in which low intensity fires are

a frequent occurrence.¹ In fact, this species is only found in climate-driven fire regimes which feature intense fires at very infrequent intervals.²

These CETH fire response traits have evolved over many millions of years (Pausas and Lamont 2022) as a result of the species living in a Mediterranean Climate region where fires were and still are a regular component (Santos, et al. 2023, Bartolome 1990). Several species in the genera of *Arctostaphylos* (manzanita) and *Ceanothus*, including *C. thyrsiflorus*, have evolved fire-response traits that provide them with a tight ecological fit for ecosystems with a specific fire regime (Keeley et al. 2024, Santos et al. 2023, Keeley and Pausas 2022, Rundel et al. 2018). The fit is so tight that they cannot survive in ecosystems with different fire regimes (Keeley et al. 2024, Pausas and Keeley 2023, Santos et al. 2023). Fire ecologist and *Ceanothus* expert Dr. Jon Keeley has elaborated on this point by saying, “plants are not adapted to fire *per se* but to fire regimes” (Keeley et al. 2011). In other words, the fire response traits of plants can be used to identify fire regimes (Kent 2014).

Unlike coast redwood, CETH does not sprout new stems or branches after burning in a fire (Keeley et al. 2024, Ford and Hayes 2007). It is a fire dependent obligate seeding species. As such, it could not persist in fuel-limited fire regimes, where frequent light fires are normal. This conclusion is shared by an expert on the life history of CETH, Dr. Larry Ford (pers. comm.). Dr. Ford co-authored the chapter on Northern Coastal Scrub and Coastal Prairie in the foundational work, *Terrestrial Vegetation of California* (Ford and Hayes 2007).

CORROBORATIVE EVIDENCE FROM TREE FIRE SCAR STUDIES

A review of tree ring fire scar history studies was undertaken to see if their findings agree with the observations of a massive CETH post-fire population recruitment.

¹ The characteristic frequency and intensity of fires that occur in any given region comprise the fire regime. Definitions of all technical terms used can be found in Appendix 3.

² CETH is thus the second species in this plant community to require long intervals between fires, as is typical of a climate-driven fire regime. The other species linked to a climate-driven fire regime is coast redwood (Keeley and Pausas 2025).

There are significant limitations in the use of tree or stump fire scar data to reconstruct the fire history of a redwood stand. Unlike other forest trees, coast redwood is well known for its inconsistencies in laying down annual growth rings and difficulties in distinguishing burn scars from internal rot or branch abscission scars (Kent 2014, Striplen 2014, Waring and O'Hara 2006, and Brown and Swetnam 1994). This makes it difficult to discern fire return intervals from fire scar studies alone. Some of these difficulties can be overcome by collecting a large number of samples and by using random sampling methods to obtain them. (Kent 2014).

Five studies of tree annual ring fire scars to identify fire intervals have been conducted in the Santa Cruz Mountains to date. These are Greenlee and Langenheim (1990), Stephens and Fry (2005), Jones (2014), Striplen (2014), and Auten Resources and California State Parks (2024) hereinafter referred to as Auten and State Parks. Only research by Greenlee (which included papers co-authored with Jean Langenheim and many unpublished reports and maps), was comprehensive enough and designed carefully enough to identify the natural fire regime (i.e., no human ignitions) of redwoods in the Santa Cruz Mountains. As fire ecologist Jon Keeley has stated, "Lightning is the only natural source of ignition that is predictable enough in time to influence evolutionary patterns" (Keeley et al. 2012).

If a fuel-limited fire regime is operative, as some propose, instead of the climate-driven fire regime supported by the CETH observations, one would expect tree fire scars to be present regularly at intervals of 10 – 15 years or less in the era of Native American burning, and to a lesser extent in the eras of Spanish Colonial and Early Anglo occupation. The best test of that theory would be to locate a dense old-growth redwood forest relatively far from the coast where Native American burning would have been minimal (Jones 2014, Striplen 2014, and Keeley 2002); and then to examine the oldest available fire scar evidence there. That is what Greenlee did.

