Tanoak and Oak Mortality in the North Coast in 2021: a Survey

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A high prevalence of tanoak and oak dieback and mortality was observed throughout the north coastal counties in 2021. To determine dieback causes and see if any of the mortality was because of sudden oak death, a survey of symptomatic trees was conducted by UC Cooperative Extension Humboldt-Del Norte and the Cal Fire Forest Entomology and Pathology Program. Sampled symptomatic tissues included twigs, leaves, and parts of cankered branches or boles. Some symptomatic tissues were sent directly to the CDFA Plant Pest Diagnostic Center (PPDC) for processing; the majority were processed at Humboldt State University or UC Cooperative Extension by culturing symptomatic tissues on acidified PDA or PARPH media. After culturing, identification was made to genus or species , if possible, by the PPDC using PCR sequencing of informative genomic regions with BLAST analysis. Following is a summary of collections and results.

Total samples collected: **65**

Samples with isolation of at least one known primary pathogen (Table 1): **47**

Samples with isolation of two primary pathogens: **5**

Samples with isolation of one or more secondary pathogens or saprophytes: **22**

Table 1. Primary pathogens isolated from sampled tissues. All samples were tanoak except for one coast live oak sample (*Biscogniauxia mediterranea* and *Tubakia californica* isolated) and one Pacific rhododendron sample (*Neofusicoccum arbuti* isolated).

Primary pathogen	Number of isolations
Tubakia californica	19
Diplodia corticola	8
Diaporthe sp./Diaporthales	7
Biscogniauxia sp.	6
Diplodia mutila	2
Cladosporium sp.	1
Phacidium lacerum	1
Sporocadus (=Seimatosporium) lichenicola	1
Pezicula cinnamomea	1
Allantophomopsis cytisporea	1
Neofusicoccum arbuti	1
Apiognomonia errabunda	1
Paratubakia sp.	1
Other bot canker fungus	1

The survey points toward some tentative conclusions, but it leaves even more open for future observation and study. Following are some of the salient points:

- Most of the isolated fungi are known for a cryptic or endophytic lifestyle. Wet, mild weather promotes spore release and infection events, and the pathogen often remains latent in infected tissue until a stress event, such as prolonged or severe drought, lowers tree resistance. When this occurs, the pathogen moves more aggressively in the tissue, colonizing and killing twigs, branches, and in some cases entire trees.

- Some symptom patterns could be distinguished for *Tubakia californica* and for *Diplodia corticola,* but not for any of the other fungi. These two most commonly isolated fungi in this survey also appear to have the greatest long-term impacts of the pathogens recovered in this survey. *Diplodia corticola* can cause large cankers on any part of a tanoak, including the roots, and can kill entire trees. On boles, *D. corticola* causes large cankers that sometimes bleed; necrotic cambium within the cankers is often darker in color than that typically associated with sudden oak death and the color contrast between living and dead cambium greater. On twigs, it causes wedge-shaped cankers that penetrate to the pith, knotty and rough patches on the twig epidermis, and sometimes witches'-broom-like growths of small twigs. Additionally, *D. corticola* usually produces small, dark, round asexual fruiting bodies that erupt through the epidermal layer of killed tissues. Incubation of these tissues in moist conditions for several days will often result in the appearance of whitish, cirrhi spore masses emerging from the fruiting bodies. Although *Tubakia californica* infects primarily leaves and twigs, it persists and spreads perennially throughout the crowns of susceptible trees—which are often located near each other in humid locations or wind corridors such as roads—causing progressive defoliation and possibly eventual mortality. It is unknown whether other fungal pathogens usually contribute to this decline process. Representative photos of symptomatic trees and tissues are shown in Figures 1 and 2.

- The large number of opportunistic or latent pathogens recovered in this survey—many of which were isolated from a single tree—may help explain the widespread dieback symptoms on tanoak in 2021 . These may have been due to the presence of these latent pathogens prior to the drought, which reduced tree resistance and increased fungal virulence.

