

- A. Date Submitted: May 18th 2026
- B. Project Title: “**Leveraging the forest practices act to restore and protect California’s coastal and foothill hardwood forests**”
- C. Project #: intentionally left blank
- D. Principal Investigator: Richard C Cobb
- E. Affiliation of PI: California Polytechnic State University, Department of Natural Resources & Environmental Science, California Polytechnic State University, San Luis Obispo, CA 93407
- F. Applying Organization: California Polytechnic State University, San Luis Obispo
- G. PI contact phone number: [REDACTED]
- H. PI contact email: [REDACTED]
- I. Names and affiliations of collaborators: **Adrian Poloni**, CalFire (Forest Entomology and Pathology Program, Southern District); **Kim Corella**, CalFire (Forest Entomology and Pathology Program, Central District); **Colin Noyes**, CalFire (Soquel Demonstration State Forest)
- J. Project Description (1987 of 2000 word limit)
 - i. Project duration

This project will span 3 years and includes the flexibility to reorder many activities to shift the budget to meet variable total funds available from the sponsor by year. Two years of field data collection and independent research by a graduate student can be structured in yrs 1&2 (assumed here) or focused in yrs 2&3. A third year is mainly focused on economic and epidemiological modeling and can be conducted either in yr 1 or yr 3 (yr 3 assumed here).

- ii. Background and Justification

This project seeks to evaluate several sections of the California Forest Practices Act (FPA) (particularly §1038, §957/959, §1052.5, and associated sub sections) as they apply to **strategic priorities 11.a, 6.c&d, and 12.a&c**. *Phytophthora ramorum* and *Agrilus auroguttatus*, also known as Sudden Oak Death (SOD) and Goldspotted Oak Borer (GSOB). These forest pests represent the most impactful current and future threats to lands managed under the Forest Practices Act.

Phytophthora ramorum emerged circa 1995 and has killed an estimated ~50 individual trees while about 2 billion additional tanoak (*Notholithocarpus densiflorus*), coast live oak (*Quercus agrifolia*), black oak (*Q. kelloggii*), and canyon live oak (*Q. chrysolepis* Lamsal et al. 2011, Cobb et al. 2020). Mortality has been concentrated in coast redwood (*Sequoia sempervirens*) forests primarily managed under Timber Harvest Plans (THPs). Of great concern, the disease increases live fuels due to prolific resprouting of pathogen-killed trees³⁻⁵, a well-known limitation to sustainable timber production⁶⁻⁸. The accumulation of live and dead fuels also magnifies wildfire-driven tree mortality, including redwood timber that would otherwise be resilient to wildfire impacts^{9,10}.

Agrilus auroguttatus (GSOB) represents the most immediate threat to a broad range of Sierra Foothill region broadleaved forests that often overlap with timber systems that are managed under the FPA. While GSOB has primarily impacted southern California broadleaved oak forests, many California black oak, Coast live oak, and Canyon live oak (*Q. chrysolepis*) forests are at risk; an estimated 2 billion trees are threatened by GSOB^{1,11,12}. GSOB has rapidly established in six southern California Counties after introduction in infected firewood moved across the Sonoran Desert. This insect also represents the largest application of pesticides for the control of an invasive pest on lands managed under the authority of the Board of Pesticide Regulation and the Federal government (Figure 1).

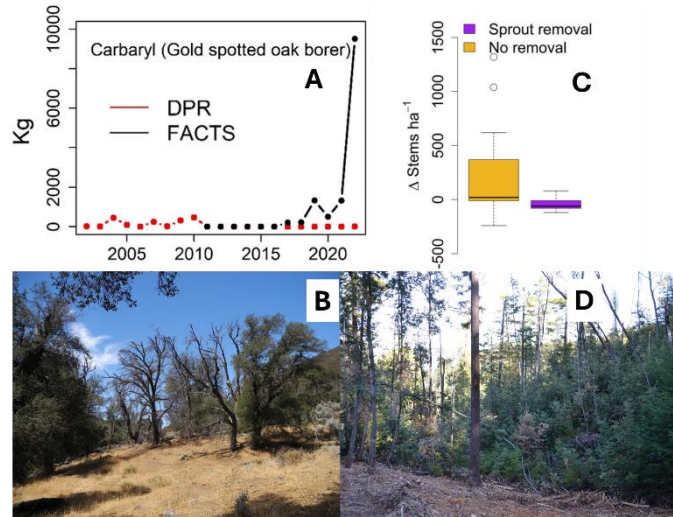


Figure 1. Study systems and key data. A) Carbaryl pesticide targeted to GSOB in state jurisdictions (DPR) and USDA Forest Service jurisdiction (FACTS); B) GSOB impacts in the Cleveland National Forest; C) change in stand density with and without basal sprout removal in SOD impacted forests (Quiroga et al. 2023); D) stand densification due to disease (right side) vs mastication (left side).