The design of the other four studies was done under the premise that the fire return intervals in the Native American burning era (up to 11,000 years BCE) were or became the natural fire regime and that the cessation of burning since then is an unnatural condition that will increase the severity of future fires.

Focusing on the Native American burning period, only two of the studies (Striplen 2014, Stephens and Fry 2005) found fire return intervals of 15 years or less. However those findings are questionable for the following reasons. First, Stephens and Fry (2005) found a fire return interval of 12 years from 48 redwood trees or stumps sampled. Jones (2014) and Keeley and Pausas (2025) have questioned their conclusions, and the authors themselves pointed out a major short-coming of their work – that a number of fire scars they found may have been from a subset of fires that started in more flammable adjacent oak savannahs or grasslands and then overlapped into their redwood cluster sample areas. In addition, they preferentially selected trees for sampling that had external signs of fire damage, thus likely biasing their results toward shorter fire return intervals.

Second, Striplen (2014) found a mean fire interval (MFI) of 7.6 years for the period 1600 to 1850 from 58 trees or stumps sampled. The exact size of his study area is not given, but it included all the redwood forests found in three heavily forested watersheds that totaled approximately 29,185 acres (11,816 ha). His sample size of 43 cross-sections was too small to adequately characterize the fire history of such a large area. Like Stephens and Fry, he introduced bias into his study by not randomly locating trees to be sampled, but instead deliberately selecting trees that had evidence of fire. He justified this approach by citing two studies that had been done in ponderosa pine (*Pinus ponderosa*) forests that concluded targeted samples in this manner yielded results similar to that of random sampling (Farris et al. 2013, Van Horne and Fule 2006). However, coast redwood forests have different fire characteristics than ponderosa pine forests, so it is unlikely that those results would also apply to coast redwood forests.

In addition, his study area boundaries encompassed a high percentage of an area where Native American burning would likely have been frequent. He sampled only 5 trees within the east half of Big Basin State Park (i.e., my study area). Those 5 trees, if analyzed separately, would have a MFI of 25 years (pers. analysis of his included data).

Jones (2014) sampled 70 trees from within a similar study area and found a MFI of 43.3 years for the period 1352 to 1849. Like Striplen, he did not randomly locate his samples. He reported a high degree of variability in his MFI values and suggested that his very large study area supported a mosaic of variably-sized fires. He took 3 samples from within my study area and found a MFI of 49.7 years (pers. analysis of his data).

The most recent fire scar study was done by Auten and State Parks (2024). They sampled about 35 trees with datable fire scars in the combined areas of Ano Nuevo State Reserve, Butano State Park, and Big Basin State Park. The earliest fire scar they found was from 1604. Unfortunately, they found a high degree of variability in their fire interval findings and cited one case where three trees in fairly close proximity had fire return intervals of 10, 34, and 62 years. They also found one old-growth redwood that showed no evidence of burning in the last 340 years. They did not provide MFI values for any time period. They concluded that “fire return intervals in the region’s coast redwood forests vary significantly.” They also observed that their data “suggests a mosaic pattern of small, more frequent [surface] fires that occurred across the landscape following the 1670’s fire and prior to the 2020 CZU fire”. Those two fires mentioned are believed to be the two most intense crown fires to have ever occurred in the park since 1670. They go on to recommend implementation of prescription burning in the park – which is ironic because their description of the data is a good fit for a climate-driven fire regime and not a fuel-limited fire regime where fires are driven by the accumulation of fuels on the forest floor.

These first four fire scar studies provide little, if any, support for a fuel-limited fire regime in coast redwood stands, nor does the study by Greenlee and Langenheim (1990), which, to the contrary, provides strong support for a climate-driven fire regime.