- Seasonality of survey probably has an effect on recovery of pathogens. Waiting too long after tissue death, or waiting too long after sample collection to attempt isolation from symptomatic tissues, will often result in the overgrowth of highly competitive secondary pathogens and saprophytes in the sample. This may decrease the possibility of isolating any primary pathogen(s) from the symptomatic tissue.

- Some samples collected as part of other efforts are meaningful to this summary. Prior to 2021, *Diplodia corticola* was isolated from dead or dying-back tanoaks in Willow Creek and Bridgeville (Humboldt County) and Van Damme State Park (Mendocino County). In 2021, *Diplodia corticola* was isolated from the root burls of dead coast live oak seedlings and from bleeding cankers on the boles of mature tanoaks in Santa Cruz County. (Additionally, Phytosphere Research has noted numerous tanoak infections caused by *Diplodia corticola* throughout north coastal California over many years.) Prior to 2021, *Tubakia californica*

was isolated from coast live oak twig dieback near Point Reyes (Marin County) and Sebastopol (Sonoma County), and leaf symptoms were observed on valley oaks also being attacked by Mediterranean oak borer in Calistoga (Napa County). In 2021, *Tubakia californica* was isolated from coast live oak in Eldridge (Sonoma County) and from tanoak near Ukiah (Mendocino County). Insect pests collected from or observed on defoliated and dying-back tanoaks, coast live oaks, and California black oaks in 2021 included oak pit scale (*Asterodiaspis* spp.), oak lecanium scales (*Parthenolecanium* sp.), California oakworm (*Phryganidia californica*), and oak treehoppers (*Platycotis vittata*).

Other Pathogens

Coastal areas south of the surveyed area reported increases in oak dieback and mortality, some caused by the same pests identified in this summary, but some caused by others. For example, foamy bark canker, caused by the western oak bark beetle transmitting the fungus *Geosmithia pallida,* was noted causing extensive mortality of several oak species, particularly California black oak and coast live oak, in locations from southern Mendocino County to southern California and east into the Sierra Nevada foothills.

Oak and tanoak mortality caused by the pests identified in this survey often strongly resembled mortality caused by the sudden oak death pathogen *Phytophthora ramorum.* The overlap of pathogens caused some confusion about the distribution and spread of this non-native pathogen on the landscape during 2021, especially in roadside and aerial surveys. However, weather conditions in 2021 were generally not conducive to the spread of *Phytophthora ramorum,* which spreads more rapidly and widely during extended warm, wet periods.

Tanoak and Oak Mortality in San Luis Obispo County

Tanoak is not that widespread in San Luis Obispo (SLO) County; in the few areas where it is present, there was observed dieback and mortality in 2021. Samples were taken from symptomatic trees to determine cause of dieback and sent directly to CDFA Plant Pest Diagnostic Lab for processing. The tissue was analyzed by culturing and PCR. Following are results from the 2 locations where tanoaks were observed to be experiencing dieback and mortality in SLO County.

Total Number of samples: 5
Samples with isolation of at least one known primary pathogen: 4

Primary Pathogen	Number of Isolations
Diplodia corticola	3
Neofabraea sp.	1

Site 1: *Diplodia corticola* was also isolated from twig cankers on tanoaks that had multiple branch dieback and were small sized trees. They were on the west side of road along the ridge top of a slope, Figure 4.

Site 2: *Diplodia corticola* was isolated from large basal cankers on tanoaks in a mature stand that had numerous trees dead and dying. This stand was near a stream at low elevation in the northern part of San Luis Obispo County, Figure 5.

Figure 1. *Diplodia corticola* signs and symptoms on tanoak. (A) Witches'-broom-like growth of twigs from infected node. (B) Fruiting bodies on cankered, killed twig tissue. (C) Bleeding canker on tanoak trunk (photo courtesy Phytosphere Research). (D) Vascular streaking caused by *D. corticola* inside twig. (E) Typical whole-branch dieback caused by *D. corticola.* (F) Spore masses emerging from fruiting bodies on coast live oak root after incubation in moist conditions for several days.