In combination, SOD and GSOB account for the most immediate threat to the function and sustainability of California's broadleaved forests and their control intersects with the strategic fuels management goals of California's forest resilience action plan^{5,13,14}. In both cases, it is unclear what forest management actions are most effective in 1) mitigating or preventing future fuels accumulation consistent with FPA rules §957 & §1038, 2) how to maximize the effectiveness of pesticide applications for the prevention of GSOB spread and impact to forest fuels consistent with California's pesticide use goals¹⁵, and 3) if the specific FPA rules designed to limit spread of SOD (§1052.1 & §1052.5) are effective in limiting within-stand fuels accumulation or the degree to which these rules can guide adaptation of FPA rules as GSOB establishes within the extensive swath of lands largely managed under THPs.

iii. Objectives and Scope

In the SOD system, we aim to resurvey a set of established field plots to determine their long-term efficacy and cost efficiency for mitigation of forest fuels and pathogen impacts. In the GSOB system, we aim to establish a set of long-term plots leveraging ongoing fuels mitigation and insect suppression activities in the Southern California region (Table 1). While the focus of the SOD portion of the project utilizes treatments conducted under the authorization of approved THPs or emergency exemptions identified under the FPA, the GSOB portion largely uses treatments established under emergency exemptions to CEQA and/or Vegetation Treatment Plan (VTP) authorities that are analogous to the specific rules focused on in this proposal. For GSOB, we seek to test the efficacy of possible modifications to the FPA using treatments conducted under related authorities to prepare for the likely invasion of GSOB into extensive areas managed via THPs.

Objectives:

1. Leveraging current combined SOD and fuels mitigation experiments to assess FPA forest health goals

Sudden oak death (SOD) management can be distinguished in the FPA in at least two ways: 1) mitigation of disease impacts via rules addressing fuels accumulation, slash, snags, and logs; 2) prevention of further spread. In practice, land managers have sought to address both problems simultaneously by removing infected individuals, manipulation of host density, and removal of dead fuels^{14,16}. To date, these adaptive management experiments have largely focused on the utility of different operational approaches (mastication, commercial thinning, prescribed fire) but have yet to evaluate the efficacy of these treatments in meeting stocking goals or their effectiveness in retaining a broadleaved component. Although SOD is a powerful pathogen that regularly severely impacts the broadleaved component of redwood and mixed evergreen forests in the coast range, there is growing evidence that low host densities, removal of infected trees, and an useful amount of natural variation in susceptibility can be leveraged to retain a broadleaved component^{2,17,18}. Furthermore, it is also clear that proactive management can prevent the severe and extremely costly stand densification that emerges in neglected forests^{3,14,19}. Specifically, we will determine the effectiveness of the FPA to maintain broadleaved forest components (“Hardwood”, **Theme 11**), mitigate wildfire hazards in broadleaved forests impacted or at risk to invasive biological agents of mortality (**Theme 6 & 12**):

1 – Determine the efficacy of SOD preventive treatments (§1052) to mitigate *P. ramorum* spread and their effects on fuels and timber species growth (aligned with or subject to slash and fuels mitigation rules and objectives of the Forest Management Task Force 2021).

2 – Determine the efficacy of operational approaches including two types of mastication and hand-crew thinning with and without pile burning for the mitigation of wildfire hazard and timber species restocking (§937, §957, §959).

3 – Determine the role of continuous forest management in preventing extreme forest density (prevention of *disease impacts*) contrasting broadcast burning, commercial thinning, and hand crew thinning applied in THP and VTP frameworks.

2. Creation of a new GSOB mitigation and fuels reduction network and framework for rapid implementation of Public Resources Code §716 within the FPA for GSOB mitigation in Sierra Foothill broadleaved forests

While SOD is a threat and realized impact to Coast Range forests, GSOB populations have established in six southern California counties via movement of unregulated firewood and is an acute threat to Sierra Foothill forests. These forests are utilized extensively by the private timber industry, particularly in the lower mid elevation and California black oak forests. Forest treatments for this emerging pest have utilized several pesticides, but largely rely on the prophylactic pesticide Carbaryl (Figure 1). Additional fuels and slash treatments are aimed at suppression of insect populations. Impacts have occurred across all land ownerships in southern California, including private lands. This proposal seeks to combine measurements of fuels and insect-driven mortality rates in a range of chemical and fuels mitigation experiments with the goal of evaluating past and ongoing treatments, including multiple pesticides. Similarly to the SOD study framework, the project seeks to establish a long-term study network to determine:

- 1 – Evaluate pesticide efficacy in reducing tree mortality and associated fuels accumulation
- 2 – Evaluate fuels reduction treatments for their efficacy in reducing tree mortality and within-stand pest incidence

iv. Research Methods

A common set of plot measurements will be employed, these measurements match a broader set of data spanning the geographic range of SOD which also provides a comparable reference dataset.