The research done by Greenlee and Langenheim (1990, Greenlee 1985, Langenheim et al. 1983, and Greenlee unpub. data) was the most comprehensive study of redwood fire history in the Santa Cruz Mountains. They, primarily Greenlee, sampled 337 trees or stumps from over 400 randomly selected points in Big Basin State Park, 174 of which were

redwoods. Thirty trees with dated fire scars were located within my study area (Greenlee, unpublished data). Because the eastern half of Big Basin (my study area) is large in size, unlogged, and too far inland to have experienced much Native American burning (Jones 2014, Striplen 2014, and Keeley 2002), it is the best place to look for fire return intervals that would be similar to those of pre-human times.

Greenlee didn't only use fire scars, but also stand structure and age analysis, historical documents, park records, California Department of Forestry records, and other sources for corroboration. Being a state park since 1902, fire records for Big Basin are more extensive and complete than for other wildland areas in the Santa Cruz Mountains.

Greenlee also developed a fire spread model showing the likely spread and frequency of fire from lightning strikes - using current day lightning ignition points, weather data, fuel moisture data, and vegetation type flammability data for the park. Based on this model he was able to estimate fire return intervals for different vegetation types within the park during the period before humans arrived on the scene. He found that the natural fire frequency, before the onset of human ignitions, to be about 135 years in redwood stands (Greenlee and Langenheim 1990). Using fire scar data alone, for the period 1792 – 1848 he found the MFI for redwoods to be 82 years, returning in the recent era to be 130 years.

Unfortunately there will always be at least two major short-comings of fire scar data. For one, they can't distinguish between surface fires or crown fires, and secondly, they can't tell us anything about the size of the fire unless the sample tree density is very high. One likely scenario for redwoods in the Santa Cruz Mountains would be that of intense crown fires occurring at 100+ year intervals. Associated with them would be numerous low intensity surface fires of small size (too small to affect overall stand fuel levels) occurring in the intervening years. This could explain why there is so much variability in the MFI findings.

Depending on how the study results from Stephens and Fry (2005) Jones (2014), Striplen (2014), and Auten and State Park (2024) are interpreted, they

could provide additional support for a climate-driven fire regime- one of infrequent but intense crown fires, with only small insignificant surface fires occurring in between.

The development of a set fire regime for the redwood forests of the Santa Cruz Mountains, and subsequent evolution of adaptive plant response traits such as those in CETH, occurred over the last 5 million years or longer (Keeley and Pausas 2022). The Santa Cruz Mountain range and members of its current-day flora were in place well before Native Americans first appeared in central California, and there is no evidence that their relatively short period of frequent burning permanently reset the natural fire regime.

LIMITATIONS OF FUEL REDUCTION TREATMENTS IN OLD-GROWTH FORESTS

A prescribed burning program was undertaken by State Parks staff in old-growth plots in Big Basin State Park in 2011 and earlier. When revisited after the 2020 CZU fire by Biblin and colleagues (2025), it was found to have had only a modest effect on fire severity. There was a 1 % improvement in understory cover, a 5 % improvement in both overstory canopy cover and the number of trees killed or top-killed by the fire, and an overall 19% reduction in tree mortality (Biblin et al. 2025).

In a small study unrelated to that one, Singer and Rinkert (2025) had plotted, before the 2020 fire, the location of 107 old-growth trees at widely scattered locations in Big Basin. These were trees with a canopy structure capable of supporting nesting marbled murrelets (*Brachyramphus marmoratus*), an endangered seabird (details in Singer and Rinkert 2025). Forty-two (42) of those trees were in areas that had been subject to prescribed burning, the other 65 had not. After the 2020 fire, 21% of the trees in the prescribed burn plots survived, versus 23% that survived in the untreated plots, suggesting that the prescribed burn treatment had no beneficial effect in protecting murrelet habitat trees (unpub. data).

IMPLICATIONS OF THESE FINDINGS FOR OLD-GROWTH FOREST MANAGEMENT

The population life cycle of CETH, and to a lesser extent, tree ring fire scar studies, support the conclusion that the operative fire regime for old-growth redwoods in the Santa Cruz Mountains is a climate-driven fire regime. In a climate-driven fire regime fires occur over a timespan closer to centuries than to decades and are of high severity not low-moderate severity (Keeley et al. 2012). Fires of small extent and low intensity likely occur irregularly in this regime but they do not significantly reduce forest fuel levels.