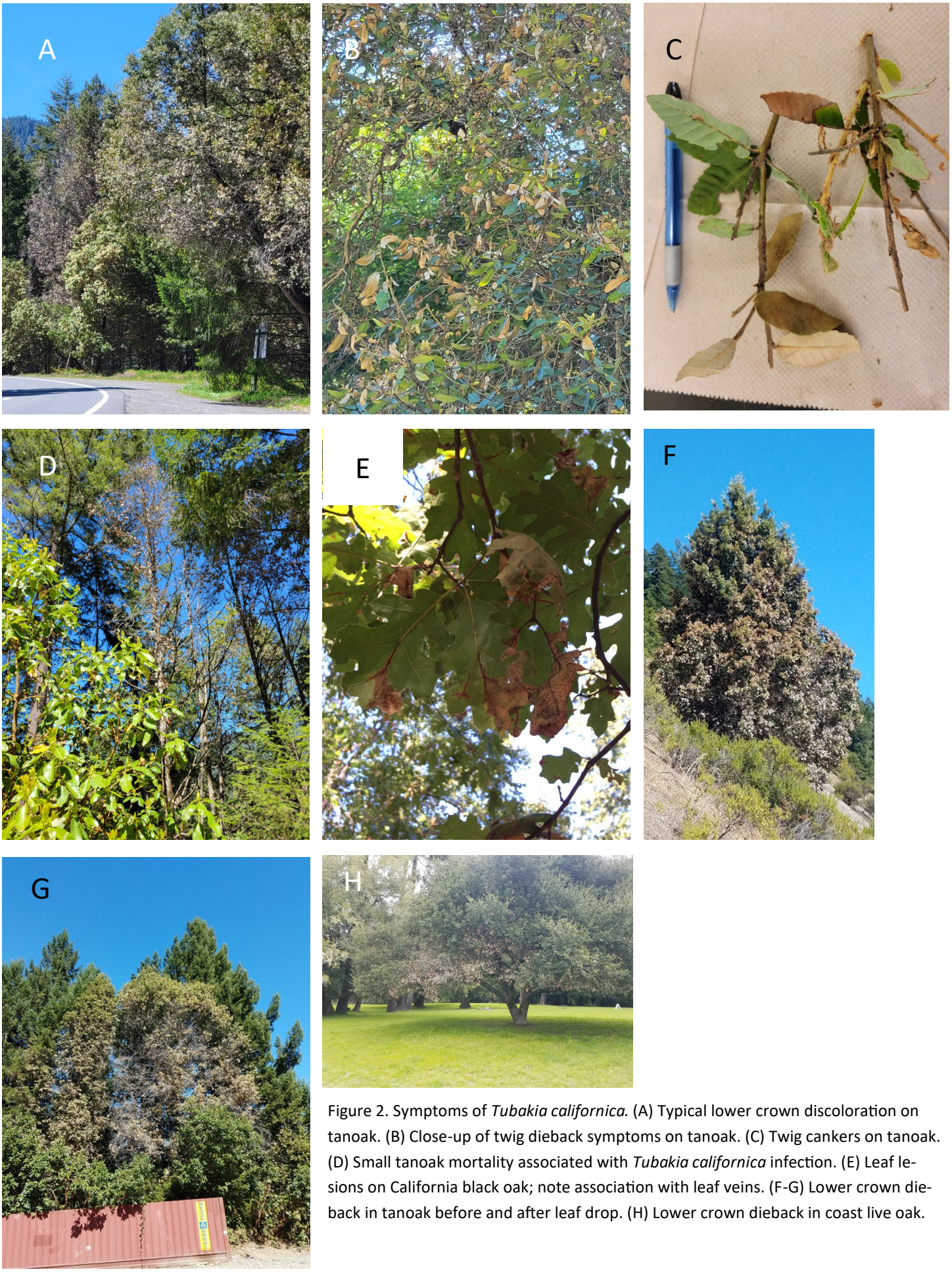

Figure 2. Symptoms of *Tubakia californica.* (A) Typical lower crown discoloration on tanoak. (B) Close-up of twig dieback symptoms on tanoak. (C) Twig cankers on tanoak. (D) Small tanoak mortality associated with *Tubakia californica* infection. (E) Leaf lesions on California black oak; note association with leaf veins. (F-G) Lower crown dieback in tanoak before and after leaf drop. (H) Lower crown dieback in coast live oak.