For both study systems have or will establish 500 m² circular plots constrained to distances of ~150 m from one another and 50m from a treatment edge with at least 10 plots per treatment type per site. These measurements capture stand biomass, type, condition, configuration and terrain positioning. During each survey, all stems >1 cm diameter at breast height (1.30 m) were measured, mapped, evaluated for health and insect or pathogen symptoms, and photographed from a fixed point allowing historical photographic comparisons. To quantify fine dead material, we will apply the Brown’s fuels transect measurement during each survey using three transects emanating from the plot center (30 m total survey length^{20,21}).

Table 1. Approaches and study site details.

Study system	Treatment details	Authority
Sudden Oak Death		
Preventive	Three treatment approaches, established in 2013 and surveyed every 5 years; Lack Creek Unit, BLM of Humboldt County.	Emergency/Categorical exemptions
Restoration	Four treatment approaches, established in 2014 and surveyed every 5 years; Marin Municipal Water District	Emergency/Categorical exemptions
Continuous	Four treatment approaches, established in 2023 and due for resurvey; Soquel Demonstration State Forest	THP and VTP
Goldspotted Oak Borer		
Pesticide only	Four candidate sites on federal and private land near Oak Grove Fire Station including >100 trees treated with Carbaryl in 2021 & 22	Future THP, VTP & CE subject to the FPA
Pesticide and Fuels reduction	Three candidate sites in the vicinity of the California State Parks Inland Empire District including >200 Carrbaryl treated trees and 80 treated with Imicide	Future THP, VTP & CE subject to the FPA
Fuels reduction	Four candidate sites on state and private land adjacent to Pesticide treatments	Future THP, VTP & CE subject to the FPA

Empirical, Epidemiological, and Financial analysis

We will quantify overstory species structure for each plot in each treatment approach and study system including quadratic mean diameter (QMD), basal area, and density by species. Empirical

analysis in the SOD system relies on a Before-After-Control-Impact (BACI) design with a random block variable (see Chevalier et al. 2019) while GSOB experiments will employ a treated-untreated paired contrast design (linear mixed modeling).

This project will leverage an existing, publicly available, and flexible SIR model constructed as an R package (SODDr model; Cobb et al. 2012, 2017, 2019; <https://github.com/noamross/SODDr>). This model has broad flexibility and can be parameterized to forecast changes due to many aspects of changing host composition. Plot-level empirical data will be used to validate previously published expectations of treatment benefits and evaluate the suitability of this model in applications for GSOB.

Lastly a simple set of financial models will be applied to SOD and GSOB management frameworks to determine net present value (NPV) from the perspective of fuels management goals in both systems. For both systems this analysis will incorporate tradeoffs from single or multiple fuels reduction treatments. In both systems, analysis of empirical datasets will be employed to create a plausible range of fuels reduction benefits and the decline of these benefits over time due to resprouting and accumulation of dead fuels. Unquantifiable and dynamic sources of uncertainty (discount rate, climate-driven wildfire risk) will be integrated by establishing reasonable scenarios from economics and climate modeling²²⁻²⁵.

v. Scientific Uncertainty and Geographic Application

The core uncertainty can be summarized in two questions: 1) What stand-level treatments best maintain broadleaved forest function in the face of combined wildfire and biological tree mortality threats? 2) how should the forest practices act be *modified to anticipate future forest threats* and limit insect movement outside of Zones of Infestation, such that it can rapidly adjust to meet its stated goals? This project will be applicable to most broadleaved and mixed conifer/broadleaved forests of California including the entire range of Coast live oak and Tanoak as well as Sierra foothill and lower-mid elevation California Black oak and interior live oak forests. This includes a large swath of private and public timberlands, including the state's most economically important timber lands measured by total economic output (Sierra Nevada) and stand-level timber value (Redwood forests).