In coast redwood forests the build-up of fuels on the forest floor is not a precursor to fire because redwood forests are relatively cool, moist forests with frequent stratus or fog occurring. Consequently, their ground fuel moisture levels are normally too high to carry a fire (Keeley et al. 2009). It can be argued that redwood forests in the Santa Cruz Mountains are dryer than forests further north, but that fact has little relevance considering the frequency of natural ignition sources, ie., lightning.

The cause of severe crown fires is the rare combination of extreme weather conditions (such as prolonged drought, an unusually hot and persistent heat wave, low humidity, and high winds) with dry lightning (Noss et al. 2006). Without an ignition source there can be no fire. Studies have shown that lightning strikes are four times more common on the north coast than in the Santa Cruz Mountains (Cart 2021, Keeley and Syphard 2018). It is for this reason (the lack of an ignition source) that severe fires occurring prior to the 1800's were rare in the old-growth forests of the Santa Cruz Mountains. It is very unlikely that Native American burning practices played a significant role (Keeley and Pausas 2025).

Safford and colleagues (2022) investigated why the 2020 CZU fire was so severe. They found the primary culprit to be high winds and a preceding period of extreme drought, and that fuel levels were not a significant factor.

Fuel reduction practices, such as prescribed burning and thinning, will not significantly lower fire severity in old-growth redwood forests because it is the fuel moisture level of dead and live fuels and not the fuel accumulation level of ground fuels that drives these fires. Extreme weather is the source of the problem, and fuel reduction treatments cannot change the weather.

Where fuel treatment measures can be helpful is in previously logged stands or young redwood forests (Kane and Carrasco 2025). This is the case because the tree and stand characteristics that make old-growth forests resistant to fire are acquired with age. These include a thick layer of fire-resistant bark, a high canopy base height, and a cool, moist microclimate (Kane and Carrasco 2025, Dellasala et al. 2022, Zald and Dunn 2018, Bradley et al. 2016, Stephens and Mogghadas 2005). Old-growth forests can maintain summer temperatures that are nearly 5 degrees (2.5 degrees centigrade) cooler than in younger forests (Frey et al. 2016). Another advantage in limiting fuel reduction efforts to second-growth or younger forests is that adverse impacts to ecosystem processes and wildlife habitat will be less.

Halofsky and colleagues (2018) explained the limitations of fuel reduction treatments in climate-driven fire regimes this way - “These extreme fires essentially cannot be managed and are largely indifferent to landscape fuel structure resulting from prior fires or fire management”. Other fire ecologists agree (Agee 1997, Johnson et al. 2001, Keeley and Pausas 2025, and Turner et al. 2003). According to Stephens and colleagues (2013) - “There are no clear guidelines for increasing the resilience of these forest types – unlike for forests adapted to high-frequency, low-to-moderate severity fire regimes – other than minimizing additional stresses from excessive grazing, recreation, and salvage logging”.

Halofsky et al. also said that there is low ecological utility or practicality of fuel treatments in such stands, and warned - “There are few options for directing or mitigating the size and severity of disturbances that ultimately shape these systems without negatively affecting values currently associated with them (e.g., carbon sequestration, wildlife habitat, timber production).” (Halofsky et al. 2018).