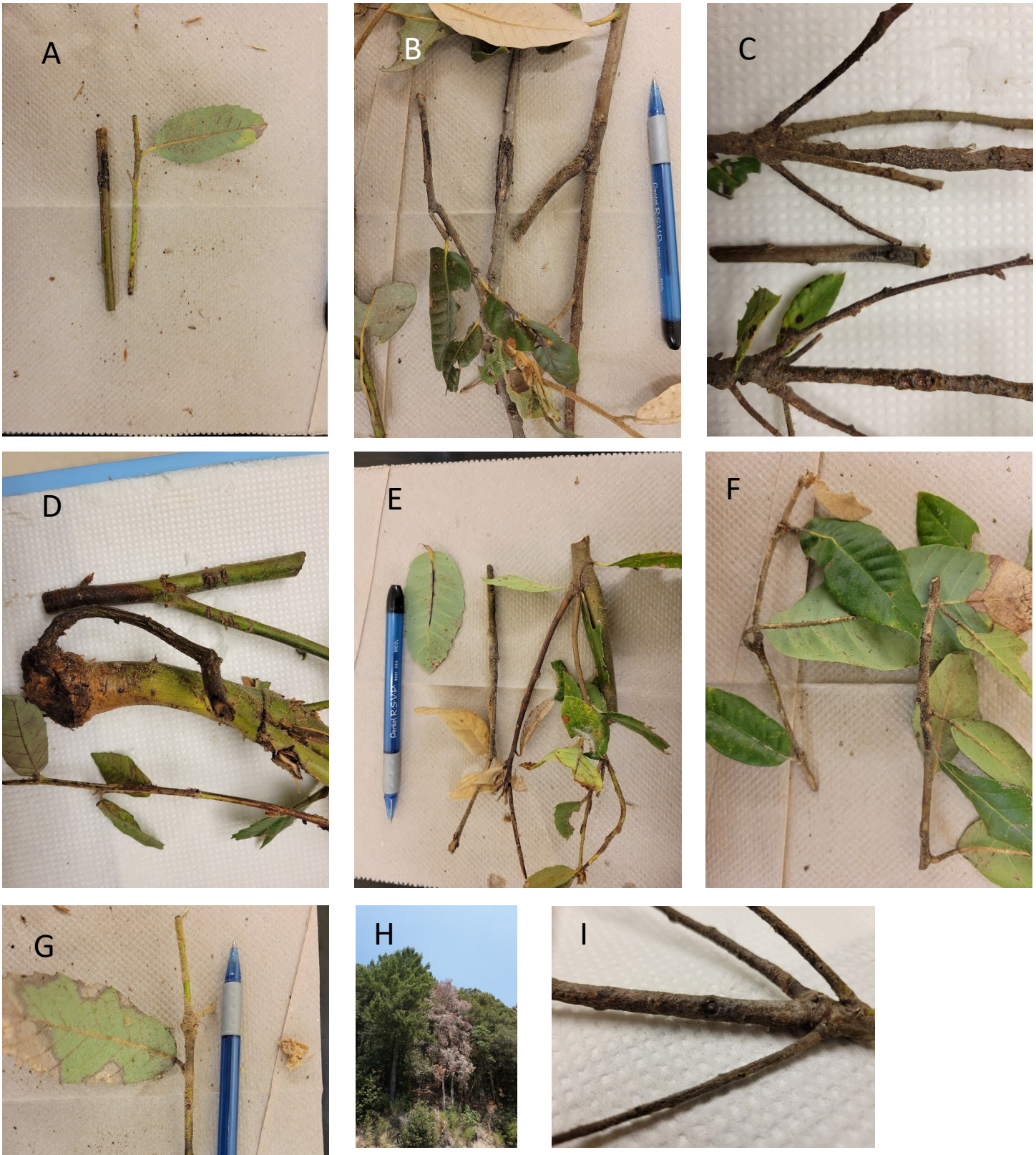

Figure 3. Symptoms caused by various pathogens on tanoak. (A) Blackened twig canker caused by *Biscogniauxia mediterranea*. (B) Cankers caused by *Biscogniauxia* sp. (C) Twig cankers caused by *Diplodia corticola*. (D) Root and crown rot associated with *Allantophomopsis cytisporea*. (E) Leaf lesions caused by *Apiognomonia errabunda* and twig cankers caused by *Tubakia californica.