K. Critical Themes and FPR addressed:

We propose a project with equal relevance to Research Themes 6 (Wildfire Hazard), 11 (Hardwood values), and 12 (Climate and wildfire resilience):

Theme 11: Most centrally, this project aims to address Theme 11 question a (11.a) with a specific focus on maintaining diverse broadleaved components of redwood timber systems and foothill and coastal oak forests imperiled by GSOB and SOD. This portion specifically focuses on **14 CCR §1038** (Zone of Infestation) with the aim of identifying suitable stocking for broadleaved species in pre and post outbreak conditions for SOD and GSOB. Related, a key set of rules include **§957.2**, **§957.4**, and **§959** given previous work demonstrating damaging tree mortality – wildfire interactions that disproportionately impact broadleaved species.

Theme 6: This project directly addresses Theme 6 questions c and d are confronted through focus on **§937**, **§957** and **§959** by developing an understanding of pre and post-outbreak management efficacy to mitigate dead fuels. Focus on **§957** rules are aimed at anticipating needed updates to the Forest Practices Act for the northern and central regions in anticipation of

GSOB arrival in Sierra Foothill, Central coast, and northern coast range forests where broadleaved species (coast live oak, black oak) are intermixed with timber species (also relevant to Theme 11 and **§1038**). As many conifer timber systems have become overstocked with broadleaved species in the redwood region (SOD invaded forests), this proposal is likely to inform stand rehabilitation in stands with high tanoak density following high grading and/or minimal post-harvest investment that often accompanies transfer of land ownership post-harvest. Furthermore, inclusion of prescribed fire to reduce slash and other dead fuels will inform **§957.2**, **§917.3**, & **§917.3** (treatment of slash) as well as the subsidiary region-specific rules and frameworks (e.g. **§917.4**, **§957.4**, **§917.5**, etc).

Theme 12: Lastly, this project addresses Theme 12 questions a and c by identifying management actions that create wildfire resilient conditions in broadleaved forests which are most impacted or most at risk for impacts by invasive pathogens and insects in general. Of course, SOD management is also governed by the outbreak-specific sections **§1052.1** & **§1052.5**. This project helps inform the effectiveness of these rules by determining the degree of avoided future mortality and within-stand pathogen dynamics. That is, even though the study sites are located in regions where the pathogen is well established, by understanding the role of fuels reduction treatments in avoiding mortality of residual broadleaved species, this project indirectly informs the potential efficacy of emergency actions aimed at containing outbreaks (e.g. **§1052.5**, “effective control or eradication”). Furthermore, the study indirectly informs **§1052.5.a.2** which requires containment activities must fully encompass the known outbreak. While the rules create flexibility to apply control even when landowner cooperation is incomplete, it is unclear how the degree of collective action influences management goals central to Theme 11 question a. Better understanding of the degree to which fuels reduction actions reduce within-stand broadleaved tree mortality will aid implementation of THP applications that meaningfully reduce SOD, even when these actions do not result in pathogen eradication. In the case of GSOB, many additional future threats to forest resources are likely in the coming decades and this project would inform the state’s response to these future threats.

L. Requested funding (196 of 200 word limit):

This project seeks \$155,756 in funding over three years (yr1 \$75,498, yr2 \$72,827, & yr3 \$7,431). This includes 0.25 months of summer salary for PI Cobb in year 1, 2, & 3 to supervise the project, conduct field and laboratory work, write reports, and present results at appropriate statewide meetings. 520 and 560 hrs and associated fringe benefits are requested for technical staff (Kerri Miracle) to conduct field work, supervise day-to-day fieldwork by student participants, oversee data entry QA/QC, and analyze data. We also request 40 and 60 hrs of support for undergraduate student involvement during the academic year in project years 1 and 2 (mentored data analysis). The total salary and fringe benefit costs for this support is estimated at \$43,625, \$48,978, & \$4,462. Travel support for field work is estimated at \$1,325 and \$2,825 for years 1 and 2. Consumable costs of \$200 & \$325 are requested in yr1 & yr2 and \$2000 for publication costs in yr3. We request indirect costs of \$20,316 (\$9,848, \$9,499, \$969, yrs1,2,&3).

Costs not subject to ICD: We also request tuition, stipend, and travel to a conference for one full time graduate student (yr 1 \$20,500; yr 2 \$11,200).