POTENTIAL FOR DAMAGE TO OLD-GROWTH STANDS FROM FUEL-REDUCTION TREATMENTS

1. Removal of surface fuels releases carbon dioxide into the atmosphere, thereby contributing to global warming. Prescribed burning typically removes more than three times the amount saved by altering fire behavior (Campbell et al. 2012)
2. Incineration of the litter layer temporarily eliminates the soil mesofauna populations responsible for decomposition, nutrient cycling, and soil formation (Pilliod et al. 2006).
3. Removal of large logs from the forest floor removes important habitat used by small mammals, snakes, and salamanders. Logs also provide refuge for invertebrates and mycorrhizal fungi during disturbance events (Laudenslayer, Jr, et al. 1999).
4. In the past, controlled burns in Big Basin had, on occasion, killed old-growth redwoods by enlarging basal hollows leading to tree failure according to the burn manager (George Gray, pers. comm.) This is an on-going risk.
5. Tree felling and the use of tractors to pull logs out of the forest run the risk of creating soil erosion and/or compacting the soil (Elliott et al. 1996). In certain situations, a single pass by a wheeled vehicle can cause soil compaction that will persist for decades (Cambi et al. 2015, Hartmann et al. 2014, and Horn et al. 2007).
6. Removal of trees and vegetation and soil disturbance from mastication and equipment operation can lead to the introduction of grasses and weedy non-native plants that are very flammable. (Blair et al. 2010, Merriam et al. 2006).
7. Tree thinning, prescribed burning, or even just novel human activity can attract ravens and jays into the area and increase predation of marbled murrelet nests if present. (Van Rooyan et al. 2011, Pacific Seabird Group 2024).
8. Introducing a short-interval fire/disturbance schedule could disrupt ecosystem processes and lead to the local extirpation of native species, such as *C. thyrsiflorus*, that are post-fire obligate seeders dependent on long-interval fires for population recruitment. (Keeley and Pausas 2022, Enright et al. 2015, Keeley and Fotheringham 2000, Zedler et al. 1983).

For these reasons and others, fuel reduction treatments should not be undertaken in old-growth redwood forests, especially when there are few counter-balancing benefits to justify the damage being done. Other measures can be taken, such as reducing human-caused ignitions during “red flag” fire weather, and increasing the capability to do quick-response fire suppression

while the fires are still small and can be extinguished. These are as-yet unperfected and under-utilized tools that can be used to reduce the risk of future high severity fires without damaging the ecosystem (Halofsky et al. 2018, Pacific Seabird Group 2024).

Also, efforts need to be increased to reduce greenhouse gas emissions and other activities that contribute to climate change, which is a major driver of fire severity and becoming more so with each passing day (Turco et al. 2023, Delasalla 2022, Williams et al. 2019, Abatzoglou and Williams 2016, Diffenbaugh et al. 2015). The existing fire regime does include infrequent high intensity fires but climate change may be increasing the intensity of those fires. A new study suggests such is the case, finding that global warming is increasing potential evaporative water demand thereby intensifying droughts which in turn will lead to more severe wildfires (Zhuang et al. 2024). Although the time lag associated with stabilizing or reducing greenhouse gas levels is a long one, by accelerating our control efforts now we would at least prevent conditions from getting progressively worse.

Currently less than 10% (about 10,500 acres) of the original old-growth redwood or old-growth Douglas-fir forest remains in the Santa Cruz Mountains (Singer and Rinkert 2025). The severe 2020 CZU fire did long-term damage to about 60 percent of those forests by burning away the live crowns of the redwoods (including the large branches high in the canopy with their specialized habitat), and killing nearly all the Douglas-fir trees (Mahdizadeh and Russell 2021). The remaining unburned old-growth stands are an especially valuable biological resource that provides many important ecosystem services (Gilhen-Baker et al. 2022); these stands should not be subjected to any type of forest management activity no matter how well intentioned.

These old-growth forests provide nesting habitat for the southern-most population of the marbled murrelet – an endangered species. Within Big Basin State Park, which has the largest expanse of old-growth forest in the Santa Cruz Mountains, the 2020 CZU fire destroyed 78 percent of potentially suitable murrelet nest trees – placing this bird at risk of extirpation (Singer and Rinkert 2025). The Pacific Seabird Group, following recommendations made

by their Marbled Murrelet Technical Committee, have recommended that in old-growth or older second-growth stands where nesting or flight behaviors associated with nesting have occurred, no disturbance be allowed (Pacific Seabird Group 2024), and additionally, the U.S. Fish and Wildlife Service (1997) recommends a 0.25 mile (0.4 km) no-disturbance buffer be established around these stands.