* (F) Twig cankers associated with *Diaporthe* and *Cladosporium* spp. (G) Twig and petiole cankers associated with *Cladosporium* sp. (H-I) Whole tree mortality and sunken twig cankers caused by *Diplodia mutila.* Dead tree is also associated with *Tubakia californica.*

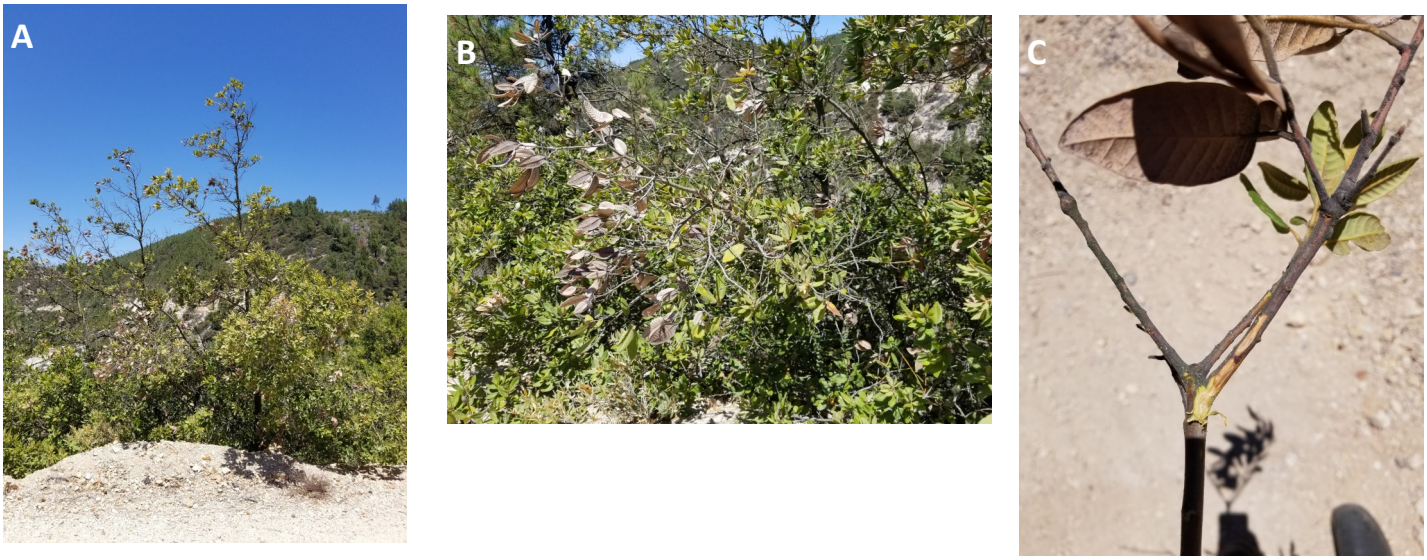

Figure 4. *Diplodia corticola* symptoms on tanoak in SLO County. (A) Branch dieback and defoliation. (B) Close-up of affected branch with dead leaves distal to canker. (C) Twig cankers.