Appendix – Literature cited

1. Lamsal, S. *et al.* Spatial estimation of the density and carbon content of host populations for *Phytophthora ramorum* in California and Oregon. *For. Ecol. Manag.* **262**, 989–998 (2011).
2. Cobb, R. C. *et al.* The magnitude of regional-scale tree mortality caused by the invasive pathogen *Phytophthora ramorum*. *Earths Future* **8**, e2020EF001500 (2020).
3. Ramage, B. S., O'Hara, K. L. & Forrester, A. B. Forest transformation resulting from an exotic pathogen: regeneration and tanoak mortality in coast redwood stands affected by sudden oak death. *Can. J. For. Res.* **41**, 763–772 (2011).
4. Cobb, R. C., Filipe, J. A. N., Meentemeyer, R. K., Gilligan, C. A. & Rizzo, D. M. Ecosystem transformation by emerging infectious disease: loss of large tanoak from California forests. *J. Ecol.* **100**, 712–722 (2012).
5. Metz, M. R., Frangioso, K. M., Wickland, A. C., Meentemeyer, R. K. & Rizzo, D. M. An emergent disease causes directional changes in forest species composition in coastal California. *Ecosphere* **3**, art86 (2012).
6. Tappeiner, I. I., John, C., Pabst, R. J. & Cloughesy, M. Stem treatments to control tanoak sprouting. *West. J. Appl. For.* **2**, 41–45 (1987).
7. Harrington, T. B. & Tappeiner, J. C. Long-term effects of tanoak competition on Douglas-fir stand development. *Can. J. For. Res.* **39**, 765–776 (2009).
8. Simler-Williamson, A. B., Metz, M. R., Frangioso, K. M. & Rizzo, D. M. Wildfire alters the disturbance impacts of an emerging forest disease via changes to host occurrence and demographic structure. *J. Ecol.* **109**, 676–691 (2021).
9. Metz, M. R., Frangioso, K. M., Meentemeyer, R. K. & Rizzo, D. M. Interacting disturbances: wildfire severity affected by stage of forest disease invasion. *Ecol. Appl.* **21**, 313–320 (2011).
10. Metz, M. R., Varner, J. M., Frangioso, K. M., Meentemeyer, R. K. & Rizzo, D. M. Unexpected redwood mortality from synergies between wildfire and an emerging infectious disease. *Ecology* **94**, 2152–2159 (2013).
11. Coleman, T. W. *et al.* Coast live oak, *Quercus agrifolia*, susceptibility and response to goldspotted oak borer, *Agrilus auroguttatus*, injury in southern California. *For. Ecol. Manag.* **261**, 1852–1865 (2011).
12. Jones, M. I., Coleman, T. W., Graves, A. D., Flint, M. L. & Seybold, S. J. Sanitation Options for Managing Oak Wood Infested With the Invasive Goldspotted Oak Borer (Coleoptera: Buprestidae) in Southern California. *J. Econ. Entomol.* **106**, 235–246 (2013).
13. Forest Management Task Force. California's wildfire and forest resilience action plan. (2021).
14. Quiroga, G. B. *et al.* An experimental comparison of stand management approaches to sudden oak death: prevention vs. restoration. *Can. J. For. Res.* <https://doi.org/10.1139/cjfr-2022-0328> (2023) doi:10.1139/cjfr-2022-0328.
15. Sustainable Pest Management Work Group and Urban Subgroup. *Accelerating Sustainable Pest Management: A Roadmap for California*. 97 (2023).
16. Valachovic, Y. S., Twieg, B. D., Lee, C., Cobb, R. C. & Stark, D. Forest stand conditions after *Phytophthora ramorum* management in northern California: post-treatment observations inform future responses. *For. Phytophthoras* **7**, 54–66 (2017).
17. Cobb, R. C. *et al.* Biodiversity Conservation in the Face of Dramatic Forest Disease: An Integrated Conservation Strategy for Tanoak (*Notholithocarpus densiflorus*) Threatened by Sudden Oak Death. *Madroño* **60**, 151–164 (2013).
18. Cobb, R. C. *et al.* Promise and pitfalls of endemic resistance for cultural resources threatened by *Phytophthora ramorum*. *Phytopathology* **109**, 760–769 (2019).
19. Cobb, R. C. *et al.* Resiliency or restoration: management of sudden oak death before and after outbreak. *For. Phytophthoras* **7**, 1–14 (2017).
20. Brown, J. K., Oberheu, R. D. & Johnston, C. M. Handbook for inventorying surface fuels and biomass in the Interior West. *USDA Serv Gen Tech Rep INT-129* (1981).
21. Valachovic, Y. S. *et al.* Sudden oak death-caused changes to surface fuel loading and potential fire behavior in Douglas-fir-tanoak forests. *For. Ecol. Manag.* **261**, 1973–1986 (2011).
22. Marglin, S. A. The Social Rate of Discount and The Optimal Rate of Investment. *Q. J. Econ.* **77**, 95–111 (1963).
23. Shafran, A. P. Risk externalities and the problem of wildfire risk. *J. Urban Econ.* **64**, 488–495 (2008).
24. Shafran, A. P. Self-protection against repeated low probability risks. *J. Risk Uncertain.* **42**, 263–285 (2011).
25. IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. (2014).