The numerous large and very severe California wildfires of 2020 seem to have had a traumatic effect on our society and how we relate to nature. While it is understandably urgent to address increasing wildfire risks, any forest management activities undertaken to alleviate those risks must be fully informed by science. Otherwise, we risk damaging the very things that we are trying to protect.

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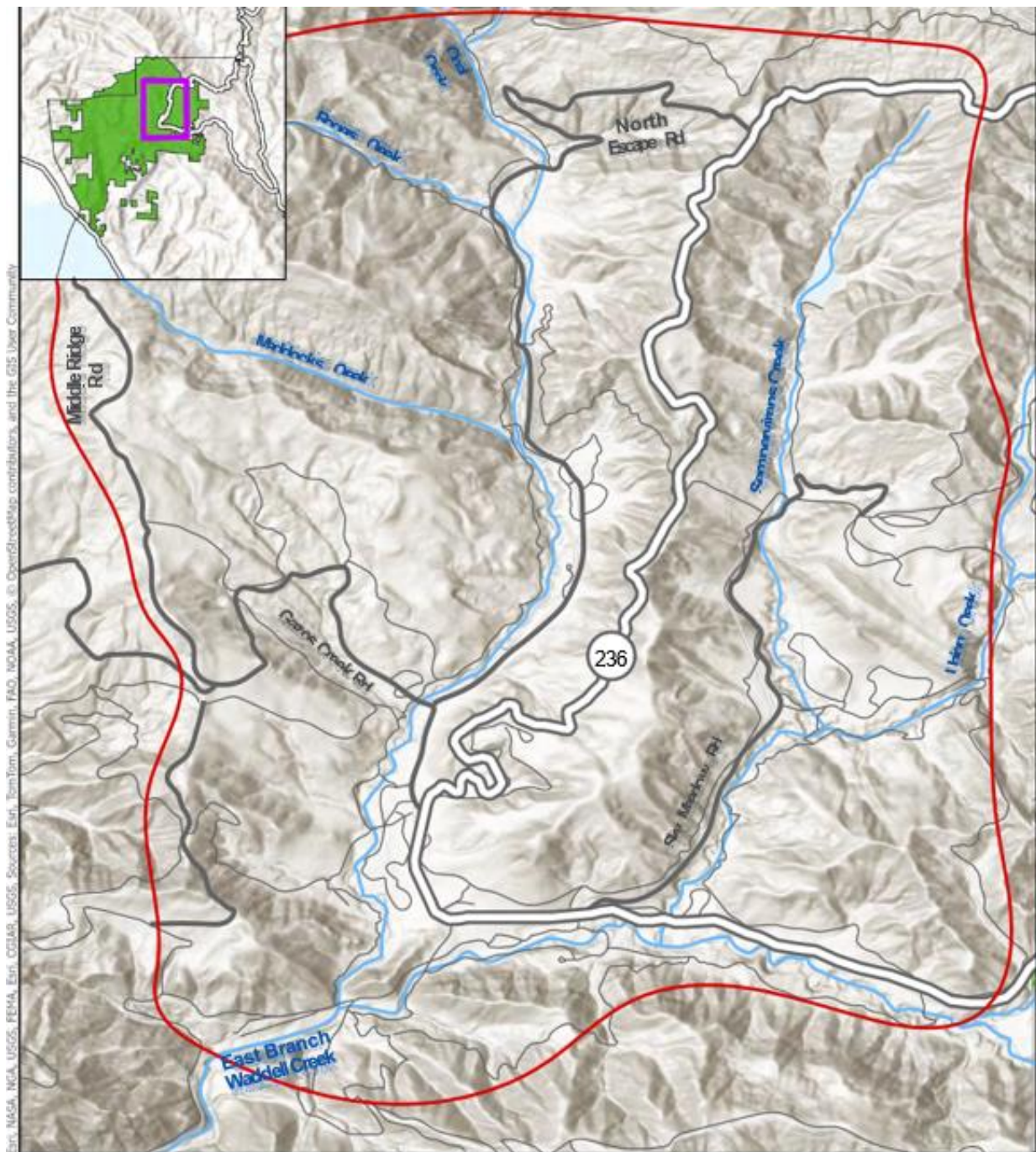
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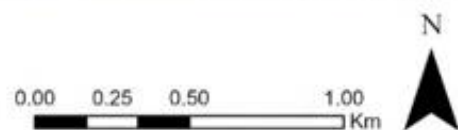
Appendices