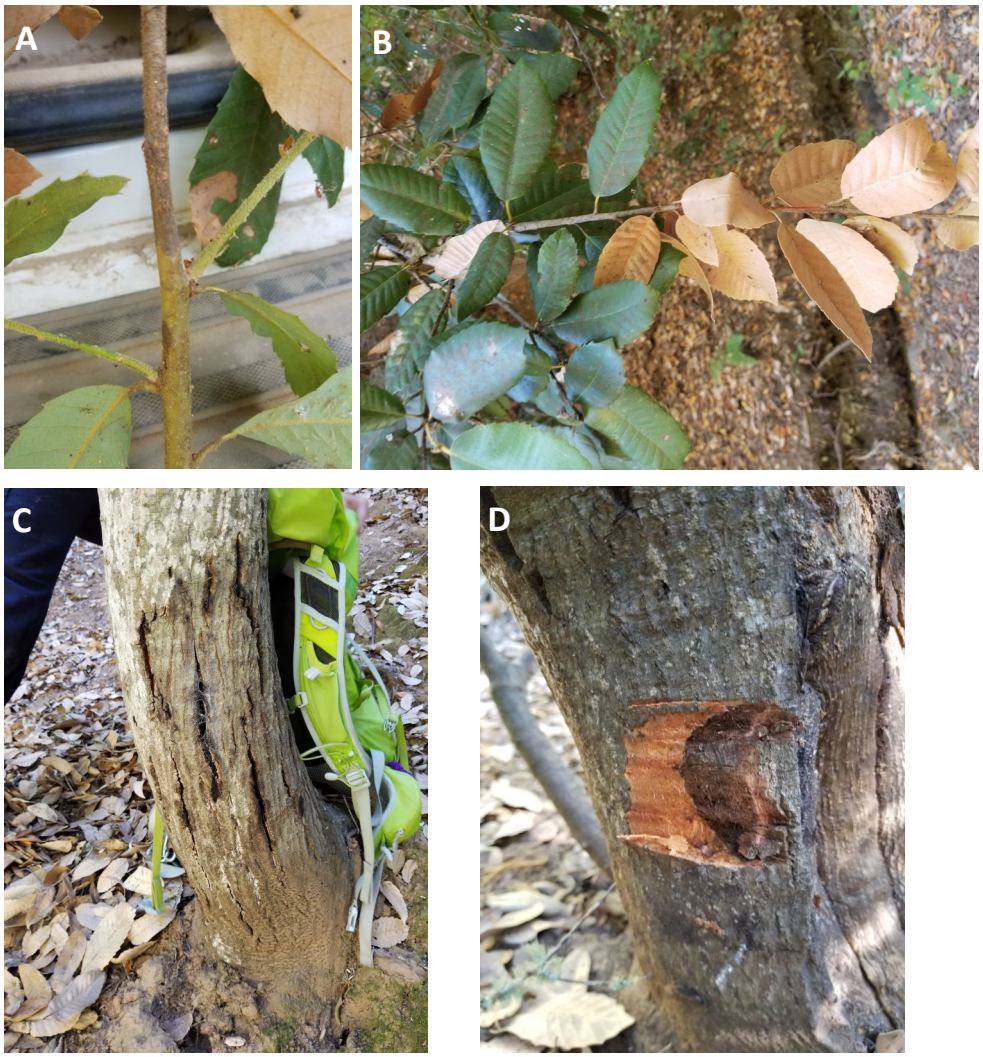

Figure 5. *Diplodia corticola* symptoms on tanoak in SLO County. (A) Branch dieback showing affected canker areas (B) Close-up of affected branch with dead leaves distal to canker. (C) Large basal bleeding canker on tanoak. (D) Margin of basal canker.