1. Map of study area
2. Flow chart of CETH life history and population ecology
3. Definition of fire ecology terms as used in text
4. Photos of *Ceanothus thyrsiflorus* in Big Basin



Appendix 1 - Map of the Study Area

- Study Area
- Major Roads
- Other Roads and Trails
- Streams

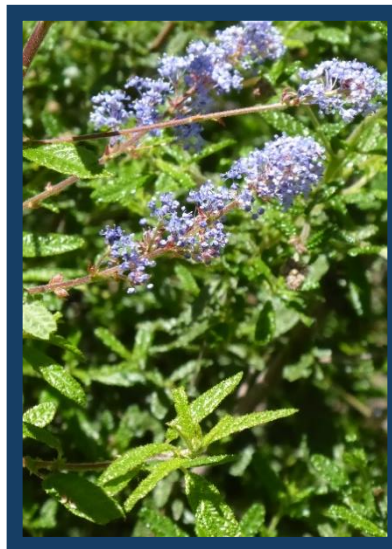


Inset Map Shows Boundaries of Big Basin State Park

FLOW CHART OF CEANOTHUS LIFE HISTORY AND POPULATION ECOLOGY

Ceanothus thyrsiflorus (Blue-blossom) occurs as an understory shrub in redwood forests in the Santa Cruz Mountains. It is a fire dependent obligate seeding shrub that has evolved to live only in ecosystems with a long interval fire regime. **If the fire regime present was a fuel-limited short interval one, extensive stands of this shrub would not be here.** Population recruitment occurs episodically after an intense crown fire. Seed can “wait” for up to hundreds of years buried in the soil for such a fire to occur, with the high heat needed to break seed dormancy. Dormancy is not broken by light surface fires, but can be broken by seed/soil abrasion from logging or road scraping operations.

References: 6, 8, 11



CEANOTHUS ESTABLISHED IN PARK AFTER FIRE

- rare before the 2020 CZU fire, it now covers nearly 100% of the ground below trees in my study area.
- plants are now uniformly 5 years old and 15-20 ft. tall
- fire's heat stimulated seed bank to break dormancy
- seed is adapted to long intervals between fires and stays viable in soil for hundreds of years
- full lifespan of mature Ceanothus needed to adequately replenish the soil seed bank.

References: 5, 7, 8

Time passes



CEANOTHUS DIES ABOUT AGE 40

- despite seed predation many seed produced
- most seed still near the surface is vulnerable to burning and death from light surface fire
- seed has a hard seed coat that needs high heat or abrasion to break dormancy

References: 1, 2, 8, 10, 11

Much time passes



- soil organisms work seed deeper so that an insulating layer of soil protects the seed from low intensity surface fires that can't break seed dormancy but kill seeds at surface

References: 9

Time passes



INTENSE ACTIVE CROWN FIRE OCCURS

- at intervals of 100 – 200+ years
- caused by rare convergence of extreme drought, extreme heat wave, and dry lightning or human ignition
- seed now deep enough to escape burning
- heat of fire is hot enough to end dormancy of buried seeds

References: 3, 4, 7, 12

Winter rains occur



SEED GERMINATION OCCURS IN SPRING

- extensive synchronous germination occurs
- Big Basin had 100,000 seedlings/ha.
- 2020 CZU fire caused first appearance of an extensive recruitment cohort in the last 125 years or longer

References: 3, 5, 13

EVERY 100 – 200+ YEARS CYCLE REPEATS

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APPENDIX 3– DEFINITION OF TECHNICAL TERMS AS USED IN TEXT

Climate-driven fire regime = A regime where conditions for burning are normally unfavorable (cool temperatures, high precipitation, and high humidity). Lightning, the only natural source of fire ignition, is rare. Fuels are normally too moist to carry a fire, so an accumulation of fuels is not a problem. Fires occur very infrequently (100- 200+ years) only when extreme weather conditions occur coincident with a dry lightning event. These fires are typically high severity crown fires.

Crown = The portion of a tree bearing live branches and leaves or needles.

Crown fire = A fire that spreads directly from tree crown to tree crown, more or less independently of a surface fire. These fires are more severe than surface fires.

Fire intensity = The amount of heat produced by a fire. High intensity fires are usually also high severity fires and vice-versa.

Fire regime = The characteristic frequency, intensity, severity, and seasonality of fires within an ecosystem.

Fire severity = The degree to which a site has been altered, damaged, or disrupted by a fire.

Fuel-limited fire regime = A regime with favorable conditions for burning (high temperatures, low precipitation, low humidity, fairly frequent lightning events) and where fuels burn readily. However, the number and frequency of fires is constrained by the lack of continuous available fuel on the forest floor. These fires are typically surface fires of light – moderate severity that occur every 10 – 15 years.

Ladder fuels = Small trees, large shrubs, and large woody debris on the ground that can carry flames from surface fires up into the tree crowns.

Mastication = The use of heavy equipment to grind, shred, or chop small trees, shrubs, and woody debris on the forest floor into small chunks or pieces.

Mean fire interval (MFI) = The average number of years between fires at a specific point, or for a stand if a sufficient number of point samples has been collected. Also known as average fire return interval.

Natural fire regime = The fire regime that would exist without human ignitions and without human fire prevention or suppression efforts. The natural fire regime is the fire regime that has shaped fire-adaptive plant traits over evolutionary time.

Obligate seeding plant species = A species that cannot resprout after fires and must rely on seed for reproduction. Survival of the species at any given location is dependent on adequate production and survival of seeds until suitable conditions for germination and growth occur. *Ceanothus thyrsiflorus* is an obligate seeding plant species that needs a severe fire to produce suitable conditions for it to grow.

Soil seed bank = An accumulation of long-lived seed in the soil that is deep enough to be safe from predation and incineration by surface fires. Seeds are queued to break dormancy by some characteristic of fire such as heat, contact with charred wood, or the release of certain volatile gases.

Appendix 4
PHOTOS OF CEANOTHUS THYRSIFLORUS IN BIG BASIN
AFTER THE 2020 CZU FIRE



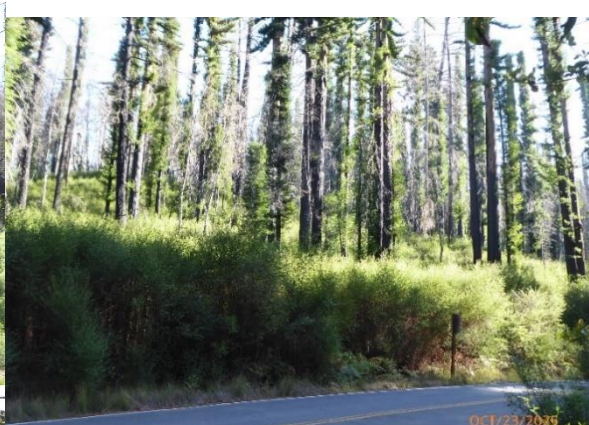
1.



2.



3.



4.

Photo captions:

1. Near Commissioner's Grove, other side of creek, 4-18-25
2. 12-foot range pole in front of CETH, former Upper Opal Creek Picnic Area, 4-18-25
3. Hwy 236 and hillside near former Sempervirens Campground, 4-27-23
4. Same location, 4-18-25, note the traffic sign for scale